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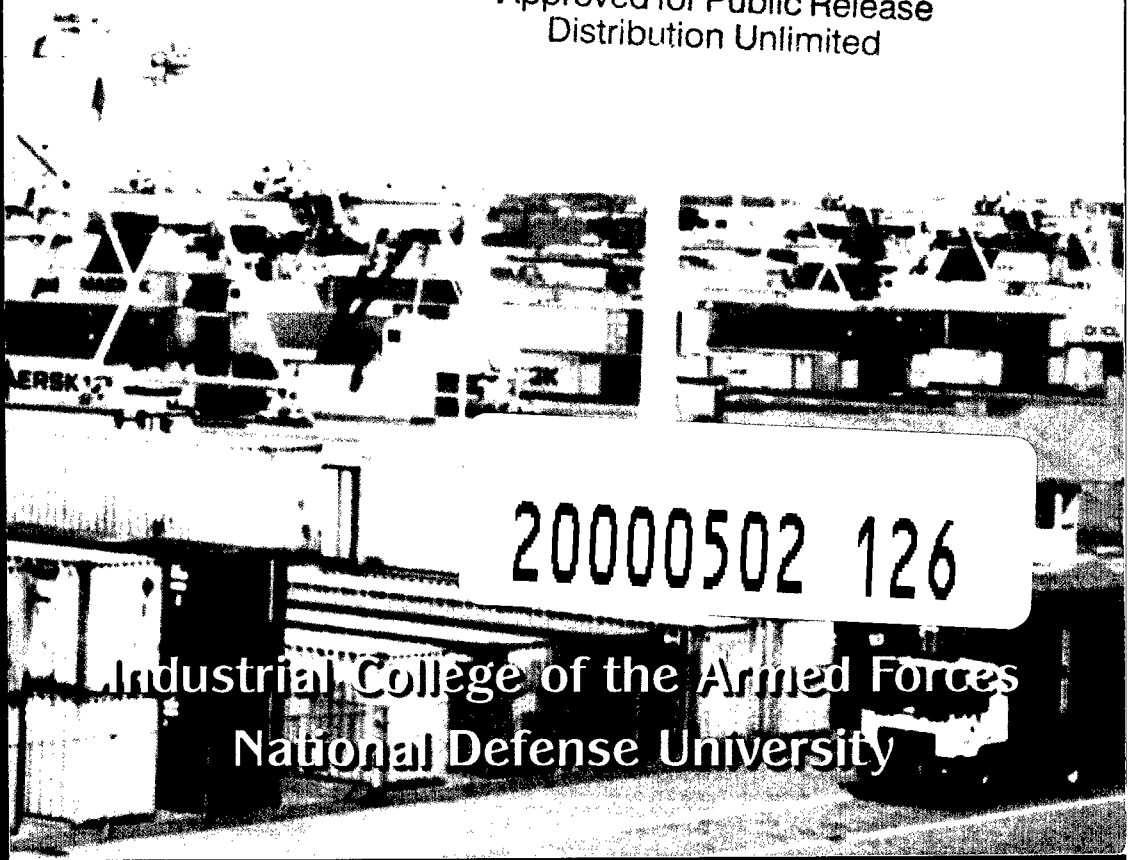

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Industrial College of the Armed Forces
National Defense University

IN TOUCH WITH INDUSTRY: ICAF INDUSTRY STUDIES 1999

GERALD ABBOTT, editor
abbottg@ndu.edu

1999

INDUSTRIAL COLLEGE OF THE ARMED FORCES
NATIONAL DEFENSE UNIVERSITY
WASHINGTON, DC 20319-5062

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Our student body has grown to over 300 senior military and civilian students including senior officer students from some 20 foreign countries and three students from industry. This increase has allowed us to expand the industry sectors under study to 20 to include for the first time the media industry and a resumption of our study of the financial services industry.

The industry studies program continues to be the College's laboratory to test in the "real world" the ideas, concepts and theories explored in the classroom. Additionally the program represents our constant commitment to Bernard Baruch's charge made over 75 years ago, at the College's founding, to "keep in touch with industry."

The following chapters provide an assessment of the condition and outlook of 20 industry sectors we consider vital to the nation's security. In addition to classroom sessions, domestic and international field studies were conducted to assess firsthand the health of each sector in an attempt to determine its ability to support the national security strategy within a global context. This book is published as a small contribution to the public policy debate over the defense industrial base in particular and the total industrial and productive base in general.

Suggestions for other areas of study or comments should be directed to the editor. I offer the thanks of our students and faculty to the many companies and agencies which have so generously shared their time and knowledge. Without their support, this vital and most successful program could not continue.

RICHARD L. ENGEL
Major General, USAF
Commandant, ICAF

ADVANCED MANUFACTURING

ABSTRACT

The manufacturing environment today is one of rapid change. Customer demands for low-cost, high-quality goods; a global market; and exponential growth in manufacturing technologies are challenging manufacturers. Many manufacturing companies in the United States and abroad are responding to next-generation challenges. The transition is not without its problems, however. Obstacles such as adversarial labor–management relations, a poorly educated entry-level workforce, and unfriendly government policies are hampering industry's ability to respond to these new challenges. Further, many manufacturers are finding it necessary to change their basic organizational structure and value chain to be flexible, agile, and globally competitive. Finally, manufacturers are discovering both the bright promise and the formidable task of embracing cutting-edge manufacturing technology.

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Dr. Linda Brandt, faculty
CAPT Paul Moser, USN, faculty
Ms. Ann Rider, faculty

PLACES VISITED

Domestic

Boeing, St. Louis, MO
Focus Hope, Detroit, MI
General Motors (Cadillac) Assembly Plant, Hamtramck, MI
General Motors Corporation, Warren, MI
General Motors Technical Center, Warren, MI
General Motors Truck Assembly Plant, Pontiac, MI
Harley-Davidson, Inc., York, PA
Henry Ford Museum, Dearborn, MI
Lancaster County Chamber of Commerce, PA
Landis Gardner Tools, Waynesboro, PA
Lear Corporation, Rochester Hills, MI
Thermacore, Lancaster, PA
University of Michigan Transportation Research Institute (UMTRI), Ann Arbor, MI
Wayne State University, Detroit, MI

International

Aisin Seiki Company, Ltd., Aichi, Japan
Mitsubishi Heavy Industries, Ltd., Nagoya, Japan
NGK Insulators, Ltd., Nagoya, Japan
Toyota Motor Corporation, Toyota City, Japan
U.S. Consulate, Nagoya, Japan
U.S. Consulate, Shanghai, China
Yamazaki-Mazak Trading Corporation, Aichi-Prefecture, Japan

INTRODUCTION

"Manufacturing is vital to our nation's economic and military security, our quality of life, and our environmental health."[1] This quote from the National Science and Technology Council captures the strategic importance of manufacturing to the future prosperity and global prominence of the United States.

Today, the manufacturing industry is healthy. The sector represents approximately 20 percent of the total U.S. gross domestic product (GDP). Manufacturing employs almost 19 million workers, accounting for about 15 percent of U.S. non-farm jobs.[2] Manufacturing workers typically earn 20–30 percent higher wages than their service and retail sector counterparts.[3] Manufacturing firms employ three-quarters of the nation's scientists and engineers, and every 100 jobs in manufacturing support more than 60 other jobs outside the sector.[4] Factories today are operating at more than 80 percent industrial capacity.[5] Enhanced by advanced manufacturing methods, productivity is high and continues to increase annually.[6] The United States is moving into the next century with one of the most prosperous economies in its history.

Nevertheless, unprecedented changes in the global environment are challenging the manufacturing sector today. As they plan for a secure future in this fast-changing global marketplace, manufacturers must consider what to produce, how much to produce, and for whom to produce it. Fundamental to operations is the ability to be responsive to changes.

Some of these changes began in the 1980s after the flood of quality Japanese imports threatened U.S. manufacturers with virtual extinction. To the horror of U.S. industry, domestic customers in droves abandoned United States–made automobiles, electronics, and other consumer goods in favor of the better quality Japanese imports. Companies were shocked and dismayed at their incredibly shrinking domestic market share. Since then, many U.S. manufacturers have adopted Japanese advanced manufacturing techniques such as "lean manufacturing" and the Toyota Production Method and fused these with U.S. information technology for even greater competitive advantage.[7] They have developed a better customer focus and are winning back domestic market share—many are now competing successfully in Japan and elsewhere overseas.

THE ADVANCED MANUFACTURING INDUSTRY DEFINED

For millennia, manufacturing was the *art* of making things, practiced under the keen eye of the skilled artisan or craftsman. Only as recently

as the 19th century Industrial Revolution has manufacturing realized economies of scale through mass production. Henry Ford revolutionized manufacturing in the United States by implementing moving assembly lines, standardizing parts, and employing largely unskilled laborers to perform single, repetitive tasks. Produced in large quantities at low prices, goods became available and affordable to an ever-growing share of the population.

Today, manufacturing's challenges are different and more complex. Consumers no longer select manufactured goods on the basis of price alone. They look for high-quality, affordable products that meet their individual needs. They buy products that represent "best value." Manufacturers today are faced with seemingly conflicting customer requirements for products that are high quality, yet low cost; mass produced, yet customized. Achieving all these goals would be impossible using 19th (and even many 20th) century manufacturing processes. Manufacturers must now seek competitive advantage by developing procedures for "mass customization," building quality into the products, capitalizing on technological superiority, and using other "advanced" techniques.[8]

Advanced manufacturing, then, can be considered a dynamic system that tightly integrates *people*, *processes*, and *technology* into a synergistic and continuously improving entity. Advanced manufacturing is defined not by the specific product that the company makes, but rather by the processes that the company employs. Advanced manufacturing processes enable a firm to differentiate its products or services in terms that customers understand and appreciate—quality, reliability, and serviceability. Further, advanced manufacturing methods help firms cut or control costs. Advanced manufacturers are adapting and thriving in these times of unprecedented change.[9]

CURRENT CONDITION

People

Labor–Management Relations. The advanced manufacturers that this group observed both in the United States and abroad manage forward-thinking human resources programs. People are more than just carbon-based tools; rather, they are valued members of the manufacturing team. Many advanced manufacturing companies take care to include labor union representatives and shop floor workers in decision-making that affects the workforce.[10] Increasingly, labor unions

see themselves as business partners, knowing that a healthy, thriving business is good for their members.

Historically adversarial, relations between labor and management have long been marred by strikes, grievances, contract disputes, high rates of absenteeism, and a perceived lack of worker dedication to company productivity and product quality.[11] Unions have viewed management treatment of workers as unfair and capricious. In the current environment, however, traditional labor–management relations are huge impediments to success. In more progressive manufacturing companies, labor and management are working to change their culture from one of confrontation to one of cooperation.[12]

Workforce Education and Training. A top-quality workforce is necessary to ensure U.S. competitiveness in the global market. The U.S. workforce cannot compete globally based solely on cost, so it must be competitive on the bases of technical skill, value, and quality. Advanced manufacturers need entry-level workers who can read, understand basic mathematics, and are computer-literate. In an era of near full employment, many U.S. manufacturers have been unable to find workers with even these most basic skills. In fact, 20 percent of U.S. adults are functionally illiterate.[13] Exasperated industry executives indicate that they cannot modernize plant equipment because workers lack the necessary skills to operate more advanced equipment. The National Association of Manufacturers, based on a series of 14 focus group meetings at the chief executive officer (CEO) level across the United States, concluded that "school systems have failed." The groups felt that the school systems are providing neither adequate basic skills nor an adequate understanding of business and the necessary work ethic.[14]

Globalization. The U.S. workforce faces a challenge from globalizaion as well.[15] Although low wages are generally equated with low skills, this is not always the case. India trains and provides many exceptional computer programmers who can compete technically with those in the United States—and at a much lower labor cost. Likewise, China's university-educated engineers and technicians rival those in the United States in skill, but earn wages that are an order of magnitude lower. Many advanced manufacturing companies, including General Motors (GM), Intel, and others, are taking advantage of the global workforce to reduce costs and improve market share.

Processes

Today's manufacturers constantly seek methods to streamline production, improve quality, and maintain their competitive edge. Over

the past several years, a variety of new or different practices have evolved. These are intended to eliminate waste in the overall manufacturing process, focus effort on generating value, maximize effectiveness of human capital and external resources, and foster productivity and adaptability. Process improvements in two key areas came to the fore during this study: the establishment of core competencies and the aggressive management of the value and supply chains.

Establishing Core Competencies. In establishing core competencies, many manufacturers have realized that diversification or horizontal integration dilutes management's focus on the work that the company does best (and with which it presumably has some modicum of relative advantage).[16] Companies such as Hughes and Texas Instruments have divested themselves of their defense components to focus their efforts solely on the private sector markets.

Managing the Value/Supply Chains. Other manufacturers looking at their value chain recognized the need to outsource internal, non-core work such as payroll, transportation, or logistics.[17] Outsourcing alleviates much of the day-to-day attention that a company must pay to details, but requires a more aggressive screening and management of suppliers to ensure uninterrupted operations. General Motors, for example, outsources manufacture of their automobile seats and interiors to Lear. Discussions with Lear executives revealed that GM management routinely set strict quality, schedule, and cost guidelines; monitored Lear's performance; and demanded compliance. Outsourcing is *not* an entirely hands-off process.[18]

Technology

It is impossible to overstate technology's importance and impact on both business and the national economy. By some estimates, information technology represents as much as 40 percent of today's GDP, and accounts for more than one-third of GDP growth since 1992.[19] Three technologies have emerged that provide manufacturers with tremendous opportunities—workplace automation, advanced materials, and information technology—and even more advanced technologies are on the horizon.

Workplace Automation. The bread and butter of the new advanced manufacturer may be workplace automation. Robotics, precision computer numerically controlled (CNC) machines, computer-aided design/computer-aided manufacturing (CAD/CAM), and flexible manufacturing systems are a few of the essential technologies

transforming the shop floor. Robots have replaced human labor in many applications, such as material handling, welding, cutting, and similar operations. There is now a grudging acceptance of robotics, once the scourge of labor unions, particularly to do dangerous, dirty, or difficult tasks. The U.S. market for robots broke $1 billion in 1998.[20]

Likewise, computer-operated machine tools allow repetitive operations to be preprogrammed and executed. Machine setup and changeover time are minimal, and operators simply keep the machines stocked with raw materials and monitor their performance. Newer numerically controlled (NC) machines, such as those sold by Yamazaki-Mazak in Japan, feature simplified programming that the average worker can master in a few hours.[21]

Modern CAD/CAM systems and flexible manufacturing systems take numerical controls a step further and incorporate design software to feed specifications directly into the NC machines for manufacturing. Designers can finalize a design on screen and electronically send it to the shop floor, where it is manufactured with little or no operator intervention.

Advanced Materials. Fiber composites, plastics, ceramics, and other advanced materials offer manufacturers a competitive advantage in new and more robust products. Composite materials have the potential to revolutionize the aviation industry. With the use of composite aircraft components, aircraft become lighter to save fuel, yet exhibit similar, or better, strength and durability than all-metal planes. Also, plastics and ceramics provide highly desirable qualities in end products, if manufacturers can perfect the designs and processes for producing them in an economically viable fashion. Many advanced manufacturers not only are perfecting processes to deal with these materials, but also are discovering new and even more innovative applications.

Information Technology. Of all the new technologies, information technology is having the greatest impact on manufacturing.[22] Companies are finding applications for modeling and simulation (M&S) of products and processes before investing the huge sums of money required to construct new plants. General Motors is using M&S in new car designs to replace the clumsy clay models previously used. Now, when GM is making design changes, the M&S software can render the image almost instantaneously—a far better, cheaper, and more intuitive process than sending the clay models back for days or weeks of rework.[23]

Advanced Technologies. Many companies are on the verge of implementing new and even more fantastic technologies, such as virtual prototyping, solid freeform fabrication, and powder metal technology. Virtual prototyping allows engineers to design products in cyberspace

using physics-based component models to determine how the products will look (form and fit), as well as perform (function), under a variety of environmental conditions. Solid freeform fabrication takes virtual design one step further. Using plastic, metal, or wood powder and lasers, machines can fabricate, layer by layer, any component designed on a CAD workstation. Powder metal technology works similarly in that metal powder is cast in shapes unattainable by conventional forming or machining. These physical prototypes can then be studied and tested. Direct fabrication through solid freeform fabrication and powder metal technology is an exciting new development in what has come to be called desktop manufacturing. In the future, these processes have the potential to allow custom parts to be made on demand, eliminating the need to stockpile spare parts and components.

CHALLENGES

People

Labor–Management Relations. The key to survival in the new manufacturing environment is to leverage human resources to boost competitive advantage. The successful manufacturer must identify needed skills, provide the required resources and training, and empower workers to play an important role in defining the production process. In advanced manufacturing, old-style labor–management relationships must be redefined.[24] The manufacturing sector had 15 major work stoppages of 1,000+ workers in 1998. In the transportation manufacturing industry alone, 3.5 million workdays were lost in 1998—including those lost during the 4-week GM strike involving 152,000 workers.[25] Labor unions must become business partners, not worker–crusaders whose demands must be met at any cost. Likewise, the trend toward outsourcing and the emphasis on core competencies demand that suppliers, joint venture partnerships, and contingent employees (i.e., temporary, part-time, and consultant workers) play an increasingly important role on the business team.

Education and Training. Unprecedented cooperation between business, government, and universities is essential to ensure that tomorrow's graduates from public schools, colleges, and universities are world-class work candidates. In counterpoint, manufacturers must accept the challenge to provide ongoing training to a continuously improving workforce. The pace of technology and fierce international competition for jobs demand no less.

Processes

Advanced manufacturers will continue to be challenged to generate value and eliminate waste from their processes. The outsourcing of non-core work, the "rightsizing" of organizations, and the corporate Kabuki dance of mergers and acquisitions will undoubtedly continue well into the next century.[26] As technology enables manufacturers to replace people with automatic devices, organizations will become leaner. Manufacturers in the United States could have the luxury of mitigating some cyclical effects through layoffs. With smaller workforces, they will have to look for other ways to do so.

While most U.S. manufacturers have successfully refocused their attention toward quality and customer needs since the Japanese "invasion" of the 1970s, process management will remain a challenge. Innovation and new product introduction are only parts of the story for truly successful advanced manufacturers. It is vital to instill a deep appreciation for *Kaizen*, or continuous improvement.[27] Some U.S. companies appear to be closer to old-style shops with laborers repetitively performing mind-numbing tasks and inspectors checking outputs, seemingly with little regard for how their processes could be improved or how defects could be eliminated at the source. These wasteful and inefficient practices differentiate them from the truly advanced manufacturers in more progressive U.S. and Japanese plants and may prove to be their undoing.

Technology

Acceptance and Impact. The challenge of technology can be summed up in two words: acceptance and impact. The first hurdle that manufacturers have in adopting new technologies is acceptance. Corporate inertia, fear of change, and an attitude of "wait and see what will happen next" keep many manufacturers from adopting technology that could improve their products or processes. Even in Japanese industry, some processes, such as the work-sequencing system *Kanban* are still accomplished manually through the use of paper cards.[28] Technology, for many, equates to uncertainty; in turn, uncertainty equates to risk. Manufacturers need to manage technology risk and understand its impact on the organization to reap the potential benefits.[29]

Technology presents manufacturers with real and difficult challenges. Standards do not always exist for data interchange, and the use of information technology may facilitate the exchange of product and process data. Many companies are on the cutting edge of technology

where systems must be adapted to work in existing organizations (or vice versa). New information systems often require radical changes in organization, policies, processes, and even culture. For example, the digitization of proprietary data, trade secrets, and intellectual property can make the information potentially more vulnerable, so new security processes must be developed and implemented.[30]

Research and Development. Another challenge of technology is to maintain the appropriate level of underlying research and development (R&D) to ensure future innovation.[31] A disturbing trend has emerged over the last two decades. Government spending on R&D, compared with overall R&D spending in the United States, has declined from more than 50 percent in 1980 to about 30 percent today.[32] Although industry R&D spending has continued to grow during this period, much of it has focused on the near-term, profit-maximizing improvements to existing products.[33] Too few dollars are being invested in long-term, leap-ahead research to ensure that the United States maintains—and indeed expands—its global technological superiority. In fact, in 1995, U.S. spending on R&D, as a percentage of GDP, was lower than that of Sweden, Japan, Korea, and Switzerland.[34]

In what may be signs of a reversal of these trends, the 1999 federal budget shows a slight R&D increase, and industry figures are projected to jump by nearly 9 percent from about $144 billion to $157 billion. University and nonprofit spending will increase about 5 percent to roughly $10.8 billion. Reversing the effects of the prolonged downward trend in long-term, high-payoff R&D may be difficult. A large upswing in federal R&D is unlikely, and expectations that industry or academia will shoulder the burden may not be realistic.[35] Since no single organization or sector will have sufficient funding (or is willing to spend it) for advanced R&D, partnerships in which everyone shares costs, experience, and resources make more sense now than ever. Industry, government, and academia could leverage each other's strengths and capabilities to improve national industrial competitiveness.[36]

OUTLOOK

People

Labor–Management Relations. Although fundamental differences and tensions will undoubtedly continue to challenge future labor–management relations, the emerging attitude of both labor and management in advanced manufacturing companies, both here and abroad, seems to be one of partnership.[37] Today, participatory

management, empowered work teams, and lean manufacturing techniques are giving workers increased influence in the companies where they work. Even to workers, company ownership through generous stock options seems to be the wave of the future, particularly in high-technology start-ups.[38]

Realizing the importance of worker contributions to the success of their companies, managers continue to institute programs to improve communication and cooperation, such as Quality Circles, Quality of Work Life groups, joint communication committees, and work teams. Regular meetings between labor and management are now commonplace, not just to discuss labor contracts as in the past, but to make joint corporate decisions—a management only prerogative just a few short years ago. Advanced manufacturers are coming to realize and value the potential competitive advantage that individual workers bring to the enterprise. Likewise, labor is beginning to see the advantage of working directly and cooperatively with corporate management in their best mutual interest.[39]

Education and Training. Manufacturing jobs of the future will require *more* skills and education than today's manufacturing jobs do, not less.[40] The good news is that efforts to improve the existing public education system are evident at every level of government and in industry. Money and resources are flowing from federal and state coffers to needy schools. Heroic efforts are shoring up the current infrastructure. New and exciting experiments and pilot programs are beginning, such as charter and magnet schools, vocational–technical "academies," and other forms of schools within schools, to better prepare future generations for the workplace. Fairfax County, Virginia, has five vocational–technical academies operating within its secondary school system, for example. The academies work closely with local industry to develop learning standards for their programs, and they implement these standards within the high-school elective system to produce skilled, job-ready graduates.

There are also both federal and private programs to provide training in job skills to unemployed and welfare recipients. Focus Hope, an inner city Detroit-based program started by a Roman Catholic priest, trains disadvantaged youth for manufacturing and information technology jobs. This tough, accredited program is a shining example of a grass-roots solution to one facet of the education problem.[41]

Industry, of course, must take a share of the responsibility for education and training. Robust internal training programs are essential to maintaining a top-quality, continuously improving workforce. In an era when the average age of the manufacturing workforce is over 40 years, many companies have rationalized that most workers are already skilled

and have abandoned or de-emphasized their training programs . To stay competitive, these same companies must now train a whole generation of replacements as workers reach retirement age.

One resource that many companies are turning to is their local junior college.[42] This collaboration is a natural fit, as a 2-year institution can provide much of the training needed in many advanced manufacturing venues. Companies can outsource much of their training to experts whose core competency *is* training and leverage the colleges' existing training infrastructure. Local manufacturers in Lancaster County, Pennsylvania have established close working relationships with nearby secondary schools and junior colleges in an innovative arrangement that benefits the workforce, schools, and industry. In the future, collaborative efforts like this one will be commonplace.[43]

Processes

Clearly, there will be further mergers, consolidations, and outsourcing among advanced manufacturers, as companies desperately seek to identify their core competencies and to gain global competitive advantage. Automobile companies like Ford and GM look to companies like Lear for their expertise in interior and seating design and manufacture. The auto companies work closely with suppliers during the design phase, then aggressively manage supplier deliveries to dovetail with final assembly. Design and assembly, then, are the core competencies of the automaker, and GM has determined that outsourcing interior manufacture gives them a competitive advantage and lets them focus on what they do best.[44]

Likewise, manufacturers realize that cost reduction and customer satisfaction are two sides of the same coin; they can achieve both goals by increasing productivity and eliminating defects. Many are leveraging technology such as robots and automated machine tools to do both. As technology becomes more sophisticated and less expensive, manufacturers are likely to accelerate the substitution of capital for labor as a means of lowering cost and reducing product variation.

Technology

Workplace Automation. Manufacturers are increasingly moving to more flexible systems of manufacturing that allow for mass customization of products and smooth changeovers from one product to another. Advanced manufacturing machine tools continue to improve in accuracy and precision, include self-diagnostics and user-friendly

controls, and provide advanced features at lower cost. Greater accuracy decreases waste and increases profitability. Improvements in programmable computer numerical controls and open system architecture (to allow interfacing with a variety of CAD tools) enable companies to establish flexible manufacturing cells. As a result, there is no need for expensive production lines dedicated to different products. Manufacturers can now accomplish the paradoxical goal of mass producing goods in lot sizes of one.

Information Technology. The introduction of information technology advances into the manufacturing processes is likely to accelerate. The incredible pace of information technology development offers competitive advantages to leading-edge manufacturers today. Tomorrow's promise is even brighter. Leading-edge design software technology is being developed to surpass today's concurrent engineering practice and CAD/CAM systems. These systems integrate expert knowledge about all aspects of product design and manufacturing, and they make it possible to shorten the length of time between product conception and availability. Such tools and products will help the United States to maintain a position of global leadership in the future.

GOVERNMENT GOALS AND ROLE

People

Labor–Management Relations. In manufacturing, labor–management relations affect a wide range of government socioeconomic objectives. Government's overarching responsibility in this area is to balance regulatory actions that protect workers and society with policies that sustain economic growth and promote economic prosperity.

The federal government plays an active role in labor–management relations through legislation, regulatory oversight, and court adjudication of complaints and grievances. Specifically, government should

- Enact legislative reforms to reverse restrictive National Labor Relations Board rulings that find many employee involvement programs and joint labor–management initiatives in violation of union rules. Employee involvement in operational decision-making is a vital component of any forward-looking organization, and no arbitrary regulation should block this involvement. Proactive employee involvement is beneficial to both the company and its employees.
- Champion reform of seniority-based pay and promotion ladders in favor of productivity-enhancing, incentive-based compensation.

While government should protect the jobs of older, more senior workers from unethical employer practices, rewards should rightly go to the most productive employees, regardless of age or seniority.

- Coordinate the efforts of the Departments of Labor and Education to strengthen vocational, technical, and community college training programs through industry tax incentives and targeted student grants and loans. Worker training and retraining are vital in a rapidly changing technology-intensive manufacturing environment. Government should be an active partner in building up a robust training infrastructure and helping citizens improve their work skills.

Mobilization and National Defense. In its national defense role, the federal government must work to sustain a viable industrial base to support current needs for defense and future needs for wartime mobilization. There should be government incentives for defense industries to adopt lean and flexible manufacturing techniques. After a decade of reduced military spending and industry downsizing, these reforms are particularly important. Specifically, government should

- Continue acquisition reform initiatives to reduce unnecessary and burdensome requirements on industry. Such initiatives may include the transition to commercial standards, the elimination of dual processes in plants manufacturing similar military and civilian products, and the adoption of a performance-based contracting system.
- Reform defense contracting to eliminate the cost-saving disincentives inherent in cost reimbursement type contracts. Contractors should be allowed to recoup the costs of installing equipment or upgrading processes that produced demonstrable downstream savings to the government.
- Evaluate the *real* impact of sole source or limited competition on the cost of defense systems. Downsizing in industry has severely limited competition and, in some cases, caused the government to use artificial methods to keep more than one contractor in business (such as submarine contractors). Cost models should be developed to determine if this practice makes economic sense. Many businesses use sole source suppliers without apparent negative economic impact; perhaps the government could do likewise.
- Evaluate critical government-owned, government-operated (GOGO) defense industries, such as shipyards and depots, to determine whether the private sector can match their capabilities (or capacity). Unless absolutely needed, the government should privatize or close these GOGO facilities.

Education and Training. Federal, state, and local governments share responsibility for facilitating education in the United States. Though local control of elementary and secondary schools is the historical precedent, state and federal dollars pour into the schools through various directed programs and block grants. Yet, even with all the attention on the quality of education today, government must do more. The federal government should

- Establish voluntary standards for teachers in public schools. Much as the Professional Engineer standard became the benchmark for that segment of the workforce, a Master Teacher certification program could help school districts identify outstanding educators and provide teachers leverage for higher salaries based on demonstrated knowledge and performance.
- Promote (and legitimize) the concept that not all students will—or should—attend a 4-year university after graduation from high school. Students who do not continue their formal education must be prepared to enter the workplace immediately, and this need calls for the establishment of a robust vocational education system in secondary schools. Thus, the federal government should provide block grants to states to establish vocational–technical programs within existing secondary schools. Two-year college programs could provide the training necessary for a smooth transition into the workforce for those who do not pursue a bachelor's degree.
- Encourage state and local governments to be open to fundamental changes in public school systems. The Justice Department should give schools the widest possible latitude to change the way that they do business, including the option of forming charter or magnet schools. States and school districts should be allowed to offer "school choice" to parents.

Processes

Globalization. Government must recognize globalization as a real and irreversible economic phenomenon. Almost all large U.S. companies are responding to the challenge to become competitive internationally, and government should work to facilitate this effort. Current restrictive antitrust regulations, onerous export licensing procedures, and archaic tax codes all have aspects that thwart U.S. business efforts to globalize. Government should review and change all policies to reflect the realities of the new global environment. Specifically, government should

- Review antitrust laws in light of the global competitive environment. Laws should protect domestic consumers from monopolistic practices by U.S. business while ensuring that U.S. manufacturers can reach sufficient size and market clout to compete successfully with foreign companies.
- Continue aggressively to open international markets, clear trade obstacles, and encourage U.S. manufacturers to compete worldwide. Congress should enact legislation granting the President "fast track" treaty negotiation authority. It is essential to continue to monitor international behavior to identify and sanction unfair market practices, infringement of intellectual property, and, of course, breaches of national security. Government should reduce restrictions on the export of "dual use" technologies from U.S. companies if those technologies are available on the world market from other countries. For example, U.S. manufacturers cannot currently export some advanced machine tools that are available in similar form from European and Japanese manufacturers.[45]
- Increase visibility and participation in the World Trade Organization, regional economic organizations, and the United Nations. These organizations can provide the United States with additional leverage and credibility to ensure fair and open markets and trading opportunities, as well as act as a stabilizing force in multinational diplomatic and economic relations.

Value Chain Management. To remain competitive, U.S. industry must continually upgrade its infrastructure; it must replace old or outdated equipment, hardware, and software. Government can facilitate this by reviewing and modifying the tax code rules for equipment depreciation to allow faster write-off of information technology–intensive industrial equipment (such as robots and CNC machines).

Technology

As noted, government can facilitate the introduction of new technology through business-friendly tax codes and regulations. In addition, government must maintain a world-class national infrastructure. Robust transportation systems and policies will help move physical goods. A robust information highway will help move intellectual goods. Specifically, government should

- Support the next-generation, high-bandwidth Internet; an affordable global telecommunications capability; and commercial access to space through R&D funding for high-risk, high-payoff technologies,

such as ultrahigh-speed routing and switching equipment for the Internet, satellite and communication technologies, and space launch vehicles. Government should also continue to broker frequency band allocation to support and promote efficient and innovative use of the spectrum.

- Encourage business to increase investment in corporate R&D—particularly long-range basic research—through tax incentives, matching grants, and programs known to be successful, such as Small Business Innovative Research (SBIR) grants and Cooperative Research and Development Agreements (CRADAs) between government laboratories and industry. Government should also coordinate and facilitate R&D through consortia with industry and academia. There should be increased federal funding for programs like those of the Department of Commerce (e.g., those at the National Institute for Standards and Technology) and for National Science Foundation research grants.

CONCLUSION

In the final analysis, the core, positive attribute of the advanced manufacturing sector is its willingness to change. The global competitive environment continues to evolve, and great opportunities are available to those who will seize them. Many manufacturers both in the United States and abroad have done so. These will become the "next-generation manufacturers."

Next-generation manufacturers are just beginning to build upon increasingly powerful information systems that integrate all elements of the manufacturing process. The massive knowledge databases that are now being compiled will be the foundation from which future systems will be designed and produced. Fully computerized integrated operations will replace currently disconnected "islands of automation."[46] Expert systems using artificial intelligence and fuzzy logic will anticipate customer demands.

To respond to the need to communicate in the global company, satellite communication systems such as Teledesic, Bill Gates' future "Internet in the sky," will supply an enormous bandwidth and facilitate rapid, multimedia communication. The rapid transfer and open sharing of information and the ability to conduct "virtual" face-to-face conferences, all via the Internet, will further the rise of "global enterprises." Value chain management, integrated by supercomputers, will use intelligent agents to anticipate product demand and

automatically adjust supplier deliveries, shop floor rates, and distribution network activities.

The next-generation manufacturer will exist and thrive in an environment of continuous change. "Agile manufacturing" will emerge as a means to manage complex relationships through innovations in technology, information, communication, organizational redesign, and new marketing strategies. Future materials will be composites of the traditional metals, polymers, and ceramics, providing radically new materials with better performance characteristics.[47]

Next-generation manufacturers are risk-takers and paradigm-busters. They value their people, are willing to hone their processes, and embrace the promise of new technology. These will be the global manufacturers of the future. With the help of benevolent government policies, a robust infrastructure, and open international markets, the United States can remain a world-class advanced manufacturing powerhouse.

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AGRIBUSINESS

ABSTRACT

Agriculture and the related agribusiness industry remain the foundation of U.S. commerce and society. Agribusiness plays a dominant role in both trade and foreign affairs in the United States. Perhaps the most striking aspect of the evolution of agriculture is the globalization of the industry. The United States is finding that it must address agribusiness issues in consonance with other nations. Finally, the nation has a vested interest in helping other countries deal with agribusiness problems and a responsibility to provide leadership in pressing for farming reforms, education, and the introduction of new technologies in growing, harvesting, and processing food. The plain fact is that the rapidly expanding world population is draining the Earth's resources, which in turn is creating conflict around the globe. In short, the national security posture of the United States is inextricably linked to global agribusiness. Understanding and appreciating the nuances of that linkage are essential tasks for U.S. national security planners and decision-makers.

COL Syamsuddin Arsad, Indonesian Air Force
COL Scott C. Black, USA
Col Wallace A. Collins, USAF
Lt Col Kathleen Fick, ANG
CDR Stephen Fitzgerald, USN
LCol Gord Grant, Canadian Army
LTC Bill Guinn, USA
COL Bruce Harrison, USA
Lt Col Jim Kerr, USAFR
Ms. Maribeth Love, Dept. of the Army
Ms. Paulette Martin, National Imagery and Mapping Agency
LTC Mark McGuire, USA
Mr. Albert Miller, Dept. of the Army
CAPT Matt Nathan, USN
Lt Col Vince Snyder, USAF
LTC Dan Taylor, USA

Dr. Steven Meyer, faculty
Dr. Hershel R. Read, faculty
Lt Col Shelby Syckes, USAF, faculty

PLACES VISITED

Domestic

Anderson Ranch, Winters, CA
Calgene Research Institute, Davis, CA
California Cattlemen's Association, Sacramento, CA
California Dept. of Food and Agriculture, Sacramento, CA
Canadian Embassy, Agricultural Council, Washington, DC
Davis Farmers Market, Davis, CA
E.M. Heard & Sons Farm, Rockville, KY
Joe Gill Farm, Allensville, Ky
Long Vue Farms, Allensville, KY
Ottenberg Bakery, Washington, DC
Price Farms, Inc., Auburn, KY
Robert Mondavi Winery, Napa, CA
Robey Farms, Adairsville, KY
Rominger Farms, Winters, CA
Smithfield Pork Processing Plant, Smithfield, VA
U.S. Agricultural Research Service, Beltsville, MD
U.S. Natural Resources Conservation Service, Lockeford, CA
United Way Food Bank, Washington, DC
University of California at Davis, Davis, CA
Van Warmerdam Dairy, Lodi, CA
Wampler Foods Poultry Processing Facilities, Broadway, VA
Western United Dairymen, Sacramento, CA

International

Australian Department of Agriculture, Forestry & Fisheries, Canberra, Australia
Bangsue Chia Meng Rice Mill Co., Ltd., Nontaburi, Thailand
Barton Sheep Ranch (Bred to Meet the Market), Greytown, New Zealand
Charden Pokphand Group Headquarters, Bangkok, Thailand
Charden Pokphand Group Shrimp, Poultry and Dairy facilities, Thailand
Deep Blue Seafoods, Ltd., Wellington, New Zealand
Gosford Reptile Farm, Gosford, Australia
New South Wales Fisheries Department, Sydney, Australia
New Zealand Dairy Board, Wellington, New Zealand
Sydney Fish Market Board (Dutch Auction), Sydney, Australia
Te Kairanga Winery, Martinborough, New Zealand
Toohey's Nathan Lion Brewery, Sydney, Australia
U.S. Embassy, Bangkok, Thailand; Canberra, Australia; and Wellington, New Zealand

INTRODUCTION

Agriculture and the related agribusiness remain the foundation of U.S. commerce and society. While popular attention may focus on topics such as personal investing and the influence of information technology, agriculture is still the heart and soul of the national livelihood. The quality and quantity of the industry's output provides a general litmus test of society's welfare and standard of living. Just as important, U.S. agribusiness plays a dominant role in both trade and foreign affairs.

Perhaps the most striking aspect of the evolution of agriculture is the globalization of the industry. The United States is finding that it must address agribusiness issues in consonance with other nations. The United States cannot decide agricultural policies in isolation, especially as the country looks to agricultural exports to help improve its trade balance and as more nations look to the United States as a global food safety net against famine.

Finally, the United States has a vested interest in helping other nations deal with agribusiness problems and a responsibility to provide leadership in pressing for farming reforms; education in agriculture; and the introduction of new technologies in growing, harvesting, and processing food. The plain fact is that the rapidly expanding world population is draining the Earth's resources, which in turn is creating conflict around the globe.

In short, the national security posture of the United States is inextricably linked to global agribusiness. Understanding the nuances of that linkage is an essential task for U.S. national security planners and decision-makers.

AGRIBUSINESS DEFINED

Agribusiness is both complex and diverse. It is not simply the production of food on an assortment of farms, but rather an all-inclusive sphere where farmer, marketer, financier, scientist, transporter, packager, and processor are intimately tied to a circle of interdependencies. Equally important, the industry competes with other industries for valuable resources, including water, land, labor, transport, infrastructure, and finances, in a desperate struggle.

Farmers and Their Farms. The United States had 2.06 million farms in 1997, compared to 2.213 million in 1987.[1] The number of farms declined about 1 percent annually from 1987 through 1997, although the average farm size increased from 451 acres to 471 acres during the same

period.[2] Labor use on U.S. farms has changed dramatically over the past several decades. In fact, average annual farm employment dropped from 9.9 million in 1950 to 2.9 million in 1997.[3]

Food Processors and Packagers. In the United States, mention of the business interests involved in the processing and packaging of foodstuffs and related products brings large corporate entities such as Archer-Daniel-Midland and Campbell's Soup immediately to mind. Perhaps less visible to the U.S. consumer, but just as dominant in the agribusiness marketplace, are thousands of international entities such as the Charden Pokphand Group in Thailand; the Bangsue Chia Meng Rice Mill Co., Ltd., in Nontaburi, Thailand; and the New Zealand Dairy Board in Wellington, New Zealand. The category of food processors and packagers is much broader, however, as it includes dairies, cheese manufacturers, and meat processing and packaging plants of all sizes. In addition, companies that produce seed derivatives, oil products, fats and even cosmetics—pig's blood is used in various products—and other types of agricultural byproducts fall within this sector of agribusiness.

Food Brokers, Wholesalers, and Retailers. Entities that provide the marketing, warehousing, distribution, and points of sale outlets for agribusiness commodities range from the Chicago Commodities Exchange to the local Dairy Queen, from the Deep Blue Seafoods, Ltd. in New Zealand to the Sydney Fish Market Board in Australia.

Agricultural Biotechnology Firms. Growing numbers of companies are conducting expensive and intensive scientific research and development programs focused on enhancing agricultural production. These wide-ranging efforts have resulted in tremendous advances, including more crop varieties and improved yields, but they are not without controversy. As could be expected, developments such as the Monsanto Corporation's "terminator seed"[4] have received widely disparate reviews.

The Consumer. Everyone eats, but each person makes individual decisions regarding diet, the convenience of food preparation, and the acceptance or rejection of new developments within the agricultural industry. Agribusiness competes for resources, and it is the consumer who ultimately influences many of the aggregate allocations of these inputs.

CURRENT CONDITION

Trade—Retaliations, Compromises, and Intransigence

The United States remains a major exporter of foodstuffs and agricultural products. Obviously, the country seeks access to international markets and presses trading partners to accept U.S. produce without restriction. Unfortunately, while the United States works closely with international trade organizations and regulatory agencies, its own policies are somewhat ignoble, if not contradictory. Other countries do not perceive the United States as a free market open to the import of foreign agricultural produce. Indeed, both the New Zealand and Australian meat and dairy marketing boards, and the Charden Pokphand Group in Thailand, were quick to point this out.

The controversy over genetically engineered products, the cloning of livestock, and related issues also inhibits trade relationships. The European Union (EU) remains opposed not only to the genetic engineering of food products and livestock, but also, by extension, to the use of antibiotics in livestock. Consequently, U.S. beef and pork are not welcome in some European markets.

The instability in North Korea, due in large part to the ongoing famine there, is creating a potential powder keg in the Pacific Rim region. Food shortages on the Korean peninsula and elsewhere in Asia have created issues that U.S. national security strategists must consider.

China is not getting closer to meeting the requirements for participation in the World Trade Organization (WTO). The latest talks between the United States and China were somewhat positive, however, resulting in China's proposal to lift import barriers on U.S. meat, wheat, and citrus, and to reduce other barriers once it becomes a member of the WTO. China's proposed agreement and acceptance into the WTO would mean a doubling of U.S. farm exports to a country containing 20 percent of the world's population.[5]

Recent U.S. actions have been characterized by the protection of rather parochial national interests. As such, trading nations remain skeptical and believe that the United States is backtracking from the decoupled income support mechanisms of the Farm Bill of 1996.[6] Indeed, some instances of subsidies to protect U.S. farmers are still evident today, such as the tariff on the butter and dry milk imported from New Zealand.

Biotechnology

On a global scale, agribusiness is embroiled in an emotional debate over the use and employment of biotechnology. Some scientists and investors extol the merits of healthier, more productive yields and livestock brought on by genetically engineered seeds, cloned animals, and antibiotics. Others, including nations (e.g., New Zealand) and trading groups (e.g., the EU), zealously oppose these efforts. Scientists are divided over the benefits, and consumers worry that they are losing control over what they are eating. It has become an issue of ethics, health, and finance.

Biotechnology provides the world's farmers with the resources to combat explosive population growth and the corresponding loss of arable acreage. Regardless, the likelihood for further disagreements concerning the trade of genetically modified agricultural products is extremely high.

Agricultural Production and Sale

Farmers are as hard-working, skilled, and industrious as ever. Moreover, today's successful farmer is an intelligent and often highly educated practitioner. They are relatively helpless, however, in the face of Mother Nature's inconsistencies, increased production throughout the world, and a global economic downturn that has reduced consumer demand in key markets.

The trend toward larger and fewer farming operations, which is driving the small operators out of business, is greatly influencing current market conditions. Meat producers in the United States are moving away from operating pasture-oriented facilities and toward confining animals and providing feed supplements to enhance the growth process. In contrast, New Zealand farmers rely almost exclusively on pasture for feeding animals.

In some areas, farmers have responded to consolidation by banding together in cooperatives, seeking to give themselves more leverage in the marketplace.[7] Nevertheless, reduced farm income and highly volatile markets leave U.S. farmers in extremely precarious financial straits. In sum, the production and sales picture remains bleak for the near term, as projections continue to call for large surpluses and depressed demand.

Farm Investment—Servicing of Debts and Capitalization

Some aspects of the agribusiness financial picture are relatively bright. Asset values have risen dramatically, while debt has remained

stable. Government figures reflect a solvent industry. The demand for capitalization of large or megafarm projects has increased significantly, however. Because of the emphasis on achieving economies of scale and increasing profit margins, many farmers are forming coalitions and cooperatives; the small, independent farm is rapidly disappearing.

Costs continue to escalate. Acquiring breeding stock, developing and producing seed, transporting the goods produced, and marketing are capital-intensive operations. Farms with limited acreage or small herds typically cannot generate enough profit to pay for the machinery and support systems necessary to compete. Increasingly, the family farm is becoming a corporation, with both owned and leased land for large fields and sizable herds. Many dairy men now have herds in excess of 500 cattle and conduct milking operations 18–24 hours per day with all of the labor and infrastructure costs. The small farm of fewer than 200 acres and herds of fewer than 100 animals will have difficulty surviving within 10 years.

CHALLENGES

Domestic and International Trade

The U.S. agriculture trade surplus has significantly decreased over the past few years, reaching $11 billion, its lowest point since 1987.[8] Moreover, agricultural exports for Fiscal Year 1999 are forecast to decrease $4.6 billion below those in Fiscal Year 1998, and imports are forecast to increase $1 billion above those in Fiscal Year 1998. The Asian economic crisis is frequently blamed for causing reduced demand and increased supplies, which in turn has led to the declining trade balance. The challenge is to reverse this trend. The United States must find new markets and enter into international cooperatives to encourage trade of its agricultural products, exploiting its comparative agricultural advantages and improving its trade surplus.

Environmental Concerns

Of the myriad of environmental challenges and concerns in agriculture, two are predominant, touching virtually all aspects of human life and threatening its very survival. Water supplies are rapidly dissipating or becoming polluted, while farm soil is subject to intense erosion through non–point water runoff, excessive irrigation, and wind exposure. As noted in Thailand, traditional farming techniques not only

are inadequate to address these problems, but also have actually exacerbated global water pollution and soil erosion.

Many countries, including the United States, face a growing scarcity of water and loss of valuable topsoil. Traditional and, regrettably, inefficient agrarian methods abet these losses, both by drawing too much water and by contributing to the pollution of the remaining surface and ground supplies. Further, the world faces a dilemma in its approach to water and soil use. Inevitably, increasing food productivity brings a rampant exploitation of natural resources. There is a race to increase agricultural production through intensive farming, the use of biotechnology, and mechanization. Crop variations, planting methods, and irrigation techniques are steeped in tradition, however, making it difficult for governments to effect the necessary attendant changes to farming practices. Even so, significant changes are essential to husband the Earth's water and soil and check the spiraling decline in both the quantity and quality of these resources.

While the intensity of these problems has been disturbing, there are hopeful solutions. The challenge is to educate the public and government officials about the need to take action. Some countries, such as Australia, have taken unilateral steps to counter these problems. Undoubtedly, it will require sacrifice, commitment, and the willingness to work as a partner with international agencies and other countries to address these issues. Forging and sustaining that international community of effort remains the greatest challenge.

Food Security and Food Assistance

From a national security perspective, the United States has been, and will surely continue to be, heavily engaged in ensuring a consistent food supply. Food security and assistance operations in Somalia, Haiti, Rwanda, and Kosovo serve as cogent examples of the depth and risk of U.S. involvement.

Over the last 50 years, the United States has provided more food assistance to countries engulfed in disasters, famine, and fighting than any other nation. Africa, Latin America, Asia, and the former Soviet Union have all reaped the benefits of U.S. food production. A number of other countries also participate in the international food relief effort, including Australia and Thailand, but on an understandably smaller scale.

Today, however, the United States is on the brink of overextending its food support to other nations. Hungry nations solely dependent on U.S. support are mired in a "food welfare" rut that fills their citizens'

bellies, but does not strengthen their resolve. In effect, the United States may actually hinder a developing nation's ability to create food security programs and thereby stifle that nation's progress toward self-reliance. These agriculturally challenged nations need a condition of integrated interdependence where they can produce or trade agriculturally and support their entire population in the process. These struggling countries need help to help themselves.

Food assistance is also a domestic concern; many U.S. citizens cannot afford to purchase sufficient foods to maintain a proper diet. The real challenge will be to maintain sufficient funding for domestic food programs. Food assistance programs are under review and, unfortunately, at risk of termination or reduced funding. The government must continue to fund food stamps, children's school meal programs, and related programs.

Food Safety

Civilized societies expect food to be readily available and plentiful. Today, the challenges to food safety have expanded to include not only the increasingly treatment-resistant and deadly natural pathogens, but also alterations resulting from human activities such as bioengineering.

Several years ago, textbooks did not even list many of the organisms that can invade foods and create illness. Even "simple" bacterial infections such as salmonellosis, once a benign but uncomfortable form of "food poisoning," have evolved into some virulent strains leading to a 30 percent chance of hospitalization and a 3 percent chance of death.[9]

The Council of Agricultural Science and Technology (CAST) has estimated that up to 33 million people each year suffer from food-borne illnesses and some 9,000 die.[10] The macroeconomic and political considerations are enormous.[11] More than 1,400 processing plants are authorized to export agricultural products to the United States. In 1995, more than 2.6 billion pounds of meat and poultry from 34 countries passed inspection for entry into the United States.[12] The challenge of ensuring proper inspection, processing, shipment, preparation, and serving is prodigious.[13] Yet, the United States must continue to provide the attendant overwatch to safeguard its citizens and, equally important, to maintain that sense of public confidence in food safety.

Biotechnology Advances

In the next 20 years, the global population is expected to increase by more than 40 percent, surpassing 8 billion people. Biotechnology

advances could provide solutions to a host of social and environmental issues,[14] but ignorance, fear, or a reluctance to trust emerging technology, particularly in the area of agricultural products, has thwarted the acceptance of bioengineered products at times. It is clearly in the national interest of the United States to develop this critical technology further and maintain dominance in its commercial applications. At the same time, however, it is essential to consider the rights and choices of people who have concerns about safety and the potential environmental impacts of the technology.

Meeting the challenge of ensuring the viability of these bioengineered products is a key element of the process that must justify the significant outlays in research and development necessary to continue these advancements.[15]

Farmland Conversion

With 945 million acres in production, agriculture dominates the nation's land, and a significant portion of the output comes from urban-influenced areas. The 1987 census of agriculture found that one-third of the nation's agricultural products originate in metropolitan counties adjacent to large cities. Still another one-fourth of these products are produced in counties adjacent to significant urban populations. Finally, nearly 85 percent of domestic fruit and vegetable production and 80 percent of dairy products come from urban-influenced areas.[16]

Farmland is disappearing in the United States, however. Cities and towns are inexorably expanding outward onto the farmland vital to the food production system. The United States loses 50 acres of farmland to development every hour. There is an annual loss of 1.5 million acres of prime agricultural production capacity to development. At the heart of the problem is the reality that once an acre of productive farmland is developed, the rich topsoil is lost forever, and the nation's food security is placed at greater risk. The challenge is to find ways to reverse this trend.[17]

OUTLOOK

To date, technological advances have enabled the agriculture industry to keep pace with the food needs of the burgeoning population of the United States and have provided enough additional production to support much of the world's requirements.

The rapidly expanding population, however, threatens agriculture's industrial viability. The Worldwatch Institute projects that over the next

two centuries, the world population will grow from almost 6 billion to more than 135 billion, assuming growth continues at the same rate it has from 1990 to 1995.[18] The organization also notes that researchers estimate the Earth can reasonably sustain a population of only 11 billion.[19] Obviously, something must give.

Accordingly, U.S. agribusiness faces a daunting future in terms of supporting the national security resource requirements. Moreover, as farmland resources dwindle and the population expands, the industry's ability to achieve full surge and mobilization potential will decline.

Domestic and International Trade

The key trade issue in agribusiness is whether the international community will fully accept the Agreement on Agriculture, established at the Uruguay Round, which reduces trade barriers and expands global trading opportunities. It appears that the answer is yes, but China may prove to be the exception. Perhaps the most difficult provision to accept is the requirement for all nations to comply with the decisions of the dispute settlement authority, the WTO. Trade subsidies, bans, and product tariffs would be subject to the dispute resolution process.

Thus far, the United States has been careful to implement price supports and other internal protective measures in a manner consistent with the Uruguay Round and the WTO rules. Overall, the outlook is promising for retaining that balance and for encouraging similar cooperation from U.S. trading partners.

Environmental Issues

Water and Soil Erosion. Worldwide, agriculture consumes about 80 percent of all water. Given that our present consumption and pollution are destroying water supplies faster than nature can recharge them, nations must address their water needs and devise credible water strategies.

As the Australian Department of Agriculture, Forestry and Fisheries, noted, the major contributors to water decline and the escalating global water stress include industrialization and urbanization, but it is the agrarian sphere that exposes water to the greatest dangers. Excessive irrigation, deforestation, pesticide misuse, unnecessary tillage and non–point water pollution caused by the runoff of livestock waste pose the greatest threats to water and soil quantity.

Excessive Irrigation. Countries are increasing crop production without regard for water economies. For example, countries such as the

United States, Australia, and Canada continue to subsidize specific crops to the detriment of water usage. Wheat, rice, and some legumes require an inordinate volume of water to grow. Yet several regions produce these crops because they have access to an abundance of cheap water.[20] As is often the case, the abundance of water is a direct result of government subsidies. There is no incentive for farmers to discontinue crops or to adopt more progressive, environmentally friendly water conservation techniques.

In addition, scientists and water-monitoring agencies now report a sizable increase in the saline content of below-ground sources. Unfortunately, there is no known method for reversing this process. With the consumption and pollution of ground waters, farmers are likely to find that boring wells into below-ground reservoirs will bring up only highly saline water that is unpotable and unusable for agriculture.

Deforestation. The race to bring marginal lands into production brings catastrophic effects to water reserves and soil levels. Forests act as large sponges, absorbing water, retaining moisture, and then gradually releasing oxygen into the soil. Large clear-cutting operations such as those encountered in visits to Thailand, Australia, New Zealand, and regions within the United States result in massive erosion, increased non–point water runoff into river systems, and the destruction of wetlands.

Pesticide Misuse. While there have been some gains in developing "environmentally friendly" pesticides, many countries lack programs to monitor and control pesticide use in agriculture. Pesticides continue as the largest pollutant, particularly in Third World nations.

Unnecessary Tillage. Traditional farming practices call for land tillage to break up the soil for subsequent planting, but this tillage exposes the lighter soil to wind and water erosion. There are practices available, such as "no-till" techniques,[21] that can yield quality crops while checking soil erosion, however. Farmers need to be educated about these options.

Non–Point Runoff of Irrigation and Livestock Waste. Farm irrigation and livestock waste pose significant environmental threats. With greater emphasis on larger farms and expanded herds, the problems of waste disposal and non–point runoff are growing and leading to greater water pollution and the decline of soil quality.

Success Stories. While there is an immediate need for agricultural reforms and changes to farming techniques, feasible solutions to the mounting problems of water pollution and soil erosion are available. During visits to several countries, farmers, environmentalists,

government officials, and concerned citizens provided a myriad of interesting and realistic solutions to these problems.

The Larry Thompson family in Kentucky has exercised diligent stewardship of their farmlands. They are determined to check soil erosion and to maintain nutrient levels. Additionally, Thompson is a leader in employing global positioning satellite (GPS) analysis of soils to determine optimal nutrient needs, providing the attendant oversight of pesticide control, and using no-till techniques.

Farms in Kentucky, California, Australia, and New Zealand displayed many positive and innovative approaches to counter non–point water runoff and livestock waste control. They have employed clay- or cement-lined ponds with elaborate seepage, filtering, and pumping systems to reprocess production water and livestock waste. These liquids do not enter natural water reservoirs.

In California, a coalition of farmers and environmentalists have experimented with measures to counter soil erosion and water runoff. They have developed a system of water catchments called tail water return ponds, coupled with a revegetation of field borders.[22] Apart from conserving water runoff, the ponds serve as a natural aquatic preserve for wildlife. Planting renewal grasses and vegetation around the ponds and borders attracts insects that help pollinate the fields and crops. Additionally, the grasses and vegetation serve as natural wind barriers, significantly reducing soil loss.

In sum, the environmental outlook for agriculture is generally positive, primarily because the people who manage the industry have the interest, intellect, and ability to recognize and overcome problems. Education is the key to sustaining and building upon important environmental achievements, however.

Food Security and Food Assistance

A myriad of complex challenges impede global food security: national production capacity and economic/political policies, environmental conservation and natural disasters, resource scarcity and allocation, information/technology and rural development, regional conflict and open trade, and distribution and infrastructure. In view of these factors, leveling the hunger rate is an epic feat in itself, let alone actually reversing the trend. The most volatile regions of concern are Sub-Saharan Africa and North Korea. Sub-Saharan Africa will be more fully discussed as an example of the challenges of food security and assistance.

In the last two decades, Sub-Saharan African nations, such as Ethiopia, Somalia, and Rwanda, have lost millions of people to starvation. Contrary to popular opinion, Africa has the resources to produce enough food to support its population. Raging ethnopolitical conflicts have precluded many countries from realizing their full potential, however.

The current outlook for the Sub-Saharan region remains dim. Fueled by starvation, future ethnopolitical conflicts will necessitate the deployment of military, and/or nongovernmental organization (NGO) humanitarian and food relief missions into this region.

Food Safety

In January 1997, President Bill Clinton proposed the National Food Safety Initiative. There are six essential areas addressed in this initiative: (1) surveillance, (2) coordination, (3) inspections and compliance, (4) risk assessment, (5) education, (6) and research.[23] Many believe that this was in response to polls revealing increasing concern and publicity about serious food-borne illness outbreaks. Regardless, the Clinton Administration has proposed major funding increases to expand the federal food safety surveillance system; to improve the coordination between federal, state, and local health authorities; and to improve risk assessment capabilities via expanded inspection, research, consumer education, and strategic planning. The 1999 budget increases funding for these purposes by 12 percent, which is approximately $105 million above the existing $900 million allocated to the U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the Centers for Disease Control (CDC) for food safety–related activities. The lion's share goes to the implementation of process control inspection and evaluation via the hazard analysis critical control point (HACCP) system quality assessment process.[24] New Zealand uses the HACCP system with tremendous success.

The government is expanding its HACCP system, which was created in 1960 by the Pillsbury Company when it was charged with supplying food to the National Aeronautics and Space Administration (NASA) astronauts. Today, the industry is concerned primarily with those microbial and chemical contaminants that cannot be seen. Therefore, the government has developed a formal quality assurance system that checks at critical points for those contaminants that are both statistically and pathologically the most significant. By January 2000, every plant must have implemented the HACCP system.

Additionally, the government has authorized food irradiation for meat processing; however, there is some public unease with the idea of "radiation." Gamma radiation has been used for more than 30 years as a means to prolong shelf life, delay ripening, and approximate sterilization in foods. There is no alteration in taste, no residue, and no nutritional sacrifices; furthermore, it is a cold process.[25] In short, there is little cause for public concern, and irradiation will continue as an essential check within the U.S. food safety program. Undoubtedly, there will be some initial fear of foods stamped "Treated with radiation." With education, however, the public should come to accept the advantages of these treated foods. In short, the outlook for progress in the area of food safety is very positive.

Biotechnology Advances

The primary issues facing the biotechnology industry and the companies advancing these technologies are safety/regulation and economics. Public exposure to the broader field of genetic engineering has increased awareness and appreciation of the positive potential of many applications, but concerns remain about the potential environmental impacts and the long-term safety of using these products. From the viewpoint of the farmer, transgenic plants offer savings as a result of higher yields, fewer pesticide applications, and lower labor costs. From a business viewpoint, companies must consider whether the revenues generated from the sale of these products will justify the mounting research and development (R&D) costs associated with bringing the products to the market.

The use of bioengineered or genetically modified products in agriculture is also an issue about which special interest groups[26] and foreign countries have expressed concerns related to potential human safety and the long-term impact on the environment. A June 1998 opinion poll published in the United Kingdom revealed that 61 percent of U.K. consumers did not want to eat genetically modified foods.[27] Indeed, hesitation to accept genetically modified products is causing foreign markets to avoid U.S. food that may have been produced by traditional techniques as well, since the two types of products are nondifferentiable. Worldwide, the organic food community has also expressed the opinion that genetically modified crops should not be permitted or categorized as "organic."[28] Australia is particularly sensitive to this issue, while New Zealand opposes any imports with biogenetically engineered contents.

In pragmatic terms, the future of agriculture will likely depend on biotechnology to handle the effects of expanding demand and declining resources. Caution is required, however, as it is necessary to introduce the public to potential advantages and be forthright about the pitfalls.

Farmland Conversion

Urban sprawl is spreading farther from U.S. city centers and can be characterized by four interrelated factors. First, advances in transportation have created a more mobile population and allowed urban workers to live farther away from work. Second, the general economic restructuring of the United States has contributed to sprawl. More than 50 percent of the population was involved in agriculture in 1900, but only 1.8 percent of U.S. citizens now live on farms.[29] Third, demographic shifts in labor have also exacerbated the problem, as decentralization of previous industry clusters has led to decreases in the urban population base. Finally, weak taxation and land use policies have greatly hastened the spread of urban areas by giving business a relatively free hand in land conversion.

There are a variety of statutory, regulatory, and voluntary programs designed to protect U.S. farmland; one of the most significant is the Farmland Protection Program (FPP).[30] The FPP provides funds to help farmers purchase development rights in order to keep productive farmland in agricultural uses.[31] Other efforts intended to preserve farmland include state and local land conservation easements; government growth management practices, taxation, and zoning policies; and mitigation ordinances.

These programs provide an impressive array of protections and clearly illustrate the depth of concern shared around the United States for the continuing loss of agricultural assets. In the end analysis, however, these legislative and regulatory protections have failed to stem the staggering loss of U.S. prime farmland. If the nation is to preserve farmland and the ability to meet future agricultural needs, it is essential to identify and implement more effective management approaches.

GOVERNMENT GOALS AND ROLE

Domestic and International Trade

The Clinton Administration faces a dilemma. Should the emphasis be on saving U.S. farmers or on supporting the tenets of the Uruguay Round and the Farmers Freedom Act? Government must move away

from subsidization and unnecessary farm support and embrace global trade and open markets. Without the aid of government support mechanisms, U.S. agribusiness must exploit its comparative advantages within the world markets.

Environmental Issues

Governments must take the lead in addressing water stress and soil erosion within agriculture. As evidenced during visits abroad, remarkable solutions to these problems are well within the abilities of societies and governments. Unfortunately, the use of reformed farming practices and new techniques is minimal compared to the size of the problem. Few farmers have accepted no-till techniques, deforestation continues, and only about a dozen farmers encountered in California have embraced the "tail pond" approach as a viable means of overcoming water and soil problems. Environmental regulation in the United States is achieving some success regarding livestock waste control, but this success is less evident in other countries.

The U.S. government must take the requisite actions and promulgate appropriate legislation to address these environmental problems. First, there must be an emphasis on education. Both farmers and the public must learn about these problems and their potential solutions in a way that does not create panic or disbelief. Second, there must be substantial incentives provided to encourage conversion to more environmentally friendly farming practices. Third, there must be some assurance that those who manage marginal lands are not wasting water to produce an uneconomical crop. Finally, the United States must form coalitions and sponsor international forums so that the entire world works together to overcome these challenges and ensure the prosperity of future generations.

Food Security and Food Assistance

It is indisputable that the U.S. government must provide the leadership in addressing food security issues. The international dimension, combined with the complexity of food security matters, can be resolved only with concerted diplomatic efforts. Third World countries must be refocused toward investment in agricultural efforts with financial support from the International Monetary Fund (IMF) and infrastructure support from agencies such as the World Bank. Both independently and in support of international organizations such as the United Nations and the Red Cross, the U.S. government can provide the

diplomatic and economic clout to force nations to face up to the problems and work to their mutual resolution.

The U.S. government must also continue to administer both its domestic and international food assistance programs. Domestically, the USDA must oversee its food and nutrition service projects and programs. Despite a burgeoning economy, there are still too many low-wage earners dependent on these programs. Internationally, countries suffering from drought and starvation, as well as those involved in conflicts, will require food assistance. As a premier producer and leader in the community of nations, the United States should be at the forefront of world food assistance efforts.

Food Safety

The issues of food safety are becoming more complex and scientifically diverse. Without question, government must continue to provide the stewardship for food safety within agribusiness. The introduction of new bioengineered strains of plants, seeds, and livestock requires considerable attention to testing before release for public consumption. Similarly, government must continue to play the dominant role in protecting the ecosystem, a function properly managed only with effective interagency cooperation.[32] Government must continue as the "honest broker" on behalf of the public.

Biotechnology Advances

The world is on the verge of an exciting technology explosion that will change the cultivation of food. At this early stage, it is impossible to appreciate the potential benefits for developing companies, growers, consumers, and the environment that can result from applying this technology. As with previous technological changes, it is prudent to move slowly and cautiously, but also optimistically.

Producers of genetically modified agricultural products should inform consumers about the application of this technology, so they can decide whether to accept the product. Government can promote the development and acceptance of bioengineered agricultural products by advancing consumer knowledge of and exposure to the extent and proliferation of these products.

Farmland Conversion

If they act soon, federal, state, and local governments can effectively resolve the farmland conversion problem. There is a clear link between protecting the continued economic viability of small farmers and preserving their farmlands for agricultural use. Farmland protection programs must be adequately funded[33] and should be revised to include incentives for participation, essentially providing a safety net against unforeseen natural or market disasters. Small farmers should not have to convert their land in order to survive. In short, federal, state, and local legislative bodies should implement long-term tax penalties for converting prime farmland. Along more unusual lines, an "endangered species" type of protection for prime farmland may provide further benefits.

CONCLUSION

Agribusiness remains a vibrant and important element of the U.S. economy, society, and national security. Today, the nation can easily feed its population and increase production in time of national emergency. Indeed, the United States continues to lead the world in agricultural production and sponsors a myriad of food assistance programs to combat world hunger. While all of this may bode well for the future, there are a number of challenges that, if not addressed, pose serious threats to national security.

First, environmental concerns over water pollution and soil erosion hold endemic consequences. There must be a marked shift to no-till farming, better control of water use, and a realignment of crop concentrations within farm belts. It is essential to work actively to conserve U.S. agricultural resources heritage.

Second, the United States must embark on the removal of barriers to agricultural trade. As a major producer of the world's foodstuffs, it is within the national interest to exploit foreign markets and promote open trade. The United States must work closely with international agencies to ensure a global free-market system while removing its own barriers to agricultural imports. Furthermore, the United States must stop "pork barrel" subsidies of inefficient farms.

Third, biotechnology can bring about healthier crops and greater yields that consume less water and nutrients. The United States must work closely with other countries to harness the benefits of this tool of

production, which is bringing the world to a new plateau of food self-sufficiency.

Overall, agribusiness in the United States and around the world faces a promising, yet uncertain future. The promise flows from the extraordinarily intelligent, dedicated, and hard-working men and women who are succeeding in all components of the industry. The uncertainty derives from the onrushing collision between a geometrically expanding world population and rapidly diminishing resources. In any case, the United States must develop its national security strategy with an understanding and appreciation for agriculture's role in shaping world events.

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[1] A farm is defined as any establishment from which $1,000 or more in agricultural products was sold or would normally be sold during the year.

[2] U.S. Department of Agriculture, *USDA Agriculture Fact Book 98*, Chapter 2-B, http://www.usda.gov/news/pubs/fbook98/ch2b.htm.

[3] U.S. Department of Agriculture, *USDA Agriculture Fact Book 98,* Chapter 3-A, http://www.usda.gov/news/pubs/fbook98/ch3a.htm.

[4] A seed that provides improved quality and yield, but cannot reproduce.

[5] "Farmers Pleased That WTO Might Open Access to China," *Newsline,* April 9, 1999, p. 2.

[6] Remarks of Deputy Secretary of Agriculture Richard Rominger, Special Grains Conference 1998—Buenos Aires, Argentina, December 2, 1998, p. 2.

[7] Remarks by Secretary of Agriculture Dan Glickman on the State of American Agriculture, 75th Annual Agricultural Outlook Forum—Arlington, VA, February 22, 1999, p. 4.

[8] "Outlook for U.S. Agricultural Trade," *ERS-AES-21*, February 22, 1999, p. 1.

[9] E.M. Foster, *Historical Overview of Key Issues in Food Safety—Emerging Infectious Disease,* vol. 3, http://www.cdc.gov.ncidod/EID.

[10] Current Topics in Food Safety, http://home.earthlink.net/~zinkd/ topics.htm.

[11] The economic impact of food-borne illness alone, in terms of medical care, lost wages, and associated costs, is estimated to be $5.6–$9.4 billion per year.

[12] Food Safety and Inspection Service, http://www.usda.gov/fsis.

[13] Food processing once meant a farmer or rancher raising the food, harvesting it, and preparing it for the consumption of one family. Now the process can involve hundreds of thousands of items processed automatically and packaged for the consumption of millions of people. For example, in 1995, the government individually inspected almost 8 billion poultry animals, 95 million swine, and 37 million cattle.

[14] Today, the United States is the world leader in biotechnology with more than 1,200 companies transacting over $11 billion per year.

[15] Biotechnological advances typically require huge investments of time and money. The Monsanto Corporation estimates that it takes 10 years and $300 million to create these products.

[16] U.S. Department of Agriculture, "Natural Resources Conservation Service, Farmland Protection Program Request for Proposals (3/20/98)," *Federal Register*, vol. 63, no. 54, March 20, 1998, 13615–13618.

[17] Why Save Farmland?, *American Farmland Trust*, http://www.farmland.org/why.htm.

[18] *Worldwatch Institute News*, http://www.worldwatch.org.

[19] *Worldwatch Institute News*, http://www.worldwatch.org.

[20] It takes 1,000 cubic meters of water to grow a ton of grain, which makes it difficult to understand why some grains are being grown in areas suffering relative water scarcity.

[21] When "no-till" techniques are employed, planting is done with precise land cuts and seed placement rather than tilling.

[22] Essentially, the farmer digs two small water runoff troughs at the corner of a field. The first trough catches water and holds silt/soil erosion. The soil is then returned as topsoil to the fields, while the water seeps to a larger hole that becomes a small pond.

[23] USDA 1999 Budget Proposal for Food Safety Initiative, http://www.vm.cfsan.fda.gov/.

[24] John Harris, "Clinton Budget to Include More Funds for Food Safety," *The Washington Post*; January 2, 1999.

[25] Peggy Van Laanen, "Understanding Food Irradiation," Texas Agriculture Extension Service, Texas A&M University, http://www.ifse.tamu.edu/ifse/irradiationart./.

[26] E.g., Greenpeace International, The International Federation of Organic Agriculture Movement, Sierra Club, National Family Farm Coalition, California Certified Organic Farmers, Institute for Agriculture & Trade Policy, and the Center for International Technology Assessment.

[27] "Knowledge for the Commonwealth, European Concerns with Transgenic Crops," *Virginia Cooperative Extension*, March 4, 1999.

[28] "Knowledge for the Commonwealth, USDA's Rule on Organic Agriculture and Biotechnology," *Virginia Cooperative Extension*, March 4, 1999.

[29] USDA Rural Sprawl Workshop Report, http://www.rurdev.usda.gov:80/nrdp/22.html.

[30] USDA NRCS Farmland Protection Program Fact Sheet, http://www.rigis2.nhq.nrcs.usda.gov:80/OPA/FB96OPA/FFPfact.html.

[31] To qualify for the FPP, the land offered must be prime, unique, or other productive soil; be part of a pending offer from a state, local, or tribal farmland protection program; be privately owned; be large enough to sustain agricultural production; be accessible to markets and have adequate infrastructure and support services; and, have surrounding parcels of land that can support long-term agricultural production.

[32] Most recently, Monsanto's terminator seeds—while found acceptable for human consumption—have caused considerable ecological imbalances with a significant increase in the death of the butterflies that eat the grains from genetically engineered seeds.

[33] The Clinton Administration's Fiscal Year 2000 budget proposes a total of $77.5 million for the FPP, Statement of James R. Lyons, Under Secretary for Natural Resources and Environment, before the House Appropriations Subcommittee on Agriculture, Rural Development, Food and Drug Administration, and Related Agencies, February 24, 1999, p. 21.

AIRCRAFT

ABSTRACT

The aircraft industry—military and civilian, domestic and international—is facing a volatile environment of increased competition, acquisitions and mergers, erratic customers' budgets, demands for innovation, and expectations of enhanced capabilities and improved reliability. To cope with these often contradictory demands, aerospace manufacturing companies are severely cutting profit margins, streamlining production, reducing support costs, and examining every aspect of their business for revenue-generating opportunities. Many of these innovations are indeed yielding new profit centers. Although the U.S. aircraft industry has long been recognized as the world's leader and is the number one export industry of the United States, European manufacturers are challenging it. No longer can U.S. manufacturers assume that they are the customers' first and best choice.

Col Mahmoud Al-qabandi, Kuwaiti Air Force
Col Tim Bair, USAF
Lt Col Art Cameron, USAF
CAPT Jeff Cassias, USN
COL Brian Clearman, USA
LTC Tom Cole, USA
Col Robert Corrie, USAF
CDR Dave England, USN
Mr. Claire Guthrie, Dept. of the Navy
Lt Col Ed Hayman, USAF
Mr. Stuart Hazlett, Dept. of the Air Force
Lt Col Wendy Masiello, USAF
COL Tom Rich, USA
Mr. Gary Wells, Dept. of the Air Force
CDR Tom Wiechelt, USN
CDR Rick Yatto, USCG

Dr. Rolf H. Clark, faculty
Col Larry C. Franks, USAF, faculty
CAPT Pat Jacobs, USN, faculty
COL Mike Miller, USA, faculty

PLACES VISITED

Domestic

Aerospace Industries Association, Washington, DC
The Boeing Company, Seattle, WA
Boeing Military Aircraft, St. Louis, MO, Long Beach and Palmdale, CA
Defense Logistics Agency, Defense Supply Center, Richmond, VA
Lockheed Martin Skunk Works, Palmdale, CA
Northrop Grumman, Palmdale, CA
Pratt & Whitney, East Hartford, CT
Shultz Steel Company, South Gate, CA
Sikorsky Aircraft Corporation, Bridgeport, CT
Smithsonian Museum, Aircraft Refurbishment Facility, Suitland, MD

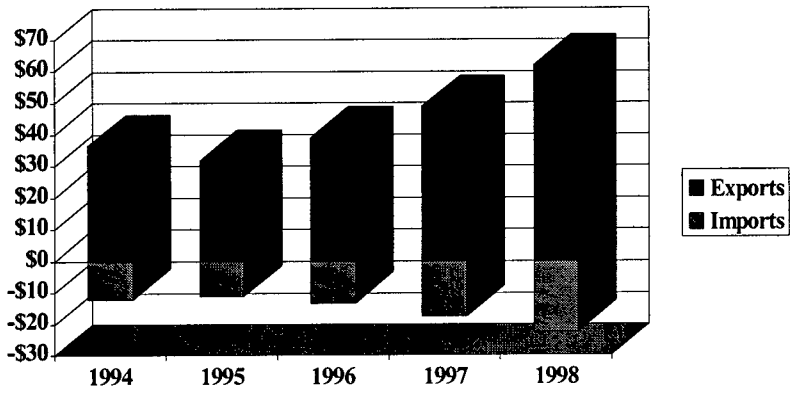
International

Aerospatiale, Toulouse, France
Airbus Industrie, Toulouse, France
British Aerospace Defence, Ltd., Warton Aerodrome & Samlesbury, United Kingdom
Dassault Aviation, Argenteuil, France
GKN Westland, Yeovil, United Kingdom
Rolls Royce Military Aero Engines, Ltd., Bristol, United Kingdom
SNECMA, Villaroche, France

INTRODUCTION

The U.S. aircraft industry has been the country's number one export industry, and there is little evidence of a likely change in this situation (Figure 1). An investigation of the industry's four main sectors—commercial fixed-wing aircraft, military fixed-wing aircraft, rotary-wing

Figure 1: U.S. Aircraft Trade Balance (Billions)



Source: *Aerospace Industries Association of America: Aerospace Facts and Figures, 1998/1999*. Washington, DC

aircraft, and jet engines—reveals a volatile business environment challenging each aerospace manufacturer to innovate and adapt rapidly and decisively. In addition to examining the four main sectors, several ancillary topics including innovations in logistics, the growing uninhabited aerial vehicle (UAV) market, the Year 2000 (Y2K) issue within the industry, and the Civil Reserve Air Fleet (CRAF) warrant examination.

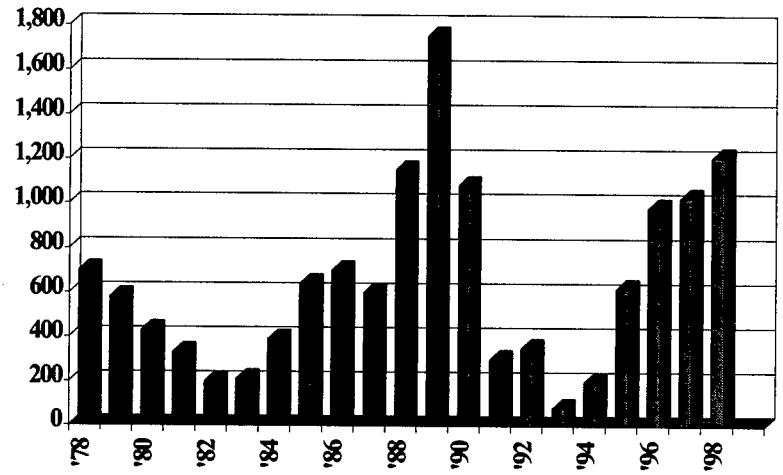
THE AIRCRAFT INDUSTRY DEFINED

Commercial Fixed-Wing Aircraft

The commercial fixed-wing aircraft industry includes medium passenger aircraft, large passenger aircraft, and large cargo aircraft. This report focuses on jet cargo aircraft and large jet aircraft that carry 100 passengers or more. The commercial aircraft sector consists of two major competitors—Boeing in the United States and Airbus Industrie in

Europe.[1] The two companies are expected to deliver nearly 900 commercial transport aircraft in 1999.

Figure 2: Aircraft Industry Sales from 1978 to 1998



Source: *Aerospace Industries Association of America: Aerospace Facts and Figures, 1998/1999*. Washington, DC

Current Condition. The commercial aircraft industry, an inherently cyclical business (Figure 2), continues to benefit from the largest commercial aviation boom in history. Boeing returned to profitability in 1998 after profit stagnation the previous year. Boeing's overall profitability was due primarily to its military market, however. Because of production surges and pricing pressures brought on by intense competition,[2] Boeing Commercial Aircraft Group earned only 4 percent of Boeing's 1998 profits. Even so, the U.S. aircraft industry continues to enjoy a significant backlog of production that equates to more than 2 years of deliveries. Boeing believes that management has corrected most of the production challenges—lack of skilled workers, raw material shortages, internal and supplier parts shortages, and productivity problems—that plagued the company in 1997 and 1998. To remain competitive and increase earnings, Boeing plans to produce more commercial aircraft in 1999 than in 1998, with fewer people and reduced labor hours.[3,4]

Airbus has faced many of the same challenges as Boeing. Its 1998 production increased more than 26 percent from its 1997 production, however, and management anticipates a 29 percent increase in 1999.[5] These increases are attributable to streamlined production, cost and

design innovations, increased use of outsourcing, and capacity expansion facilitated by a smaller workforce driven by European labor laws.

The Asian financial crisis has not affected the airline industry as much as it has affected other sectors of the economy, since Asian air travel accounts for less than 20 percent of the world travel market. As a result, the crisis has presented a mixed blessing for the aircraft manufacturers. Future orders from Asian carriers have dropped, particularly for Boeing's flagship B747. Contrary to conventional wisdom, Asian airlines have delayed rather than canceled many existing orders. These delays are especially beneficial for Boeing and have alleviated many of their production problems, helping the company return to overall profitability in 1998.

Competition in the commercial aircraft industry is particularly intense with regard to price, operating costs, and production schedules.[6] To manage costs and to meet customer demands, relationships among customers, manufacturers, and suppliers have become closer. Major manufacturers are teaming with suppliers to push responsibility to the vendor base for quality and product reliability. Additionally, they have asked component manufacturers to assume greater risk in the design and production of new aircraft. In fact, Boeing has joined Airbus in becoming, essentially, final assemblers of aircraft—with subcontractors performing most of the manufacturing tasks. Both manufacturers have reduced overhead costs by minimizing inventories through a combination of just-in-time delivery and conservative ordering of parts and supplies.

The aftershocks of restructuring continue to reverberate throughout the aircraft industry. Growing pains from the 1997 $20 billion merger of Boeing, McDonnell Douglas, and Rockwell International continue as the separate corporate cultures blend. Boeing intends to streamline operations and contain costs by divesting itself of excess facilities and unprofitable non–core business activities. Similar corporate restructurings in Europe, such as the impending conversion of the Airbus consortium into Airbus single corporation entity (SCE), have been slow to materialize—establishment of the SCE appears unlikely before 2000. The Airbus SCE presents the potential for increasing the transparency of Airbus consortium members and eliminating inefficient business practices. Independent motivations for profitability among Airbus' four partner companies drive existing inefficient business practices. Furthermore, national policies, interests, and subsidies support many of these inefficient practices.

Challenges. The principal challenge facing the U.S. commercial aircraft industry sector is increasing production while containing costs. Backlogs continue to plague Boeing, while Airbus increases its market

share for single-aisle aircraft. Boeing has attempted to dampen the effects of the commercial aircraft industry's "boom-and-bust" cycle through the acquisition of McDonnell Douglas and its more stable military business, as well as through a move into the more lucrative and stable aircraft services business.[7] These actions have reduced Boeing's dependency on the cyclical commercial aircraft business; commercial aircraft now account for 59 percent of Boeing's business, instead of the pre-merger 80 percent. Airbus is also exploring entry into the military transportation market in an effort to stabilize its overall market cycles.

A critical measure of competition is the delivery of aircraft to customers. Boeing will deliver approximately 67 percent of all commercial aircraft over the next 2 years. At the same time, Airbus has recently garnered almost 50 percent of future commercial aircraft orders within their target market—the single-aisle and smaller twin-aisle aircraft.

Competition to find innovative financing and create international offset methods to assist customers in aircraft acquisition is a challenge for the commercial aircraft industry. For many aircraft buyers, the deciding factor in an acquisition is the financing package, not the aircraft itself.

Outlook. Projected trends over the next 10 years indicate sales between 6,000 and 7,500 commercial jet transports valued at nearly $1.2 trillion. Increases in commercial passenger point-to-point travel instead of the hub-and-spoke system will result in a proportional increase in the use of smaller twin-aisle aircraft, such as the Boeing 767/777 and Airbus A330/A340. This may lead to a decline for Boeing's B747 market and could delay Airbus' efforts to produce its jumbo A3XX.[8]

Airbus' potential development of the mammoth A3XX is a huge undertaking with estimated development costs of $10–$12 billion. This represents a significant risk that the Airbus consortium appears willing to explore. Airbus believes that developing the A3XX will mark their entry into the large-capacity aircraft market now cornered by Boeing and will catalyze the European economy.[9] Boeing is not convinced that a market exists for an aircraft with 600 or more seats, and research appears to support Boeing's position. Regardless of this assessment, all parties agree that the market has room for only one manufacturer to develop an aircraft with this capacity.

Boeing's commercial profit margins are too small to support the development costs of an A3XX equivalent, but its experience with developing and producing larger aircraft gives Boeing the luxury of letting Airbus force the market decision. If Boeing elects to develop an A3XX competitor, it may be able to catch up quickly with a derivative of

the B747. Additionally, Boeing may wish to be more financially sound before announcing plans to develop a competitor for the A3XX.

The growing demand for business travel is likely to have two effects on the market for commercial aircraft. First, there will be a growing market for larger, long-range business jets, such as extended range variants of the B737. Second, there may be sufficient demand to make the development of a supersonic business jet feasible in the next 10 years.

In the commercial air transport market, the demand for rapid movement of large quantities of material may result in the development of large airships capable of transporting several hundred tons of cargo across the United States in less than a day. Boeing's efforts to sell the MD-17 as a commercial air transport face an uphill battle without government support—the MD-17 carries less cargo and is more expensive than the B747-400F. Furthermore, freight and commercial package carriers do not require the performance advantages that the MD-17 offers over other available freighters.

In summary, there is sufficient market demand to support two global commercial aircraft producers. Competitive market pressure and government interventions in this critical industry will probably result in converging market shares for these two industrial giants. Although Airbus will continue to compete aggressively in the market for small to medium aircraft, Airbus does not compete in all of Boeing's markets. As a result, Boeing will probably deliver approximately 60–65 percent of all commercial aircraft over the next 10 years.

The overseas markets will remain critical to U.S. manufacturers because they are the major source of future growth, particularly as Asia emerges from its financial crisis. Reductions in the cyclical nature of the aircraft industry; closer relationships among customers, manufacturers, and suppliers; as well as continued innovations in technology and manufacturing processes, will increase the competitiveness of U.S. manufacturers.[10]

Military Fixed-Wing Aircraft

The military fixed-wing sector of the aircraft industry consists of strategic, tactical, and support aircraft designed and built for military missions. The acquisition and life cycle maintenance costs of these aircraft constitute significant portions of the Department of Defense (DOD) budget. The United States is committed to its military aircraft industry as a strategic element of national power.

Internationally, internal security requirements and industrial base considerations encourage countries to design and build military aircraft indigenously, although more cost-effective and technically advanced capabilities may exist in the international market.

Current Condition. The military fixed-wing sector of the aircraft industry continues to face lean times. Defense spending in the United States and Western Europe stabilized following Cold War reductions, but planned increases in the acquisition funding needed to recapitalize or modernize tactical aviation have been slow to materialize. Disproportionately high operations and support costs for aging aircraft consume a large share of defense budgets.

The future U.S. military market relies on DOD intentions to replace many of its tactical aircraft over the next decade. Current inventories of F-14, F-15, F-16, and F/A-18 aircraft are scheduled to be updated by the F/A-18E/F, F-22, and Joint Strike Fighter (JSF). Low-rate production of trainer and cargo aircraft, such as Boeing's T-45 and C-17, will continue for the next several years.

Industry consolidation leaves Boeing, Northrop Grumman, and Lockheed Martin as the only U.S. prime contractors for military aircraft. Lockheed Martin's F-22 is completing developmental flight testing for the Air Force and is entering low-rate production. Boeing's F/A-18E/F has completed developmental testing and is entering full production for the Navy. Foreign military sales of earlier models, such as the F-15, F-16, and F/A-18C/D, have kept U.S. military production lines open for the past several years and are sustaining the U.S. military aircraft industry.

The JSF program calls for a significant production run of nearly 3,000 aircraft. Three JSF variants are under development: vertical, carrier, and conventional takeoff and landing configurations. Boeing and Lockheed Martin are vying for the JSF production order in a "winner-take-all" competition. Both companies are staying within the government's timeline and dictated cost requirements, with demonstrator flights scheduled for early 2000. The JSF procurement signals a major paradigm shift in military procurements—price is becoming more important as an independent variable than aircraft performance. As a result, a JSF unit cost of $28 million is the most important factor in the procurement.

Northrop Grumman recently completed B-2 bomber production, and the company no longer produces aircraft. It will continue to maintain the only existing B-2 modification capability while it follows the industry trend of reorienting toward the more lucrative production integration and subcomponent assembly markets.

Internationally, major military aircraft manufacturers include the Eurofighter Consortium, Dassault, and Saab. The former Soviet Union producers appear insufficiently capitalized to participate seriously in the military market European offerings include the multinational Eurofighter, Dassault's Mirage 2000 and Rafale, and Saab's Gripen. A British-led consortium of Germany, Italy, and Spain produces the Eurofighter. Each country manufactures specific parts of the aircraft, but maintains an indigenous ability to assemble the entire aircraft.

Airbus has proposed a new business venture for a large military transport aircraft, the A400M. This transport, called the Future Large Aircraft (FLA), would accommodate anticipated European intertheater airlift requirements. The FLA would be sized to fill a niche market between Lockheed Martin's C-130 and Boeing's C-17.[11]

Challenges. The lack of a high-technology threat and the increased use of smart munitions in regional conflicts have reduced the demand for new military aircraft. Instead, older aircraft are being refurbished to meet post–Cold War needs.

The few types and numbers of new aircraft being produced do not sustain the U.S. industrial base. Thus, manufacturers have increasingly turned to other markets, such as life cycle support and foreign military sales, to stay in business. Manufacturers are faced with the dilemma of balancing overhead expenditures for idle capacity against retention of production capability to meet surge requirements.

Competition for international military aircraft sales is fierce. International sales decrease unit costs and enable the United States to maintain a warm production line for spares and repair of domestic units. Additionally, foreign military sales increase military-to-military diplomatic contacts and interoperability for coalition activities. The expense of military aircraft is forcing foreign buyers to pass up state-of-the-art technology in order to meet budget constraints, however.[12]

Worldwide excess capacity is a particular challenge facing the aircraft industry. In the United States, market pressures indicate that room exists for further consolidation, but government concerns about a declining competitive industrial base may preclude additional consolidations, as evidenced by the recent rejection of a proposed merger between Lockheed Martin and Northrop Grumman.

Outlook. Austere defense budgets will result in reduced U.S. military aircraft procurements over the next 10 years. Because U.S. defense budgets over the next several years are not adequate to support planned buys of the F/A-18E/F, F-22, and JSF aircraft, one of these programs may be significantly reduced or canceled.

As discussed earlier, the DOD has presented the JSF program as a "winner-take-all" competition. It seems more likely that Boeing and Lockheed Martin will share JSF production in an effort to preserve a competitive military aircraft industry. Results of the competition will determine whether the two companies produce distinct models or whether they co-produce the same aircraft.

Life cycle support and management will be a growth area for aircraft manufacturers. They will gain an increasing share of depot level maintenance to offset reduced procurements.

Foreign military sales will remain a major market for the U.S. military aircraft industry, but technology transfer concerns will limit export sales of new U.S. military aircraft, such as the F/A-18E/F and the F-22. . The time delays incumbent with these technology transfer issues may give the next-generation European fighter aircraft a competitive advantage in the lucrative and highly competitive export markets.

In the end, military aircraft manufacturers will flourish if they can produce aircraft from lean, efficient, and flexible production lines and deliver them with significant operational capabilities and low ownership costs.

Rotary-Wing Aircraft

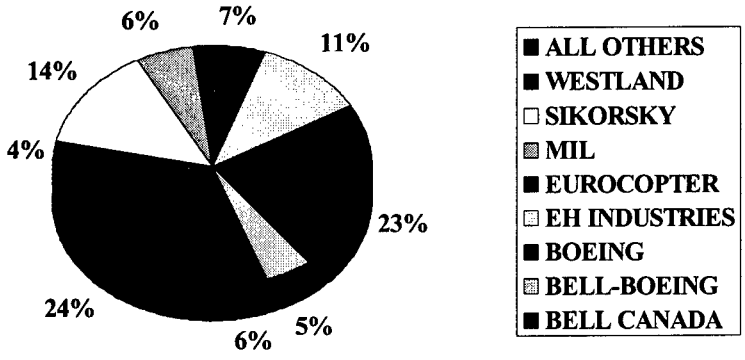
The rotorcraft sector of the aircraft industry consists of military helicopters, civilian helicopters, and tilt-rotor aircraft. Civil and military missions include medical evacuation, cargo and personnel transport, search and rescue, training, and utility. Military missions also include attack, reconnaissance, antisubmarine warfare, special operations, observation, courier, and mine countermeasures. Rotorcraft are subdivided by gross weight: light (less than 12,000 pounds), medium (12,000–35,000 pounds), and heavy (greater than 35,000 pounds). Major U.S. producers are Bell Helicopter Textron, Boeing Military Aircraft and Missile Group, and Sikorsky Aircraft (Figure 3). Major foreign manufacturers include Eurocopter (a French–German consortium), Agusta (Italy), GKN Westland (United Kingdom), MIL and Kamov (Russia), and Hindustan (India). Each producer has focused on niche markets to ensure profitability and survival.

Current Condition. The rotorcraft sector has largely stabilized from a post–Cold War market marked by turmoil and reduced defense budgets. The worldwide rotorcraft market was $5 billion in 1998. Production included 848 civilian and 293 military rotorcraft valued at $1.4 billion and $3.6 billion, respectively. Unit production and total value bottomed out in 1998.[13] Employment in the U.S. rotorcraft sector

was 22,359 in 1998, compared to 26,087 in 1994.[14]

Challenges. Significant overcapacity characterizes the rotorcraft sector of the aircraft industry. Worldwide, too many companies are chasing limited business opportunities. In 1990, 11 U.S. military rotorcraft models were in production or in development. By 2000, there will be only four models in production and one in development. The 2002 forecast for worldwide capacity utilization is 53 percent, with Sikorsky projected at 41 percent, Boeing at 68 percent, Bell at 96 percent, and Eurocopter at 86 percent.[15] Consolidation has been limited; however, in March 1999, the United Kingdom's GKN Westland and Italy's Agusta announced plans to merge. Otherwise, discussion has been superficial, focusing primarily on marketing, and research and

Figure 3: Projected Market Share 1999 - 2003



development (R&D) with little actual production consolidation. Joint ventures seem the industry trend, as evidenced by the Bell-Boeing V-22 Osprey and the Boeing-Sikorsky RAH-66 Comanche.[16] In the end, overcapacity raises costs and makes manufacturers less competitive.

To remain solvent in a budget-conscious DOD climate, companies are pursuing more military upgrade and modification business. By 2007, remanufacturing is expected to be about 21 percent of the total military rotorcraft market value, up from 8 percent in 1998.[17] Companies will work with the DOD to increase their share of prime vendor support at aviation depots, while this vendor support reduces DOD costs and logistics structure, provides greater cost visibility, and speeds parts flow.

Outlook. The rotorcraft industry's long-term outlook through 2008 is one of cautious optimism. The 1990s slump is over, and total rotorcraft production is likely to increase gradually. The military market appears somewhat brighter with several new models in or near production. In contrast, annual production for the civilian market should remain relatively flat. Competition for sales in the commercial market will be fierce. Meanwhile, industry restructuring will continue as producers evaluate their market roles and niches.

Military rotorcraft production should gradually increase through the next 10 years. Annual production will range from its low of 293 units in 1998 to about 456 in 2004. The dollar value will show a comparable trend, although sales will peak in 2006. The value of new military models (in FY99 dollars) is forecasted at $6 billion in 2006, compared to $3.6 billion in 1999.[18] A 1998 DOD analysis rated the military helicopter sector as low risk—meaning that there are either several sources providing the required industrial capabilities, or there is at least one reliable source with potential alternate sources available, if necessary.

Major new military aircraft in production include the Bell-Boeing V-22 Osprey. The Boeing-Sikorsky RAH-66 Comanche is a top Army priority and should enter service in 2006. New European models include the EH-101 utility helicopter, NH-90 transport, and Eurocopter Tiger attack helicopter.

All three U.S. companies—Bell, Boeing, and Sikorsky—are profitable and split the market share at roughly $1.5 billion each.[19] Although Bell is dominant in the commercial rotorcraft market, it is not a market leader in the military sector. Boeing has jettisoned its commercial division and will remain dominant in the high-profit military attack and heavy transport sector. Sikorsky has suffered in the 1990s downturn, falling from a world market share of 44 percent in 1994 to 31 percent in 1997.[20]

Rotorcraft production for civilian use increased in 1997 and 1998. New sales also increased with growth in business aviation, emergency medical services, and law enforcement.

Fractional ownership is becoming increasingly important in the purchase and use of rotary-wing aircraft. This type of ownership involves the corporate or private purchase of an aircraft share based on the annual total of flight hours required. A separate company maintains the aircraft and provides flight crews. The HeliFlite Corporation in Dallas has launched a fractional ownership program with Bell 430s.[21]

Another trend is toward tilt-rotor technology. Bell Helicopter has partnered with Agusta to develop the BA609 civil tilt-rotor aircraft and

has already received 72 orders. The tilt-rotor performs rotary-wing and some fixed-wing missions.[22]

Additional characteristics of the civil sector include reduced cost of ownership and multinational partnerships. These traits are readily apparent in the development of Sikorsky's new S-92 Helibus. Partners in the venture include Japan's Mitsubishi, China's Jingdezhen Helicopter Group/CATIC, Spain's Gamesa, Brazil's Embraer, and Taiwan's Aerospace Industrial Development Corporation.[23]

The total commercial helicopter market for the 1999–2008 time period is forecasted at more than 7,800 units valued at approximately $19.9 billion (FY99 dollars). Annual production should increase in 1999, flatten in 2000, and decline slightly in 2001. Production should remain fairly stable for the remainder of the period. On the other hand, the dollar value should increase through 2006 due to the production of tilt-rotor and multi-engine turbine helicopters.[24]

Again, cautious optimism describes the outlook for the rotorcraft industry during the next 10 years. Only modest sale gains are projected in an environment of overcapacity and intense foreign competition. To ensure future survival, rotary-wing aircraft manufacturers will need to size their capacity to match reduced demand, expand their upgrade and remanufacturing support capabilities, and pursue rotorcraft logistics services.

Aircraft Engines

Differences between the commercial and military aircraft engine industries are blurring. The high-thrust, short-duration requirements of a fighter engine no longer guarantee the numbers and profits of the past. Today's profits are evolving toward the lower thrust, longer duration needs of commercial engines. With engines making up approximately 25 percent of the flyaway cost of any aircraft, this is a significant market.

The aircraft engine industry remains dominated by four principal manufacturers: General Electric and Pratt & Whitney in the United States, Rolls Royce in the United Kingdom, and SNECMA in France. Rolls Royce has merged with Allison, a U.S. manufacturer, to form the first transatlantic aircraft engine company. The worldwide market does not seem adequate for continued growth of all four companies. Thus, while engine manufacturing will remain a core competency, companies will need to adapt and expand operations in service-related areas to remain viable.[25]

Current Condition. The aircraft engine industry is caught in a dilemma that is slowly eroding the profitability and the number of

companies that the market can support. Competition, technological improvements, and customer demand have created an environment in which companies are developing increasingly reliable engines, but must offer these engines at low prices. Engine manufacturers often sell engines at a loss with the expectation of profiting through future spare part sales. During the past 5 years, increased reliability has stretched the timeline to profitability of large commercial aircraft engines to nearly 20 years.

This slow return on investment has had two significant effects on the aircraft engine industry. First, manufacturers have become very efficient in product improvement and assembly processes. On the average, engines have 20 percent fewer parts than they did 10 years ago. Manufacturers use technology advancements in the development of new engines and include them in product improvements for engines already in service. The reduction in the number of movable parts and the automation of production lines makes it possible to build an outstanding product in a minimum of time.

Second, companies are moving away from engine manufacturing as a single core competency to engine maintenance. Engine manufacturers are pursuing profit in commercial and military engine maintenance programs with alternatives that range from leasing engines to providing depot level support. Innovations, such as maintenance agreements that are priced as a function of the amount of time an engine is operated (e.g., Rolls Royce's "power-by-the-hour" program) are becoming commonplace for both airlines and military aircraft.

The F/A-18E/F, F-22, JSF, Gripen, Eurofighter, and Rafale bring future opportunities for military engine development and production. Opportunities in the commercial market are a function of future airline sales and modification to existing engines to meet more strenuous noise and emission standards.

Challenges. Dollars for R&D are at a premium and are restricting advancements in the aircraft engine industry. In the past, many innovations used in military aircraft engines fed changes in commercial engines. Significantly lower production rates and reduced military aircraft development funding have reversed this trend. Now companies look to incorporate commonalities of commercial engines into military engines with an eye toward leveraging maintenance practices. The margins on the commercial side are not adequate to support development costs of up to $2 billion for a new engine, however.

Outlook. Aircraft engine manufacturers are in the process of shifting their business focus to the service sector. This shift coincides with many commercial airlines' desire to outsource their maintenance requirements.

The military sector will continue to retain a depot capability for aircraft maintenance, teaming with aircraft engine manufacturers rather than completely relying on them. The costs associated with retaining this core competency must be weighed against the risk of placing engine repair capability solely within the commercial sector.[26]

Transatlantic cooperative efforts, teaming, and mergers are blurring the lines of competition and company composition. The extreme risk of an all-or-nothing competition in an environment of reduced acquisition opportunities causes companies to take actions to minimize risk and remain viable. It is necessary to re-examine traditional "Buy America" and "Fortress Europe" barriers in order to create an equitable worldwide competitive environment.

The recessive trends of the aircraft engine industry raise the possibility that there may be only one U.S. aircraft engine manufacturer in the future. This potential decrease in the number of U.S. engine manufacturers is a national security concern, because such a decrease would adversely affect competition and responsiveness in time of crisis.

OTHER TRENDS IN THE AIRCRAFT INDUSTRY

Uninhabited Aerial Vehicles

Increasingly important multirole weapon systems, UAVs can perform hazardous missions in certain tactical environments without risking human life. *Joint Vision 2010* and DOD's Integrated Airborne Reconnaissance Strategy recognize and incorporate UAV concepts. While many U.S. defense contractors and analysts believe UAVs are the future of the defense aviation industry, aircraft and engine manufacturers are only dabbling in independent UAV R&D. Most are waiting to see if the DOD provides funding for its strategic vision for UAVs.

Although UAVs may well represent the wave of the future, they will not significantly affect the aircraft industry within the next 10 years. The low unit cost of UAVs relative to manned aircraft and DOD's current procurement plans, which tend to focus on more expensive manned aircraft, will ensure that the aircraft industry will continue to treat UAVs as a niche market for the foreseeable future.

If UAV technology matures as anticipated, the JSF may well be the country's last manned fighter.

Y2K and the Aircraft Industry

The aircraft manufacturers use computers extensively not only in aircraft, but also in the industry's support infrastructure. Therefore, the aircraft industry is more reliant on computer-driven systems than most other industries. This high-technology infrastructure includes design, inventory management, technical support, and manufacturing.

Because of its reliance on information technologies, the aircraft industry recognized and acted on the Y2K problem earlier and more aggressively than others.[27] For example, due to the long lead times incumbent in aircraft engineering and manufacturing processes, Boeing identified and began to mitigate potential Y2K concerns in its commercial, defense, and space products as early as 1993.[28] Airbus started formal work on Y2K technical issues in early 1996.[29]

Like most Information Age companies, both of these manufacturing giants have implemented comprehensive Y2K plans and have published portions of the plans on the worldwide web. Both Boeing and Airbus have excellent Y2K plans that comply with accepted Y2K plan models, such as the plan presented in the General Accounting Office's *Year 2000 Computing Crisis: An Assessment Guide*, and are available on their Internet web sites. Airbus' Y2K web site is outstanding, especially given the significant amount of press coverage devoted to the European lack of Y2K preparation. Airbus also takes the extra step of defining its meaning of the term *Y2K-compliant*—a rare occurrence on Y2K web sites.

The companies' Y2K plans have a number of similarities; for example, both plans reflect early recognition of the Y2K problem. Furthermore, both companies have established Y2K program management offices to evaluate their aircraft as well as their production and support systems, and both are assessing their suppliers Y2K preparation as part of their risk mitigation. Both companies seem keenly aware of the legal implications of providing assessments of their suppliers' Y2K readiness. Neither company discusses the apparently significant cost of their Y2K efforts.

The companies' plans also reflect the different origins and cultures of Airbus and Boeing. With few legal disclaimers, Airbus' plan presents detailed information about potential problems with its aircraft and support systems. Perhaps as a reflection of the litigiousness prevalent in the United States, Boeing's Y2K plan focuses on its aircraft and is replete with numerous legal disclaimers.

Boeing details more of its plans to ensure its manufacturing support infrastructure is Y2K-compliant. Airbus "glosses over" this issue with the exception of a discussion about updating its business-related computer systems. Without elaborating on the reason, Airbus' Y2K timeline shows "internal operations" as the last organization to achieve Y2K compliance—slated for June 30, 1999.[30,31]

Clearly, Boeing and Airbus are taking Y2K seriously. Only time will show how effective their preparations have been in preventing problems with their aircraft and support systems. The public's confidence in the performance and safety of the commercial aircraft industry as the new millennium arrives will measure the success of their Y2K plans.

Civil Reserve Air Fleet

The strength of the U.S. military depends on power projection, which in turn relies on the military's airlift capability to support wartime requirements. Since 1951, one of the crucial anchors in this power projection capability has been the use of the CRAF to provide surge capability for airlift requirements.[32]

The U.S. government activates the CRAF in three stages, depending on the seriousness of the national emergency. The only time the United States has implemented the first two stages was during Operations DESERT SHIELD and DESERT STORM. The government would activate the third stage only to support two near-simultaneous major theater wars; it has never implemented CRAF Stage III.[33]

As the U.S. industrial and military sectors have shifted to a just-in-time logistics focus, dependence on commercial package carriers to sustain the U.S. economy is greater than ever. Commercial air cargo delivery is essential to mobilize the economy for a national emergency and to prepare for conflicts that mandate the third stage of CRAF implementation. It is necessary to reevaluate the government's ability to implement CRAF Stage III while ensuring minimal effect on the economy.

One possible solution could affect the aircraft industry significantly. The DOD could reanalyze Stage III airlift support requirements and buy enough C-17s to provide the airlift capacity needed during the implementation of CRAF Stage III. This program could include providing subsidies to commercial package carriers for purchasing MD-17s, which are capable of carrying oversized military cargo.

Advances in Lean Logistics

Many of the practices used by industry have valuable applications in the DOD as the share of the budget dedicated to logistics and sustainment is trimmed. From the C-17 to the JSF, most new weapon systems are incorporating innovative sustainment processes early in the design stages, significantly changing the way that the DOD carries out logistics business.

Civilian industry has implemented innovative sustainment programs aimed at improving efficiency. Government adaptation of these programs would mean turning a function over, in part or completely, to a contractor.[34] Most outsourcing initiatives simply trade contractor for government employees. A fully empowered contractor may be able to improve efficiency significantly if old paradigms or legacy systems are not imposed on them. Allowing a prime aircraft contractor to assume overhaul and sustainment functions would help keep that production experience base employed. This method to keep the industry "warm" would also help bridge the growing gap between the end of one major acquisition program and the start of the next.[35]

Contract logistics support (CLS) is already in place for most existing weapon systems within the bounds of Title 10 depot requirements. There are also provisions for an increased role for civilian contractors in the sustainment of weapon systems now in procurement.[36] Additionally, these new systems all put logistics considerations upfront in their design, with increased availability as the primary goal.[37] Support infrastructure for these systems must accommodate fewer numbers (either components or end item), higher reliability, and little or no scheduled depot maintenance. The cost per unit to establish an organic depot repair capability rises with fewer numbers and rarer visits. Turning the depot functions over to a contractor that already has the infrastructure in place—as in the case of the original equipment manufacturer—makes economic sense.

The Aircraft Industry Association polled their member companies concerning recommended improvements for their industry. An increased contractor role in support of defense was one of the most common responses. All of the interviewed prime contractors welcomed the opportunity to increase their presence in the sustainment of their weapon system. They unanimously agreed that logistics services are a growth market and felt that they could provide these services less expensively than the government. Most of their business strategies saved money by investing in modern information technology opportunities, material

distribution systems/strategies, and reliability improvements.[38]

Arguments against an increased role for CLS fall into two categories. First, war or contingency-based emergencies require unquestioned loyalty and flexibility, which federal employees and government-owned facilities can provide. These services would almost always be available at a relatively predictable cost, regardless of demand. Second, some concern arises because a contractor would essentially become a monopoly once a CLS contract is awarded and firmly in place. The implication is that prices would increase once the government depot is eliminated from the competition. The fear of labor union strikes and "bottom line" incentives are also used to reinforce this argument.

GOVERNMENT GOALS AND ROLE

The aircraft industry provides the United States with a significant national security advantage. Consistently, U.S.-produced military aircraft prove to be the world's most superior product. Led by Boeing, the U.S. commercial aircraft industry is the world market leader in what is the nation's number one export industry. The industry appears to be healthy, and market forces, in general, are adequately shaping the aircraft industry. Challenges abound, however, and government support is necessary to ensure continued success. With both the civil and the military aircraft industries at a crossroads, the U.S. government has the opportunity to take a significant role in shaping the future of these industries.

Stable military aircraft procurement programs are essential. They allow manufacturers to reduce unit production costs, stabilize their vendor base, reduce risk, and compete more effectively in the international market. The government must determine the level of capability needed in the aircraft industry to support national defense and the U.S. economy and must fund aircraft procurement accordingly. Multiyear funding should be used when appropriate.

The government must strike a balance between domestic antitrust considerations and international competitiveness. The United States must recognize that global interdependence has changed the risk criteria associated with domestic monopoly. Foreign competitors enjoy a range of state-sponsored support, including financial and investment support, favorable labor laws, and marketing programs. Competitive international pressures dictate that U.S. manufacturers effectively control manufacturing overhead costs. Firms in the United States require the latitude to consider and execute mergers and consolidations in order to

reduce capacity and overhead expenditures without undue government intervention.

The U.S. government should modify Title 10, which governs organic/private depot share requirements. Commercial industry is rapidly mobilizing to take on a growing share of the logistics sustainment for defense fleets. Title 10 and A-76 governing public/private commercial activities stipulate a 50 percent distribution of depot workload. A change to this ratio is required if the DOD intends to increase private sector involvement through CLS. Decreasing repair cycles for components and authorizing fewer depot level maintenance actions will eventually force the DOD to accomplish a depot "bottom-up review" if the goal is to optimize government capability and maximize cost-saving opportunities offered by industry. The industry promises to save money through modernization in systems software, distribution, and component improvements.

Government should adopt an industrial policy that helps U.S. producers maintain a competitive edge. Space programs are crowding aviation R&D and hurting aircraft industry competitiveness. In order to maintain the technological superiority that the United States has enjoyed over the years in military aircraft, the government needs to address the dwindling R&D efforts within the industry, particularly in military aircraft engines. General Electric and Pratt & Whitney cannot afford to allocate the funds necessary to pursue innovative changes within the industry, even through joint ventures. Continuing to work the margins with the focus on improvements to existing "families of engines" will not result in the improvements that U.S. citizens expect in their military.

CONCLUSION

The aircraft industry is a mature industry with a cyclical nature. The industry continues to evolve from one with numerous competitors offering a wide choice of products to one with fewer manufacturers producing a smaller variety of aircraft. The leading firms will continue to move toward an emphasis on final aircraft assembly while passing subcomponent manufacturing and increased risk to the supplier level.

In the commercial sector, there is insufficient demand to justify the $10- to $12-billion expenditure necessary to develop a passenger jet with 600 or more seats. It seems likely that Airbus will continue to examine and evaluate this alternative, but not initiate development in the near term.

Military fixed-wing aircraft production continues to decline from the boom of the 1980s. Austere defense budgets will result in reduced U.S.

military aircraft procurements over the next 10 years. Because the defense procurement budgets are not adequate to support the planned buys of the F/A-18E/F, F-22, and JSF, it can be anticipated that one or more of these programs will be significantly reduced or canceled.

Despite public pronouncements from the government of a winner-take-all competition, it is highly unlikely that either Boeing or Lockheed Martin exclusively will produce the JSF. In order to preserve the industrial base and maintain domestic competition within the aircraft industry, the government will mandate some type of sharing arrangement, such as leader–follower or licensing arrangement, upon awarding the JSF contract .

In the rotorcraft sector, significant overcapacity remains at odds with the limited industry consolidation, and further consolidation is both necessary and likely. The trend for joint ventures will continue as a means to reduce risk and start-up costs.

The recessive trends of the aircraft engine industry raise the strong possibility that one of the two U.S. manufacturers may be the object of a merger proposal. This potential reduction in the number of manufacturers is a national security concern and will adversely affect competition and responsiveness in time of crisis.

Those organizations operating both military and commercial aircraft will continue to look for industry to provide logistics services and life cycle support. Firms will expand CLS to allow users to reduce their risk and overhead expenditures, while increasing their readiness and flexibility.

Interest in UAVs will remain strong, and major manufacturers worldwide will continue developmental efforts. Technology and strategy have not developed sufficiently for UAVs to affect the aircraft industry sufficiently in the next decade, however.

The aircraft industry is a leader in globalization. The worldwide consolidation of commercial and military aircraft industries will increasingly confront the U.S. government with issues such as technology transfer, subsidies, antitrust regulation, Buy America requirements, and sustainment of the U.S. industrial base. Market forces are adequately shaping the aircraft industry. The U.S. government should allow these market forces to prevail and should intercede only when necessary to guarantee national security interests. Despite its many challenges, the U.S. aircraft industry is healthy. It will support the national security requirements for fixed-wing, rotary-wing, and transport aircraft into the 21st century.

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BIOTECHNOLOGY

ABSTRACT

The synergy of new discoveries in multiple disciplines, coupled with insightful legislation and investors with a long-term view to profit, resulted in the world leadership role enjoyed by the U.S. biotechnology industry. Maintenance of this position and of the ability to affect multiple industrial sectors, such as health care, agriculture, environment, forensics, and defense, depends on a close partnership between government and industry. Supportive legislation and regulation related to patenting, licensing, incentives, and partnerships, as well as specific focus on the ability to detect, prevent, defend, and respond to biological attack, represent some of the measures that government must take to maintain U.S. worldwide preeminence as the leader in biotechnology.

BG Hamad O. Alhunaity, Jordanian Air Force
Lt Col Stephanie A. Brotherton, USAFR
CDR Manson K. Brown, USCG
Col Richard Davila, USAF
Lt Col Fred W. Gortler, III, USAF
COL Eileen B. Malone, USA
CDR Susan L. Martin-Sanders, USN
Lt Col Thomas J. Masiello, USAF
LTC Richard L. Polczynski, USA
CDR Clyde C. Porter, Jr., USN
Ms. Debra H. Richardson, Dept. of the Army
Dr. Andrew B. Sisson, U.S. Agency for International Development
LtCol Denise R. Van Peursem, USMC

Ambassador Jane E. Becker, faculty
Dr. Joseph E. Goldberg, faculty
Dr. Steven P. Kramer, faculty
Ms. Marva J. Nesbit, faculty
CAPT David S. Tyson, USN, faculty

PLACES VISITED

Domestic

Advanced Tissue Sciences, Inc., La Jolla, CA
Agricultural Research Center, Beltsville, MD
Agricultural Research Service, Pacific West Area, Albany, CA
ARCTECH, Inc., Chantilly, VA
Armed Forces Institute of Pathology, Bethesda, MD
Gene Logic, Inc., Gaithersburg, MD
MedImunne, Gaithersburg, MD
The Salk Institute, La Jolla, CA
Scripps Institute, La Jolla, CA
XOMA, Inc., Berkeley, CA

International

BASF Ludwigshafen, Germany
British Ministry of Defence, London, England
Centre for Applied Microbiology and Research, Salisbury, England
European Molecular Biology Laboratory, Heidelberg, Germany
Moredun Scientific, Ltd., Midlothian, Scotland
Pfizer, Ltd., Sandwich, England
The Roslin Institute, Midlothian, Scotland
The Sanger Institute, Cambridge, England
Society, Religion, and Technology Project, Edinburgh, Scotland

INTRODUCTION

The exponential explosion of new information resulting from the synergy of biological, chemical, physical, and informational advances has challenged our understanding of living things. Unique tools such as genomics, combinatorial chemistry, high-throughput screening, nanotechnology, miniaturization, and robotics facilitate biotechnology applications that affect all dimensions of human existence. The food we eat, the diagnostic tests and medicines we take, the raw materials we use, the identification of criminals, the treatment of waste, and even the defense of the nation are increasingly revolutionized by the biotechnology industry.

Biotechnology provides a pervasive stimulus, one that increasingly influences and shapes industries from agriculture to health care. As a result, biotechnology must be of strategic concern to the government. The government must develop the policies and laws necessary to cope with both the opportunities and the challenges associated with biotechnology, an industry with seemingly endless applications. Each new discovery brings a new set of moral and ethical dilemmas that warrant comprehensive debates within the government and other policy-shaping pillars of U.S. society. Public education represents the first step.

Historians may well define the 21st century as the biotechnology century—one in which diseases are understood and eradicated and the world population fed—all courtesy of biotechnology.[1] As the undisputed world leader in the biotechnology industry, the United States possesses the ability and responsibility to facilitate worldwide strategic opportunities, as well as public consideration about the darker side of biotechnology applications. Leaders must anticipate the profound impact that these changes bring to every aspect of society. No other industry has the potential to improve the human lot so significantly.

THE BIOTECHNOLOGY INDUSTRY DEFINED

Because of the diverse and unpredictable ways in which it shapes and enables so many other industries, the biotechnology industry resists definition. Simply, biotechnology includes "various techniques for using the properties of living things to make products or provide services."[2] A brief examination of the properties of living things is necessary to understand the blueprint of all living organisms.

Life's Blueprint: Simple Questions with Complex Answers

Protein governs the dynamics of all living things; it determines an organism's structure, function, and response. Twenty different building blocks, called amino acids, configure in a seemingly infinite variety of combinations and lengths to form proteins. The blueprint for these combinations appears in deoxyribonucleic acid (DNA), which lies in the nucleus of every cell. In 1973, two U.S. geneticists developed a procedure to transfer a gene from one organism to another, a process called recombinant DNA. The production of Factor VIII to treat individuals with hemophilia involves an application of recombinant DNA. The gene for Factor VIII is placed in *Escherichia coli*, a bacterium that then replicates at a rate sufficient to produce enough factor for hundreds of individuals.

Genes constitute the building blocks of DNA, with the description of each gene representing the first step of the molecular properties of life. Deciphering a gene's composition by means of genetic sequencing serves as the focal point for multiple worldwide scientific efforts—the best known being the Human Genome Project. The gene sequences hold the key to understanding specific, diverse life attributes—the first step in determining possible applications. The development of unique tools, enhanced by information technology, has now transformed the scientific pursuit of this information.

Unique Tools Enhanced by Information Technology

Major technological advances have revolutionized the discovery process. Gene-mapping technologies establish the link between genes and diseases, rapidly producing targets for interventions through a process called genomics. Combinatorial chemistry, which uses automation, robotics, and miniaturized biosensors, creates large libraries of chemical molecules that can be screened for potential pharmaceutical application.[3,4] High-throughput screening of these molecular libraries rapidly identifies "hits" or leads that affect a particular biological target, a method exponentially reducing the lead time to discovery. Robotic devices working around the clock have replaced many repetitive, labor-intensive laboratory procedures. Advances in miniaturization techniques suggest that it will not be long before an entire human genetic reference profile is placed on a single chip.

Information technology's continuous computational advances facilitate the analysis of the vast volumes of data generated by these tools, enhancing the scientist's ability to study the complex patterns that

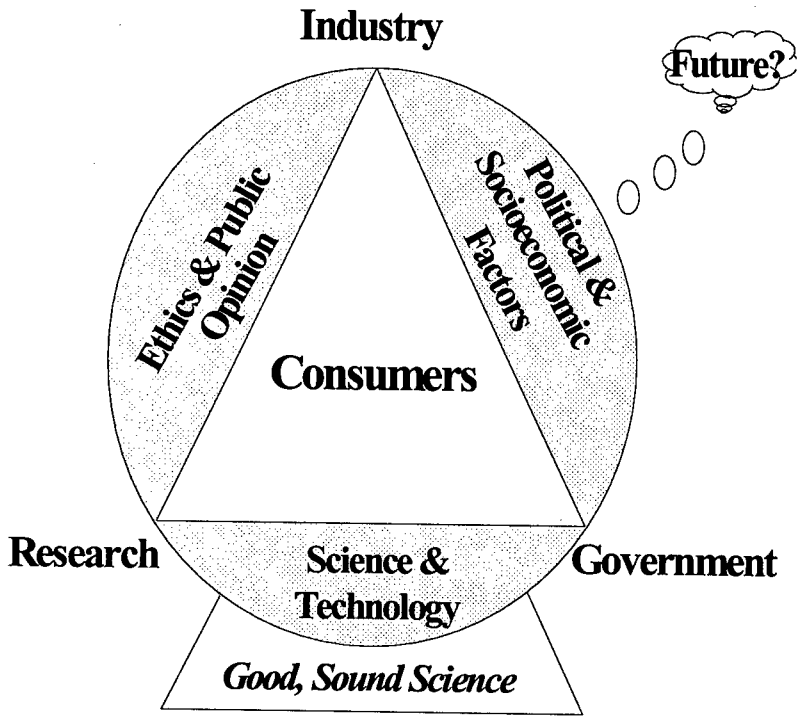
underlie the network of genes regulating all life. Significant advances in database management systems, including a new technique called "data warehousing," now permit researchers to catalog and retrieve data across an entire enterprise versus a single organization or function. These technologies greatly facilitate sharing of critical information among scientists such as those who place daily genomic sequence discoveries on the Internet for worldwide access.

Synergistic Communities

The catalyst for the recent exponential explosion of information fueling advances in biotechnology arises from synergistic communities. The critical mass, collaboration, and collocation of scientists from a myriad of fields—microbiology, virology, genetics, therapeutics, chemistry, physics, engineering, and informatics—provide the incubator for an integrated approach to molecular discoveries. Today is the golden age of biology, an age dependent on the talents and the synergy produced by many disciplines and by the forces of the marketplace. Figure 1 portrays the biotechnology industry today.

Good, sound science serves as the foundation for the entire industry. Research and development (R&D) conducted by academic, nonprofit research agencies and the government consume the lion's share of capital investment, producing world class scientists and discoveries that lead to patents. These discoveries not only further the knowledge of biology, but also serve as the springboard for new industry applications. The government plays a role through the provision of laws and regulations facilitating technology transfer from the laboratory to the marketplace (e.g., through patent law) and fostering favorable economic conditions (e.g., through trade policies). The biotechnology industry enables multiple industrial sectors around the world, with the major ones being health care, agriculture, environment, forensics, and defense. Driven by scientists "experimenting our way forward," biotechnology represents a new impetus for the 21st century economy.

Figure 1: Biotech Industry Model



Each sector carefully tracks and capitalizes on the scientific discoveries facilitated by the 1986 Bayh-Dole Act, which supports technology transfer from the research environment to industry applications. Each technology investment by industry is based on a careful value chain analysis and a close scrutiny of future potential markets. The entire industry actively responds to a number of interrelated, external variables: political and socioeconomic issues, ethical issues, scientific and technological issues, and public opinion. The impact of these variables may ultimately determine the industry's future health.

CURRENT CONDITION

Biotechnology remains intensely dynamic, with competition driving firms to form, merge, create alliances, and sometimes declare bankruptcy, mirroring the scientific discoveries that drive the industry itself. Many variables contribute to this dynamism and are best understood by examining each industry sector enabled by biotechnology.

Inroads in Many Sectors

The synergy of new discoveries in multiple disciplines stimulates the biotechnology industry. Rapidly exploited due to informational advances, molecular discoveries serve as pieces of a puzzle and dramatically reduce the time to discovery, particularly for new medicines.

Health Care. Major technological innovations are decreasing the need for the "needle-in-the-haystack" approach to drug discovery and making the process more efficient. The Human Genome Project, a 15-year multinational effort coordinated by the U.S. Department of Energy and the National Institutes of Health, is identifying all the estimated 80,000 genes in human DNA, with project completion anticipated in 2003. Already more than 50 biotechnology-produced and Food and Drug Administration (FDA)–approved therapeutics exist, with more than 350 biotechnology medicines produced by 140 pharmaceutical and biotechnology companies.[5] Evidence of biotechnology's accelerating importance for the health care sector is that while the FDA approved 14 biotechnology-produced pharmaceuticals in 1998, it had already approved 11 in the first quarter of 1999.[6,7]

Agriculture. In the agriculture sector, gene modification has resulted in crops that are naturally resistant to specific insects and herbicides, and that slow down the ripening process (extending shelf life). Other strains are being developed to withstand marginal soil and weather conditions. Since 1990, more than 25 agricultural biotechnology products have successfully progressed through the U.S. regulatory system and reached the marketplace.[8] Transgenics, the process whereby genes are selectively copied from one cell species and inserted into another, represents an additional tool by which scientists have improved crop species.

Environment. Bioengineering represents a growing component of the environmental industry. With more than 200 million tons of hazardous materials being generated annually in the United States alone and the costs of remediating the associated hazards now estimated to be in excess of $1.7 trillion, industry analysts see bioremediation as a growth industry.[9] The Department of Defense (DOD) alone has an estimated 8,000 sites requiring remediation, including removal of such hazardous materials as ordnance, and it has budgeted $1.2 billion in Fiscal Year 1999 for this purpose.[10] At least one biotechnology firm has developed, and is now testing in conjunction with the DOD, technologies that use organic material to convert munitions into fertilizer and fuel. Some firms have developed technologies to produce natural plastics that are fully

biodegradable; Monsanto, for example, hopes to have such plastics in production by 2003.[11]

Forensics. Since 1980, it has been possible to distinguish individuals using DNA markers, and forensic science now uses DNA fingerprints for identifying criminals and paternity. The Armed Forces Institute of Pathology (AFIP) uses DNA testing to identify the remains of service members once missing and unaccounted for and maintains a repository of DNA specimens for DOD personnel.

National Defense. Biotechnology itself poses both traditional and new challenges for U.S. national security. Potential adversaries seeking asymmetrical advantage over the United States may employ biological weapons against unprotected populations or deployed military forces. New, highly drug-resistant and virulent strains of microorganisms derived from technological advances in microbiology and genetic engineering pose tremendous challenges. Various open and official sources estimate that between 10 and 20 countries possess or are pursuing the means to produce biological weapons, and as many as 100 nations have the technological capability to develop a rudimentary program.[12] Though turning biological agents into weapons is a complex undertaking, 100 kilograms of anthrax delivered by an efficient aerosol generator on a large urban target would be between two and six times as lethal as a 1-megaton thermonuclear bomb.[13]

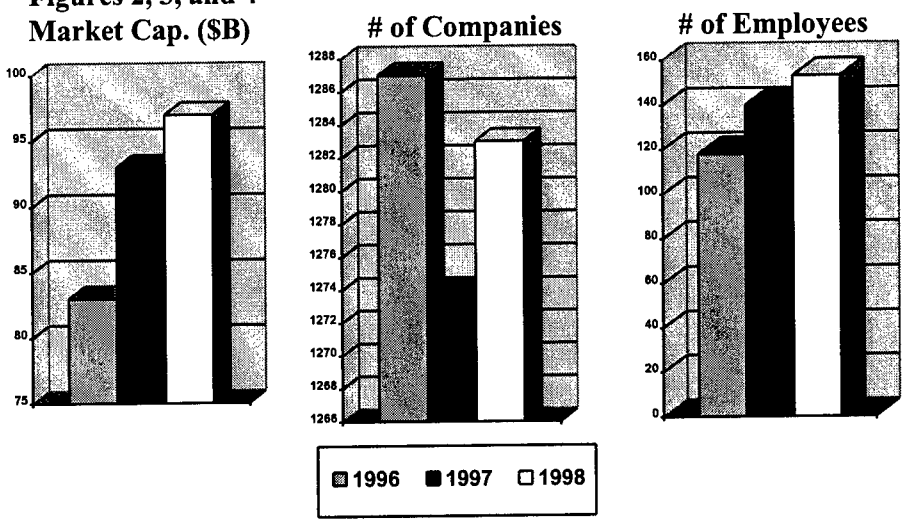
Industry Structure

The biotechnology industry has grown considerably since its early days in the 1970s. Total market capitalization of the industry in 1998 was $97 billion, up 4 percent from 1997 and up 17 percent from 1996. Although employment has increased, the total number of companies has remained flat; companies that have merged or gone out of business have offset the number of new entrants. Despite its rapid growth, the biotechnology industry is still relatively small compared to the large pharmaceutical companies, often referred to as 'big pharma.' The $197 billion capitalization of the pharmaceutical company Merck alone is larger than the combined capitalization of all biotechnology firms. Figures 2, 3, and 4 illustrate the level of market capitalization, number of companies, and number of employees for the biotechnology industry.

The biotechnology industry in the United States remains fairly concentrated. At the end of 1998, the 20 leading biotechnology companies accounted for nearly two-thirds of the total market capitalization of the industry.[14] Biotechnology companies generally start out as privately held companies, which tend to be much smaller than

publicly held companies; however, one of their objectives is to grow sufficiently so that they can go public and grow even more.

Figures 2, 3, and 4

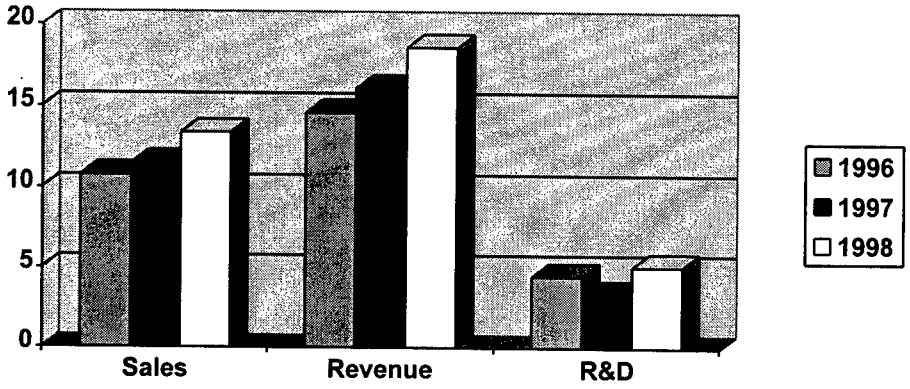


While publicly held companies account for only 25 percent of the industry's total number, they account for 94 percent of its market capitalization. Among publicly held companies, Amgen, the largest biotechnology firm, dwarfs its rivals. Its market capitalization of $33.7 billion is three times larger than that of its closest rival, while the average market capitalization of public companies in 1998 was just $279 million. Biotechnology has experienced tremendous growth in the United States since the first company, Genentech, was founded in 1976. Compared to just 25 publicly traded biotechnology companies 15 years ago, there are now more than 300 publicly traded biotechnology companies and about another 1,000 private ones.[15]

Financial Performance

The financial performance of the biotechnology industry has improved as companies have succeeded in bringing more products to market (Figure 5). Product sales in 1998 were up 17 percent from the previous year, while net losses were flat (if special charges are excluded). Expenses for R&D continued to grow rapidly, up 16 percent last year from 1997, and were an impressive 53 percent of revenues. In 1998, publicly held companies earned more than 81 percent of the industry's total revenues, but most biotechnology companies still have no product revenue.

Figure 5: Industry Financial Performance ($ billions)



Sources of Capital

Because most firms within the industry are not yet earning any revenues, they must raise capital from external sources in order to survive and grow. Cash and cash equivalents on hand, an indicator of the industry's financial survivability that has improved in publicly held companies, rose by 45 percent from 1996 to 1997. In 1998, however, 41 percent of public companies remained vulnerable with only enough cash on hand to keep them functioning for 2 years or less (although this percentage is lower than the 51 percent of public companies in this situation a year earlier).[16]

Large pharmaceutical and chemical companies are investing in biotechnology with their own substantial revenues because of established markets with very high potential returns. After rapidly increasing in the early and mid-1990s, new financing has been declining in the past 2 years, owing largely to the decrease in public offerings. Last year, biotechnology firms found it harder to raise funds. Investors lost enthusiasm and became impatient with firms' overall inability to obtain FDA approvals and bring products to market. Some investors turned to more lucrative Internet companies. Also, the consolidation of financial institutions led to banker demands for larger investments, leaving small capitalization biotechnology firms less attractive.

To make up the difference, biotechnology firms have pursued financing through other means. There was a 32 percent increase in venture capital financing last year. More important, funding from partnering arrangements or alliances between biotechnology companies and other companies increased from $5.9 billion in 1997 to $6.2 billion

in 1998. These arrangements have become dominant in the industry, especially in health-related biotechnology and bioagriculture. Typically, the investing company is a large pharmaceutical company that provides a substantial infusion of cash in return for an ownership share in the biotechnology firm and/or marketing rights and a hefty share of the profits. The number of alliances has grown steadily from 69 partnerships in 1993 to 224 in 1998.[17]

Human Resource Requirements

The biotechnology field integrates many disciplines: biochemistry, cellular biology, chemistry, genetics, chemical engineering, process engineering, and computer science, to name a few. The industry employs about 150,000 people in high-paying jobs. Entry-level positions and education run the gamut from laboratory assistant, with a high school diploma and no experience; to a process development engineer, with a bachelor's degree in engineering with a minimum of 2 years' experience; or to a geneticist, with a doctorate and several years of postdoctoral experience.

Global Position

The United States serves as the world leader in biotechnology measured in any number of ways: number and size of firms, number of patents and products on the market, and amount of exports. Nationality is blurring, however, because foreign firms are acquiring or allying themselves with many U.S. biotechnology firms. Thus, U.S. biotechnology firms face increasing competition from overseas. The growth of the industry internationally, particularly in the United Kingdom and Germany where biotechnology is growing in response to government regional development progress, is adding to the supply of products and to the demand for scientists, skilled labor, and capital. The recent creation of the EASDAQ in Europe (akin to the NASDAQ in the United States) and the Euro currency will help European biotechnology firms raise funds and might reduce the availability of European capital for U.S. firms. On the other hand, for U.S. firms that master these new developments, European financial markets could be a boon.

CHALLENGES

Societal Debate and Choices

How a society admits that a new technology is intrinsically valuable, develops a consensus that balances risks with benefits, and accepts the technology through a process of education and assessment constitutes the crux of biotechnology's challenge. As new technologies arise, enabling the implementation of new procedures, legal and ethical issues surface as to whether the new procedures should be allowed, encouraged, or discouraged. Central to this concern is who should decide and contribute to the decision: the government, the scientific community, or the general public. Although public authorities ultimately have decision-making authority, the other sectors cannot be ignored. Nowhere is this challenge more evident than in one of the most salient biotechnology issues of the day—the use of genetically modified organisms.

The ability to transfer the gene of one organism to a completely different organism challenges inherent beliefs about 'naturalness' and humanity's right to proceed in this fashion. Do humans have the right to deliberately tamper with nature? Does the world really need genetically modified crops? Relatively few U.S. citizens clearly understand that many of the agricultural products that they consume on a daily basis are the result of genetic alteration with genes from organisms other than plants. In contrast, heated debate about the requirement for and safety of genetically modified organisms presently rages in Europe. Public trust dissolved in the wake of Mad Cow Disease, which undermined confidence in the scientific community. Europeans now demand the details of genetic modifications and assurances that the technology is truly necessary and safe, not merely another ploy by multinational corporations to line their corporate pockets.

The issue of the need for genetic modification pales by comparison to the capabilities of the biotechnology industry to transform humanity. These technologies are unique because the object upon which they operate is humanity itself.[18] Biomedical applications may ultimately cause a change in an individual's destiny, modifying specific genes linked to specific behaviors, attributes, or characteristics.[19] Biotechnologists discuss some of these issues within the confines of professional societies, but many scientists indicate that society must ultimately decide these issues. Government should facilitate an

extension of these debates to the U.S. public to promote consumer education and appreciation for the value of biotechnology.

The biotechnology industry must become better skilled in listening to the public and handling public expectations. Values cannot be negotiated, and competition may not be driven solely by price. Scientists must assume an active role in separating fact from fiction, distinguishing between applications, and identifying the real ethical issues. Public perception regarding industry arrogance poorly serves the industry and does not further public understanding of the science upon which the industry rests. To promote public choice and trust, scientists and industry need to get public information right. Rigorous scientific accountability serves as the first step in earning public trust, and an appropriate level of regulation strengthens scientific accountability.

The government's challenge remains to ensure the public safety and provide for the public good, while not encumbering the biotechnology industry with unnecessary regulations that impede the industry's development. Given the global nature of the industry, a more streamlined and standard approach to regulation requirements is a priority. Basic research funding represents an essential government role for biotechnology, an industry in which serendipitous discoveries often prove the most worthwhile. Government must strike a balance between government-driven and industry-driven research to address business and national security needs, particularly in those areas where market forces do not necessarily drive desired biotechnology initiatives, such as environmental remediation.

Challenges to Industry

The most pressing business challenge remains the high cost of bringing products to market with the associated need to generate substantial investment capital for R&D. Government must understand this dynamic and must provide incentives not only for emerging biotechnology companies and venture capitalists, but also for researchers. Revenue generation requires flexibility and a patience to realize outcomes that often take 15 years or more to bring to fruition. Industry must establish methods to manufacture biotechnological products more efficiently, bringing down the cost of the process. Competition from foreign biotechnology industries represents another challenge, requiring an active role on the part of the U.S. government. Trade issues, including cultural barriers, pose an additional challenge, as illustrated by the ongoing agricultural genetic modification debate between the United States and the European Union. The multinational

nature of corporations and the potential threat to the security and defense needs of nation-states will complicate this issue.

National Security Challenges

Like other emerging asymmetrical threats, biological weapons pose uncertain challenges to U.S. national security. While the likelihood of a biological attack or even an industrial accident is difficult to assess, the consequences of either event are so severe that proactive contingency planning is essential. Striking the right balance in apportioning resources to deal with the potentiality of a biological attack or accident and to reserve the bulk of resources for more productive biotechnology pursuits is an early and fundamental challenge. Once the apportionment has been decided, crafting the means to protect and defend against traditional biological agents, as well as to prepare for more powerful ones created through advanced biotechnology processes presents thorny technological challenges. These defensive capabilities include the requirement for sensors to detect the presence of an expanding list of biological agents; emergency personnel to treat people and sanitize property; and cooperation among a host of federal, state, local, and private responder elements. Building an adequate defense against new asymmetrical threats, including biological agents, may require more aggressive tactics by the U.S. intelligence community and law enforcement. Public awareness and debate on the issues presented by biotechnology is necessary to determine how the United States will manage the risk of biological agents.

Other Challenges

Keen competition for highly educated workers exists. Many biotechnology companies are forced to hire scientists from overseas because of an insufficient supply of experienced personnel who hold doctorates. The fact that many postdoctoral trainees in the field are paid around $25,000 per year—not particularly enticing compensation for an individual with many options—complicates this challenge. The education system must be improved to reflect the multidisciplinary, highly technical needs of this growing field.

Intellectual property rights and technology transfer issues both within the United States and around the world pose challenges to the industry. Access to information is vital to the industry, and its management provides significant challenges. As discussed earlier, nonprofit research efforts, such as the Human Genome Project,

immediately place findings in the public domain via the Internet. There is no such disclosure of private mapping results, however, nor are the mapping procedures compatible with public efforts. The expanding knowledge in the field of biotechnology will push the limits of computational analysis and stretch computer systems and informatics as a whole to keep pace with the needs of biotechnology.

OUTLOOK

An assessment of the future health of the biotechnology industry must integrate the various industry sectors (e.g., health care, agriculture) with those factors that will shape the industry in general. These factors include the structure of industry in the global marketplace, ethical and moral issues, public safety concerns, national security issues, education, socioeconomic and political issues, and government regulation.

Future Structure of the Industry

Mergers, acquisitions, and partnerships, many in a multinational setting, are becoming the norms in the biotechnology industry. Pharmaceutical companies acquire or collaborate with biotechnology firms. Chemical companies diversify their operations by adding biotechnology groups; some even shed their chemical divisions. The traditional boundaries separating pharmaceutical and agricultural firms are blurring. Government, private, and academic research institutions partner with commercial firms to bring technological advances to market. The multidisciplinary nature of biotechnology will drive continued business transformations in this already dynamic industry to promote synergy and efficiency.

In the short term, the U.S. biotechnology industry is likely to maintain its preeminent position in the global marketplace. Experts predict that as the economies of Europe and Japan increase in strength, markets will improve, and that as more products move through the late phases of the FDA approval process, more companies will introduce profitable products on the market and become more attractive to investors. Innovation and entrepreneurship in U.S. biotechnology represent the keys to its success. As volatility continues and competition from international sources increases, however, the U.S. government has an important role to play in promoting a good environment for the industry.

Survival in this high-speed environment depends on flexibility created through strategic alliances that allow corporations to draw upon

the niche expertise of smaller companies, which are often able to provide some services more efficiently because of superior capabilities and proprietary technology.[20] A company that strikes an appropriate balance between its internal operations and outsourced services represents the key to future success for many large corporations.[21] One of the major business shifts necessary for industry survival is the movement toward the consumer-centric service niche—services focused on the increasingly activist consumer,[22] many of whom are the demanding baby boomers.

Enabling Factors

The biotechnology industry enjoys several enabling factors, the first being consumer demand. When the youngest baby boomers reach 65 in 2029, almost 20 percent of U.S. citizens will be elderly, 2.5 times more than in 1950.[23] The most concentrated demand for health care usually occurs in the later years of life, with the greatest health care costs typically incurred in the last year. Those 65 and older, currently representing approximately 13 percent of the population, account for almost 34 percent of health expenditures today.[24] As the baby boomers approach 65, there will be increased demand for biomedical products to eradicate diseases, enhance the quality of life, and promote longevity. This focused demand will fuel technological advances in health care and agricultural sectors.

Expanding global markets represent the second enabling factor in the biotechnology industry. Consumers in the Third World and developing countries will demand the same products available to the most developed nations, products such as nutriceuticals. With an anticipated rise in foreign competition in the long term, U.S. biotechnology firms will have to respond to that competition. The third enabling factor is government policy and regulation. It is clear that government initiatives designed to encourage venture capitalists to invest in biotechnology or to bring government research advances to consumer markets have bolstered U.S. competitiveness. These initiatives have created the equivalent of biotechnology enterprise regions where academic, industrial, and government elements forge synergistic partnerships. These initiatives will continue to support the competitiveness of the U.S. industry for decades to come.

Information technology serves as the fourth enabling factor. The rate at which U.S. innovations are transformed into useful products has made the United States a global leader in information technology. Almost daily, there are significant improvements in data storage capacity, computer processor speeds, and the myriad of software tools available to

support biotechnology research. Thousands of scientists and academics rely on state-of-the-art computer technology to store, retrieve, analyze, and visualize volumes of biological research data. Use of the Internet is exploding; industry insiders agree that it will probably be the tool with the single greatest impact on future progress. In the areas of manufacturing and marketing, medical and pharmaceutical companies are implementing network-based systems that will provide worldwide access to centralized databases to help control testing, packaging, and distribution of their products. Because of the fierce competition among information technology firms to develop breakthrough technologies that will generate revenues and ensure their future survival, one can reasonably conclude that U.S. biotechnology firms will continue to benefit from the competition and maintain their status as world leaders in this vital industry.

Limiting Factors

The state of public education in the United States represents the first potentially limiting factor for the biotechnology industry. Despite world-class graduate-level education, additional emphasis on the basics of science at the elementary and high school levels remains imperative. Fortunately, top foreign talent, attracted by the quality of graduate education and the U.S. lead in biotechnology, has augmented the pool of skilled workers required by the biotechnology industry. Biotechnology firms are looking for individuals who can work both independently and collaboratively with others in a multidisciplined setting. Workers need to be adaptable, creative, and committed to continuous learning. The education system must be strengthened so that it can increase the base of multidisciplined scientists while emphasizing team skills. On a different plane, the education system must help to improve the public's ability to comprehend the scope and impact of revolutionary technological advances.

In this regard, the apparent widespread public ignorance in the United States about the current use of genetically modified food products is a potential limiting factor in the short term. Unlike the rising public concern in Europe, people in the United States seem less informed and less concerned about surfacing indications that there may be some unintended or even untoward consequences of biotechnological interventions. For example, the length of Dolly's telemeres—the wrappings on the end of her chromosome—is more consistent with that of the telemeres in the older ewe from which she was cloned than with that of the telemeres in a ewe at her biological age. Other concerns

surround the use of hormone- and antibiotic-supplemented feed for livestock intended for human consumption. A recent study pointing to transgenic corn's destructive impact on monarch butterflies could represent only the tip of the iceberg,[25] resulting in a strategic pause in the further introduction of genetically modified products. Unlike health care issues, which have a life-or-death character, agricultural issues are more discretionary in nature, and the European issue of choice will likely become the central theme of the debate until science definitively proves the absence of unintended consequences with genetically modified food.

As emphasized earlier, the ethical and moral dilemmas posed by technological advances in the biotechnology field present the greatest potential limiting factor for biotechnology's application. Forecasting a long-term outlook in view of the anticipated debates remains somewhat speculative. It is likely that the passionate desire to ease pain and suffering, and to improve the quality of life will continue to drive the outlook for the health care sector, however. The debate becomes much more fractured as technological advances cross the line between that which mitigates life-threatening conditions and that which is cosmetic or elective in nature (e.g., selection of eye or hair color for offspring). Health care issues will drive the technology, and agriculture and environmental biotechnology applications will follow. The ethical and moral issues of this debate will shape the long-term future of the industry. The debate must consider public safety needs, as well as individual rights and privacy issues.

National Security Factors

To support national security goals, specifically as related to the mitigation of emerging bioweapon and bioterrorism threats, the U.S. government must continue to exploit the technological advances of the biotechnology industry. Risk and consequence management for force protection and homeland defense will be the drivers for the short- and long-term application and specialized development of biotechnology to support national security needs. Data banks of DNA makers for force identification, anthrax vaccines, and the use of organisms to neutralize outdated munitions are applications representing the beginning of the biotechnology armamentarium for national defense.

Beyond the issue of the biotechnology applications, the national security challenges pose lingering questions. The military is embroiled in a debate that casts the medical rights of an individual against the mandate for involuntary anthrax vaccinations for force protection. Similar concerns arise from the ongoing program to catalog DNA profile

data for all members of the military services, a program intended to improve the process of identifying human remains. In these instances, the national defense establishment will lead the ethical, social, and political debate. The applications of biotechnology associated with national security may serve as an enabling or limiting factor for more general applications of the technology, depending on the outcomes of this debate.

There are more vexing issues to be resolved on the international scene. How can the United States pursue its national interests through international bioweapon conventions when the near identical similarities with legitimate facilities render verification of bioweapon production facilities impractical? Is it possible to span the process and cultural differences between the United States and its allies to achieve a common vaccination protocol for military forces and/or civilian populations? How does the United States monitor the activities of bioweapon production experts from the former Soviet Union so its adversaries do not exploit this potentially available expertise? Government clearly has a role in developing solutions for these problems.

GOVERNMENT GOALS AND ROLE

The Goals

Changes in the biotechnology industry outpace government's ability to influence the course of the industry's maturing process. Forces such as multinational business enterprises and the global marketplace may overwhelm any single government's attempts to pursue its national interests. Because biotechnology challenges traditional concepts of life, liberty, and happiness, and what constitutes public good and private rights, the government must interact with these forces. Biotechnology in the new millennium demands a precarious balance between the enduring principles of the U.S. government on one side and the continued prosperity of the nation on the other. Government's goal must be to facilitate the debate on what constitutes the proper balance and then to foster the conditions to achieve that balance. The prosperity, security, and influence of the nation in the new century rely substantially on the quality and outcome of the debate.

The Role

The primary role of government remains that of public protector. Aggressive government involvement is required in investment and

business incubation, public health and welfare, education, national security, defense, and national will in order to maintain or improve the lead held by the U.S. biotechnology industry. The traditional government role of regulator, addressed in business incubation, clearly pervades all areas. As regulator, the government can safeguard against onerous requirements that detract from overall competitiveness, especially for smaller enterprises that might be blocked from entering the industry.

Investment and Business Incubation. Domestic and foreign business leaders agree that government occupies a central role in creating the conditions for commercial success in biotechnology. Private industry, research houses, and even foreign competitors often credit the Bayh-Dole Act as the single most important contribution to the U.S. biotechnology industry. Closely associated with the Bayh-Dole Act are federal funding for basic research and the government's removal of obstacles that kept small commercial ventures from entering the biotechnology field and created opportunities for them to compete. These actions allowed the private sector to focus on transforming the most promising basic research into lucrative commercial applications. Federally funded basic research is credited with helping to create the biotechnology industry with the discovery of recombinant DNA in 1973 and with fueling its development ever since, for example. Another significant contribution in investment and business incubation is government funding and advocacy for baseline, advanced technologies. The important link between information technology and biology has revolutionized the research, development, and commercialization of biotechnology processes and products. State and local governments also have made sizable contributions. At least 34 states support the industry, either through nonprofit biotechnology centers or programs at state universities.

To ensure that the United States continues to lead in a field growing increasingly competitive, the government must maintain a direct role in legislative and regulatory matters, patenting and licensing, incentives and partnerships, and paperwork reduction. Through close involvement with industry, the government should remain alert to legislative and regulatory requirements if the U.S. lead is to be maintained. The government can continue to create the conditions for investment in high-cost, high-risk biotechnology enterprises by improving patenting and licensing procedures. Innovative partnerships between government and industry offer risk and burden sharing while advancing the interests of both parties.

Public Health. Government occupies a unique, direct role in public health. Reform of the FDA's regulatory functions began with the

Prescription Drug User Fee Act of 1992 through which the pharmaceutical industry agreed to pay $327 million during 1993–1997 to hire 600 additional reviewers.[26] This action reduced the median review time for new drugs from 20 months in 1993 to approximately 12 months in 1997. The 1997 FDA Modernization Act extends the 1992 law and enables the agency to streamline its operations.

In another important initiative, the Orphan Drug Act provides commercial incentives (market exclusivity and tax credits) for firms to develop drugs to treat diseases that affect fewer than 200,000 patients. The law is deemed to be highly effective, as almost 100 orphan drugs have been approved in the decade since it was initially enacted, compared with only 10 in the previous decade. The government should assist industry by maintaining an adequate pool of skilled reviewers who balance the safety of the food and health systems with the need for new biotechnology processes and products. By adequately funding regulatory functions, directly or through partnership with industry, the government creates the conditions for industry to get new biotechnology processes and products to the global marketplace ahead of foreign competitors.

Education. Federal and state government roles in education are indirect, since school funding is primarily local. Nonetheless, the government must provide incentives for the nation's school systems to produce sufficient numbers of qualified personnel for the growing biotechnology industry. Many biotechnology industry leaders agree that the United States is not currently producing sufficient numbers of qualified workers. In contrast, many European competitors in the United Kingdom and Germany believe that their education systems produce the type and number of graduates necessary for their rapidly expanding biotechnology industries. Fortunately, top foreign talent attracted by U.S. universities and by the nation's lead position in the field have offset shortages in the U.S. workforce. This offset may evaporate as foreign biotechnology industries mature and compete with the United States, however. Additional emphasis on education below the graduate level is required. The federal government should fill an important leadership role in ensuring that governments at all levels work together to improve the U.S. education systems below the graduate level and create incentives to attract top foreign talent.

National Security and Defense. The development of biotechnology opens new doors for enemies of the United States, creating potential risks for deployed forces and unprotected populations. These trends shift the most extreme dangers from the battlefield to the heartland, challenging the national security in new and fundamentally different ways. The very nature of biological weapons makes it difficult to characterize the threat

precisely. The detection of biological agents is difficult, time-consuming, and expensive, a situation exacerbated by the lack of reliable detection and early warning systems.

The government has a direct and exclusive role in defending the nation from the biological weapons threat. The homeland defense initiative being debated by the current Administration and Congress demonstrates the high-level interest necessary to address biological warfare issues. The United States is ill-equipped to respond quickly and efficiently to biological attack. To remedy this, the government must devise the means to detect, prevent, defend, and respond. This requires the government to address new defense concerns, including focused intelligence gathering, advanced sensor technologies, antibiotic defenses, standardized nationwide public awareness, and seamless interagency transfer of intelligence and information. Creating interagency policy and procedures to focus vaccine research efforts, streamline production, and stockpile the necessary supplies represents an appropriate federal role.

National Will. So far, the debate on the moral and ethical dimensions of biotechnology has been limited to elite intellectual and scientific circles. The broader public debate has not yet occurred in the United States. In Europe, consumers are creating a backlash against foodstuffs developed through biotechnology in a move that may substantially affect United States–European Union trade. A complex web of technical, political, ethical, and cultural dimensions cloud the issue and promise to complicate U.S. relations with Europe for the foreseeable future. Britons refer to the "three *B*s," adding biotechnology to bananas and beef as major obstacles to harmonious transatlantic trade.

The long-term success of the government role in investment and business incubation, public health, education, and national security and defense is contingent upon U.S. public opinion about the current state and future of biotechnology. In turn, in a very real sense, the national will integrates all of the roles for government in biotechnology and ultimately determines the long-term success of the industry. The federal government must assume the leadership role in mobilizing the national will, the broad consensus to support scientific and technological achievement in biotechnology while simultaneously considering the moral and ethical dimensions.

CONCLUSION

Stunning biotechnology discoveries and anticipated applications possess the capability to transform society, offering opportunities to enhance national security and bolster prosperity. At the same time,

biotechnological developments open new doors for the nation's enemies, creating potential risks for deployed forces and unprotected populations. Risk and consequence management for force protection and homeland defense serve as the impetus for short- and long-term applications of biotechnology to support national security needs.

The U.S. biotechnology industry remains the world leader by any measured variable—number and size of firms, amount of R&D investment, number of patents, products on the market, and exports. Biotechnology provides a pervasive stimulus that revolutionizes many other industries, including medicine, agriculture, environment, forensics, and defense. Biotechnology's influence on the national economy is growing; by 2010, the industry will affect 70 percent of the economy.[27] The most pressing business challenge for the industry remains the high cost of bringing products to market, which makes it necessary to generate substantial investment capital for simultaneously conducting R&D activities and coping with emerging European sources of competition.

The primary government role remains that of public protector. Enthusiasm for the commercial opportunities afforded by biotechnology should not cloud this primary responsibility. The government needs to assume the leadership role in building the broad consensus to support scientific and technological advancement, while at the same time considering the moral and ethical dimensions. Aggressive government involvement is required in investment, business incubation, public health, education, national security, defense, and national will in order to maintain or improve the current lead. Specific focus on the means to detect, prevent, defend, and respond to biological attack remains an essential government responsibility. The reward for success is great. This strategic industry possesses technologies that can describe and eradicate disease, increase crop production, clean the planet, and strengthen the national defense, creating a brighter future for those in the United States and all the other people of the world.

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CONSTRUCTION

ABSTRACT

Studies of the construction industry reveal several trends, such as deterioration of the national infrastructure, changes in the way that construction projects are funded and executed, the loss of skilled workers, and the impact of technology. Counterterrorism and outsourcing by the Department of Defense (DOD) are also key construction industry issues that have national security implications. There are likely to be regular and repeated construction demand surges in the international marketplace, and the U.S. government should take a more proactive role in helping the construction industry take advantage of international construction opportunities.

Ms. Georgienne Bednar, Dept. of State
Lt Col Marv Fisher, USAF
Ms. Ramona Harper, US Information Agency
Ms. Judy Heckl, Dept. of Transportation
LtCol Larry Huffman, USMC
COL Tom Julich, USA
LTC Ray Mason, USA
CAPT Brian Meyerriecks, USN
CDR Dave Montgomery, USN
Lt Col Rebecca Ritchey-Fritz, USAFR
Mr. Paul Roche, Dept. of the Navy
LTC Mark Roncoli, USA
Mr. Jamie Sadler, Dept. of the Army
COL Mark Tillotson, USA
Ms. Rita Walters, Defense Threat Reduction Agency

COL Gary Berry, USA, faculty
Dr. Hugh Conway, faculty
Dr. Michael Frazier, faculty

PLACES VISITED

Domestic

Associated General Contractors of America, Washington, DC
Bechtel Corporation, San Francisco, CA
Boston Harbor/Central Artery Tunnel, Mass. Transit Auth., Boston, MA
Hamilton Army Airfield Base Realignment and Closure Office, CA
Huber, Hunt, Nichols/Kajima, Inc., San Francisco, CA
IFC Kaiser Engineering, Boston, MA
Massachusetts Water Resources Authority Boston Harbor Project, MA
National Association of Home Builders, Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
Odebrecht Contractors, Inc., Seven Oaks Dam, Los Angeles, CA
Parsons Brinkerhoff, New York, NY
Parsons Corporation, Pasadena, CA
Port Authority of New York, World Trade Center, New York, NY
Ray Wilson Co./Tokyu Construction, General Contractors, Pasadena, CA
Raytheon, Boston, MA
Ronald Reagan Federal Triangle Building, Washington, DC
San Francisco International Airport/Port Authority, CA
Sheet Metal Workers' Union - Local #100, Suitland, MD
Stromberg Sheet Metal Works, Beltsville, MD
U.S. Army Corps of Engineers, L.A. and San Francisco Districts, CA

International

Airport City Link Railway Tunnel Construction Site, Sydney, Australia
Australian Defence College, Canberra, Australia
Australian Defence Estate/Dept. of Ind. Relations, Canberra, Australia
Australian Industry Group Office, Canberra, Australia
Department of Defence, Sydney, Australia
Holmes Construction, Ltd., Christchurch, New Zealand
Housing New Zealand—Regional Office, Christchurch, New Zealand
New South Wales Dept. of Public Works/Services, Sydney, Australia
New South Wales Government on Infrastructure Dev., Sydney, Australia
New Zealand Ministry of Defence, Wellington, New Zealand
Olympic Authority Construction Project, New South Wales, Australia
Opus International Consultants, Ltd., Wellington, New Zealand
Sodexho Marriott Corp., New South Wales, Australia
U.S. Embassy, Canberra, Australia
Victoria Barracks, Sydney, Australia
Westin Corp. Sydney Hotel Construction Project, Sydney, Australia
Westpac Trust Center Project, Christchurch, New Zealand

INTRODUCTION

Developing from an industry of artisans and journeymen, the construction industry is a very large, competitive, market-driven sector of the U.S. economy. Industry activities include consulting, design, engineering, construction management, construction, maintenance, repair, renovation, demolition, removal, and disposal.

The infrastructure of the United States is a critical element of national security. The construction industry provides and maintains the infrastructure necessary to ensure U.S. economic, political, military, and diplomatic strength. The condition of the infrastructure is not only an important factor in U.S. productivity and international competitiveness, but also a quality-of-life factor. For example, the vast highway and rail network in the United States helps the nation's industrial productivity by allowing faster and cheaper transportation of products.

THE CONSTRUCTION INDUSTRY DEFINED

The U.S. construction industry employs about 7 million people[1] and accounts for about 8 percent of the nation's gross domestic product (GDP).[2] Construction activity, on average, grows at a rate that approximates the rate of GDP growth. The total value of domestic construction put in place during 1998 was $657 billion.[3] (The construction industry accounts for 15.2 percent of Japan's GDP, 14.6 percent in Germany, 21 percent in China, and 7.9 percent in the United Kingdom.[4]) Total global spending on construction in 1998 was $3.22 trillion.[5] The United States is the largest single-country construction market.[6]

Construction work includes private residential, private nonresidential (telecommunications, industrial facilities), public construction, and utilities. Small firms make up the bulk of the industry. According to U.S. Census Bureau reports, there were 649,601 construction establishments in 1997.[7] Construction may be categorized as general construction, which involves private residential building and private nonresidential building (198,124 firms); heavy construction, which involves public industrial construction such as roads, highways, bridges, dams, sewage treatment plants, public hospitals, schools, prisons, tunnels, and utilities (42,010 firms); and special trade construction, which involves steel erection and the placement of concrete, mechanical, electrical, sheet metal, masonry, and other construction components (409,467 firms). It is estimated that as much as 90 percent of the industry consists of special trade contractors who perform under

subcontract to general contractors. Total payroll for 1997 was $175 billion, a 49 percent increase over the 1992 total payroll.[8]

The U.S. construction industry has experienced an average annual growth rate of 1.9 percent over the last 20 years with only a slight downturn in the early 1990s. The domestic construction market seems to have reached maturity, providing steady work and modest overall growth.

About 80 percent of worldwide construction activity takes place outside the United States. The nation's construction and engineering firms are successfully competing internationally through foreign affiliates using local labor. Despite the economic downturn caused by the Asian financial crisis, U.S. construction equipment and parts producers managed to increase exports during the first half of 1998. During the first 6 months of 1998, these producers shipped $3.6 billion in equipment and parts overseas, 5.5 percent more than in the same period of 1997. The increase was due to strong demand from Canadian users, which offset falling demand in Asia and Africa. Exports to Canada increased 25.3 percent to $1.4 billion.[9]

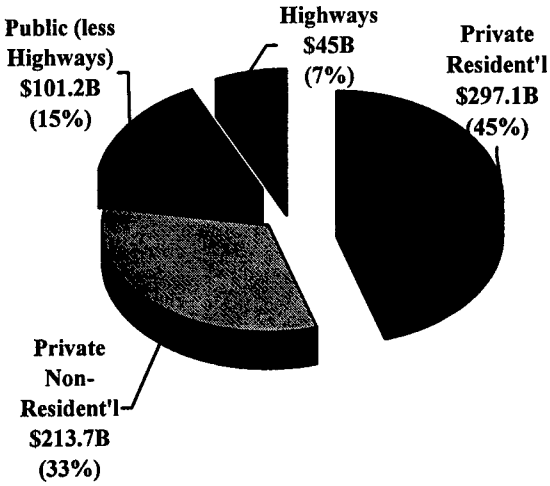
The construction industry is highly competitive. Increasingly, the competition is expanding from the domestic to the international arena, as world economic and social conditions improve. At the same time, globalization and advances in the use of technology are creating growth potential worldwide for the industry.

CURRENT CONDITION

The construction industry can be divided into four major sectors according to spending: private residential, private nonresidential, public (less highway), and highway. In 1998 dollars, the value of construction in these sectors was $297.1 billion, $213.7 billion, $101.2 billion, and $45 billion, respectively, for a total of $657 billion. (See Figure 1.)

New private residential housing construction has experienced steady growth since 1990, except for 1995 when sales dropped 5 percent. Construction of residential housing accounts for 45 percent of the total value of construction put in place for 1998. Private nonresidential construction spending for 1998 was about the same level as that in 1997. Within this category, construction of hotels, motels, and offices, as well as religious, railroad, and educational facilities, has had strong growth over the last 3 years. Construction for manufacturing, commercial, hospitals, and institutional buildings experienced a decrease in spending from 1997 levels. This probably reflects a market adjustment to offset strong growth since 1993.

Figure 1: 1998 U.S. New Construction (Total: $657 Billion)



States own most public facilities (88 percent) and spend more money on public construction than the federal government. While aggregate spending in public construction fell slightly in 1998 from the 1997 level, spending in 1997 and 1998 for education-related construction was more than 10 percent higher than the 1996 level. Public spending in 1997 and 1998 for housing, federal (industrial), and military construction projects dropped significantly below 1995 levels. Table 1 shows annual changes in the value of U.S construction for the last 7 years.

Labor. In 1995, only 17.7 percent of construction employees were members of a union. The membership rate was 40.1 percent in 1973 and 87.1 percent in 1947.[10] Union contractors face difficulties competing for construction work with open-shop contractors because of the unionized firm's higher labor costs—about $13 per hour more on average than the non-union rate in 1996.[11] Recently, this differential has narrowed as open-shop contractors have boosted wages in an effort to keep workers from leaving and to attract new workers.

An extreme shortage of competent construction workers, union or non-union, presents a serious problem. In 1995, *Engineering News-Record* (*ENR*) surveyed the top 400 U.S. construction firms and learned from the 217 union and non-union firms responding that more than half of the 18 crafts examined suffered from shortages.[12] Of these 217 firms, 26 percent reported moderate labor shortages while 12 percent described

Table 1: Value Of Construction Put in Place (Billions of 1992 dollars)

TYPE CONSTRUCTION	Constant 1992 Dollars						
	1990[1]	1993[1]	1994[1]	1995[1]	1996[2]	1997[3]	1998[3]
TOTAL NEW	479.0	465.0	487.6	486.7	496.3	520.1	539.8
PRIVATE	370.1	347.8	367.9	363.1	378.2	395.3	418.4
Residnt'l Bldgs. Total	188.0	200.5	218.0	207.4	212.1	221.5	242.9
New Housing	131.6	137.2	153.2	142.8	154.0	156.0	173.1
Single family	111.8	127.0	140.4	127.1	135.5	137.2	153.1
Multiply family	19.8	10.2	12.8	15.9	17.4	18.9	20.0
Improvements	56.4	63.2	64.7	64.6	58.1	60.5	62.9
Non-Residential Total	146.7	106.7	111.4	119.8	130.4	139.1	139.4
Office	35.8	20.2	20.6	22.6	24.1	27.6	31.2
Manufacturing	34.4	25.6	26.8	28.9	28.0	26.4	24.7
Hotels and Motels	10.9	4.4	4.3	16.4	10.3	10.7	11.7
Other Commerical	40.9	31.3	34.8	37.8	41.3	42.7	40.8
Religious	3.6	3.7	3.5	3.9	4.0	4.0	5.2
Education	4.7	4.5	4.5	4.9	5.8	7.1	7.5
Hospital & Instut.	11.1	12.0	10.0	10.0	10.5	11.8	11.0
Misc. Buildings	5.2	5.0	5.6	5.3	6.5	7.9	7.3
Farm Structures	2.9	3.2	3.0	3.1	2.7	NA	NA
Public Utilities	29.5	34.1	32.7	30.2	30.8		
Telecommunicatio	9.9	9.5	9.8	9.8	10.4	9.9	10.3
Railroads	2.6	3.1	3.2	3.0	4.0	4.2	4.6
Electric Utilities	11.6	15.1	13.9	11.8	11.2	12.0	12.4
Gas Utilities	5.0	5.5	4.9	4.7	4.3	4.5	4.6
Petroleum Pipeln's	0.4	1.0	0.9	0.8	0.9	0.9	0.9
Misc. Structures	3.0	3.2	2.8	2.6	2.1	2.1	2.1
Public Building Total	108.9	117.2	119.8	123.6	115.4	124.88	121.4
Buildings	44.6	50.2	49.9	53.4	49.4		
Housing & Redev	3.9	4.6	4.9	5.4	3.9	4.0	3.7
Federal Indst'l	1.5	1.6	1.4	1.4	1.2	0.8	0.8
Education	16.4	21.3	21.7	22.9	20.1	22.8	22.4
Other Hospitals	2.9	3.5	3.6	3.9	4.6	4.2	3.2
Other	19.9	19.0	18.4	19.8	20.2	21.6	22.0
Highways	31.8	34.2	36.5	34.9	33.3	38.6	37.8
Military Facilities	2.7	2.4	2.3	2.7	2.2	2.2	2.2
Conservation & Devel	4.9	5.7	6.0	5.8	5.2	4.8	4.7
Sewer Systems	10.7	9.1	9.5	9.8	9.1	9.0	8.9
Water Supply	5.0	5.1	4.9	5.4	5.1	5.4	5.6
Misc. Public Struct's	9.3	10.4	10.8	11.5	11.1	11.3	10.1

Table 1 Notes:

1..U.S. Department of Commerce, Economics and Statistics. Bureau of the Census. Statistical Astract of the United Stated 1997. 117th Edition. Table 1180.715

2. Construction Review Quarterly Report Fall 1997. Table A2. p3-5

3. U.S. Census Bureau. *Highlights from the value of Construction Put in Place Press Release.* 10:00 A.M. EST. Monday. 1 Feb 1999. p5 (see also http:/www.census.gov/pub/const/c30-curr.txt

severe shortages. The crafts experiencing the largest shortages included electricians (13.7 percent shortage), carpenters (10.6 percent), sheet metal workers (8.8 percent), and pipe fitters (7.9 percent). The shortages continue today with no sign of abating. Like the U.S. military, the construction industry is currently having difficulty attracting sufficient numbers of young people. Although recent wage hikes, expected to continue for the next few years, are helping to draw new workers into the industry, there remains a real question whether the United States will have a sufficient number of trained craftsmen to provide the labor pool necessary to meet industry needs in the future.

Infrastructure. The Federal Highway Administration reports that approximately 60 percent of U.S. primary highways are in poor to fair condition. Highway usage by private automobile and commercial trucking has increased substantially over the last 40 years, causing major congestion, intensifying safety concerns, and accelerating road deterioration. Highway spending was at an all time low during 1980–1990, but the Intermodal Surface Transportation Efficiency Act of 1992 (ISTEA) authorized increased levels of funding for U.S. highways. The recently signed Transportation Equity Act for the 21st Century (TEA-21) is the largest federal public works legislation in U.S. history.[13] Along with the Airport and Airway Trust Fund and the Highway Trust Fund, the TEA-21 provides appropriations in excess of $200 billion over 5 years for highway capital improvement, research, mass transit support, and new highway construction across the United States.[14] Transportation spending significantly increased during 1997–1999 and is expected to remain high through 2003 with the passage of the TEA-21.

Construction Services. Exports of construction services from the United States were about $3.0 billion in 1996.[15] Most U.S. exports of construction services are construction management services, engineering, design, and specialized technology. In 1997, the Asia-Pacific region imported 45.6 percent of exported U.S. construction services. Europe imported 14.2 percent; the Middle East, 8.9 percent; Africa, 6.2 percent; and other Western Hemisphere countries (i.e., Canada, the countries of Central and South America), 25.1 percent. Imports of these services amounted to only about $500 million—an industry trade surplus of $2.5 billion.[16]

Technology. Computers have had a positive impact on the construction industry. Computer-assisted design/drawing programs let architectural and engineering firms produce drawings and plans in a matter of hours, rather than days or months. Design or construction changes that used to be costly and time-consuming can now be incorporated at the stroke of a key, saving both time and money. The Internet provides an avenue for the high-speed exchange of information and for immediate document delivery. Architectural and engineering firms and contractors can also have design and drafting work done overseas (overnight) with enormous savings. Increasingly, computers are serving in design, engineering, and management of construction projects. Computers, robotics, and global positioning systems can be used to operate "uninhabited" equipment (e.g., graders, trenching equipment, earth-moving equipment) in large grading and excavation projects or in remote locations.

Project Delivery. The process by which owners, architects, engineers, and construction companies initiate and complete construction projects is changing. The design–bid–build (DBB) process has been used for some time and is considered traditional in the United States. The design and construction functions are completely separate in the DBB process, a sequential one. An owner hires an architect to design a project and deliver construction documents, and general contractors then bid on the project. Design–build (DB) is a "one-stop shopping" project delivery process in which an owner purchases design and construction services from a single entity. The advantages of DB include cost savings of 10–15 percent and time savings of 15–25 percent. The company in charge of design is continuously re-estimating construction costs and can project final costs at a much earlier stage than a company using the DBB process. Owners have more early information and, therefore, more choices about the project. The potential for change orders is reduced. Performance factors are clearly defined prior to starting construction. The DB process requires extensive planning and oversight, however. Many bonding and insurance companies are unfamiliar with the DB process.[17]

It is generally agreed that DBB is more suitable for very large, complex projects; DBB provides a high degree of comfort to both the owner and the contractor. There is an extensive body of DBB case law. There are, however, several disadvantages of the DBB process. It encourages litigation, as firms often submit "low" bids in the hope of making up the difference later through change orders and/or litigation. In addition, DBB projects tend to exceed initial cost estimates, run behind schedule, involve costly delays, and discourage innovation

because DBB is a rigid process that restricts the construction contractor to the confines of the engineering drawings.

In 1985, DB commanded only 5 percent of the overall construction market. In 1995, the percentages were 25 percent for DB and 65 percent for DBB; the balance, 10 percent, was accounted for by construction management. In Europe, more than 50 percent of nonresidential construction projects are delivered using DB. In Japan, DB project delivery exceeds 70 percent. Railways in Naples, Genoa, Athens, Paris, London, Istanbul, Ankara, and Hong Kong were all completed using the DB process.

Codes, Standards, and Regulations. Much of the workmanship and material in construction projects is ultimately hidden, but the codes, standards, and regulations that govern the construction industry address the safety and quality of each project and protect the interests of business, the community, and individuals. Currently, there are three regional sets of codes and standards. The biggest problem with the building codes lies in the fact that they are not uniform among states and regions. Often, local standards vary between adjoining counties within the same state. The National Association of Home Builders recognizes the strains that multiple codes place on contractors. Therefore, they are seeking to establish one national building code through the International Code Council (ICC), a nonprofit organization dedicated to developing a comprehensive and coordinated national code. International standards in this area are coordinated through the American National Standards Institute (ANSI), the sole U.S. representative of the two major non-treaty international standards organizations, the International Standards Organization (ISO), and the International Electrotechnical Commission (IEC). Many laws and regulations apply to the construction industry, including appropriation laws, procurement laws, labor laws, occupational safety laws, environmental laws, base realignment, and closure laws.

Construction Research and Development (R&D)—Public/Private Sector. The fragmented nature of the construction industry makes R&D funding and accomplishment extremely difficult. In the public sector, the National Science Foundation, the National Institute of Standards and Technology (NIST), and the U.S. Army Corps of Engineers sponsor construction research and development organizations. The National Science Foundation is responsible for promoting science and engineering through programs that invest nearly $3.5 billion per year. It conducts more than 20,000 research and education projects annually. The purpose of NIST is to assist industry in R&D to improve product quality, ensure product liability, and facilitate rapid commercialization of new products.

It provides expert research for performance prediction, measurement, and testing of building materials, components, and systems.[18]

The DOD conducts construction-related R&D because it has extensive military-related infrastructure to operate and maintain. Research and development provides new technologies that ensure the efficient and cost-effective construction, operation, and maintenance of DOD facilities. Among DOD agencies, the U.S. Army Corps of Engineers has the largest involvement with construction-related R&D. Technology transfer to the private sector is an important function for the Army Corps of Engineers.

The American Society of Civil Engineers (ASCE) supports the research and education needs of the civil engineering profession. Particularly concerned with infrastructure research and innovation, the ASCE established the Civil Engineering Research Foundation (CERF) to foster a unified research effort and to coordinate R&D programs that address construction industry needs.

CHALLENGES

Global Public Sector Challenges. Nations, including the United States, must construct, maintain, and expand critical infrastructure (e.g., highways, roads, bridges, ports, waterways, water/sewer systems). Traditional methods of financing needed public works are not sufficient to keep up with construction requirements in most nations. National, state, regional, and local governments—once the world's sole source of investment in infrastructure development—are looking to leverage their limited resources against private sector investment capital as a means to obtain infrastructure projects. Privatization of new and existing infrastructure is rapidly becoming a frequently used method to stretch limited public resources. Integrated privatization programs allow governments and private firms to choose among several acquisition and operation schemes. Choices for new construction include build–operate–transfer (BOT), build–own–operate (BOO), build–transfer (BT), build–transfer–operate (BTO), or build–lease–transfer (BLT). For existing infrastructure, choices are rehabilitate–operate–transfer (ROT), rehabilitate–own–operate (ROO), develop–operate–transfer (DOT), and contract–add–operate (CAO). Each of these options provides a different level of involvement for the private sector in owning and operating infrastructure systems, as well as asset control options for the government. Each one requires private sector financing of infrastructure projects.

Global Market Challenges. The worldwide construction market represents 10 percent (approximately $3 trillion) of the world's economy. It is a relatively stable market, and data indicate that it will remain so for the foreseeable future.[19] Approximately 30 percent of the top 225 international construction contractors are U.S. companies.[20]

Although the United States is a highly competitive nation, U.S. construction firms are reluctant to compete for international construction business. The U.S. economy is now at an all-time high, and ample construction opportunities exist domestically. The healthy economy produces a very low unemployment rate that translates into a labor shortage for the construction industry. In addition, U.S. firms do not compete for international infrastructure construction projects because foreign infrastructure investment opportunities have been too risky. Financing projects in overseas locations is also an obstacle for U.S. contractors, who see foreign cash flows for billing purposes as too uncertain—requiring too much up-front capital. Finally, U.S. construction firms are not as competitive in overseas markets because of the concessionary finance practices of some competitor governments, discriminatory government procurement policies, nontransparency of financial transactions, corruption and bribery, and trade barriers.[21] For many U.S. construction firms, the risks, complexities, and barriers of international markets outweigh the benefits.

Despite the obstacles, several large U.S. construction companies have been very successful internationally. To date, smaller companies have been more hesitant to incur either the risks or the costs of operating in a global environment. Yet it is a potential market with ample opportunities for all types and sizes of companies.

The motivation to engage internationally resides at two levels. For individual contractors, the motive to undertake projects outside the United States derives from the profit incentive and the desire to neutralize the effect of the cyclical downturns that routinely occur in the domestic construction market. For the nation, the strategic interest in promoting greater U.S. contractor involvement in international projects originates in global defense responsibilities and the likelihood of perpetual involvement in peacekeeping activities and hostility containment. Invariably, the U.S. defense presence requires concomitant construction activity in order to provide the necessary infrastructure for troop support. The strategic interests of the United States would be better served by the existence of a cadre of U.S. contractors broadly experienced in managing construction projects in foreign countries. This contractor resource would facilitate adjustments to a different culture, unfamiliar labor and work conditions, and the management challenges

inherent in doing business in a foreign country. Preexisting business partnerships and alliances with local area contractors overseas translate into added leverage, advantage, and military effectiveness.

Domestic Challenges. The condition of the U.S. infrastructure has deteriorated significantly. The ASCE estimates that it will take $1.3 trillion to bring the nation's roads bridges, schools, and drinking water and wastewater treatment facilities to an adequate level. Rating the condition of infrastructure systems, the ASCE gave mass transit, aviation, bridges, and solid waste facilities a grade of "C"; roads, drinking water and wastewater treatment facilities, dams, and hazardous waste facilities received a "D"; and public schools received an "F" because more than 60 percent of public school facilities need major repairs.[22] Unfortunately, most public sector corrective action is reactive rather than proactive.

DOD Construction Challenges. Two factors, threat and budget, drive nearly every decision made within the DOD. At issue is whether the DOD can meet its national security obligations over the long run in an environment of declining budgets, when a significant percentage of those budgets is consumed by support functions rather than direct war-fighting requirements. How can the DOD maintain its force modernization goals and at the same time provide an adequate quality of life for personnel and families? One method for resolving these issues is to shift support activities to the private sector.

Privatization is a subset of outsourcing and involves the complete transfer or sale of government assets. It is DOD policy that activities can be outsourced if in-house performance of that activity is not required to meet mission requirements; a competitive commercial market exists for the activity; and outsourcing results in the best value for the government.[23] The Logistics Civil Augmentation Program (LOGCAP) plans worldwide use of civilian contractors in support of DOD missions. It resolves combat support and combat service support shortfalls; provides contract augmentation in the United States during mobilization; and assists contractors in planning for logistics, construction, and engineering services for base or logistics camp construction, operations, and field services.[24] Similarly, the Navy's Construction Capability (CONCAP) Atlantic Briefing document identifies construction and engineering services to support natural disaster recovery, military-supported humanitarian assistance, and military conflict support for Navy forces deployed worldwide.[25] Currently, CONCAP is supporting Navy forces in Bosnia for base construction and management. The Air Force Contract Augmentation Program (AFCAP) provides base operating support and temporary construction capabilities to relieve or

augment military support forces and resources involved in military operations other than war.[26]

Military Family Housing Privatization. The DOD's 300,000 military family housing units (average age of 33 years) need management attention, repair, and improvement in order to remain at an adequate level of quality. The 1996 Defense Authorization Act allows the DOD, in some cases, to work with the private sector to build or renovate military housing. A key advantage of the law is that it permits developers to build to local standards rather than to federal standards and military specifications. The law allows the DOD to provide civilian firms with a variety of contractual and/or financial instruments that privatize military family housing:[27] loan or rental guarantees; mortgage payment guarantees and insurance; limited guarantees against base realignment and closure, force reduction, or major deployment; leasing opportunities (DOD to lease units that have been acquired or newly constructed); investment opportunities (DOD to provide funding limited to 33 percent of the total capital investment to private firms to acquire or construct units); and direct loans (title, land, and improvements to remain with owner). Congress, however, has become concerned about unpredictable program outcomes, unexplained costs, impacts on Congressionally approved military construction (MILCON) family housing improvement and repair work, potential loss of installation commander control, and potential financial impacts of housing privatization on military members and families. The jury is still out regarding this privatization, pending the outcome of several test cases.

The Antiterrorism Construction Challenge. The United States is rebuilding ("hardening") State Department facilities and a limited number of military facilities to better protect building occupants against a terrorist attack. Recent State Department studies suggest that as a matter of national culture, U.S. embassies have been far more concerned with being "open" as opposed to being "secure." Admiral William J. Crowe (former Chairman of the Joint Chiefs of Staff), head of two State Department investigations, was blunt in his assessment that there was a collective (institutional) failure by several Administrations and Congress over the past decade to reduce the vulnerability of U.S. diplomatic missions adequately. According to Admiral Crowe, the United States must change its way of looking at the world. Overall costs are large. The Administration provided $2 billion for counterterrorism, including monies for hardening embassies, after the recent embassy bombings in Africa. Of that money, $1.4 billion went to rebuild the embassies in Nairobi and Dar es Salaam, to relocate eight other vulnerable embassies, to upgrade security equipment, and to harden portions of 250 other

embassies and consulates. To date, military facilities are not receiving the same attention. Local commanders must request funds for hardening facilities through the facility management process. The Combating Terrorism Readiness Initiative Fund is provided to the DOD to address emerging or concurrent antiterrorism and force protection problems.[28] In 1998, $15 million was available for the Chairman of the Joint Chiefs of Staff to harden military facilities, an amount that does not allow extensive rebuilding..

OUTLOOK

Domestically, the outlook for the construction industry is strong in homebuilding. The largest increases in public construction activity are expected in highways, public safety buildings, housing redevelopment, prisons, water supply systems, and waste management systems. The biggest declines will be in military facilities, conservation, sewerage, and federal industrial facilities.

The main impacts of the Year 2000 (Y2K) problem on the construction industry would be in the design systems, automated processes, machinery, and liability areas. Large firms are taking the necessary actions to prepare for Y2K. Small firms are not as automated as the larger firms, do not have the assets to address the issue as easily, and therefore are not as proactive as the large firms. Construction firms could be sued for not providing Y2K-compliant systems or services (e.g., heating, ventilating and air conditioning systems, elevators, security systems) for the facilities that they have built. Some firms recognize this potential liability and are contacting customers and testing to ensure compliance. Overall, Y2K impacts on the construction industry should be minimal. Secondary impacts resulting from Y2K problems among construction material and equipment manufacturers could not be accurately measured.

Global Outlook. Demand for basic infrastructure is on the rise, with a significant portion of the growth in the emerging markets. The World Bank estimates that annual infrastructure investment needs total $200 billion.[29] Developing nations know that without investment in a solid, modern infrastructure, they will not be able to create modern, competitive economies. Despite the economic and financial crisis that began in the Asian markets in 1997 and spread to the rest of the world, many countries continue to invest sizable amounts in their infrastructure programs. In 1998, the world's 200 largest design firms reported a 10.9 percent increase in billings for design projects worldwide.[30]

Many foreign governments are turning to joint ventures with the private sector for their public infrastructure and maintenance needs. For example, European nations are permitting private firms to build, own, and operate major portions of their highway systems. There are more than 5,000 miles of toll roads operated by private firms in Italy, France, and Spain alone, far more than in the United States.[31] Developing nations are relying increasingly on build–operate–transfer (BOT) projects as conventional funding becomes harder to obtain, development aid becomes tighter, and spending caps force changes in the ways that nations obtain and maintain infrastructure.

As the financial crisis in Asia begins to turn around, the opportunities for infrastructure privatization projects will increase; Asian governments will work to restart projects that had been put on hold for several years. As interest rates and currencies stabilize, many countries in this region will once again invest in their infrastructure programs to fuel their economies. The Asian Development Bank estimates that Asia's power generation sector needs investments of $75 billion per year and that the telecommunications sector is likely to need $40–$70 billion per year.[32] Raytheon has been selected to complete a $700-million design–build dam in the Philippines and, along with other U.S. firms, is involved in a $2-billion private development project for the design, construction, and operation of power, water, rail, and port facilities in Australia.[33]

The biggest market potential lies in China. The World Bank estimates that China will spend more than $700 billion on infrastructure needs through the year 2005.[34] In the past, China's construction industry has suffered from poor regulation and corrupt practices. The Chinese are now adopting new laws and policies to open their country to more foreign trade and investment. Government officials are seeking private sector involvement to develop BOT projects to meet their tremendous demands for power, water, wastewater treatment, and other infrastructure requirements.

Latin America withstood the recent financial crisis and continues to privatize infrastructure systems in an effort to improve efficiency. The Inter-American Development Bank reports that more than $22 billion in infrastructure assets have been sold, leased, or contracted out to private firms, and Latin American countries need $50 billion in infrastructure investments annually.[35] Since local and federal governments lack the available resources, private investments will have to meet the demands. Latin America has become more attractive to U.S. firms because of improved laws to promote and protect international investors. Mexico is privatizing its transportation infrastructure by pursuing joint ventures

between Mexican and European or U.S. firms to modernize and operate seaports, airports, and railroads. Argentina is planning to spend $10 billion over the next 6 years to privatize its highway network.[36]

One of the leaders in privatizing infrastructure in Latin America is Chile. The Chilean government first launched privatization initiatives in the early 1980s when it opened its energy and telecommunications industries. Underinvestment in its infrastructure over the last two decades has led to deterioration of its roads, water treatment facilities, and wastewater treatment systems, however. The government is now moving from owner to regulator in the water and wastewater treatment business and expects to fund $9 billion per year for transportation and environmental infrastructure work over the next 5 years.[37] The Ministry of Public Works will parcel out highway, airport, and seaport concessions in order to reach the necessary investment levels for Chile's infrastructure systems.

Europe lags behind Latin America in adopting new legislation and policies that protect private investors. Recent reports indicate that private sector and international organizations will have to participate in the infrastructure development in Eastern Europe, because government resources will not be adequate. Hungary is planning to spend $13 billion over the next 10 years for roads and railways. The remaining Eastern European nations need to invest an additional $100 billion.[38] Many of these projects are expected to follow the European concession system of private sector development.

Opportunities in Africa will be limited, as this region continues to lag in economic development. South Africa is the one exception, as it has numerous infrastructure projects in the planning stages. Tourism, which is growing 16 percent annually, is driving the need for improved infrastructure. The U.S. Trade and Development Agency estimates that South Africa will spend $8.2 billion on 45 planned projects in the coming years, with many projects to be public–private partnerships.[39]

Participating in public–private ventures in foreign countries is not easy business for U.S. firms. They have to overcome many barriers to be competitive. Some barriers are local in nature, such as the culture, language, regulations, and building standards, while other factors, such as project financing stipulations and political issues, make investing risky. Corruption, bribery, and lack of transparency in financial institutions contribute to the high risks of operating in some nations. Many U.S. construction firms choose not to participate in these markets, because the risks are so great.

Financing challenges are significant for U.S. firms in overseas markets, but there are capital sources available to reduce the investment

risk for companies involved in infrastructure development. Groups such as the World Bank, the International Finance Corporation, the Inter-American Development Bank, the Inter-American Investment Cooperation, the Asian Development Bank, the African Development Bank, and the European Bank for Reconstruction and Development provide financing for large international infrastructure projects. Other groups, such as the Export–Import Bank of the United States, the Overseas Private Investment Corporation, and the Multilateral Investment Guarantee Agency, provide insurance against political unrest, currency devaluation, and commercial risk.[40]

Construction Materials. Many factors influence the international and domestic demand for construction materials. Industry experts report that the internationalization of the building materials industry has grown through exporting and investing. Building material companies in the United States have a strong production presence abroad, particularly in Canada, Mexico, and Europe.[41] Major export items for U.S. producers include flat glass, builders' hardware, fabricated structural metals, plastic pipefitting, insulation, and prefabricated metal buildings. These items are exported mainly to Canada, Mexico, and Japan.

Exports of U.S. construction materials have risen over the last several years, but imports have risen at a faster pace. In 1996, the United States exported about $4.9 billion of nonlumber construction materials, up 9 percent from 1995. The United States imported $6.7 billion, however, a 14 percent increase from 1995. This resulted in a U.S. trade deficit of about $1.8 billion. The U.S. market will continue to be a large and strong market for foreign suppliers, while rising levels of construction activity worldwide should help U.S. exports. Foreign companies own construction materials–producing facilities in the United States, especially cement, clay brick, and flat glass plants. Imports of ceramic tiles, cement, and builders' hardware come mostly from Canada, Mexico, Italy, and Spain. Among the construction materials that U.S. firms produce overseas are flat glass, insulation, flooring, and gypsum board. Generally, U.S. construction materials are well accepted overseas for quality and price, but face some trade barriers involving standards, building codes, product certification, and testing. Closed distribution systems in some countries are also a problem.[42] Industry observers[43] expect U.S. imports to increase by about 10 percent per year, exports by 5 percent. Growth in foreign construction markets is expected to drive the U.S. building materials export market.[44] Current and anticipated improvements in trade agreements, regional agreements (e.g., the European Community and the North American Free Trade Agreement

[NAFTA]), and bilateral arrangements will tend to increase construction materials trade.[45]

Construction Machinery—Earth-Moving Equipment. The international construction machinery industry manufactures such machinery as earth-moving equipment, power cranes, mixers, bulldozers, as well as components and parts. Major players include the United States, Japan, Germany, and South Korea. Caterpillar (United States) and Komatsu (Japan) are world leaders—they participate in every major market and offer full product lines. Industry observers report that these companies are involved in a perpetual battle to increase their market share. The competition has led to the formation of strategic alliances with other major construction machinery producers.[46] In addition, there are many collaborative agreements in the industry for reasons of production and technology sharing, cost containment, and market access, and U.S. construction machinery manufacturers are striving to develop close relations with construction and engineering firms to guarantee an outlet for their equipment.

The United States exports about 30 percent of its construction equipment production to foreign markets. In 1996, the major U.S. export markets included Canada, Australia, Chile, Belgium, and Mexico. Due to the growing internationalism of the industry and the competitiveness of the U.S. industry, major U.S. manufacturers produce many models of equipment solely for overseas markets. All of the major U.S. producers are seeking to establish a solid position in the emerging markets of developing countries through joint ventures.[47] In 1999, a subsidiary of Fiat (Italy) acquired a controlling interest in the third largest U.S. equipment manufacturer, the Case Corporation.

GOVERNMENT GOALS AND ROLE

The important issues facing the U.S. government today in regard to the construction industry center on competitiveness, privatization, deregulation of markets, establishment of effective national-level programs that facilitate flexible labor markets, establishment of strategic alliances through multilateral trade agreements and treaties, and provision of incentives for continued investment in new technology by the private sector.

The U.S. government can take action to increase U.S. competitiveness in foreign construction markets. It can reduce the financial risk to U.S. firms in foreign markets by providing tax incentives for investing in foreign infrastructure development. It can increase the amount of financial protection. Government agencies such as the Export–

Import Bank, the Overseas Private Investment Corporation, and the U.S. Trade Development Agency have programs that assist U.S. construction companies by providing insurance against political unrest, devaluation, and commercial risk. Officials of the U.S. government can work with those of foreign governments to minimize the risk to private investors and U.S. construction firms from unfair business practices. The U.S. government can also create more opportunities for U.S. firms by supporting reforms to increase financial transparency and oversight, reduce corruption and graft, and reduce organized and other crime.

Government promotion of the U.S. construction industry abroad has tremendous potential advantages for U.S. national interests. Globalization of the world's economies and infrastructure systems, including telecommunications, transportation, and power generation, is the trend of the future. The United States must not squander the opportunities available in the international infrastructure market. Billions of dollars will be spent on infrastructure systems in the near future, and U.S. firms must participate and be competitive in this global market. To the extent that rising living standards contribute to political stability, infrastructure development can influence other nations and serve as a deterrent for conflict.

To enhance competitiveness in global markets, the U.S. conversion to the metric system must become a priority. Because conversion will be costly for U.S. businesses, the U.S. government should consider offering incentives for speedy conversion.

CONCLUSION

Global demand for basic infrastructure is on the rise with a significant portion of the growth in the emerging markets. In addition, globalization of world markets will present tremendous opportunities for the U.S. construction industry. In the past, U.S. construction firms have concentrated mainly, due to real or perceived risks, on work in the Middle East. In the future, they should pursue global construction opportunities—with emphasis on work in Asia and South America. The U.S. construction industry (especially small firms) should position itself to better capitalize on global construction opportunities. The industry should seek active U.S. government support toward this objective.

For individual contractors, the motivation to undertake projects outside the United States should derive from the profit incentive and from the desire to neutralize the effect of the cyclical downturns that routinely affect the domestic construction market. The strategic level of interest is related to U.S. global defense responsibilities for peacekeeping

and hostility containment. National strategic interests would be better served by a cadre of U.S. contractors broadly experienced in managing construction projects in foreign countries. This contractor resource would be of significant importance during adjustments to a different culture, unfamiliar labor and work conditions, and the management challenges inherent in doing business in a foreign country. Preexisting business partnerships and alliances with local area contractors overseas translate into added leverage, advantage, and military effectiveness.

Foreign countries spend a much larger amount on construction-related research and development than the United States does. More coordinated public–private R&D within the construction industry is recommended. In the United States, the need for infrastructure investment has grown rapidly in the last decade. The nation's roads, bridges, wastewater treatment plants, and other infrastructure need substantial work. Significant fiscal constraints at the federal, state, and local levels are making it more difficult to fund these much needed infrastructure projects. Some privatization will be necessary. The U.S. construction industry, like the U.S. military, must take action to attract and retain workers, especially young workers and skilled workers. In general, the construction industry is capable and willing to meet the national security needs of the United States.

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EDUCATION

ABSTRACT

Education is a key element of U.S. national power. It is perhaps the most vital component in that it imparts the knowledge, skills, critical thinking, and basic citizenship tools needed for a motivated, creative, and productive U.S. workforce. The Information Age has propelled the nation into a highly competitive and dynamic economic and political environment. If the United States is to maintain its starring role on the world stage, its education system must keep in step with the ever-changing requirements for individual and organization success. As a vital foundation of the nation, it must be constantly assessed and adequately resourced. The debate on the quality of U.S. education is an ongoing process, one that promises to continue well into the next century.

Mr. Marc Borkowski, Dept. of the Navy
Ms. Paula Brickates, Dept. of the Air Force
LTC Maureen Coleman, USA
LtCol Eugene Conti, USMC
CDR Edward Delaney, USN
COL Aaron Hayes, USA
CDR Mike Hewitt, USN
Mr. Paul Kube, Dept. of the Air Force
Lt Col Naomi D. Manadier, ANG
Ms. Kathleen Monahan, Dept. of the Navy
Chaplain, Col Carlo Montecalvo, USAF
LtCol Keith Oliver, USMC
CDR Diane Saggus, SC, USN
Mr. S. Richard Scalco, National Security Agency
LTC Mike Stine, USA
CDR Bob Zellmann, USN

Dr. Francis A'Hearn, faculty
Dr. John Bokel, faculty
Col Nancy Linzy, USAF, faculty
Dr. Susan Studds, faculty
CAPT John Yaeger, USN, faculty

PLACES VISITED

Domestic

American Federation of Teachers, Washington, DC
The Archdiocese of Detroit, Detroit, MI
Boston Renaissance Charter School, Boston, MA
Boston Private Industry Council, Boston, MA
Boston University, Boston, MA
Chelsea Public Schools, Chelsea, MA
Education Development Center, Newton, MA
Focus: HOPE, Detroit, MI
General Motors University, Detroit, MI
Harvard University, Cambridge, MA
Maryland State Department of Education, Baltimore, MD
Minuteman Science-Technology High School, Lexington, MA
Montgomery County Public Schools, Rockville, MD
Motorola University East, Mansfield, MA
National Alliance of Business, Washington, DC
National Governors' Association, Washington, DC
Northern Essex Community College, Haverhill, MA
Organization for Economic Co-operation and Development, Washington, DC
Potomac Job Corps Center, Washington, DC
Thomas Jefferson High School for Science and Technology, Alexandria, VA
U.S. Department of Education, Washington, DC
U.S. Department of Labor, Washington, DC
U.S. House of Representatives, Committee on Education and the Workforce, Washington, DC

International

British Telecommunications, London, England
DaimlerChrysler, Ulm, Germany
Department for Education and Employment, London, England
Deutsche Bundesbank, Frankfurt, Germany
Enfield County School, Enfield, England
Goethe Gymnasium, Frankfurt, Germany
Ministry of Education, Baden-Württemberg, Germany
Qualifications and Curriculum Authority, London, England
Training for Skills, Kensington, England
University of Karlsruhe, Karlsruhe, Germany

INTRODUCTION

"Education is not preparation for life; education is life itself."
—Albert Einstein

As the world approaches a new millenium, the United States remains the world's only superpower—militarily, economically, politically, and technologically. The primary cornerstone of this country's phenomenal success is its people. Their adaptability, productivity, and ingenuity accelerated the Industrial Revolution and created the Information Age, defining new horizons, not just for the United States, but for the world. These abilities are the result of many factors, but education is seen to be the linchpin in the development of U.S. capabilities.

The purpose of this research was to analyze whether the U.S. education systems are producing citizens with attributes essential to the preservation of society and the maintenance of the country's long-term national security. The United States has some truly phenomenal organizations. Thomas Jefferson High School for Science and Technology consistently produces a record number of National Merit finalists; Minuteman High School graduates young licensed tradesmen; and Focus: HOPE (a not-for-profit organization) educates and trains youth from an inner-city environment to be machinery specialists and computer network administrators. Taxation systems, donations, grants, community and business partnerships, and corporate philanthropy provide the resources for these education systems.

It has become increasingly clear that the education industry is a very complex system, with direct links to communities, global competitiveness, and national security. In many ways, it is the best of times and the worst of times across the spectrum of the education industry. Although most U.S. citizens would agree that the education system in the United States needs some improvement, the degree of change needed remains a debatable issue.

THE EDUCATION INDUSTRY DEFINED

Every citizen has an opinion regarding both the scope and direction of the education industry. The 1998 *U.S. Industry and Trade Outlook* recognizes the education and training industry as a $582 billion enterprise.[1] The concepts of education are changing with the arrival of the Information Age. In the past, the economy was based on the early industrial model where hard work, a strong back, and common sense could secure a decent job for even an illiterate person. Today's economy

is global and is increasingly oriented toward information technology. The previous industrial and agrarian grounded notions are being recast to fit the concepts of "lifelong learning." Jobs are being defined more and more by constantly evolving technologies such as fiber optics, robotics, bioengineering, advanced telecommunications, micro-electronics, and artificial intelligence.[2]

Schools (Pre-Kindergarten through Grade 12)

With more than 52 million students, the United States now has more young people in its schools than ever before.[3] In the 1996–1997 school year, the elementary and secondary programs accounted for 111,486 schools, 52,217,000 students, and 3.1 million teachers within roughly 14,772 school districts. Institutions in the elementary and secondary programs include all types of public (traditional, charter, regional, and vocational–technical) and private (religious, in-home, and secular) schools. School districts vary greatly in size and organizational structure. A few districts (24) enrolled 100,000 or more students, while a large number (1,725) supported fewer than 150 students. Viewed from a different perspective, almost half of the school districts in the United States had fewer than 1,000 students in 1996–1997. At the same time, almost half of the public school students in the United States attended schools in districts of 10,000 students or more. Management and oversight of the education process varies greatly within each state. Today, the nature, degree and effectiveness of each school system resides within the purview of the state or local authorities.

Public schools receive limited federal dollars (7 percent of the total funding)[4] and are primarily supported by state and local funds. In the 1996–1997 school year, expenditures for all public elementary and secondary schools equaled 1.2 percent of the U.S. gross domestic product, or $266 billion.

Transitional (School to Career)

The transitional stage includes the programs and processes involved in moving the individual from the school into the workplace and a career. Shaping the basic education elements that were established in pre-kindergarten through grade 12 into developed and applied skills for the emerging U.S. economy is the task of the transition process. This stage also supports the need for retraining workers voluntarily en route to a new career or displaced due to corporate restructuring. Due to the

overlap of responsibilities and changing approaches, the definitive associated cost of the transition phase is difficult to quantify.

The scope and diversity of transition programs reflect the wide variety of opportunities available to the individual participants. Approaches vary from proprietary universities to distance learning via the Internet, from vocational schools to community colleges, from private training groups to 2-year high-school technical academies, and from government-funded training to business-supported partnerships such as Focus: HOPE in Detroit, Michigan. The U.S. higher education system is very competitive and in great demand by both domestic and international students. As the U.S. economy changes, the traditional lines of responsibilities within the transition phase among high schools, community colleges, and universities have blurred. In some cases, colleges are doing what high schools fail to do, and the better high schools offer college level courses. As a result, new and innovative approaches and alliances are emerging.

Workplace (Employee Training)

Business leaders in the United States have long recognized the need to conduct training in order to remain competitive. As world economies become increasingly global, interdependent, and information-based, employee training becomes a critical resource. Partnering with educators, U.S. businesses are searching for new approaches to introduce technologies, increase employee loyalties, inculcate the corporate culture, and generate new directions and markets within the global economy. Corporate U.S.A. is vigorously pursuing a variety of training efforts and spending $55 billion annually.[5] Training concepts range from informal on-the-job training to formal training classes. From community colleges whose curricula are in harmony with local business requirements, such as those at Northern Essex Community College near Boston, to "web"-based classes. Corporations integrate fly-away "train-the-trainer" teams and make greater use of full company-sponsored degree-granting college partnership programs (e.g., Motorola and General Motors Universities).

The U.S. education industry is a process of moving along the pathways from early childhood development programs (e.g., Head Start), into elementary and secondary classrooms, through the transition period and into the repetitive cycles of workplace training. The goal of the industry, in today's Information Age, is to provide U.S. citizens with the building blocks for achieving lifelong learning. Education is the

foundation for achieving the levels of economic productivity vital to national security.

CURRENT CONDITION

The debate over the state of education in the United States continues. Since the 1983 publication of *A Nation at Risk*[6] through President Clinton's 1999 state-of-the-union address, and into the foreseeable future, education in all its forms will remain in the public and political limelight. It will almost certainly be one of the most contentious issues in the coming presidential election—an opportunity for the country to assess the many challenges facing this vital national industry. Analyzing the education system as it relates to and supports U.S. national security interests is a complex and controversial undertaking and must include the full spectrum of the industry, from pre-kindergarten through college, and beyond to an individual's lifelong pursuit of learning for both employment and enjoyment.

A host of highly informed writers and education analysts have built a strong case that the U.S. public school systems (pre-kindergarten through grade 12) are not keeping pace with the rapidly growing requirements of Information Age technology and its impact upon today's highly competitive, globally focused workplace. It appears that U.S. industry is increasingly concerned that U.S. schools, albeit with notable exceptions, are not producing young people with the requisite skills for today's economy.

Things *have* changed in the United States, but it is arguably not as simple as an erosion of standards and expectations. There have been fundamental cultural and technological changes in this country over the past few decades that have affected education. As one leading educator pointed out, during the past 20 years, the skills required to succeed in the economy have changed radically, but the skills taught in most schools have changed very little. If the schools are indeed not turning out the type of qualified individuals needed in today's workplace—and the school system is only one of many factors influencing the development of quality citizens—it is most likely the result of a ponderous, bureaucratic, and tradition-bound public education system that is remarkably resistant to change as compared to the dynamic and fluid realm of modern U.S. business. The resultant mismatch between the needs of employers and the "tools" carried by the average public school graduate is having a substantial impact in U.S. society.

Many, including the National Governors' Association and the National Alliance of Business, seem to have recognized by now that

something substantial must be done to align the school systems with the realities of the workplace. Education reformists, politicians, industry leaders, and perhaps most important, parents are clamoring for a more focused curriculum, based upon higher (or more relevant) standards that will enhance student performance and lead to an educated, innovative, and competitive workforce of the future. The debate will reach a national audience in the elections next year (or before), but questions remain about the possibility of reaching something close to a nationwide consensus. The role of the federal government in orchestrating education reform remains a contentious issue, as does its authority and ability to establish and maintain national standards.

One of many issues within the pre-kindergarten through grade 12 school system is the availability of qualified teachers. Teacher shortages are increasingly problematic in many areas, both in public and private schools, and the answers to this shortfall are not easy. In a February 1999 speech, Secretary of Education Richard W. Riley cited a potential shortfall of some 2 million teachers nationwide within the next decade.[7] Teacher pay and incentives, accreditation, the role of teacher unions, and certification requirements represent key issues in this debate. An increasing number of teachers at the primary and even secondary level are teaching subjects in which they have little to no formal training. According to one study, roughly 40 percent are teaching in subjects outside their primary field.[8] There is growing concern that, in an effort to fill the growing ranks of teacher vacancies, the qualification standards for teachers will be lowered. The question of alternative certification is a hot topic in the search for new ways to attract qualified instructors.

Alternative school choices, such as magnet and charter schools, represent a slowly growing trend in some areas. Many people believe that the opportunity for parents to choose such schools for their children will lead to a healthy and long overdue competition among public institutions. As traditional public schools lose quality teachers and student populations to these "choice" schools, they may be forced to dedicate themselves to achieving higher and more focused academic standards. In the United States, public schools have increasingly found themselves in the position of trying to be all things to all people. They have spread their limited resources across a wide range of nonacademic endeavors in an effort to make up for a growing diversity, changing family structure, and federally mandated programs. Social programs in the schools have offered a refuge of sorts for many young people, but these programs are consuming valuable resources that might otherwise have been used to promote academic learning. Whether public schools will be able to divorce themselves from the now expected extracurricular

social, cultural, and athletic roles (including preschool and after-school programs) that have diverted resources away from the academic curricula is another question.

In terms of international competitiveness, the verdict on U.S. public education is mixed. The 1997 Third International Mathematics and Science Study results indicate that U.S. schools, particularly in the middle-school levels and beyond, are lagging well behind many of the world's industrialized nations in student performance. For example, U.S. 12^{th} graders ranked 17^{th} of 21 groups from different nations in mathematics and science achievement, the culmination of a downward trend that is first identified in U.S. 8^{th} graders' performance against the same field. Interestingly, U.S. 4^{th} graders fared quite well, placing 3^{rd} in science and 11^{th} in mathematics among similar groups from 26 nations. Many feel that, unless the schools develop better mathematics, science, and technology programs, the future U.S. workforce will be unable to compete effectively in the global marketplace. Others, however, are not convinced that these results represent a fair measure of where the United States stands in relation to other nations. They argue that some countries have a much narrower (perhaps more "hand-picked") student population taking the test than the United States does.

The fact that the U.S. economy and business sector continue to set the pace for the rest of the world indicates that the United States must be doing something right in education and training. Again, depending upon the point of view, the results of the Third International Mathematics and Science Study can be viewed as a disturbing descent in U.S. education or as an unbalanced and unfair comparison that has little correlation (at least so far) to the nation's security and competitiveness. At the very least, however, the results of the study have raised awareness and have led to a serious examination of what students are learning and achieving in the schools. In a world where the mastery of liberal arts is taking a back seat to the demands of science, technology, and the economy, the debate on this issue is probably overdue.

The colleges and universities in the United States continue to be among the finest in the world. Despite some concerns that they have lowered standards for admission in order to fill seats, U.S. institutions of higher learning have universal respect. Even though the goal of a college education still pervades U.S. culture, a large percentage of jobs do not require a college degree. Thus, alternatives to a traditional 4-year college experience appear to be gaining momentum. School-to-work programs, industry–school partnerships and apprenticeships, and a plethora of excellent community colleges nationwide all provide viable options for young people who lack the academic or financial means to

pursue college life or who see no practical utility in it. Universities find themselves competing for applicants in a society where the perceived need for a bachelor's degree may not be as compelling as it once was—although according to recent data, the earning power of college graduates is still considerably more, on average, than that of high-school graduates. A booming economy and an emerging generation of youngsters who possess highly advanced and marketable skills in the information technology arenas have offered another choice for those who would have normally chosen the college route.

An encouraging development in recent years has been the commitment of many U.S. corporations to the concept of lifelong learning. A growing number of large companies have dedicated significant resources to their own organic "universities," where they offer their employees the opportunity for career-long education and training at company expense. Many of these programs focus on management and technical skills related specifically to jobs within the companies. These businesses realize, however, that offering a full range of educational development choices to their workers, including master's degrees and other purely academic endeavors, will greatly enhance the quality and competitiveness of their people and, it is hoped, foster a sense of loyalty to the organization. Heavy personnel turnover is increasingly commonplace in industry, and many businesses hope that devoting resources to allow their workers access to continuing education will lead to stability, longevity, and hence long-term productivity. These programs not only offer in-residence training at designated industry "campuses," but also feature a wide use of distance learning media to export training and education to their workers around the globe.

The U.S. educational scene is in the early stages of transition. This is a continuation of many years of scrutiny—certainly going back at least as far as the days of Sputnik—but the realities of the Information Age and global competition have pushed education to the forefront. Public awareness is at a high level, and the debate over quality and relevance is gaining momentum. Public schools, in particular, are under considerable scrutiny, and much of the attention is warranted. The fundamental skills and principles that U.S. children are learning now may or may not be significantly different from those learned a generation or more ago, but the question to be answered today is whether this level of general education is sufficient to meet the needs of the 21st century and the attendant national security implications.

CHALLENGES

When asked to define the challenges for education in the United States, educators, school administrators, government officials, industry representatives, and constituents of the education industry provided a list that was varied and endless. Although education as defined is a continuum from pre-kindergarten through grade 12 to transitional institutions to workplace training, market factors drive many of the challenges beyond primary and secondary education. Focusing on the challenges facing the traditional schools (i.e., pre-kindergarten through grade 12), it is possible to identify four major topics: vision, resources, teachers, and families.

Vision

The path to a high-quality education for all U.S. citizens has many directions; the challenge is to find a common ground for education reform that preserves the most successful practices and institutions, yet addresses what must be fixed. A lack of consensus among key players in education, together with a system of decentralized authority, has created a hodgepodge of educational concepts that state and local governments struggle to implement. Recognition that "one-size-fits-all" education does not work in a pluralistic democracy has compounded the challenge by creating unprecedented and rapid change. Two of the most volatile areas demanding leadership and vision originate in the creation of standards for educational achievement and the establishment of parental choice within many new forms of schooling (in addition to public and private institutions).

Many U.S. citizens believe that education reform must begin with strong academic standards. The debate includes the level of standards, as well as the decision of who should define the standards (i.e., industry; federal, state, or local governments). It seems likely that, without definitive standards to benchmark the industry, all other reform efforts will improve education only around the edges.

Alternatives to the current education system must be explored to provide choice to families and communities on how and where their children will be educated. There is concern that choice could lead to the destruction of the public education system, however, by siphoning resources from poor schools and leaving public schools for those who are unable to implement choice (i.e., the poor and disabled). If each state fully embraces and uses choice programs as a resource, many believe that such programs can provide educational freedom, especially to the

poorest families. With choice comes competition, something the current school system has not faced in its monopolistic environment. Charter schools are generally allowed more freedom to experiment and craft programs that appear to better meet the needs of students and parents. Advocates claim that choice and competition, while radical ideas to the status quo, will empower consumers, while protecting education for those segments of society least able to choose.

Resources

Amid the national debate that followed the release of *A Nation at Risk* in 1983,[9] per-pupil funding for public schools (pre-kindergarten through grade 12) increased by one-third. Resourcing the nation's public school system remains a debatable issue at all levels of the government, however. There are some voices that say funding is still inadequate across the spectrum of U.S. schools. Current pay levels for teachers would certainly indicate that schools and education are not a high priority.

There are other critics who feel that the funding is adequate in the aggregate, but not effectively distributed. Unbalanced and ineffective allocation definitely exists in some areas. In the state of Maryland, for example, the Montgomery County Public School System exists alongside the Baltimore City Public School System. These systems represent both ends of the education spectrum, ranging from those whose results are outstanding to those whose results are appalling. A major cause of the inequity is the system of local property taxes that provides a major portion of the funding for pre-kindergarten through grade 12 education. This system, while maintaining interest in local school systems, does not ensure an adequate level of funding for all children—including those living in inner-city and rural areas. So long as funding for public education comes directly from localized property taxes, it is a certainty that resourcing the schools will remain a challenge.

In addition to the inequities created by the property tax system, non-academic programs are draining resources from the classroom. From school safety to reduced-price lunches, there are many programs with merit, but the fact remains that these programs are depleting the resources of some schools. The heaviest impacts occur in the school systems that can least afford any more expenses.

Finally, a discussion of resources would be inadequate without mentioning the role that bureaucracy plays in the management (or mismanagement) of educational resources. From Fairfax County, Virginia to Boston, Massachusetts to London, England, administrators

are making tough choices. The best ones are making the choices that focus on student achievement. The worst are simply held unaccountable for performance. The complexity and impact of this issue cannot be overstated.

Teachers

The Department of Education estimates that the nation's school districts will need to hire approximately 2 million teachers in the next decade. This requirement comes at a time when the states are implementing higher standards for teachers, the President has set a goal to reduce class size by hiring 100,000 new teachers, and the country is experiencing 30-year lows in unemployment. To fill the void, it will be necessary to create opportunities for professionals who want to become teachers, but have not been formally trained in traditional programs. Alternative licensure programs can capture subject-knowledgeable professionals and quickly place them in the teaching profession. The principal of each school should judge their performance by standards established for individual schools and ultimately by their students' achievements.

The teacher shortage brings a real danger that states will reduce their standards to fill the teacher gap. This will only exacerbate current problems, however; an ineffective teacher in a room with relatively fewer students is still an ineffective teacher. The current U.S. teaching system provides a virtually guaranteed job for tenured teachers without regard to performance. It is difficult to demand accountability when it is next to impossible to fire an ineffective teacher. Before they can be held responsible for the performance of their teaching staff, principals and schools need additional tools. More performance-based incentive pay and less difficulty in firing poor teachers will help retain the best educators and attract quality professionals to the field.

Families

Perhaps no bigger challenge exists for the education industry than the desperate need for increased parental/family involvement. Research over the past 30 years has consistently shown that greater family involvement is a critical factor for high-quality education and a safe, disciplined learning environment for every student.[10] Parents' efforts to help their children learn have a greater effect on their children's achievement than does family income or education.

Family demographics have changed: 25 percent of children live in single-parent families (compared to 11 percent in 1970); 28.2 million children, aged 6–17 years, have working mothers; and today, one child in five lives in poverty. The cultural diversity of the student body is changing. In the next 10 years, the white, non-Hispanic population will decrease by 13 percent in pre-school and 2 percent in the elementary school, and Hispanics will become the largest school-aged population.[11] The challenge for parents is straightforward: they must become more involved in their child's education. Ultimately, it requires more than tax dollars, it requires resources that they have very little of—time and commitment.[12]

Educators are as culpable as parents for the lack of family involvement. Schools must change the institutional culture that places little value on the participation of parents, and they must also provide concrete skills, knowledge, and positive attitudes about family involvement.[13] Developing partnerships with families will be difficult; schools must be given the autonomy to structure their organizational qualities to maximize the partnership that works best for their constituency. There are proven models (e.g., Boston Renaissance School) to improve student achievement through increasing parental involvement, even in a difficult environment.

OUTLOOK

The challenges facing the education industry and the current state of transition in which the industry is operating make an accurate outlook for the industry difficult. Some general themes are continuing issues, however.

Short-Term Outlook

In the near term, guarded optimism about the prospects for positive change seems appropriate, if for no other reason than that the topic of education is now at the forefront of the public and political conscience. It promises to be the subject of an intense national debate in the upcoming presidential and Congressional elections. As such, it should be the beneficiary of much deserved attention and action. The nation must first clearly articulate the problems in education and target those entities that can affect positive reform. Without defining the problem, it will be impossible to chart a course to improve the performance and skills of those in the education system.

The pre-kindergarten through grade 12 public school systems in the United States are destined to continue to receive mixed reviews unless the challenges noted are addressed. The United States must be willing to debate the contentious issues of public education (e.g., standards and choice) and forge some common ground for a national vision. Without a consensus from community leaders, captains of industry, and government officials, the public school system will continue to muddle through, improving around the edges, but seeing no real transformation. This means continuing problems with resources (including teachers).

The good news here is that serious debate is ongoing—evidenced by the myriad front-page headlines in recent months. There is even evidence of some consensus. For instance, assessment instruments have been at the forefront of the debate for months. There may be no decision on which assessment instruments are best for a given student, school, or even state, but there seems to be little disagreement that assessment is necessary if the education system is to improve. This allows the controversy to move forward and embrace type, timing, and publication of assessment instruments.

Without strong academic standards, any attempt at education reform will fail. Among government officials and school administrators in the United Kingdom, there was a general consensus that England's national standards provided a much needed framework for the schools. The national curriculum received some praise and some criticism from these same officials, but the criticisms were about the *content* of the curriculum, not about its very existence. Of course, the United States is not England. The U.S. student population is more than 7 times that of England, so not every lesson learned from England is applicable. The existence of a system of national standards allows England to debate achievement levels and refine the curriculum, however. Those in the United States remain mired in an argument over who should develop and implement the standards for primary and secondary schools. Until there is some resolution to this particular debate, the outlook for improvement is poor.

In the short term, teacher shortages will continue to be a major concern. Massachusetts and other states have already gone as far as offering pay bonuses and other incentives to attract more teachers, but it is apparent that not all states will be able to solve their teaching shortages through such methods. States that are unable to retain qualified teachers will have few choices: (1) hire unqualified teachers, (2) change qualifications to allow more professionals to enter the teaching field through routes other than a traditional teacher college, or (3) force larger classes with fewer curriculum choices. Because the organization in each

state that sets teacher certification requirements is also the one responsible for school achievement, the states have a vested interest in solving the issues surrounding teacher skill shortages. In the short term, the problem will get worse before it gets better, but extensive shortages in some states will force true alternative certification and licensure programs with an emphasis on student achievement, not pedagogy from traditional teacher colleges.

Family involvement may be the most difficult challenge for individual schools to address. As U.S. demographics continue to shift to a more ethnically diverse population with working parents, school administrators must continue efforts to get parents involved with their children's education. As the national debate over education reform intensifies and issue awareness extends to more of the population, the link between education and continued prosperity will be more widely accepted. This will lead to more partnerships between industry and education, perhaps leading to more understanding from businesses so that parents who also happen to be employees can increase their involvement with local schools.

Long-Term Outlook

The economy will be the primary factor in a futuristic view of the education industry. It appears that business and industry, in large part, drive the current debate over education reform. As the 21st century approaches, many are troubled by the narrowing gap between the economic and technological achievements of the United States and those of its international competitors. Increasing global competitiveness drives much of the discussion regarding the quality of education in the United States. If the nation continues to enjoy economic prosperity, valid concerns that are now on the table will fade into the background and those who continue to advocate reform may be labeled as education's "Chicken Little." In an era of affluence, business leaders may be less inclined to push the issue of education reform. In that same vein, politicians operating in prosperous times may not feel compelled to campaign for education reform.

Teacher shortages are currently forecast for the next 10 years. Consequently, the long-term outlook on teachers is similar to the short-term view. As teacher shortages increase, individual states will be forced to review their certification requirements and college course prerequisites, and to reshape these requirements. It can be hoped that teacher effectiveness does not suffer, but the emergence of alternative

certification programs that are divorced from traditional teacher college preparation seems likely.

Resources for schools are also tied to economic conditions. Recognizing that resource allocation and distribution are essentially political issues, continued economic prosperity might lessen the urgency currently surrounding education reform. On the other hand, while an economic "scare" may be just what is needed for truly revolutionary changes, a prolonged recession (or depression) may prevent government and industry from investing the resources (including time) needed to strengthen the education system.

One overriding prediction: the U.S. education system will become more reliant on building partnerships with business and industry. Leaders of U.S. industry want workers who are highly skilled and knowledgeable because today's competing global workforce is well educated and skilled. They also want and need a workforce possessing collaborative and critical thinking skills and an ability to communicate effectively. Corporate U.S.A. and the government sector are in the best position to articulate the skill sets needed to succeed in tomorrow's world. As such, they will be powerful instruments of long-term education reform. With education reform, and the development of standards, it will be possible to begin to address the development of critical science and mathematical skills of students in pre-kindergarten through grade 12. Business and industry involvement is an absolute necessity if the U.S. education system is to achieve its potential and fulfill its mission of educating the next generation.

GOVERNMENT GOALS AND ROLE

The nature of government involvement in the education system evolves from the Constitution and the cultural belief that everyone is entitled to a high-quality public education. While there is some involvement at the national level, the Constitution allows for state and local control, resulting in thousands of different approaches to education. This makes the challenge of the federal government's role in education reform enormous and arguably disconnected at best. With the rapidly changing environment and global perspective, there are some things that government could and should do to enhance the education system.

Federal

At the federal level, government should be involved in setting a vision for the country and providing the incentives and resources needed

to help carry out that vision. Education should be a national nonpartisan issue. In reality, programs become attached to political policies and platforms that dampen, if not deaden, their effectiveness. The President and Congress, working together, should urge U.S. citizens to demand higher performance in formal education and to establish a national vision for academic excellence. There is no substitute for leadership, and the President of the United States must rally the support of Congress and, most important, the state governors to construct a vision and platform for educational standards and achievement. The President's Goals 2000 were a step in the right direction, but the approach lacks bipartisan commitment. Congress, in concert with the President, should lead the charge for a public debate on national standards.

The Serviceman's Readjustment Act of 1944 (often referred to as the GI Bill) profoundly changed the culture of the United States and promoted achievement in higher education. Other similar measures promoting education can be enacted. Congress should provide incentives to industry, educational institutions, and communities to establish partnerships. The Education Flexibility Partnership Act of 1999 (Ed Flex) and the Workforce Investment Act of 1998 (WIA) both encourage these types of partnerships, although neither bill provides meaningful incentives for industry to get involved. Even though the education system is under local control, there are no prohibitions on federal involvement. Federal oversight of appropriated funds is a natural extension of this responsibility. The rightful emphasis should fall on program outcomes rather than on detailed written outlines for program implementation.

Congress also imposes statutory responsibilities on schools through such legislation as the Individuals with Disabilities Act. These are costly, comprehensive programs that place severe fiscal constraints on local jurisdictions. If the federal government mandates requirements on localities, then Congress needs to provide a commensurate increase in resources. Funds should also be made available to promote research and development of effective models for export to both inner-city and urban areas. There should be better cooperation and coordination between the Departments of Education, Labor, and Health and Human Resources to provide incentives to individuals to seek more education and, thus, increase their opportunities for employment.

State

States have the authority to influence their education systems directly. Governors must hold their schools accountable to a high

standard of performance, and states should provide legislation to increase both teacher qualifications and educational standards. In addition, states should seek new avenues to recruit and retain a highly skilled, high-quality cadre of teachers and provide them with appropriate incentives to reward them for demonstrated success in pupil or school performance. Title II of the Higher Education Act (HEA) of 1998, for example, provides Teacher Quality Enhancement Grants. Although this is a promising avenue for increasing state resources, in reality, it is marginally funded, has burdensome reporting requirements, and mandates matching funds. States have difficulty accessing, supporting, and implementing fragmented, poorly funded federal legislative actions. Both the federal government and the state governments should look at ways to stabilize and streamline various programs in order to reduce restrictive provisions and to create an integrated federal–state collaborative response.

States should serve as the oversight body for locally controlled school boards to prevent political abuse and demand high-quality results. They need an effective teacher certification process to produce good teachers. The pay performance system should be focused on results and should be coupled with a flexible administrative system to weed out ineffective teachers at either the state or local level. States, in collaboration with local districts and industry, should establish the framework to improve curricula and select appropriate texts. Through tax benefits, grants, and other incentives, states should promote and encourage partnerships between communities, businesses, and universities to increase overall educational performance (e.g., the Chelsea Public Schools–Boston University Collaborative Partnership). States, which provide 45 percent of public education funding, are in an excellent position to promote equity within education among the various districts and to help provide overall planning and guidance in capital improvements. States are also responsible for distributing federal funding, and it is vital that state and local bureaucracies do not filter these funds, but funnel them directly to the schools.

Local

While the federal government provides overall direction to education and states retain the traditional right of oversight, each community (which supplies a significant portion of the funding for public schools—approximately 48 percent) should assess its own unique needs. Authority, responsibility, and accountability should accompany local control. School boards, whether elected or appointed, should be held

accountable by the mayor or governor. Principals should be accountable for the results at their school and empowered to achieve results. Through cooperation with businesses, schools of higher education, and others, individual schools or districts should be encouraged to tailor their state-established curriculum framework to maximize its effectiveness in meeting their own community needs. The establishment of such a strong linkage between business and the community should help not only to close the gap between the skill set needed to be productive members of society, but also to strengthen the culture to encourage career development and lifelong learning.

Communities should focus on effective early learning programs (ages 3–6 years) with strong emphasis on reading to ensure proficiency by the third grade. Otherwise, illiteracy will deprive them of the benefits of the rest of their educational opportunities and future avenues to success. Today, 40 percent of U.S. third graders are not reading at that level.[14] The consequences have already been felt. According to Norman Augustine, young people entering the labor market are unable to write a proper paragraph, fill out simple forms, or read instruction manuals.[15] States, communities, principals, and guidance counselors working together need to establish strong safety nets for students at risk of dropping out of the education system for any of a variety of academic or socioeconomic reasons. In fact, school principals should stress the importance of structuring schools to provide an environment that stimulates thinking and interaction among the entire student body since each student learns differently. To ensure that they meet the technology needs of the future, school curricula should emphasize student proficiency in computers and other emerging technologies. Students should be encouraged to work together in teams, communicate effectively, and apply the curriculum in a variety of tasks.

As the federal government sets the framework and provides a national direction for education, and the states keep their traditional rights of oversight, content, and quality, local communities must reach each and every child in their community. With the changing demographics in the United States and the decrease in parental involvement, schools have assumed a much larger role for society. This role has evolved through each school's response to its community needs, as well as through federally mandated equity programs. It is essential to prevent the core competencies of U.S. schools from eroding further. States must address the changing role of their schools, use schools in the evenings and on weekends, and perhaps expand the school system to become a predominant community resource.

CONCLUSION

Although the U.S. education industry can hardly be described as outstanding, the industry is basically meeting national security needs. The United States remains the world's only superpower, and the economy continues to prosper. This says that the education system has been doing something right.

The publication of *A Nation at Risk* in 1983 prompted a new round of debates about the quality of the U.S. education industry, specifically the primary and secondary public school system.[16] The debate continues to rage. While some reform is obviously necessary, there are promising signs for the future. New business and education partnerships are fostering change in the schools—forcing schools to re-prioritize. Schools on the leading edge are changing teachers, standards, curricula, organizations, programs, lesson plans—virtually all aspects of schools are being analyzed, probed, and converted to ensure that students entering the workplace are productive citizens. There are many shining examples in every realm of the educational continuum that can serve as standard bearers for others to emulate.

For progress to expand and absorb a wider range of schools, the national debate over standards, assessment, choice, and resources must continue or reach resolution. The biggest danger for the schools is indifference. From parents to Congress, from industry to the individual teacher, school involvement is helping students to achieve. This is not a one-way street, however, as those organizations and individuals that get involved are learning themselves. Parents are learning why Johnny does not like reading; teachers are learning that Johnny takes care of his two younger brothers every day. Businesses are learning that these children are bright and can become great, productive workers; principals are learning that the local industry needs more plumbers (or webmasters). Everyone is learning that the issues are not simple, the problems are not easily resolved, and nothing is free. It takes a step to start the journey, however, and we have at least walked the first mile.

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ELECTRONICS

ABSTRACT

Electronics is a growing industry with a quarter century record of increasing sales and profitability. Each year, it becomes increasingly central to the success of advanced economies. The U.S. electronics industry is competitive, innovative, and profitable; it is in a dominating leadership position in the important semiconductor, computer, and software markets. The U.S.-based electronics industry benefits from intense competition for new markets, willingness to invest in research and development (R&D), the availability of venture capital, and willingness to adapt new business models. It enjoys the synergies of regional production networks in Silicon Valley and elsewhere, a demanding domestic customer base, and advantageous access to the world's single largest market for electronics products. Sales of personal computers, one of the best indicators of overall electronics industry performance, increased 17 percent globally in the first quarter of 1999 and 21 percent in the United States.[1]

Lt Col Michael Butler, USAF
LTC Timothy Considine, USA
Ms. Patricia Gamble, Dept. of the Navy
CDR Michael Mara, USN
CAPT Paul Normand, USN
Mr. Martin Pirkl, DaimlerChrysler Aerospace
LTC Danny Price, USA
CAPT Jorge Rodriguez, Peruvian Navy
Lt Col Joseph Smyth, USAF
Mr. Paul Stoskus, Dept. of the Army
COL Csaba Ujfalusi, Hungarian Army
Mr. John Zorich, Defense Logistics Agency
Ms. Karen Zuckerstein, General Accounting Office

Mr. Robert Leary, faculty
Dr. Kenneth B. Moss, faculty
LTC Timothy Robertson, USA, faculty
COL Harold Tucker, USA, faculty

PLACES VISITED

Domestic

III Corps Headquarters, Ft. Hood, TX
3rd Signal Bde, Ft. Hood, TX
Dell Computer Corporation, Austin, TX
Dominion Semiconductor Company, Manassas, VA
Ericsson, Dallas, TX
GEC Marconi, Austin, TX
GTE, Research Triangle Park, NC
IBM, Research Triangle Park, NC
Motorola, Austin, TX
Northrop Grumman Corp, BWI, MD
Oracle, Reston, VA
Raytheon, Austin, TX
Red Hat Software, Research Triangle Park, NC
Sensys, Newington, VA
Texas Instruments, Dallas, TX
TRW, Reston, VA
Virginia Semiconductor Company, Fredericksburg, VA

International

Acer Computer Systems, Subic Bay Freeport, Philippines
American Institute Taiwan, Taipei, Taiwan
Analog Devices, Gateway Business Park, Cavite, Philippines
Aparri, Subic Bay Freeport, Philippines
Armed Forces University, Lungtan, Taoyuan, Taiwan
Chief of the General Staff, Taipei, Taiwan
First International Computer Int'l, Inc., FIC Group, Linkou, Taiwan
Gateway Electronics Corp., Gateway Business Park, Cavite, Philippines
Hitachi, Subic Bay Freeport, Philippines
Industrial Technology Research Institute, Chu Tung, Taiwan
Information Technology Research Institute, Chu Tung, Taiwan
Institute for Information Industry, Taipei, Taiwan
Intel Philippines, Manila, Philippines
Microtek International, Inc., Chu Tung, Taiwan
Minister of Defense, Taipei, Taiwan
National Defense Management College, Taipei, Taiwan
Taiwan Semiconductor Manufacturing Co., Ltd, Hsin Chu Science Industrial Park, Taiwan
U.S. Embassy, Manila, Philippines

INTRODUCTION

Electronics industry products range from supercomputers and the complex components of satellites to the latest simple and inexpensive consumer electronics offerings. As the price of semiconductor products continues to fall, increasingly large portions of our daily lives rely on electronic appliances. Embedded chips, electronics components, and software have assumed an increasing value in cars, homes, and the products of numerous other industries. In combination with the information industry, the electronics industry fuels the U.S. economy and sustains the U.S. global competitive position.

Without electronics industry sales abroad, the U.S. trade balance deficit would be considerably greater, and the U.S. economy would be less prosperous.[2] Jobs producing computers, office equipment, semiconductors, and software all pay approximately double the average national salary.[3] Its leadership in the electronics industry and domestic trends in the use of information technology suggest that the United States may sustain its competitive advantage into the 21st century. The world is now so connected by the Internet that a virus released on the anniversary of the Russian Chernobyl nuclear disaster spanned the globe in 1 day and is estimated to have caused more than $250 million in damage.[4]

THE ELECTRONICS INDUSTRY DEFINED

Electronics is a critical industry and one of the largest industrial employers in the United States. Most sectors of the industry experience rapid technological change and short product cycles. Price competition is intense, even in some near-monopoly markets. The demand for highly skilled workers perennially exceeds the supply available locally and nationally. At the sector level, there are differences in technology, manufacturing practices, business models, markets, and issues. For analytical focus and grouping of common issues, the electronics industry can be divided into five sectors: computers, software, semiconductors, consumer electronics, and defense electronics .

Computers

Computers are programmable electronic devices that store, retrieve, and process data. The computer industry consists of five markets: supercomputers, personal computers, workstations and Internet servers, mainframe computers, and mobile computing devices—including smart hand-held devices (SHDs). A global high-technology market, the

computer industry is diversified in terms of equipment type and geography. The U.S. industry remains the trendsetter in the global computer industry.

Software

Computers and their associated hardware do useful things as instructed through software language programs. The software industry includes prepackaged software that is written for a mass market and computer programming that is created for a particular client. Software companies vary significantly in size from one-programmer operations to the tens of thousands employed by the industry leaders. Software companies in the United States hold approximately two-thirds of the global software market.[5] Microsoft's Windows operating system runs well over 90 percent of the personal computers in use worldwide.[6]

Semiconductors

Typically silicon-based, semiconductors are electronic devices whose physical properties allow for rapid processing. They are formed into integrated circuits for use in handling digital data. The semiconductor sector is chiefly responsible for the dramatic cost decrease and performance increase of electronic systems in the past and for the foreseeable future. Success and failure in the semiconductor industry underpin success and failure in electronics as a whole. Following the "law" that Gordon Moore proposed in 1965 and its corollary, the number of components (transistors) integrated in a single circuit roughly doubles every 18 months, and their cost is cut in half.[7] Semiconductor devices, such as microprocessors, memory chips, and digital signal processors, are the basic building blocks of many electronics industries. Declines in the price:performance ratio of semiconductor components have propelled their adoption in an ever-expanding array of applications, and semiconductor technology has increased the variety of products offered in other industries.

Consumer Electronics

The consumer portion of the electronics industry is primarily oriented to household entertainment products, home information systems, after-market automotive equipment, and telecommunication equipment. Consumer electronics products include home computers, televisions, radios, home entertainment systems, videocassette recorders

(VCRs), compact disc (CD) players, digital videodisc (DVD) players, home satellite systems, and digital cameras.

Defense Electronics

From office automation to weapon systems under production, defense electronics touches all facets of the military environment. The sector produces stand-alone electronics; communications equipment; and subsystems embedded in aircraft, guided munitions, ships, tanks, satellites, and individual soldier gear. Applications include electronic warfare, avionics, command and control systems, computers, communications, reconnaissance, air defense, and surveillance systems.[8]

CURRENT CONDITION

The computer industry had a global market of about $340 billion in 1998.[9] The U.S.-based industry continues to dominate the global market, reaching a total of $140 billion in 1998. Domestic growth is slightly less than in the 5 previous years, decreasing from 14 to 10 percent.[10] The recent Asian financial crisis contributed to this slower growth.[11]

Firms from the United States lead in most computer markets. Compaq, Packard Bell-NEC, IBM, Dell, and Hewlett-Packard control 41.2 percent of the personal computer market, a 4.6 percent increase in the last year. United States Unix-based machines control 67 percent of their market, which has suffered from the availability of cheap, powerful desktop computers.

IBM, Hewlett-Packard, Compaq/Digital, and Sun Microsystems control 66.2 percent of the server market. This market grew 22 percent in 1998, down from a 41 percent increase in 1997. IBM is the world leader in the development of supercomputers. With approximately 67 percent of the market, IBM continues to dominate the mainframe computer market, but other manufacturers of supercomputers, client/servers, and minicomputers increasingly challenge this market.[12]

The market for SHDs is evolving. About 7.4 million SHDs were sold in 1998. 3Com led sales with 45 percent of market share.[13] Industry projections suggest global sales of more than 20 million units in 2002 with potential to exceed personal computer sales by 2005.[14]

Despite the U.S. leadership position, foreign suppliers have gained significant world market shares. With many U.S. firms establishing production abroad, the United States is the number one computer importer, purchasing about $79 billion in foreign computer equipment. Most of this equipment consists of peripherals and personal computers

from Asian countries, such as Japan, Singapore, Taiwan, South Korea, and Malaysia. With Europe as the major customer, U.S. computer exports peaked at $44 billion.

The personal computer industry experienced a demand slowdown in the first half of 1998, resulting in an inventory surplus. Manufacturers adopted new market and manufacturing strategies to address the lower profit margins that resulted from lower prices caused by the market glut. These strategies, such as build-to-order and channel assembly, allow manufacturers to reduce inventories. The resulting cost savings facilitate competitive pricing and sustainable profits.

Software

One industry study ranks the computer software industry behind electronics (minus software) as the third largest U.S. manufacturing business.[15] Of the world's top 10 software providers, 6 are U.S. firms, including the top 4.[16] The top 10 firms account for 56 percent of the revenues earned by the world's top 500 software companies.[17] In 1998, the top 2 software manufacturers, IBM and Microsoft, each with more than $13 billion in revenues, had more than double the revenue of their nearest competitor.[18]

Packaged software industry growth rates have averaged 12 percent or higher throughout the 1990s.[19] The world market is projected to reach $150 billion in 1999 and $257 billion in 2003, with annual increases of more than 14 percent. The latest Department of Commerce figures for packaged software markets indicate that the U.S. packaged software industry is the world's largest. Furthermore, a recent examination of 12 worldwide software markets in 20 industries indicated that software sales are growing most strongly in the United States. It also suggested that manufacturing should decline in relative importance as a source of software revenue and that software sales for wholesale and retail industries should grow in the next several years.[20]

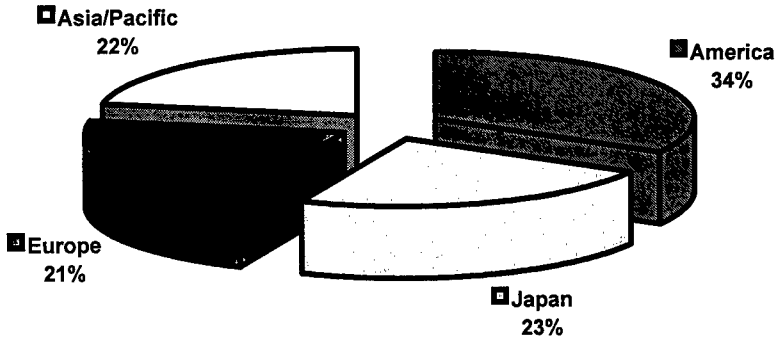
This year, spending on the Year 2000 (Y2K) issue may disrupt some software markets. As business and government focus on fixing the problem, they may divert their funds and attention from purchases of new computers and software. It is estimated that it will cost $300–$600 billion simply to fix programs written in COBOL. Total Y2K-related expenses from 1994 through 2005 may exceed $3.6 trillion.[21]

Semiconductors

The condition of the U.S. semiconductor industry has improved significantly since the early 1990s.[22] Successes have induced new problems, however. New manufacturing technologies for large- and very large-scale integration make it possible to produce increasingly complex circuits at a very low cost per unit, but it is necessary to manufacture those circuits in ever larger quantities to spread the growing costs of R&D. At the same time, because circuits become more complex, they tend to become more specialized and can fit fewer specific applications. Therefore, two related but distinct technological trends co-exist. The first trend pushes the industry toward the production of large quantities, at a low unit price, of relatively simple and standard components. In contrast, the second trend emphasizes innovation, characterized by the growing number of new niche markets for complex custom-integrated circuits designed to answer the needs of specific users.

Demand for semiconductors has doubled every 5 years.[23] Because of short product life cycles and the high cost of manufacturing facilities, the semiconductor industry goes through historically predictable cycles of overcapacity. In 1998, the global chip market fell 8.4 percent to $134.8 billion, and 1999 will mark the beginning of at least 3 years of healthy growth, with the market reaching $182 billion by 2001.[24] Figure 1, global semiconductor sales by country of ownership, illustrates the position of the U.S. semiconductor manufacturing industry in the world market.

Figure 1: World Semiconductor Sales by Region (1997)



Source: Semiconductor Industry Association

Consumer Electronics

In 1998, consumers increased the amount of discretionary spending on consumer electronics products, such as televisions, stereos, computers, telephones (primarily cellular), and emerging new technologies (e.g., digital cameras, DVD players). The Consumer Electronics Manufacturing Association (CEMA) estimates that total U.S. sales of consumer electronics goods increased by 5.1 percent for 1998 and predicts that the value of 1999 consumer electronics sales will exceed its earlier prediction of $76.03 billion by about 5.1 percent.[25] "Home information products" made up the single largest group of consumer electronics goods accounting for the overall consumption. This category of goods, as classified by CEMA, includes personal computers, telephones, printers, and software. Together, the items in this category accounted for 45 percent of all consumer electronics sales by dollar value.[26]

Video products—including televisions, DVD players, and set-top Internet access devices—made up about 19 percent of the consumer electronics market. Set-top Internet access devices allow consumers to access the worldwide web with their television. Sales of set-top systems were approximately $80 million for 1998. Mobile electronics and electronic gaming hardware/software each account for 10 percent of the consumer electronics market.

Defense Electronics

In previous years, when the Department of Defense (DOD) developed much of the leading-edge technology, defense electronics were more than 25 percent of the total U.S. electronics market.[27] Now, however, the defense electronics sector is less than 10 percent of the total U.S. electronics market.

The need to develop information-superior forces is driving all services to increase the amount of digital electronic systems on all sensors, weapon systems, logistics, and command and control systems. Thus, defense electronic procurements continue to rise. In 1999, defense electronics will account for $57.6 billion of the overall DOD acquisition and operations budget, a $6.1 billion increase over the amount budgeted in 1998.[28]

The military services continue to take advantage of DOD's "commercial-off-the-shelf" (COTS) procurement strategy to use commercial, leading-edge technologies without the fielding delays associated with unique DOD-developed systems. The COTS strategy for

procurements saves money by eliminating expensive military specifications and standards.

Lockheed Martin, Raytheon, Northrop Grumman, Litton, and ITT remain the top defense electronic firms. Although profit margins are likely to continue increasing for the defense electronics sector,[29] key defense contractors (i.e., Lockheed Martin, Raytheon, and Northrop Grumman) reported losses in January 1999.[30] Recent mergers and acquisitions as the big firms vertically integrate their organizations have squeezed many second- and third-tier supply chain firms out of the defense electronics sector.

The structure of the defense electronics industry continues to change. Lower tier firms are now beginning the consolidation process that the larger U.S. defense firms went through between 1987 and 1998. The continuing globalization of economic markets is driving foreign electronics firms to consolidate as they partner with each other and with U.S. firms. Defense contractors increasingly focus on architectures and standards. The surviving firms focus on hardware production, systems integration, and systems engineering.

The United States remains the world's number one producer of defense electronics equipment. Continued globalization of markets implies not only more opportunity for sales, but also more competition for U.S. products. It also means that more electronic components and subsystems are being manufactured offshore.

CHALLENGES

The electronics industry faces several challenges that constrain growth or present a threat to U.S. technological leadership. Chief among these is the shortage of skilled labor, particularly in computer-related disciplines. High research and facilities costs pose significant risks. The DOD faces difficulties in keeping pace with rapid innovation in commercial electronics. Parts obsolescence, piracy, and export controls present further challenges.

Labor Shortages

The shortage of skilled labor is one of the greatest challenges in the electronics industry. Skilled personnel are needed to support software development, to design and manufacture next-generation computers, and to integrate complex defense electronics systems.

Labor shortages are likely to worsen. The Bureau of Labor Statistics projects that jobs in computer science occupations will more than double

over the 1996–2006 period. Jobs for systems analysts will increase by 103 percent; computer engineers and scientists, by 113 percent; and database administrators, computer support specialists, and all other computer scientists, by 109 percent.[31]

This shortage is encouraging software companies to move projects overseas. According to one report, there has been a 40 percent rise over the last year in the number of U.S. information technology companies establishing overseas operations.[32] Software projects shipped to India increased by 60 percent. Lower wages overseas further encourage this trend; the United States is the second most expensive market for information technology skills (Switzerland being the most expensive).

The industry has also sought to alleviate the labor shortage by hiring software professionals from overseas. In 1998, Congress increased the limit on high-technology work visas (H-1B visas) from 65,000 to 115,000, although the limit will return to 65,000 in 2002. The new limit still falls far short of the 177,034 computer-related visa petitions filed in 1997.[33]

The shortage of skilled personnel presents special challenges to the defense sector. Military personnel with engineering and computer science skills are leaving the military early to pursue high-paying jobs in the commercial sector. This exodus has contributed to retention and recruitment problems for all military services. Because of the intense competition for civilian contract personnel, professional services firms are increasingly marketing their services to commercial companies. The DOD's requirement that software developers and systems engineers working on most defense systems be U.S. citizens also accentuates the shortage.

High Research and Facilities Costs

Segments of the industry face high research and facilities costs. Some firms spend about 10 percent of their revenue on research. They see this high spending level as necessary to keep up with the rapid pace of technological change.

In February 1999, the President's Information Technology Advisory Committee reported significant shortfalls in information technology research, despite the high level of corporate spending on R&D. The Committee found that the nation is underinvesting in long-term, high-risk research. Among the areas that the Committee identified as needing attention are research on human–computer interfaces and interaction; the capture, management, analysis, and explanation of information; the behavior of the global-scale network; the physics of the network;

innovative architecture and technologies for high-end computing; and software for high-end computing. The Committee concluded that research in such areas is necessary to replenish the reservoir of ideas that will lead to innovations in future years.

Facilities costs are also high. For example, each new semiconductor facility costs between $1 billion and $2 billion. In 1998, the U.S. semiconductor industry spent $13 billion in new plants and equipment.[34] At the same time, product life cycles can be very short. A new semiconductor fabrication facility takes about 2 years to place in service from initial conception, and it may take up to 10 years of production to break even.[35] Thus, there is a risk that changing market conditions during the 18 to 24 months needed to build a new manufacturing facility will render it obsolete by the time it is ready for service. The semiconductor industry has reacted to these challenges by increasingly outsourcing its production to firms abroad, particularly those in Taiwan and Malaysia.

Struggles in Defense Electronics

Commercial industry is driving much of the technology innovation in the electronics sector. Yet, restrictive and outdated acquisition policies limit the DOD's ability to take advantage of state-of-the-art commercial technology. Today, the electronics industry develops and evolves electronic capabilities rather than buying lifetime electronic systems. As a result, the DOD needs to become more adept at inserting technology at different stages of a system's life. Moreover, the DOD procurement process is still laden with considerable administrative overhead and legal limitations, making it difficult to retain commercial contractors. Commercial companies continue to shed their defense electronics business for the more lucrative, less burdened commercial electronics markets.

Parts Obsolescence

There have been several indicators—Moore's law is the most famous—showing that electronic parts have effective life cycles of 18 months to 3 years before becoming obsolete. The Government Industry Data Exchange Program (GIDEP), charged with maintaining a current database of obsolete parts, shows that approximately 32,000 parts per year are declared obsolete.[36] One industry executive noted that 11 generations of microprocessors have been introduced in the last 30 years.[37] The average introduction rate for new generations of

commercial integrated circuits is 2 years or less for logic, memory, microprocessors, and gate arrays. The only longer time spans are 3 years for digital signal processors and 8 years for linear interfaces. Consequently, it is necessary to modernize pure commercial applications approximately every 3.5 years; military applications, every 12 years.[38] This obsolescence problem drives electronic component manufacturers to adopt defensive strategies, including a reliance on alternate sources such as third-party vendors, lifetime buys of components, wafer banking (i.e., storage of wafers that are manufactured to the point at which the final metals are applied to them so that they are ready for later customization), and remanufacture/emulation of existing designs.

Software Piracy

A software industry report estimates that 40 percent of the personal computer business software used or sold worldwide in 1997 was pirated, with a market value of $11.4 billion.[39] It further suggests that, worldwide, more than 40 percent of all software in use may have been copied. Software piracy is estimated to cost more than 130,000 U.S. jobs annually, with that number projected to grow to 300,000 by the year 2005. Software piracy is a concern to foreign firms as well. Taiwanese companies identified piracy problems in the China market as a particular concern.

Export Controls

As technology changes, export controls again become a problem. The United States has limited the export of computers with capabilities exceeding certain computing thresholds (i.e., 2,000 per 10,000 million theoretical operations per second) to selected countries, including China, India, and Russia. With the expansion of computing capabilities, personal computers are expected to cross existing thresholds in the next year. Without a change in these thresholds, controls will restrict U.S. firms' abilities to compete in key markets such as China, which appears to be a market with substantial growth potential. To the extent that the need to obtain licenses on an export-by-export basis handicaps U.S. manufacturers, they will face threats to their cost competitiveness, revenue flows, and research capital.

OUTLOOK

Spurred by the rapid pace of technological innovation, prospects for continued growth in the electronics industry are strong. The information revolution continues to expand, affecting more aspects of our lives. The expansion of computing power and networking, coupled with the growth of the Internet, is transforming the way people do their work, communicate with each other, buy and sell products, and spend their leisure time. The desire to take advantage of these rapidly changing capabilities can be expected to increase the sales of computers, semiconductors, software, defense electronic systems, and consumer electronics. The highly competitive character of much of the industry will affect the structure of the industry. The rapid pace of mergers is likely to continue as technological change influences what companies see as capabilities essential to continued growth. Globalization of the industry will likely expand as firms seek to increase sales in overseas markets, share technology, and reduce risk.

Technological Change As a Spur to Growth

Sales of consumer electronic products that take advantage of emerging digital technologies are expected to grow, taking the sting out of flat or declining sales for older technologies, such as corded telephones, VCRs, and camcorders. The expanding availability of high-definition television (HDTV) will encourage television sales. As consumers appreciate the quality of HDTV, their demands may also help promote the sales of other digital products, such as DVD and digital cameras. Unit sales of digital cameras in the United States are projected to jump by 45 percent in 1999. Last year, sales of DVD players more than doubled to $323 million, and it seems probable that sales will break $535 million (1997 dollars) for 1999. High-definition DVD will offer consumers even greater picture resolution, and interactive DVD is also likely to win consumer attention. The interactive capabilities of some DVD players allow viewers to switch between different camera angles with continuous uninterrupted audio. For example, in viewing last year's Superbowl, viewers could analyze key plays from multiple angles and could choose to listen to one of four separate audio tracks.

New technologies, lower costs, and expanding capabilities will also stimulate computer sales. Technology trends for the computer industry include multimedia capability, mobile computing, and computer networking. These technologies extend the scope of computers, adapting them to global consumer and business needs. As a result, worldwide

sales of personal computers are expected to increase 10 percent for 1999. Unit sales growth is projected at 15 percent, as average system prices are expected to decline to less than $1,000.[40] Future hardware trends include computers based on optical technologies and devices based on quantum mechanics. Since semiconductors still offer many technological opportunities, however, these new technologies will not be available until 2025.

Technological shifts, particularly the growth of the Internet, will also shape software sales. Internet expansion will stimulate and reinforce the growth of electronic commerce. Currently totaling approximately $4 billion per year and expected to grow by 30 percent annually, electronic commerce is a significant opportunity for the software industry. It represents a new market and provides a delivery channel that may be a competitive advantage. As electronic commerce becomes more prevalent, it will require sophisticated software to support the services that it offers and the new business models created to exploit its potential.[41] Software firms are tailoring their products to integrate web features, to reach the web from within applications, and to transmit documents through the web.[42] The Internet offers the possibility of providing software as a service with no charge.

Several software market segments are benefiting from the shift to client/server systems, where sophisticated software applications reside on a network server. Systems management software, which provides tools to measure computer performance and programmer productivity, is expected to grow from $10.7 billion in 1997 to $19 billion in 2001.[43] Enterprise resource planning software, which automates office business processes, also benefits. Several large electronics industry firms have installed or are installing this software. The German firm SAP has a commanding lead in this market.

Earlier this year, Sun Microsystems previewed a technology, dubbed "JINI," based on the idea that the network itself, not the computer, is now the center of the computing universe. Later this year, JINI-enabled consumer electronic devices should be available in stores. Microsoft is competing for this emerging market of clients and consumer devices with a concept dubbed "universal plug and play," which aspires to create networks of Windows 98 desktops and consumer electronics-enabled devices. The two companies, Sun Microsystems and Microsoft, are racing to become the de facto standard for distributed computing.[44]

The concept of open-source software has come of age and promises to change the software market. Companies such as Oracle and Informix have released versions of their software running on Linux, an open-source operating system available without charge. Linux offers ease of

installation, low maintenance costs, and reliable performance. Linux uptimes are reportedly measured in months and years, in comparison to uptimes measured in days and weeks on competing operating systems.[45] Businesses and government users concerned about minimizing computer downtime increasingly consider Linux a credible alternative to the Microsoft Windows and commercial Unix operating systems. Moreover, Linux can run on older systems, unlike its operating system competitors. Multiple Linux systems of any size can be clustered for supercomputer levels of performance. It is the operating system of choice among Internet service providers and companies that have the lowest tolerance for downtime and the smallest profit margins.[46]

The DOD will also seek to incorporate the increased performance capabilities offered by the electronics industry while pursuing cost reductions. Performance gains will come from advances in cutting-edge technologies, while cost reductions will come from the increased incorporation of commercial products in DOD systems. New DOD electronics systems will stress modularity and a high degree of commonality across the services as the Department builds information dominance into the military force structure.

An emphasis on building information superiority will continue to drive increased procurements in the defense electronics sector. Electronics spending by the DOD is projected to rise from $57.6 billion in 1999 to $61.7 billion in 2008.[47]

Consolidation and Globalization

For much of the industry, mergers and consolidations are escalating as firms seek to expand their capabilities. In 1998, the semiconductor industry saw Micron acquire Texas Instruments' DRAM facilities. National Semiconductor acquired Cyrix, while LG Semicon and Hyundai Semiconductor merged.[48] These events left the industry with a smaller number of larger players. One industry representative predicts that in 10 years there will be only five semiconductor manufacturing companies worldwide.

Mergers and acquisitions are a common growth strategy for software companies. It is not unusual for a quarter or more of the leading software companies to acquire a company or product line, or to merge with another company during the year.[49] Some believe that Microsoft's involvement in the government's antitrust suit has enabled mergers and acquisitions among software firms, Internet providers, and other information technology firms that might not have occurred otherwise.

Many computer and semiconductor firms have also formed strategic alliances with foreign firms. These alliances allow U.S. companies to gain access to foreign markets, share risk, and make the best use of their technology and manufacturing capability. It often results in more vertical integration and specialization.

The growing trend in international alliances will likely continue because of[50]

- Increased development costs and the need to share risk
- Advances in technology and the need to swap technological and production expertise
- The need to respond to new applications and consumer demand
- The need to take advantage of production economies, as well as marketing and distribution networks

Globalization is also a reality for the defense industry. Strategic alliances are common between U.S. and European firms as a means to sell in each other's markets, but the prospects for cross-border mergers and consolidations are less clear. Defense-related industries operate under different parameters than firms in commercial industries. In the defense world, there is limited sharing of technology, and the United States and other countries worry about maintaining critical design and manufacturing capabilities within their national borders. These restrictions hamper the potential scope of consolidations, limiting potential gains from increased economies of scale and technology sharing.

There has also been a trend toward outsourcing manufacturing in some segments of the industry. In the semiconductor industry, for example, this trend reflects a tendency toward the disintegration of functions. Until recently, a single company carried out circuit design, foundry service, and sales. In the past few years, third parties have provided manufacturing foundry services more and more often. Firms in the United States and other countries have emerged as design and sales houses while outsourcing the foundry service to Taiwanese companies. By 2005, specialized foundries without their own sales activities will be producing about 30 percent of all semiconductor products.[51]

The decrease in the number of U.S. firms manufacturing semiconductors, increasing vertical integration resulting from strategic alliances, and greater dependence on Southeast Asia for manufacture of a large share of the world's semiconductor requirements pose a potential risk to semiconductor availability for U.S. equipment manufacturers.

GOVERNMENT GOALS AND ROLE

Government policies must consider the critical uncertainties affecting the future of the electronics industry to enhance the competitiveness of U.S. corporations in the global economy. The government should act upon the following policies:

- Sponsor high-risk, high-cost R&D expenditures
- Support business investment in people, education, and processes
- Implement policy changes to assist the military in keeping pace with rapid technology advances and in fostering cost savings
- Advocate minimizing tariffs and taxes on electronic commerce while continuing to support intellectual property rights internationally
- Foster cooperative R&D agreements to maintain the U.S. lead in semiconductor design
- Provide regulatory incentives for industry to share proprietary intellectual property to relieve parts obsolescence problems

There are significant shortfalls in information technology research. The government should invest in long-term, high-risk research in such areas as global-scale networks, human–computer interfaces and interaction, and technologies for high-end computing. Carefully structured international cooperation in R&D in these areas may provide long-term economic, strategic, and political benefits that can outweigh short-term security concerns. While minimizing military risks, policymakers must not overly constrain industry in the evolving global environment. Well-considered and crafted policy decisions today enable the electronics industry to reach its full potential and ensure long-term national and global security.

The shortage of skilled workers to support growth in the industry is acutely in need of government attention. As part of the approval for H-1B work visas, Congress increased visa fees and channeled the funds to provide scholarships for disadvantaged students who want to study engineering, mathematics, and computer science, as well as to support federal job training services. Additional efforts to expand the number of students in these fields are necessary, particularly since the decline in the number of students matriculating in these fields seems to be continuing.

The labor shortage poses a particular challenge for the DOD, because it does not want to depend on foreign workers for the development of software or for the manufacture of defense electronics. The DOD has undertaken projects to expand the available pool of software developers. For example, it has undertaken a project with one industry group to train former machinists as software developers.[52]

Government can best serve the defense electronics industry by implementing policy changes to foster cost savings, enforcing antitrust laws to maintain several competitive prime contractors, and helping the military to keep pace with rapid technology changes. In addition, it is important that government monitor further defense industry consolidation to ensure that such consolidation does not reduce competition and hinder innovation. In 1998, the Department of Justice, along with the DOD, disapproved the merger of Lockheed Martin and Northrop Grumman because of concerns that the merger would create an unacceptable degree of market concentration in one company. This action indicates that the consolidation of the prime contractors may come to an end as the government attempts to maintain competition in the industry. The action does not suggest that consolidation among subtier companies yet poses a threat to competition.

The U.S. government has been the force behind the Trade Related Intellectual Property Rights Agreement reached by the World Trade Organization (WTO), which provides basic protections for software for 50 years and rental rights for computer program owners. The WTO also conducts an annual review of the adequacy and effectiveness of intellectual property protections in many countries.[53]

The software industry supports the passage of "fast track" negotiating authority, which allows the President to negotiate trade agreements. "Fast track" authority is seen as necessary for the United States to play a leadership role in keeping global tariffs down, strengthening copyright protections, and challenging software piracy. A new round of trade agreements is expected at the end of 1999. Attention is also essential to ensure that developing countries meet the January 1, 2000 deadline for implementing the Trade Related Intellectual Property Rights Agreement.

Because of the global dominance of the U.S. software industry, the United States must be an advocate for minimizing taxes and tariffs on electronic commerce. In a proposal to the WTO, the U.S. government has called for nations to join in not imposing tariffs on cross-border electronic transmissions.[54] The Administration also subscribes to the position that no customs duties and no new discriminatory taxes should be imposed on Internet commerce.

The export of encryption software continues to be a source of disagreement between government and industry. This disagreement highlights the difficulty of balancing national security and commercial interests. Software companies in the United States report that they are losing a significant share of the encryption market to foreign competition because the United States restricts the export of the most secure

encryption products, which are considered essential to the expansion of electronic commerce. On the other hand, the United States regulates the export of encryption software on the grounds that terrorists or hostile governments may use it to cloak their communications. In December 1998, the United States signed an encryption export agreement with 33 nations. Among its provisions is authorization for packaged software products to include more complex scrambling than U.S. regulations permitted in the past. The agreement seems to put U.S. companies on a more equal footing with foreign competitors.[55] The United States has also relaxed encryption controls for the financial, securities, and medical segments of industry.

Semiconductors are now central to virtually all communications and other electronics, including weapon systems. The United States should carefully monitor further dependence upon a single nation or region for their manufacture and distribution.

The United States needs to maintain its lead in semiconductor design. In 1987, government and industry formed the jointly funded SEMATECH R&D consortium. This nonprofit organization funds research to improve semiconductor-manufacturing techniques. Although all funding to SEMATECH now comes from industry, there have been recent cooperative R&D agreements with national laboratories, such as Sandia.[56] The government should continue to foster such agreements, since they improve the competitiveness of the U.S. semiconductor industry and support the technology base of the laboratories.

In the area of parts obsolescence, the government can provide regulatory incentives for industry to share proprietary intellectual property to help relieve the burden of electronic component redesign. Trademark/patent adjustment to decrease the length of time of property protection is one approach. An approach similar to that used in the pharmaceutical industry, in which a design is trademarked for the period of design and initial manufacturing and "generic" versions of the design are permitted after the trademark expires, would encourage the growth of the third-party vendor market and allow continued support of discontinued parts and components. Industry also has a part to play. Major integrated circuit and component manufacturers should take positive steps through trade associations (e.g., the Semiconductor Industry Association) to alleviate the need for reactive strategies to deal with the problem. These steps may include

- Committing to industrywide notification (through the GIDEP and other commercial databases) of intended part discontinuations and offering reasonable (1-year) time frames for executing lifetime buys of those parts.

- Entering into long-term business arrangements with third-party vendors to provide customers with extended life support for their products.
- Forming an intellectual property bank for circuit designs and processes to ease third-party vendor entrance into the market. This intellectual property bank could also serve as a focal point for royalties and license fees paid to the original manufacturer.

CONCLUSION

The electronics industry has spurred the most dynamic economic boom in this century, and the United States leads the world with innovations and new technological developments in this industry. The Internet is revolutionizing communications, creating a virtual world where people across the globe can eliminate the barriers of time and space. The electronics industry is providing the hardware and software for that capability. World markets are intertwined as never before. Electronic commerce is displacing the stone and mortar store of the 20th century.

The proliferation of new and exciting technologies provides the consumer with a mind-boggling array of electronic toys and gadgets to entertain and reduce the monotony of daily chores. Home entertainment systems will provide multifunctional capabilities for interactive experiences.

Electronic technology will continue to change the face of battle. Smart munitions with pinpoint accuracy and communications systems that provide real-time situational awareness from anywhere in the world are becoming a reality. Whereas the airplane revolutionized warfare in the 20th century, the computer will revolutionize the way armies shoot, move, and communicate in the 21st century.

While the United States enjoys a distinct advantage in electronics technology, the industry has significant challenges to overcome:

- Electronics firms continuously compete with each other for highly skilled personnel in short supply. Education in mathematics and science requires improvement to meet industry needs in the coming decade. Many companies now recruit from other countries to meet the needs of the industry.
- Piracy of software and consumer electronics products negatively affects the U.S. economy by robbing U.S. workers of an estimated 130,000 jobs each year.
- Although the United States leads the world in industry innovation, adequate funding for R&D is critical to maintaining that competitive

edge in the global marketplace, as well as in defense electronics capabilities.

At present, none of these issues significantly affects the ability of the electronics industry to support national defense, but they could if left unattended. Ensuring an adequate supply of skilled, technically trained people to meet commercial and defense needs presents the most immediate challenge. Overall, however, the electronics industry is strong and able to support the national security strategy into the foreseeable future.

As Gordon Moore predicted, the power of the computer chip doubles every 18 months, as cost decreases proportionally. Inexpensive networked computers and enhanced intelligent software systems provide the capability to interface with each other with technological ease. Within the next 25 years, experts predict that humans and machines will communicate and understand each other without the awkward need to put hand to keyboard. Computers will perform a multitude of functions previously done by humans alone. The possibilities are endless.

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[2] In 1996–1997, the software industry generated 619,438 direct jobs and $7.2 billion in tax revenues for the U.S. economy. Price Waterhouse Coopers, Contributions of the Packaged Software Industry to the Global Economy: Executive Summary, October 1998, p. 3.

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[6] "Computers: Software," *Standard & Poor's Industry Surveys,* September 1998, p. 9.

[7] This is not a scientific or natural law; rather, it is a prediction that has proven extremely accurate, based on the technological advances in the past three decades.

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ENERGY

ABSTRACT

Energy is the "stuff" of life. It is a global commodity that literally affects all of humankind. It is the key to the prosperity of the global economy. Sometimes taken for granted, inexpensive, reliable energy enables the national lifestyle in the United States and spurs a growing economy. The U.S. energy industry is robust, fiercely competitive, and technologically attuned to opportunities for change. This report reviews the current status and the future of the energy industry, and it includes specific policy recommendations to ensure the continued growth, prosperity, and security of the United States as the 21st century arrives.

Lt Col Joseph A. Abbott, USAF
Mr. John S. Bartenhagen, Defense Logistics Agency
Mr. Joseph L. Berry, Office of the Secretary of Defense
Mr. E. Scott Bozek, Dept. of Commerce
Mr. Donald L. Damstetter, Dept. of the Army
Col David J. Eichhorn, USAF
CDR Peter F. Grause, USN
Mr. James D. Grembi, Dept. of the Navy
Mr. W. Scott Hale, Dept. of the Navy
LTC Donald P. Kotchman, USA
Col Nedeltcho Mintchev, Air Force, Bulgaria
LTC David S. Pate, USA
CDR Samuel J. Pena, USN
Mr. George W. Solhan, Dept. of the Navy (USMC)
Col Michael G. Therrien, USAF
LTC Jackie L. Vance, USA

Dr. Maureen Crandall, faculty
CAPT Philip Kasky, USN, faculty
CAPT James Reid, USN, faculty

PLACES VISTED

Domestic

Anadarko Petroleum Corporation, Houston, TX
BGE Nuclear Power Plant, Calvert Cliffs, MD
BP/Amoco Corporation, Houston, TX
CONSOL, Inc., Blacksville #2 Mine, Morgantown, WV
Enron Corporation, Houston, TX
Exxon Corporation U.S.A., Houston, TX
Exxon Corporation U.S.A., Baytown Refinery, Houston, TX
Halliburton Corporation, Houston, TX
Koch Industries, Houston, TX
Landmark Graphics Corporation, Houston, TX
Potomac Electric Power Company, Dickerson, MD
Reliant Energy, Inc., Houston, TX
Rowan Company, Gas Platforms, Gulf of Mexico
Solarex, Frederick, MD
U.S. Department of Energy, Washington, DC

International

ARCO Corporation, Caracas, Venezuela
Brazilian Institute of Petroleum (IBP), Rio de Janeiro, Brazil
Brazilian National Petroleum Regulatory Agency (ANP), Rio de Janeiro, Brazil
Conoco Corporation, Caracas, Venezuela
Enron Corporation, Rio de Janeiro, Brazil
ELETROBRAS Company, Rio de Janeiro, Brazil
ESSO Corporation, Buenos Aires, Argentina
Federation of Industries of the State of Rio de Janeiro (FIRJAN), Rio de Janeiro, Brazil
Instituto Altos Estudios de Defensa Nacional, Caracas, Venezuela
National Bank for Social and Economic Development (BNDES), Rio de Janeiro, Brazil
Nucleoelectrica Argentina S.A., Atucha I, Lima, Argentina
PETROBRAS Corporation, Rio de Janeiro, Brazil
Petroleos de Venezuela S.A. (PdVSA), Lake Maracaibo, Venezuela
PdVSA INTEVEP, Caracas, Venezuela
Secretaria de Energia, Buenos Aires, Argentina
Siderar Steel Company, San Nicolas, Argentina
Wholesale Electricity Market Administrator (CAMMESA), Buenos Aires, Argentina
YPF Corporation, Buenos Aires, Argentina

INTRODUCTION

"One drop of oil is worth one drop of blood of our soldiers."[1]
—Georges Clemenceau, World War I

Hyperbole? Absolutely! Times and options have changed, but energy is still the most basic commodity. Energy conversion is the mechanism by which food is produced and biological life maintained. Energy is also the seminal concept. It is equivalent to matter, the "stuff" that makes up the universe. What other industry affects every person's daily life? Reliable, affordable energy is the key to the economic well-being of the United States. It powers our factories and computers, heats and cools our homes, and fuels our transportation systems. Energy is an enabler. It enables commerce, communications, the defense of the nation, and even the ability to earn a living or to make war.

Energy is a global commodity subject to worldwide market forces. For instance, a disruption of the supply of Middle Eastern oil caused the oil price shocks of the 1970s. This disruption dramatically drove up the price of oil over a very short period of time. That price increase encouraged the development of other sources and alternative supplies of energy. Today, the United States is more dependent on imported oil than in 1973, but the majority of oil imports now come from the Western Hemisphere.

The oil price shocks of the 1970s are burned deep into the psyche of most U.S. citizens. Virtually everyone experienced some effect. The gross domestic product (GDP) dropped. The automobile industry began to emphasize efficiency and economy rather than flash and size. The increased costs of electricity spurred efficiency efforts to such an extent that, within a short period of time, there was an excess of electricity generation capacity.

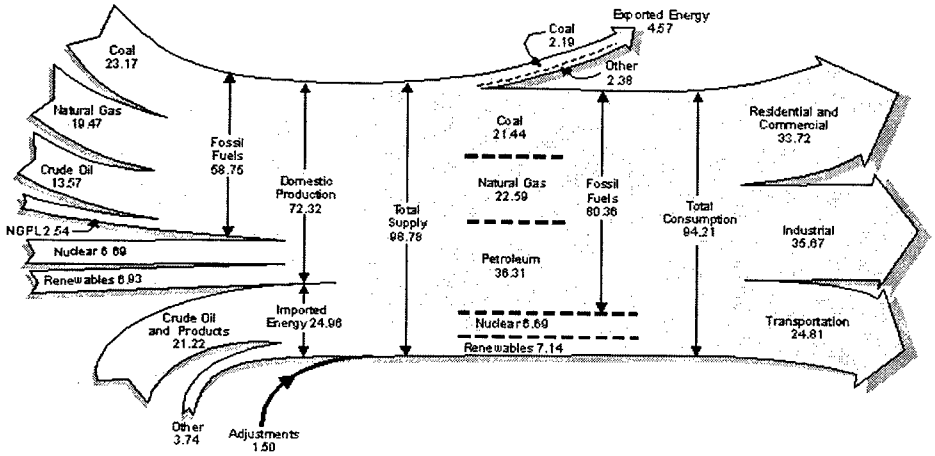
Energy is also personal. Ice storms over the winter of 1998–1999 knocked out electrical power to regions in suburban Washington for as long as 5 days. This became front-page news. Many frustrated homeowners even wrote their Congressmen in an attempt to get power restored.

THE ENERGY INDUSTRY DEFINED

Energy can be thought of in terms of a flow process from production to consumption. On the production side are the energy sources, or raw products: coal, natural gas, crude oil, uranium, renewables, and alternatives. These sources are either produced domestically or

imported. The U.S. 1997 energy flow, in terms of quadrillion British Thermal Units (BTUs), is shown in Figure 1.[i]

Figure 1: 1997 U.S. Energy Flow



Source: *Annual Energy Review 1997*, Energy Information Administration, http://www.eia.doe.gov/emeu/aer/contents.html, May 26, 1999

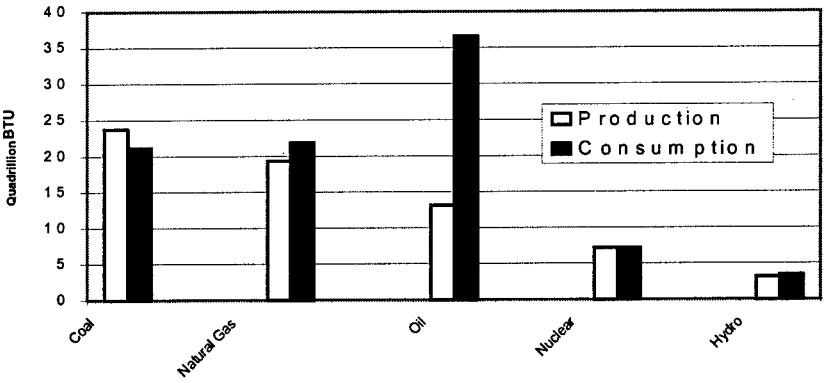
The production sources, listed on the left, are refined or converted. The energy is then distributed to the three basic sectors of the economy, residential and commercial, industrial, and transportation, where it is ultimately consumed.

Primary Energy Sources

Domestic production makes the United States self-sufficient in coal, nearly so in natural gas, and reliant on imports for nearly two-thirds of its oil. Figure 2 shows U.S. production compared to consumption. Differences generally reflect exports (coal) or imports (oil and natural gas). Oil is the largest single energy source consumed in the United States, followed by natural gas and coal. These three industry segments provide approximately 88 percent of U.S. energy needs.

[i] A British Thermal Unit is the quantity of heat needed to raise the temperature of 1 pound of water by 1 degree F at or near 39 degrees F. BTU equivalents: 1bbl of crude oil: 5.8 million; 1Mcf gas: 1.03 million; 1kWh electric: 3.4 thousand; 1 ton coal: (about) 22 million.

Figure 2: U.S. Energy Production/Consumption



Source: *Monthly Energy Review*/May 1999, Energy Information Agency, DOE www.eia.doe.gov/emeu/mer/contents.html, May 27, 1999.

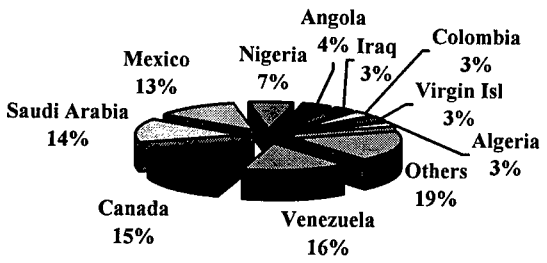
Oil. Approximately 40 percent of the energy consumed in the United States comes from oil. In 1998, the United States produced the equivalent of 13.2 quadrillion BTUs of oil and imported the equivalent of 23.4 quadrillion BTUs (Figure 2). The oil industry's activities can be defined as upstream (exploration and production) and downstream (refining and marketing). Crude oil production represents the supply side of this industry. The United States consumes 26 percent of the world's crude oil production.[2] When adjusted for inflation, today's price of crude oil is near an all-time low, making oil cheaper to buy than bottled water.

The oil industry is a global one; suppliers are scattered all over the world, although certain areas hold predominant reserves. Studies of estimated ultimately recoverable (EUR) global oil have concluded that the EUR amount falls within the range of 1,800–2,200 billion barrels.[3] These estimates periodically increase with the opportunities to explore and produce crude oil in different parts of the world that arise as politics and technology change. For example, we visited with a premier oil services firm, Halliburton Corporation. We learned of the integrated services provided by Halliburton and their subsidiaries Landmark Graphics and Brown and Root. Landmark uses its state-of-the-art technology for integrating information into a common database to reveal and model additional sources of oil. Those new sources can then be exploited by means of directional drilling techniques such as those performed by Rowan Company for Anadarko in the Gulf of Mexico. Similar technologies allow the Brazilian oil company, PETROBRAS, to

perform deep-water drilling in their offshore area known as the Campos Basin at depths unachievable a decade ago.

The dependency of the United States on imported oil is much greater today than it was before and during the oil crisis of 1973. Then, U.S. crude oil production was more than 9 million barrels per day, and net imports were more than 3 million barrels per day.[ii] In 1998, U.S. crude oil production was slightly more than 6 million barrels per day; imports, 8.6 million barrels per day.[4] The United States has, however, de-emphasized reliance on imports of Middle Eastern oil and increased reliance on imports from the Americas.[5] Venezuela now leads the list of suppliers by providing 16 percent of U.S. imported oil (Figure 3). We visited with PdVSA in Venezuela and saw their oil field at Lake Maracaibo and their R&D facility INTEVEP, where they are developing new technologies to recover and use the extra-heavy crude oil, bitumen, found in massive reserves along the Orinoco River. Should these technologies mature, Venezuela's recoverable oil reserves may surpass those of Saudi Arabia. These new reserves would provide years of supply while keeping the price of oil products affordable. One company is already processing gasoline from bitumen, and soon more will be doing the same.

Figure 3: 1998 Sources of Imported Oil



Source: American Petroleum Institute
http://www.api.org/edu/y2k.htm, May 26, 1999

Downstream, refining is the process of distillation of crude oil to produce gasoline, jet fuel, kerosene, distillate fuel oils, residual fuel oils, lubricants, and other petrochemical products. Marketing consists of the retail operations associated with selling the products. We visited Exxon

[ii] A barrel is equal to 42 U.S. gallons.

and Enron refineries in Houston and were impressed with the range of consumer products derived from oil.

Two trends mark refining operations: mergers and increased efficiencies. These trends have led to a large number of closures, but even so, U.S. refineries have kept pace with demand. The top six refiners are projected to control 41 percent of the U.S. refining capacity. Exxon-Mobil will have the most capacity, with 12 percent, followed by BP-Amoco with 9.percent.[6] BP-Amoco's capacity will increase further with the projected acquisition of ARCO. There has been a trend in the growth of independent refiners, as distinguished from vertically integrated oil companies. Over the 8 years that ended in 1998, the independent refiners have increased their capacity from 8 to 23 percent of total U.S. refining capacity.[7]

Natural Gas. The source of about 24 percent of the energy consumed in the United States is natural gas. In 1998, the United States produced the equivalent of 19.4 quadrillion BTUs of gas and imported the equivalent of 2.5 quadrillion more to meet demand (see Figure 2). The gas-processing industry gathers, treats, conditions, and delivers more than 18 trillion cubic feet of natural gas per year into the U.S. energy economy, the equivalent of about 3 billion barrels of crude oil.[8] Natural gas is distributed in two basic forms, dry and cryogenically liquefied natural gas (LNG). Producers also manufacture natural gas liquids (NGLs) at petroleum refineries or natural gas–processing plants.

Global recoverable natural gas reserves have doubled during the past 20 years, from 764 trillion cubic feet to 1,517 trillion cubic feet, with the former Soviet Union and the Middle East (primarily Iran) owning 70 percent of these reserves.[9] The U.S. reserves-to-production ratio now stands at 70 years compared to 45 years in 1988.[10] These increases are a result of capturing data on existing reserves that had not previously been included and identifying new gas fields in conjunction with coal-bed methane production. Major U.S. supply basins are located in the Gulf Coast area, Appalachia, and the Rocky Mountains.

Since U.S. deregulation in the 1980s and 1990s, the natural gas industry has evolved into four activities: production, transportation, distribution, and marketing. Production encompasses exploration, extraction or drilling, and the processing necessary to make gas ready for shipment. Independent producers, or non-major oil companies, account for the majority of the total U.S. production of natural gas.

Approximately 250 companies make up the U.S. gas-processing industry. They operate more than 600 gas-processing plants in the United States. Average plant capacity is around 110 million cubic feet per day, which is about 70 percent of capacity.[11]

In the United States, interconnected pipelines transport and deliver natural gas to customers, principally from the producing areas in the Gulf states and offshore areas of the Gulf of Mexico to the Northeast and Midwest. This geographical mismatch between production and consumption centers is forcing innovation and price reduction in the transportation of natural gas, as the natural gas industry competes for a greater share of the total energy market.

With the advent of new technology, the construction of more natural gas pipelines, and deregulation, the natural gas industry will expand rapidly in the future. According to projections of the Department of Energy (DOE), world gas consumption will grow by 3.3 percent annually through 2020. Domestic natural gas production is projected to increase from 18.9 trillion cubic feet in 1997 to 27.4 trillion cubic feet in 2020.[12] We viewed some of the new technology at Enron's fully automated gas pipeline center in Houston. We were impressed with Enron's efforts in South America to bring natural gas to a market hungry for energy.

While the supply of natural gas will increase, so will demand. Natural gas prices are expected to rise somewhat for the industrial, electricity, and transportation sectors. Prices should decline through 2020 for the residential sector (in constant 1997 dollars), however, from $7.00 per 1,000 cubic feet in 1997 to $5.91 in 2020. The prices in the business and commercial sectors are projected to decline (in constant 1997 dollars) from $5.79 in 1997 to $5.24 in 2020.[13] These decreases reflect declining distribution costs to these sectors due to anticipated efficiency improvements in an increasingly competitive market, where most customers buy natural gas through local distribution companies.[14]

Coal. The only U.S. energy source for which exports are greater than imports, coal accounts for 23 percent of the energy consumption in the United States. In 1998, the United States produced the equivalent of 23.8 quadrillion BTUs of coal, surpassing U.S. domestic demand (see Figure 2). It is found in 27 states, and the estimated total national resource is 3.9 trillion tons. This level of reserves is the greatest of any single nation, representing about 23 percent of the world total, and it generates some $93 billion in annual business income.[15] These reserves represent approximately a 250-year supply at present consumption rates.[16] Coal is used primarily in the generation of electricity.

Three main trends have marked the production of coal in the United States: (1) a shift westward in U.S. coal production; (2) an increasing reliance on improved mining technology, resulting in an increase of 6.3 percent in annual productivity, while employment has been decreasing; and (3) consolidation. From 1976 to 1991, the number of mines decreased by 50 percent, but total production increased by 45 percent,

and the average mine size tripled. By 1991, as little as 7 percent of the nation's mines were producing two-thirds of U.S. coal.[17]

According to officials at CONSOL in West Virginia, long-wall mining technology has made the company's Blacksville #2 Mine capable of producing approximately 23,000 tons of coal per day. The limited number of personnel involved in mining operations is striking. CONSOL officials expressed concern over the rising average age of their miners, which is causing a growing disparity in age between younger management and the aging miners.

The average mine-mouth price of coal is projected to decline from $18.14 per ton in 1997, to $12.74 per ton (in 1997 dollars) in 2020.[18] This projected decline is a result of increasing productivity in the industry, more production from lower cost Western mines, and competitive pressures on labor costs as a larger number of miners compete for an increasingly smaller pool of available jobs. The DOE expects coal production to grow from 1,099 million tons in 1997 to 1,358 million tons in 2020, an average increase of 0.9 percent a year, to meet rising domestic and export demand.

Nuclear Power. In the United States, nuclear power accounts for 7.2 quadrillion BTUs, or 8 percent of the energy consumed (see Figure 2). In 1997, 105 nuclear reactors supplied 21 percent of the country's electricity.[19] The period of rapid nuclear expansion ended abruptly in 1973 after the first oil price shock. The cost of oil and electricity went up, which led to economic disruption, recession, and dramatic electricity conservation measures. Annual growth in the GDP slowed from 7 to 2 percent, and doubling time for energy requirements increased from 10 years to 35 years. Despite the post-1973 cancellations of 108 nuclear and 93 fossil-fuel plants that were on order, a surplus of electricity generation capacity continued for more than 25 years.[20] More than 70 percent of today's U.S. nuclear power plants are expected to remain competitive, even if the electricity industry's marginal cost per kilowatt-hour drops from its current level of about 4 cents to below 2 cents.[21]

In the United States, fear of accidents, increased regulation, and the long construction time for nuclear power plants have stunted the development of the nuclear power industry. The same nuclear power plant design that can take more than 15 years to build in the United States is being built in 4–6 years outside the United States. Standard designs would eliminate unneeded and redundant reviews and make nuclear power plant construction a viable option.[22] We visited BGE's Calvert Cliffs, Maryland, nuclear plant and the Atucha I nuclear power plant in Argentina and saw firsthand the differences in oversight of plant operations.

The nation is still struggling with decisions about the disposal of high-level nuclear waste. So far, more than 19,200 cubic yards of high-level nuclear waste from more than three decades of plant operations have been collected and have no place for disposal.[23] The volume, which is small by today's landfill standards, is not the problem, however. The problem is the isolation required. Delays in approving the Yucca Mountain underground repository have set back a permanent solution for nuclear waste disposal.[24] BGE and others have temporarily solved this problem by expanding semipermanent on-site storage, such as that seen at Calvert Cliffs.

These problems are not limited to the United States. Argentina has two operating nuclear power plants and a third planned. At the Atucha I plant, officials indicated that they experience problems similar to those experienced by the U.S. nuclear industry—both the "not-in-my-backyard" syndrome and the problem of nuclear waste disposal. They have developed interim on-site waste storage similar to that in the United States. Officials also expressed concern over the cost of constructing nuclear power facilities. In fact, some expressed doubt that the third facility will ever be completed due to the expense.

Renewables. Providing approximately 11 percent of the nation's electricity, renewable energy falls largely into three basic categories: water, wind, and solar. The United States generates the equivalent of 3.3 quadrillion BTUs of energy annually from renewable sources, of which the vast majority is hydropower (see Figure 2).

At the margin, hydropower is the most cost-efficient form of electricity produced.[25] Each kilowatt-hour of hydroelectricity is about half the cost of any other competing energy resource. Brazil generates about 95 percent of its electricity through an extensive system of hydroelectric dams. Brazil sells excess electricity to Argentina when hydropower is plentiful, while Argentina plans to sell Brazil power during times of drought.

The Federal Energy Regulatory Commission (FERC) and the DOE conducted studies that show the United States has significant untapped hydropower resources. Less than 3 percent of the more than 75,000 dams in the United States are used to generate electricity.[26,27]

Costs for wind energy have steadily declined since the early 1980s; however, without continued federal tax credits, it is not competitive.[28] The amount of wind resource land areas available for usable wind power is approximately 460,000 square kilometers. This is only about 6 percent of the total U.S. land area, but it could provide about 500,000 megawatts of electricity.[29]

The solar renewable energy market—composed of photovoltaics and solar thermal—though continuing to grow, still produces less than 1 percent of the total electricity used in the United States. Viewed by some as the ultimate answer for an unlimited, nonpolluting source of electricity, solar technologies continue to suffer debilitating limitations. First, they work well only in geographical areas with a great many sunny days. Second, they do not produce the quantities of power (megawatts) that people in developed nations require. Although the technology at Solarex is impressive, for example, its massive solar array is insufficient to power its own facility. Finally, in the developed world, they usually suffer an economic disadvantage compared to more traditional, less costly sources of electricity.

Secondary Energy Sources

Secondary energy sources include biomass, synthetic diesel and hydrogen.

Biomass. Because biomass technology focuses on naturally produced substances, it covers a broad spectrum of energy-producing sources. The products with alternative fuel applications are

- Ethanol. Fermenting biomass, most commonly corn, produces ethanol, or grain alcohol. It is mixed with gasoline in a ratio of 85 percent ethanol and 15 percent unleaded gasoline to produce gasohol, thus conserving gasoline. The main disadvantage in the widespread use of ethanol is that it is much more expensive than gasoline. Without subsidies, this fuel is not commercially competitive.
- Methanol. Produced from natural gas or through fermenting biomass (commonly referred to as wood alcohol in the latter case), methanol is not yet proven to be economically feasible to produce for widespread use as a fuel. Additionally, environmental problems are likely to reduce its use even further in the near future.
- BioDiesel. Oils derived from animals, plants, or micro-algae are normally mixed with traditional diesel fuel in ratios of 80 percent diesel fuel and 20 percent oil-derived products to form BioDiesel. As animal and vegetable oils are displaced from the U.S. food market, they become more economically viable for use as fuel additives. BioDiesel research, when teamed with micro-algae developments, could result in almost 50 percent more diesel fuels in the U.S. market. The primary disadvantage of BioDiesel is the cost. It requires government subsidies in order to compete in the open market.

Synthetic Diesel. Ford Motor Company and DaimlerChrysler have been working on synthetic fuel systems produced from coal and wood as a way to meet increasingly stringent mileage standards, as well as to reduce CO_2, SO_2, and NO_2 emissions. This fuel is still in the early research phase.

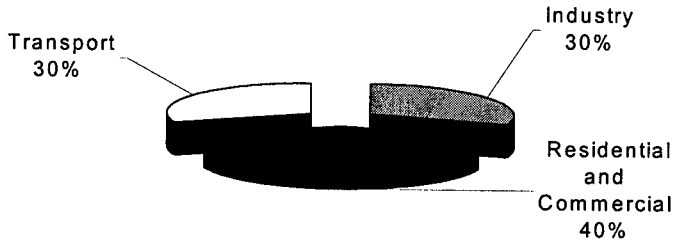
Hydrogen. Many scientists believe that hydrogen is the fuel of the future. It has been called the most alternative of all the alternative fuels. Because it is the most common element on earth, hydrogen could provide an endless source of energy. Hydrogen, however, is currently expensive and difficult to generate, handle, and store.

The preferred method for hydrogen use is in a hybrid fuel cell, which uses a transformer to convert a fuel such as natural gas, gasoline, or methanol into hydrogen that is then combined with oxygen to generate electricity. DaimlerChrysler has announced that, beginning in 2005, it will produce 100,000 methane fuel cell engines annually.[30] Methane fuel cells provide a natural transition to hydrogen. There is also a strong environmental benefit, as an engine powered by pure hydrogen emits only pure water.

Energy Consumption

Energy is consumed in three major sectors of society: residential and commercial, industrial, and transportation (Figure 4).

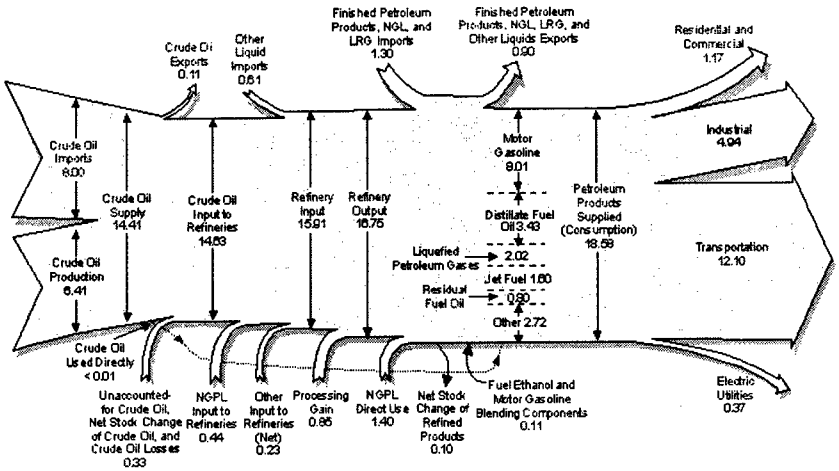
Figure 4: 1998 Energy Consumption (BTUs)



Source: *1998 EIA Energy Outlook*

Oil. The 1997 U.S. flow of oil, in millions of barrels per day, from production through the refining process to its ultimate consumption is depicted in Figure 5.

Figure 5: U.S. Oil Flow (millions of barrels/day)



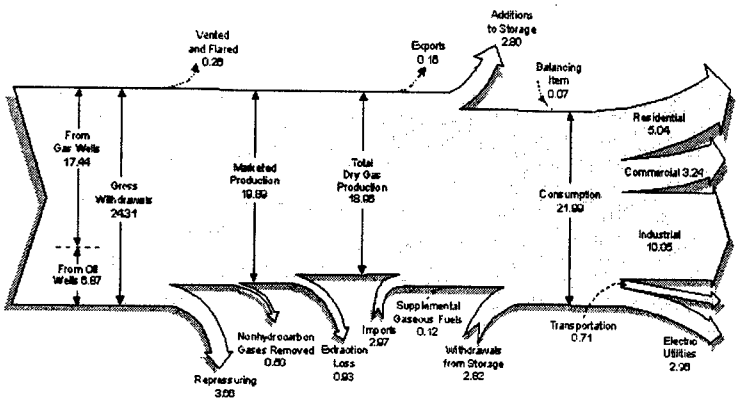
Source: *Annual Energy Review 1997*, Energy Information Administration, http://www.eia.doe.gov/emeu/aer/contents.html, May 26, 1999

The transportation sector is the largest oil consumer (65 percent in 1997) and is the only end user with anticipated annual demand growth above 1 percent.[31]

Downstream, major oil companies have refocused their retail marketing efforts and consolidated in the geographical areas where they have had the most success. Since 1984, the number of branded outlets owned by major oil companies has decreased by 65 percent.[32] Independents and foreign owned refiners are doing just the opposite. In contrast, independents are establishing captive markets with an efficient product distribution network between the refinery and the retail outlet. Such a network allows refiners to keep running at high utilization rates (above 92 percent) and to maximize profits. Also, retail margins generally run countercyclical to refining margins.

Natural Gas. The 1997 U.S. flow of natural gas in terms of trillion cubic feet is shown in Figure 6. By 2003, domestic demand for natural gas will surpass that of coal.[33] The most rapid growth market is for electricity generation, with gas projected to increase its market share from 14 to 33 percent by 2020. Natural gas use in the residential sector is projected to grow by 0.6 percent a year through 2020 due to the increase in the average size of homes and the trend toward the use of natural gas as the primary home energy source.

Figure 6: 1997 U.S. Natural Gas Flow (trillions of cubic feet)



Source: *Annual Energy Review 1997*, Energy Information Administration, http://www.eia.doe.gov/emeu/aer/contents.html, May 26, 1999

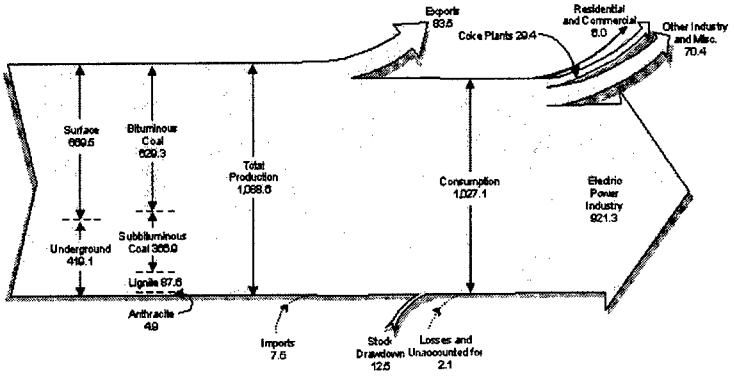
The industrial sector, which includes agriculture, mining, construction, and traditional manufacturing, is expected to increase its energy use by 8 percent a year.[34] Electricity and natural gas (given its ease of handling) are the major energy sources for the industrial sector. Because relatively low prices are projected for natural gas, an increase in consumption of 26.2 percent is anticipated by 2020.[35] Given the increasing demand for low-cost energy, a projected 1,210 new plants with a total of 363 gigawatts of capacity will be needed by 2020. Natural gas or a combination of both oil and natural gas is expected to fuel 88 percent of those new plants.[36]

In South America, numerous pipelines are planned or under construction to transport natural gas from its sources to areas where it can be used. Enron Corporation and others are actively involved in building these pipelines to meet the growing demand for natural gas.

Coal. The 1997 flow of coal in the United States, from production through consumption, is shown in Figure 7. In 1996, coal accounted for 26 percent of the world's primary energy consumption and 36 percent of the energy consumed worldwide for electricity generation. In the United States, it is the nation's most economical source of power, accounting for 55 percent of electricity production.

For the next 20 years, coal is projected to have declining prices, increased supply, and a secure hold on its prominent place in electricity generation. It has been estimated that U.S. electricity demand will grow by 1.4 percent per year through 2020; however, the overall share of coal-generated electricity will decline slightly (3–5 percent) by 2020, because

Figure 7: U.S. 1997 Coal Flow (millions of short tons)



Source: Annual Energy Review 1997, Energy Information Administration, http://www.eia.doe.gov/emeu/aer/contents.html, May 26, 1999

market restructuring and environmental constraints appear to favor the construction of less capital-intensive and more efficient natural gas generation technologies.[37]

Nuclear Power. In 1997, nuclear power plants supplied 21 percent of the United States' electricity.[38] Worldwide in 1997, 17 percent of the electricity came from nuclear power.[39]

Between now and 2015, the closure of 46 U.S. nuclear power plants is scheduled. Each utility company is free to apply for an extension of its operating license. Originally, the Nuclear Regulatory Commission required 15–20 years for review of extension applications, but the process can now take as little as 29 months.[40] Streamlined regulatory oversight could save each nuclear power plant—and ultimately, the nation's electricity consumers—$10 million per year.[41] As of this writing, only two facilities have applied for an extension. One of them, the Calvert Cliffs facility in Maryland, is optimistic that its application will be approved within the next few months. There are no new nuclear facilities presently planned.

Renewables. Today, 69 percent of the renewable energy produced is used for electrical power.[42] Hydropower and wind power are economically feasible, reliable, and environmentally sound approaches to the generation of electrical power. Despite falling costs, the principal hurdle seems to be the high initial financial outlays. The prospects for solar energy, which accounts for less than 1 percent of the electricity produced in the United States, are dim. Without a technological breakthrough to increase the efficiency of the solar collectors, this sector of the energy industry will be confined to niche markets in developed

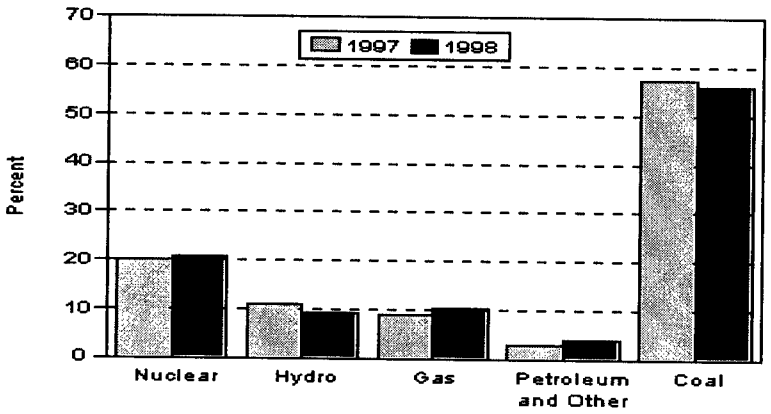
nations and electrification for low power usage in developing countries. Enron has recently divested itself of its solar interests; Solarex, however, is attempting to exploit this niche solar market and is currently a profitable company

Brazil has perhaps the most developed renewable sector in the world. An incredible 96 percent of the electricity produced in Brazil is derived from hydropower. Along with Paraguay, Brazil maintains the world's largest hydrocomplex, the Itaipu facility with a capacity of 12,000 megawatts.[43] The Brazilian state company responsible for planning electrical development, ELETROBRAS, feels certain that investor funding can be obtained to complete additional hydroelectric projects.

Alternatives. Of the total U.S. energy consumed today, alternative fuels provide only a minute amount. With the possible exception of hydrogen, this sector is not expected to grow substantially in the foreseeable future. There are many who believe that hydrogen will supplant petroleum as the fuel of choice over the next century, because hydrogen-powered fuel cells offer the potential for grid-free electricity generation and pollution-free transportation. Unfortunately, the high production costs of fuel cells in comparison to the low costs of other fuel sources keeps this technology commercially cost-prohibitive. In recent years, however, fuel cell production costs have declined dramatically.

Electricity. Figure 8 shows the percentage of raw materials used in the production of U.S. electricity during 1997 and 1998.

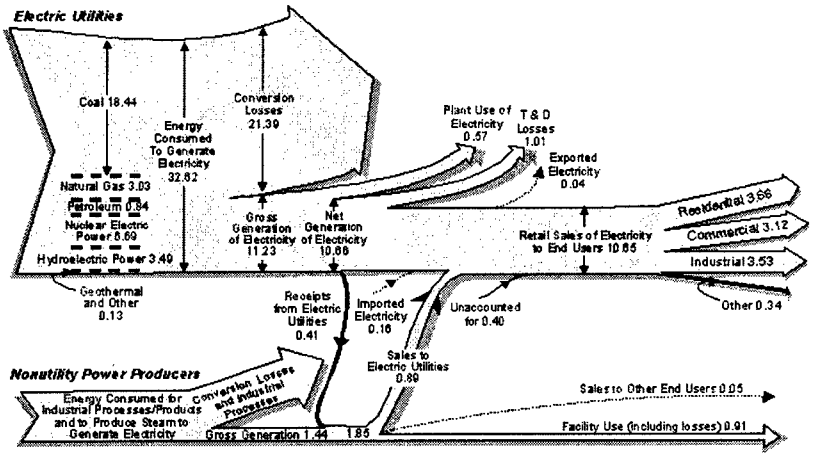
Share of Electric Utility Net Generation by Energy Source, 1997 vs. 1998



Source: Energy Information Administration, *Electric Power Monthly, March 1999*, DOE/EIA-0226(99/03) (Washington, DC, March 1999); Form EIA-867, "Annual Nonutility Power Producers Report," and 1998 estimates for 50 power plants

The flow of this electrical power generation, in terms of quadrillion BTUs is depicted in Figure 9.

Figure 9: Electrical Power Generation Flow (quadrillion BTUs)



Source: *Annual Energy Review 1997*, Energy Information Administration, http://www.eia.doe.gov/emeu/aer/contents.html, May 26, 1999

CHALLENGES

The main challenges confronting the energy industry today are environmental concerns and the technological development necessary to mitigate those concerns, deregulation of the electricity market, management of diverse energy sources, and the participation of the United States in the establishment of environmentally friendly energy sources in the developing world.

Environment

Global warming from fossil-fuel gases has received much attention in the last decade, and the Kyoto Protocol addressed this issue in December 1997. There are, however, many uncertainties as to the validity and magnitude of global warming, its causes, and its timing. It is not certain that global warming is even a valid concern, although the reduction of carbon emissions is a major issue in all markets of the energy industry. Even though the Kyoto Protocol has not been ratified, the Clinton Administration has signaled its intention to abide by Kyoto restrictions. These restrictions could adversely affect the future of fossil fuels unless technological advances can drastically reduce emissions.

The challenge is to determine the impact of carbon emissions on the environment and the least economically disruptive means to mitigate that impact. There is considerable dispute over the severity of the socioeconomic effects should the Kyoto Protocol be adopted.

Disposal of radioactive waste generated by nuclear power plants is another challenge that remains. In response to a lawsuit by utility companies, a federal court has ruled that nuclear utility owners are entitled to damages for the government's failure to dispose of its radioactive waste. The yearly volume is around 2,000 metric tons, and the federal liability could reach as high as $53 billion.[44] The proliferation of foreign nuclear plants makes nuclear waste disposal a global challenge.

Continued research and development are necessary to develop safer, cheaper, and environmentally friendly nuclear fuels while simultaneously developing other renewables to meet niche energy needs.

Deregulation of Electricity

The vertically integrated monopoly of the U.S. electricity supply is being dismantled as individual states have begun to embrace deregulation and competition. In some states, consumers can already select their electricity provider. Further deregulation is coming in the future, and the challenge is to establish consistent national rules and regulations across all state borders. Additionally, upgrades to the electrical transmission grid are necessary so that power can be sold on spot and futures markets and be delivered within the North American Free Trade Agreement (NAFTA) geographical market with a minimum of government regulation.

The United States could look to Argentina as a model of successful privatization of the electricity industry. As a result of an electricity shortage of crisis proportions during 1988–1989, Argentina aggressively embarked upon privatization. Under its system, generation companies compete to sell electricity to transmission companies through a clearinghouse known as CAMMESA. Transmission companies charge a carrying fee to the distribution companies. CAMMESA, a nonprofit company owned jointly by the government and the power companies, is key to this process. It monitors the spot prices of electricity and sells the lowest cost first. This model has brought efficiency and reliability to the Argentine electricity industry

Management of Energy Diversity

The United States must have continued access to plentiful forms of energy (including oil, natural gas, coal, nuclear power, and renewables) from a wide range of suppliers, both domestic and foreign. The challenge is to continue the development and application of technology and know-how in domestic and foreign markets in ways that reduce U.S. energy dependence upon imported oil and diversify the sources of energy used within the United States.

DOE Investment

The DOE's investment portfolio is diverse and broad-based, but appears not to integrate basic research and basic science. As a result, it is difficult to tell if the portfolio is adequately resourced to achieve the goals of the Comprehensive National Energy Strategy. The investments in hydrogen and computation/information technologies appear to be robust, while investments in superconductivity and fusion are difficult to track and are insufficient to adequately exploit their revolutionary far-term promise.

Assistance to the Developing World

An international energy assistance program offers multifaceted opportunities for the United States and its energy industry. The privatization wave in the developing world and the massive need for energy sources have opened a tremendous potential for exploration, production, and supporting infrastructure for all energy-related industries. With their know-how, U.S. companies can provide a definite competitive advantage while promoting environmentally friendly energy sources. This involvement could also bring the United States to the forefront in the global environmental protection area vis-à-vis the mandates of the Kyoto Protocol. The challenge is to match the resources and markets with technology and capital as enablers, all within an open-market framework. The U.S. focus should shift from the East–West priorities of the current century to a North–South emphasis for the next century. The result could be a Hemispheric Co-Prosperity Energy Alliance. Although there are questions about industry's willingness to commit capital for a long-term payoff and the U.S. government's willingness to a geopolitical course change, there is no question about the mutual advantages to U.S. participation in the trade organizations with an agenda oriented toward energy.

OUTLOOK

Fossil Fuels

For the foreseeable future, fossil fuels will continue to be the dominant energy source. In 1998, fossil fuels accounted for 85 percent of the energy produced in the United States and 88 percent of the energy consumed.[45] The energy demand in the United States is forecast to increase by 1.1 percent per year from 1997 to 2020.[46] The transportation sector leads the way in increased consumption with an annual increase of 1.7 percent each year between 1997 and 1999. Residential, commercial, and industrial demand are projected to increase by 0.8 percent, 0.7 percent, and 0.8 percent, respectively, per year from 1997 to 2020. When these rates of energy demand growth are compared to the projected GDP growth rate of 2.1 percent over the same period, it becomes obvious that the United States will become more efficient and energy use per dollar of GDP will continue to decline.

Crude oil consumption is projected to increase 18.3 percent over today's level by 2005. The projected growth in demand for developing countries and Eurasia—30.7 percent and 31.2 percent, respectively—will continue to outpace the projected energy demand growth of the Organization for Economic Co-operation and Development (OECD) countries, which is forecast at 10 percent.[47]

Despite the forecast for increased demand in the industrialized and developing countries, fossil fuels will remain plentiful and inexpensive, compared to alternate energy sources. The current oil, gas, and coal reserves are sufficient to meet this increased demand. Technological advances have substantially increased the efficiency of coal mine operations, as well as oil and gas exploration and production, thereby increasing known reserves. On the other hand, fossil fuels are heavy polluters and an ultimately finite resource.

In the absence of war, the threat of disruption to oil supplies is low. The United States imports oil from diverse sources, thus mitigating the threat of disruption, price escalation, and volatility. Additionally, oil-producing nations are dependent on oil revenues, and the marginal costs of producing an extra barrel of oil are low in most oil-prolific areas. Thus, the oil-producing nations have incentives to produce additional oil, increasing the worldwide supply. For these reasons, historical attempts to cut back on production by the Organization of the Petroleum Exporting Countries (OPEC) in order to reduce supply and raise prices have failed. The latest attempt at limiting production, however, has shown surprising strength.

Even so, there persists a sense of price uncertainty that, in turn, has created a bank of forecasters and futures traders who focus on the daily issues of this seemingly volatile industry. The New York Mercantile Exchange (NYMEX) has become the world's predominant energy trading forum and has for the last 15 years traded crude oil future contracts. These contracts, besides bringing competitive prices to the oil industry, have limited the oil companies' influence on prices; now, price transparency characterizes spot market activities and cargo movements.[48] The NYMEX prices capture the minute-by-minute active trading results and form the basis for a forward price curve.[49]

Less-than-hoped-for revenues for the oil-producing nations, including Mexico and Venezuela, may create problems. Our southern neighbors' economies have already shown signs of stress. Economic turbulence or decline, especially in Mexico, one of the top three trading partners of the United States, would have a negative impact on the U.S. economy. The resulting political instability could threaten petroleum imports and, in turn, the U.S. economy.

Promising Technologies

Time horizons play a crucial role in forecasting technology. Forecasts of the next 5–10 years are often so predictable that they fall into the realm of market research, while those more than 30 or 40 years away are mostly speculation. The following is a forecast of promising technologies.

Near-Term. The use of synthetic diesel fuels is likely to bring about a 12 percent mileage improvement on a tank of fuel, and fuel cells promise low emissions for powering vehicles.

Mid-Term. In the mid-term, minimizing transmission losses through advancements in superconductivity can make electricity, whether generated by nuclear or conventional means, even more attractive. The DOE has a comprehensive and successful program in high-temperature superconductivity.

Some say the trend in worldwide energy use presages a third fuel age—a hydrogen economy. Although it is fairly easy to retrieve hydrogen from fossil fuels, there are problems in its storage, piping, and use in vehicles. These are not technology problems so much as engineering and economics problems, and they would succumb relatively easily to market forces.

The real promise of hydrogen lies in the fact that it can be produced by splitting water in an electrolysis process. With current technology, this process requires cheap and abundant electricity. In the 1970s, it was

believed that the nuclear industry would provide the electrical power, but economic, safety, environmental, and some hysterical concerns intervened. In 1990, the Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Act directed the DOE to accelerate its hydrogen research efforts, as did the subsequent Hydrogen Future Act of 1996 (Public Law 104-271). The DOE now has a significant hydrogen program executed primarily by the National Renewable Energy Laboratory. It is not clear whether the level of funding (as well as the share of total DOE budget) is appropriate in view of the potential benefit nor whether the hydrogen program is actually focused on the holistic goal of developing a hydrogen industry.

Far-Term. Industry deregulation, availability of natural gas, and efficient turbine technologies will significantly change the electricity landscape. True transformation will not happen, however, until the energy conversion process gets closer to the "physics roots" of the universe. Nuclear fission is a step in the right direction, but it has societal, economic, and environmental problems. All of these are surmountable, but in this era of inexpensive fossil fuels, the national will is lacking.

In the far-term, the promise of fusion as the energy conversion source is extremely tantalizing. The DOE has a program directed at fusion plasma science and plasma containment, and a cooperative venture with South Korea is planned, but these efforts are funded at low levels.

GOVERNMENT GOALS AND ROLE

- The government should defer attempts to embrace the Kyoto Protocol, pending definitive scientific conclusion. Considering the lack of consensus within the scientific community regarding global warming, the costs of this agreement to the U.S. economy (and subsequent impact on its citizens) are unacceptable. Specific research aimed at global climatic consensus must be vigorously pursued.
- Given the continued environmental concerns about emissions, spills, and leaks of all types, the government must ensure funding for research to mitigate the full range of environmentally harmful effects of fuel consumption. The government must also ensure the safe disposal of fossil and nuclear wastes.
- Government-sponsored energy research and development must be reviewed and refocused. This includes mid-term development of promising new energy sources (e.g., fuel cells) and long-term

research on nuclear fusion, solar and hydrogen energy sources, and superconductivity to improve energy efficiency. Collaborative teaming with industry is the preferred approach.

- The states should be encouraged to deregulate utilities rapidly to the maximum extent practicable. The U.S. government should put forth a model deregulation scheme to mitigate non-uniform deregulation that would hinder interstate energy markets.
- The federal government should provide incentives to industry to increase energy efficiency, for example, by reducing electricity transmission losses.
- The government must dispel the incorrect public perception of the dangers associated with nuclear energy with reasoned dialogue within the framework of environmental 'least harm.' It is important to pursue new nuclear plants, to streamline the certification process, and to adopt current nuclear technologies used abroad.
- To assist U.S. energy companies in their competitiveness in foreign markets, the government should ensure that bilateral and multilateral trade/investment agreements include consideration of the energy industry.

CONCLUSION

The energy industry within the United States is robust, fiercely competitive, technologically advanced, and committed to innovation. With extensive coal and natural gas reserves and a broadened array of international petroleum sources, curtailment of the energy sources necessary to ensure continued strong economic growth and national security is not likely for the next 20 years. The near-term potential for clean, new practical energy sources such as fuel cells and high-efficiency gas turbines may enable a full spectrum of environmental mitigation without resort to self-punishment or wealth transfer to developing nations. Furthermore, globalization of energy commodity markets will continue as more countries adopt free market principles. While somewhat lagging behind the United States, the forces of liberalization, globalization, and technology are very powerful in Argentina, Brazil, and Venezuela. The energy outlook for the Western hemisphere and the rest of the world is bright. We approach the 21st century with renewed optimism for a prosperous and secure future.

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ENVIRONMENT

ABSTRACT

The U.S. environmental industry is a diverse collection of services and technologies struggling in a highly competitive and mature domestic market. Today, U.S. environmental practices are not simply the products of a distinct industrial sector, but rather reflect good business decisions in all sectors. The shift to prevention rather than cleanup has resulted in a flat domestic U.S. market. This has forced the environmental industry to look internationally for growth and opportunities, primarily in developing nations. These nations have huge demands for infrastructure projects, especially solid waste disposal, wastewater treatment, and the production of potable water. Because of cultural differences, limited resources, and uncertainty within the market, however, U.S. industry does not appear to have a competitive advantage.

LTC Kurt Andrews, USA
CAPT John Scott Atkinson, Jr., USN
Dr. C. David Brown, Dept. of the Army
Col Guy Dahlbeck, USAF
Mr. Ronald C. Eller, Dept. of the Army
Lt Col Michael A. Giroux, USAF
Mr. Milton E. Hill, Dept. of the Interior
Mr. J. Phil Huber, Dept. of the Army
LTC William R. Johnson, USA
Mr. James D. Love, Dept. of the Air Force
Colonel Pat Ongartitthichai, Royal Thai Armed Forces
LtCol Mark R. Savarese, USMC
Mr. Edward A. Tomchick, Dept. of Labor
Ms. Maureen E. Wylie, Dept. of the Army

Dr. Greg Foster, faculty
Mr. Michael Habib, faculty
Ms. Holly Wise, faculty

PLACES VISITED

Domestic

Aberdeen Proving Grounds, MD
Aerovironment, Simi Valley, CA
ARCTECH, Inc., Chantilly, VA
Bank of America, San Francisco, CA
Bechtel Group, San Francisco, CA
Boeing Company, Seattle, WA
California Environmental Business Council, Redwood City, CA
CH2 M Hill, Santa Ana, CA
Chevron Corporation, San Francisco, CA
Earthtech, Long Beach, CA
EMCON, San Jose, CA
Foster Wheeler Environmental Corporation, Los Angeles, CA
Pacific Northwest National Laboratory, Richland, WA
Port of Los Angeles, CA
Siemens Solar, Camarillo, CA
Sierra Club, San Francisco, CA
Sunshine Makers, Inc., Huntington Harbor, CA

International

ADEG Engineering Consultants, Rio de Janeiro, Brazil
Ambio Engineering, Rio de Janeiro, Brazil
Aracruz Cellulose, Rio de Janeiro, Brazil
Bechtel Corporation, Mexico City, Mexico
CEGESTI, San Jose, Costa Rica
Comision Nacional del Agua, Mexico City, Mexico
Costa Rican–American Chamber of Commerce, San Jose, Costa Rica
DuPont Corporation, Mexico City, Mexico
Environmental Finance Corporation, San Jose, Costa Rica
FEEMA (State Environmental Agency), Rio de Janeiro, Brazil
ICF Kaiser, Rio de Janeiro, Brazil
Johnson Wax, Rio de Janeiro, Brazil
KS Engineering, Inc., Rio de Janeiro, Brazil
National Center for Cleaner Production, San Jose, Costa Rica
National Institute for Biodiversity, San Jose, Costa Rica
U.S. Filter, Mexico City, Mexico
WWP Continental, San Jose, Costa Rica

INTRODUCTION

The U.S. environmental industry is multidimensional and complex. The term *environment* entered the language of public policy debate only in the late 1960s. Accordingly, the definition of environmental industries remains fluid, with older, more established industrial enterprises and newer, technology-based firms referring to themselves as "environmental industries." These industries continue to evolve concurrently with the legal, political, and cultural mechanisms that define any given nation's environmental requirements—laws and regulations, the marketplace, or customs. The environmental industry differs from other traditional industrial sectors in that its products and services have resulted from government mandates that, in turn, resulted from international treaties and federal, state, and local legislation and regulations.

The industry contains both traditional and nontraditional components. Identified by Standard Industrial Classification (SIC) codes, traditional components include laboratory services; consulting services; and air, water, and waste pollution control services. Nontraditional components include an array of non-government organizations that act as policy advocates for single or multiple issues or that assist in emergency or developmental activities in which no traditional business is interested because of significant associated risks or minimal profit opportunities. Both traditional and nontraditional components of the environmental sector affect other major sectors such as the energy, chemical, and automobile industries.

The environmental industry in the United States is at a critical juncture. What was a high-growth industry is now clearly an industry in transition. Most major industrial sectors in the United States have achieved substantial compliance with existing environmental regulations. That, coupled with the adoption of fewer new regulations, has diminished industry demands for environmental services and products. Thus, the U.S. environmental industry has gone through a transition as industry at large has learned that sound environmental practices can be profitable. The most cost-effective way to deal with waste is not to produce it.

National environmental policy is moving the environmental industry toward sustainable development—a policy that fosters concurrent economic growth and environmental stewardship. The U.S. environmental industry is focusing on research and improved technologies, and is seeking out new markets, primarily in the developing countries.

Environmental issues have major national security ramifications. The current U.S. national security strategy makes the link between environmental degradation and national interests clear:

> Decisions today regarding the environment and natural resources can affect our security for generations. Environmental threats do not heed national borders and can pose long-term dangers to our security and well-being. Natural resource scarcities can trigger and exacerbate conflict. Environmental threats such as climate change, ozone depletion and the transnational movement of hazardous chemicals and waste directly threaten the health of U.S. citizens.[1]

THE ENVIRONMENTAL INDUSTRY DEFINED

The 1999 *U.S. Industry and Trade Outlook* defines the environmental industry as one that advances "sustainable development by reducing risk, enhancing cost-effectiveness, improving process efficiency, and creating products and processes that are environmentally beneficial or benign." The industry includes "air, water, and soil pollution control; solid and toxic waste management; site remediation; engineering, design, and consulting services; environmental monitoring; recycling; and industrial and clean process technology."[2]

CURRENT CONDITION

Although relatively flat in the United States, the market for environmental business is one of the fastest growth sectors worldwide. The most authoritative estimates available suggest that the global environmental market will have grown from about $420 billion in 1995 to approximately $600 billion by the year 2010.[3] There will be some growth in U.S. and Western European markets, but these markets will continue to decline as a percentage of world market share (Table 1). The largest growth as a percentage of the world market will be in Asian markets (not including Japan).

Although this global picture appears promising, the U.S. environmental industry is in a period of mergers and acquisitions due to overcapacity, a mature market, and intense foreign competition. The environment in the United States has improved dramatically over the past 20 years, causing environmental issues to take a back seat to other concerns. As a result, market demand—driven by environmental legislation, regulations, standard setting, and enforcement—is shrinking. In 1995, the U.S. environmental industry employed about 1.3 million

Table 1: Global Environmental Market[4]

Region	1995 ($B)	1995 Share (%)	2000 ($B)	2000 Share (%)	Growth (%)
United States	172.1	40.3	209.4	38.5	-1.8
Western Europe	132.3	31	161.2	29.7	-1.3
Japan	67.8	16	81.7	15.0	-1
Canada	11.3	2.6	14.5	2.7	0.1
Latin America	7.4	1.7	13.0	2.4	0.7
Eastern Europe/Russia	6.9	1.6	10.2	1.9	0.3
Australia/New Zealand	6.5	1.5	8.3	1.5	0.0
Middle East	4.0	.9	5.4	1.0	0.1
Africa	2.0	.4	3.2	0.6	0.2
Rest of Asia (less Japan)	16.6	3.8	36.4	6.7	2.9
	426.9		**543.3**		

people (1 percent of the U.S. workforce) and produced more than 23,800 new jobs. According to estimates from Environmental Business International, the U.S. environmental industry reached $176 billion in revenues in 1995, a 4.3 percent increase over 1994. Current figures released by the Department of Commerce show annual revenue growth slowing to 1.2 percent by 1998, however.[5]

Because of a dearth of new federal regulations and lax enforcement of existing regulations, there are likely to be few opportunities for expansion in the U.S. environmental market. In its 1999 industry survey, Standard and Poor's (S&P) portrays a lackluster, fragmented U.S. environmental industry that is suffering from sluggish demand and commoditylike offerings that are typical for a mature market.

U.S. Domestic Picture—Industry at Capacity?

Standard & Poor's divides the U.S. environmental industry into four major segments: water supply and treatment, solid waste management, air pollution control, and environmental remediation.[6]

Water Supply and Treatment. The largest of the four segments is the $82 billion water supply and treatment industry, which is growing at about the rate of inflation. The only ways for companies to grow in this mature market are either to acquire regulated water utilities or to expand into nonregulated markets. In recent years, U.S. Filter-American Water Works—the largest U.S. investor-owned water supply company, with revenues of $995 million—has acquired more than 20 water supply

operations. The intense foreign competition is quite evident in the municipal water treatment subsegment where the giant French water utilities, Vivendi (with revenues of $28 billion) and Suez Lyonnaise des Eaux (with revenues of $15 billion), as well as several British water companies, have been purchasing U.S. water treatment plants. Competition in this sector currently favors foreign firms that have more experience with plant operation and are often able to bring additional "tied aid" or self-generated financing to the table.

Solid Waste Management. The $39.5 billion solid waste management segment of the U.S. environmental industry struggles in a slowly growing market characterized by weak demand, increasing capital costs, an overabundance of landfill capacity, intense competition, and increasingly stringent federal and state regulations. In response to these weak fundamentals, many smaller, investor-owned and municipally run operations are being forced either to close or to sell their operations to large, publicly traded firms.[7]

Air Pollution Control. Weak markets continue to hold back the mature and low-margin $12.5 billion air pollution control segment. Both the automotive emissions control and smokestack pollution control subsegments face an uncertain regulatory environment. Federal legislative support for new regulations that would give this industry segment a boost has not been forthcoming. In the past few years, Congress has dramatically reduced the number of new air pollution regulations passed. The lack of an infusion of any new monies due to budgetary constraints has forced both the federal Environmental Protection Agency (EPA) and state-level environmental agencies to curtail the enforcement of existing regulations.[8]

Environmental Remediation. The $8 billion environmental cleanup (remediation) industry is also suffering from a weak market and low-margin, commoditylike service offerings. The U.S. government, which initially was a primary source of business for this segment, has been reducing its funding over the last several years. Currently, government remediation funding is used mainly to finance cleanup of old military and Superfund sites, although the effort to restore ecosystem health is also receiving some attention.[9]

It is in this arena—ecological restoration—that there is some potential for market growth. Scientific advances in the understanding of complex ecosystems have come as traditional compliance and remediation business is leveling off. In this market, government agencies with land management responsibilities will be the largest customer, although private firms are likely to increase their restoration efforts as well. There is room for both large firms with engineering and

construction experience and smaller, more ecosystem-focused firms in this market.

As in the environmental industry as a whole, firms in the ecological restoration niche are generally small companies.[10] There are a few firms that span market segments; for example, some of the large engineering and consulting firms have added ecological restoration to their remediation planning and management business. As part of the overall slowdown of the environmental industry as it matures, however, large firms are consolidating or downsizing. This change is fueling the number of small, niche firms positioned to act as subcontractors to leaner large firms.[11] Ecological restoration work is ideal for smaller, subcontracting firms that may specialize in baseline surveys and analysis, design, plant material development and supply, or installation.

Forest products, mining, and agribusiness firms are all potential customers for ecological restoration products and services. For example, large forest products companies such as Georgia-Pacific and Weyerhaeuser not only intensively plant trees in plantations, but also are often required to undertake riparian restoration to ensure that water quality standards are met. Hard rock and strip mining firms are required to clean up mine wastes and restore sites. Agribusiness is involved in soil conservation, water quality management, and wetlands permitting.

There is also a growing international market for ecological restoration services. The market outside the United States is strongest in Canada, Europe, Australia, and Japan. In addition, there is a demand for ecological services or restoration expertise to address problems such as deforestation, desertification, or soil erosion on disturbed sites in the developing world.

Global Picture—Help Needed for U.S. Industry?

If the U.S. environmental industry is to grow, it must seek developing world markets. In the world market, however, the successful company is the one that offers a wide range of affordable solutions to infrastructure problems and tailored packages, ranging from consultation to complete operational management of a site or project. Success in the world market also requires companies to be flexible. In general, U.S. environmental companies have not competed well internationally because they typically do not provide total solution packages; rather, they provide solutions only to part of the customer's problem. This is a challenge that U.S. environmental companies must overcome if they are to renew the health and growth of the industry in the United States.

Developed and developing countries may have different types of impediments to U.S. access or increased market share of their environmental business. Developed countries may inhibit U.S. access by use of conventional market barriers or by use of nontariff barriers (e.g., requirements for technology-specific performance or performance-specific equipment). Developing countries may have limited or no control over the forces that restrict demand in or access to their markets. In such countries, the absence of environmental regulations or enforcement fosters a low demand for environmental technologies. Many native companies may not comply with environmental laws or may choose to pay fines instead of investing in pollution prevention/control equipment or services. Developing countries are also more reliant than developed countries upon external financing from development assistance or multilateral development banks to pay for their environmental investments.[12]

Federal government intervention could assist U.S. environmental companies in competing more successfully in the tougher international markets. The U.S. government could help by guaranteeing payment and liability protection to U.S. firms that provide environmental industry services to developing nations. By doing so, the government could stimulate the U.S. environmental industry abroad while, at the same time, achieving international environmental objectives. Government could also assist by providing economic offsets to developing nations that meet strict environmental goals.

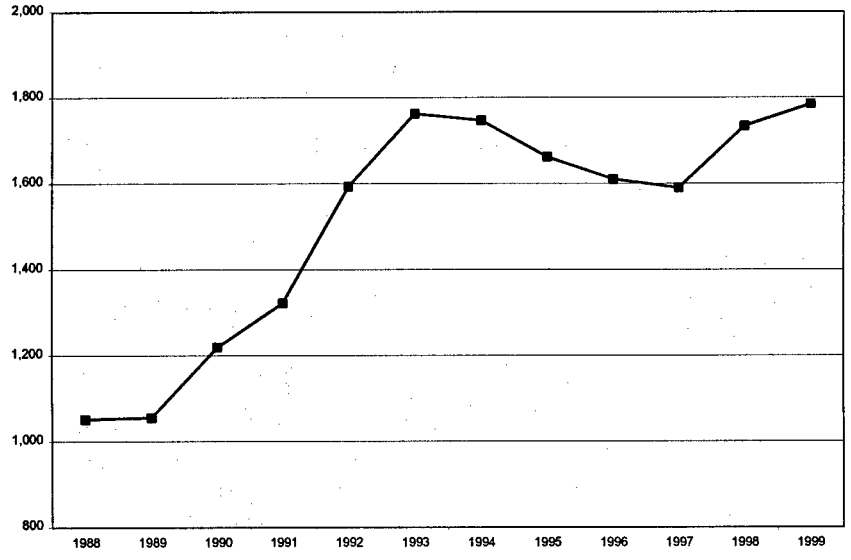
To energize the environmental industry, the United States must regain the sense of urgency and emphasis on the environment that it had in the 1960s and 1970s. One way to provide that stimulus for industry growth is through a greater emphasis on research and development (R&D) for environmental technologies. The United States has been a leader in R&D for most technologies; however, other countries are rapidly catching up. If the United States is to stay ahead of other countries and increase its share of the world market, the nation must take the lead in innovative environmental technologies.

Low rates of private and public investment in environmental technology R&D, a lack of coordination between researchers in the government and private sectors, and inefficiencies in the investment of government R&D resources reduce the rate of environmentally beneficial technology innovation. The rate of environmental companies' investment in R&D, particularly basic research, for new products and services is very low compared with that of other industries. Many U.S. engineering, environmental infrastructure, and service companies make no investments in technology R&D and product development. The

number of companies on the equipment side investing in research continues to decline because of market uncertainties, and companies in this segment invest only about 3 percent of their revenues in research, most of it for short-term product development projects. By contrast, companies in such high-growth industries as semiconductors invest about 10 percent of revenues in R&D.[13] Without public sector support and new policies, this shortfall in environmental R&D will continue to be the case.

The need for more public sector support has been and remains of concern to the environmental industry, as well as to those manufacturing industries heavily affected by environmental issues. These industries need more cost-effective and innovative ways to address environmental issues. Although R&D is the leading edge for those new and innovative solutions, federal R&D budgets have not shown that the country is seriously concerned about the environment. Even though there have been increases in R&D budgets for Fiscal Year 1998 and Fiscal Year 1999 (Figure 1), these increases have been primarily for applied product development rather than early basic research. Even with the increases, the federal environmental R&D budget for 1999 is only 1.3 percent above that of 1993. The energy industry is among those most directly

Figure 1: Environment Research and Development (in millions)



Source: *Standard & Poor's, 1998.*

affected by this trend:. "New technologies on the horizon are likely to have profound effects on the future structure and operation of the electric power industry. Many of the technologies will not come about unless new ways can be found to expand investment in basic technology research."[14]

Trends

Two trends are particularly noteworthy in the shape of the U.S. environmental technology sector today. The first is in the nature of environmental technology itself. In the past, the focus was on controlling releases and cleaning up past pollution: building scrubbers that remove sulfur dioxide from a smokestack, for example, or cleaning up contaminated waste sites. Increasingly, environmental technology is emphasizing ways to avoid pollution altogether. Energy systems are shifting toward cleaner fuels, such as natural gas or renewable sources. Manufacturing firms are adopting products and processes designed from the outset to minimize the use of raw materials and the output of pollutants. The resultant effect of this trend is to move from "end-of-pipe" solutions to environmental problems to "at-the-source" solutions by focusing on new fuels, more sustainable technologies, and "green production methodologies."[15]

The second trend is related to the markets for environmental technologies, particularly overseas.[16] Major U.S. foreign competitors include Germany, Japan, the United Kingdom, and France. These countries have a strong export orientation because they have relatively small domestic environmental markets; consequently, they must export in order to realize economies of scale in their production of environmental goods.

In world markets, U.S. firms lead in remediation and management of solid and hazardous waste; European firms are especially strong in soil and water treatment; and Japanese firms lead in air pollution control. Many U.S. competitors receive significant government support. In Mexico alone, Germany committed $3.5 million in 1994 to promote its environmental technologies exports. Japan has committed $2.2 billion over 10 years to finance exports of Japanese environmental industry. These commitments become more important as state and local governments privatize infrastructure to avoid up-front capital expenditures. Firms are increasingly expected to bring their own money or their government's money to new projects.

Public and private expenditures on environmental technologies in the United States will almost surely change significantly in the future.

Technology trends alone make it clear where the United States must be in 2040 to maintain a competitive posture. In the early 2000s, investments in remediation will have cleaned up a large proportion of existing hazardous waste sites. Increased expenditures in technologies to avoid environmental harm should have paid off significantly by that time. Manufacturing processes will be more efficient in the use of resources; consumer products will be designed with the environment in mind; and the infrastructures that supply energy, transportation services, water, and food will be more resource-efficient and environmentally benign. By the year 2040, most industries should be at or near zero discharge of pollutants, although some control technologies may still be required to deal with residual discharges. Investments in large, macroscale monitoring systems and new microsensors will permit continual assessment of the environment in ways not now possible. At some point before 2040, the United States will move from an environmental paradigm based on cleanup and control to one based on anticipation, avoidance, and assessment.[17]

Several industry researchers and expert observers have speculated on the future of environmental technology. One of the more respected forecasts comes from the Department of Energy's Pacific Northwest National Laboratory (PNNL). Researchers there have identified the ten most important technological breakthroughs, which they believe will lead to a cleaner environment while providing major benefits to consumers over the next decade. Foremost among these technologies are preventive ones that PNNL researchers believe will provide major technical advancement, meet a serious need, and/or create an entire new industry within the environmental technology field.[18]

Two of the more significant such technologies are smart water treatment, and enviromanufacturing and recycling. Smart membranes, or filters, will improve water treatment at sewage plants and municipal water supplies by adjusting simply or even automatically to unclog themselves. Membranes and other techniques will remove organic compounds that currently can produce undesired reactions with chlorine. Spongelike grains of sand will attract and hold nitrates and heavy metals to further protect drinking water in large and small systems.

In 10 years, "green" companies will emphasize enviromanufacturing and recycling. They will create products that are environmentally friendly from cradle to grave. Plastics, paper, beverage containers, inks, cars, and computers will be more biodegradable or recyclable. Also, newer processes, such as dry cleaning with liquid carbon dioxide, will minimize or eliminate waste. Not only will cleaners cease to use

hazardous chemicals to clean clothes, but also they will capture and recycle the carbon dioxide so as not to add to atmospheric carbon.

Other key future technologies identified by PNNL researchers include agrogenetics (genetic plant engineering), renewable energy sources, micro-engineering, advanced display systems to reduce paper consumption, molecular material design, bioprocessing, real-time environmental sensors, and lightweight cars.

The environmental technology industry today is in serious need of a comprehensive national R&D policy. The United States does not currently have the technology to efficiently and effectively clean up its more than 300,000 dangerously polluted soil and groundwater sites. Because first-generation technologies will require decades and billions of dollars to remove only a fraction of the pollutants, significant portions of the pollutants will remain within the soil and groundwater. Without a national emphasis on environmental technology R&D, it will be virtually impossible to develop the technologies needed to increase the effectiveness, reduce the time, and minimize the costs of these cleanup efforts. Moreover, the United States will not be able to take the lead in the world markets of tomorrow.

CHALLENGES

Environmental challenges affect virtually all major industries. The materials used in manufacturing processes and the processes themselves have enormous effects on air and water pollution, for example. A review of three major U.S. industrial sectors—energy, chemical, and automobile—and their efforts at environmental compliance and stewardship shows that each of these sectors has dealt with significant environmental issues in the past and faces more environmental challenges in the future.

Energy Industry

Energy, particularly oil, is critical to the security of the United States. As former Secretary of Energy Federico Pena has observed, "Energy plays a vital role in our economy, accounting for over 7.3 percent of our gross domestic product, or about $2,000 per year for every man, woman, and child in the United States." Pena goes on to say that the national security of the United States depends on affordable sources and abundant supplies of energy. This is particularly significant in view of the fact that the United States depends on oil for about 40 percent of its primary energy needs. Oil becomes even more important as U.S.

dependence on foreign oil seems likely to grow from approximately 50 percent today to 60 percent by 2010.[19]

While oil is critical to the security of the United States, it is also an industry facing difficult times. Crude oil prices have dropped over the past 2 years by more than 40 percent. The abundant supply and weakening world demand, especially in Asia, contribute to the lowest world oil prices since the early 1970s. Weak oil prices are an immediate concern of oil and gas executives, but most have adapted to the volatility in modern energy markets and have used technology to reduce costs in exploration, recovery, and refining. Any treaty or regulation reducing greenhouse gas emissions would have a significant monetary impact on petroleum producers—an impact that they are not eager to accept.

At the 1998 annual meeting of the American Petroleum Institute (API), members were urged to get involved in human rights and ethical issues in the countries where they work and to find solutions to such issues as the environment. Gregg Easterbrook, senior editor of *The New Republic* and a vocal critic of environmental doomsayers, told API members, "Environmentalists are never going to like you, but the important question is: Will the public like you?" Whereas the public has the impression that environmental quality is declining, in reality, the environment is actually improving. In Easterbrook's words, "It takes 25 years of continuing good performance to get the message to the public. Regulation gets a lot of credit for dramatic improvements in air and water quality . . . and society will need more regulation in the future."[20]

Global warming and the final outcome of the Kyoto Protocol to reduce greenhouse gas emissions will have a significant impact across the U.S. energy landscape. The global warming issue is an emotional topic, and many advocates argue that severe measures must be undertaken at the earliest opportunity. A growing body of scientific data, however, suggests that the problem is not as clear-cut as first thought and that the economic consequences of the proposed solution to the alleged problem far outweigh the potential benefits. Regardless of the debate, it seems clear that global warming is a constructed, if not an actual, reality from which there is no turning back. Large companies like Chevron, Boeing, and others have already reduced their emissions below the 1990 levels required by the Kyoto agreement. These early actions, which have allowed such companies to accumulate emissions credits, are both noteworthy from an environmental standpoint and shrewd from a business standpoint. The credits have huge potential value to the company that holds them, but the value will be realized only if the United States eventually ratifies the treaty. With enough companies pursuing this strategy, there will be increasing pressure for ratification.

Chemical Industry

Environmental regulators and environmentalists probably watch the chemical industry closer than they watch any other sector. The chemical industry touches everyone's lives in one way or another. Strategically, it is the largest of all manufacturing sectors in the United States. In 1997, the industry accounted for 11.5 percent of the U.S. manufacturing gross domestic product (GDP) and almost 2 percent of the total GDP. It experienced a $19.1 billion trade surplus and employed more than 1 million workers.

The industry's reporting via the Toxic Release Inventory (TRI) reflects the environmental progress in this sector. From 1988 to 1996, the chemical industry reduced releases of core chemicals by 51 percent, or 535 million pounds. In 1996, toxic releases by the industry totaled 785 million pounds—50 percent air emissions, 11.5 percent water emissions, 25.5 percent underground injections, 8.7 percent on-site land releases, 0.3 percent landfill releases, 4 percent transfers for off-site disposal. Of the air emissions, seven chemicals accounted for two-thirds of all releases—ammonia, methanol, carbon disulfide, ethylene, propylene, toluene, and hydrochloric acid.

The chemical industry's environmental progress has resulted not only from regulatory compliance efforts, but also from voluntary efforts to decrease toxic releases. It has cooperated with the EPA and has created a management program for improved environmental performance. From 1988 to 1992, the chemical industry spent nearly $20 billion for pollution abatement. In recent years, industry expenditures on the environment have been on the decline. In industrial chemicals, the largest chemical subsector, 3.6 percent ($5.7 billion) of company sales were spent on environmental protection in 1992. The figure fell to 3 percent ($5.1 billion) in 1994 and 2.7 percent ($4.9 billion) in 1996. The largest chemical firm, DuPont, reported environmental expenditures of $1 billion in 1993, $950 million in 1994, and $800 million in both 1995 and 1996. This reflects the industry's move away from large capital investments for pollution abatement and toward more economical and efficient methods for dealing with chemical pollution.

Environmental industry opportunities associated with the chemical industry will depend on the environmental challenges facing the latter. These challenges are threefold: new EPA programs focused on the chemical sector; better performance metrics; and the industry's reorientation toward sustainable development. The chemical industry

will look to the environmental industry to provide information systems and software to find the best and most cost-effective solutions to ecoproblems.

Automobile Industry

The United States is a major player in the world's automobile industry. In an age in which environmental protection and recycling are socially acceptable and increasingly mandatory, the automobile industry remains one of the largest environmental offenders. Some air quality–monitoring groups blame automotive emissions for 60 percent of all air pollution in U.S. urban areas, and yet our lives revolve around the use of the automobile. This industry is also key to the U.S. economy. This industry is large enough and geographically widespread enough that a production slowdown for any reason, from a labor strike to a downturn in sales, has a significant negative impact on the U.S. economy. The principal environmental legislation regulating the automotive industry is the Clean Air Act of 1970, with amendments in 1977 and 1990. All three bills look toward transportation to reduce air pollution, and automobiles are the most numerous vehicles in this class. State implementation plans addressing measures and milestones are mandatory under the 1990 Clean Air Act Amendments.

Since the passage of the Clean Air Act in 1970, aggregate emissions have declined for virtually every pollutant that EPA monitors. The reduction in hydrocarbons and nitrogen oxides is important because they are precursors of ozone. Significantly, the amount of lead in the air has been checked substantially, dropping 75 percent between 1987 and 1996 due to the removal of lead from gasoline. The greatest boon to the decline in mobile source emissions has been the gradual ratcheting of vehicle emission standards, lowered targets that the automobile industry has consistently met. While advances in technology have held emissions in check, other emission control strategies, such as reformulated gasoline, oxygenated gasoline, and inspection and maintenance programs, have found little success, despite high costs.

Economic Impacts Beyond the Environmental

Environmental requirements are based on health standards, available technologies, and the use of standard procedures and prescriptive processes. Accordingly, any business or government activity that wants to minimize environmental degradation by virtue of compliance or economic efficiency must use a combination of services, techniques, and

management strategies to accomplish the dual goals of being a good environmental steward and operating efficiently. Environmental programs are expensive and require significant capital investments, as well as long-term maintenance programs, to be effective. On the average, businesses invest 1–2 percent of their annual expenditures for environmental concerns. Not all governments are equal in their abilities to achieve these goals. To this end, global environmental issues present a much more daunting and significant challenge for the world's nations to resolve—integrating legal, technical, financial, cultural, and other national systems both intrastate and interstate.

CONCLUSION

The U.S. environmental industry that exists today is multidimensional and complex. This industry grew feverishly, driven by government actions such as the ratification of international treaties and the passage of domestic legislation, the promulgation of executive requirements, and the adoption of standards established by professional and public interest organizations. The pace of new legislation and regulations has declined, however, and this rapidly changing industry is facing the challenges of maturity by seeking ways to maintain competitiveness domestically and globally. Parts of the industry as it is today will disappear in the United States as the requirement for end-of-pipe compliance or large-scale remediation disappears.

Government has a key role to play in increasing U.S. competitiveness. To give the United States the lead in 21st century environmental technology, there must be greater emphasis on R&D. Not only will the emphasis on technology play to U.S. strengths, but also technology is the key to sustainable development in both the developed and developing worlds.

The U.S. environmental industry must prepare for the shift away from compliance and remediation in its core market. Although interested parties continue to call for additional regulation and enforcement, this approach is short-sighted in light of the gradual movement to market-based compliance and pollution prevention. A commitment to emerging techologies and potential overseas markets is essential, despite the short-term risks. Government can help by providing risk management resources, such as profit liability protection and more environmental technology–based assistance to developing countries.

The environmental industry can be instrumental in achieving the goal of sustainable development around the world. If U.S. industry wishes to play the leading role, it must look beyond business practices that

generated past successes. Instead, it must assume greater risk, fund the development of innovative technology, and search for total package solutions to customer needs. These changes will not come easily. Accordingly, the U.S. environmental industry will find it difficult to maintain a competitive advantage into the next millennium.

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FINANCIAL SERVICES

ABSTRACT

Economic prosperity is an essential element of U.S. national security, and the financial services industry is at the core of economic growth and development. The United States can no longer guarantee economic prosperity at home as easily as it once did, because its financial systems are interconnected with other ventures around the globe. Economic globalization has introduced a tougher challenge for maintaining prosperity. The United States cannot afford to allow global economies to falter because of the adverse effects on its own economy. As a result, when global financial crises occur, it is in the self-interest of the United States to be a part of the solution. Crony capitalism, lack of transparency, and poor accounting practices complicate global business ventures. These practices often result in significant financial failures, loss of investor confidence, and rapid capital flight, ultimately contributing to global scale economic crises. A policy of cooperation complements the strategy of engagement and leads to greater political stability for developing countries. Under these circumstances, expect the U.S. financial services industry to lead—now and into the future.

Ms. Audrey Y. Davis, Defense Finance & Accounting Service
Ms. Kathy Lee Froehling, Defense Intelligence Agency
Mr. Ronald V. Gaines, Defense Intelligence Agency
LTC Richard A. Grabowski, Jr., USA
Mr. Robert R. Jordan, Office of the Secretary of Defense
CAPT Marcio Menezes Mendonca, Brazilian Navy
Lt Col Christopher E. O'Hara, USAF
CDR Douglas S. Roark, USN
LTC Luis D. Sans, USA
CAPT Jay S. Snowdon, USN
Lt Col Terence R. Szanto, USAF
COL Francisco V. Uson Ramirez, Venezuelan Army
CAPT Barry N. Wilbur, USNR
CDR Jim Wilkins, USN
Lt Col Carl Williamson, USAF
Dr. Carol Carpenter-Yaman, U.S. Agency for International Development

Col Mack Foster, USAF, faculty
Dr. Irene Kyriakopoulos, faculty
Dr. Robert Pirog, faculty

PLACES VISITED

Domestic

American Stock Exchange, New York, NY
Banco Real, New York, NY
Bankers Trust, New York, NY
Board of Governors, Federal Reserve System, Washington, DC
Chase Manhattan Bank, New York, NY
Chevy Chase Bank, Bethesda, MD
Embassies of Argentina and Brazil, Washington, DC
Export-Import Bank of the United States, Washington, DC
Federal Reserve Bank of New York, NY
Lockheed Martin Corporation, Rockville, MD
Merrill Lynch, Baltimore, MD
MONY Life Insurance Company, New York, NY
NASDAQ, Washington, DC
New York Mercantile Exchange, New York, NY
New York Stock Exchange, New York, NY
T. Rowe Price Associates, Inc., Baltimore, MD
U.S. Department of Commerce, Washington, DC
Wall Street Journal, New York, NY
World Bank Group, Washington, DC

International

Association of Financial Markets/Institutions (ANDIMA), Brazil
Banco Central, Buenos Aires, Argentina
Banco Central, Rio de Janeiro, Brazil
Banco de Brazil, Rio de Janeiro, Brazil
Banco de Galicia y Buenos Aires, Buenos Aires, Argentina
Banco Real, Rio de Janeiro, Brazil
BankBoston, Buenos Aires, Argentina
Bolsa de Valores, Rio de Janeiro, Brazil
Buenos Aires Stock Exchange, Buenos Aires, Argentina
Citibank, Buenos Aires, Argentina
Fundacion Capital, Buenos Aires, Argentina
J. P. Morgan Bank, Buenos Aires, Argentina
Ministry of Economy, Buenos Aires, Argentina
Municipal Government of Rio de Janeiro, Rio de Janeiro, Brazil
National Bank for Economic & Social Development (BNDES), Brazil
National Power Research Center (CEPEL), Rio de Janeiro, Brazil
U.S. Consulate, Rio de Janeiro, Brazil
U.S. Embassy, Buenos Aires, Argentina

INTRODUCTION

The financial services industry is crucial to national security and is an indispensable element of the nation's economic strength. Globalization, the changing role of the international financial institutions, and the potential challenge of a single European currency are all having an impact on the preeminent financial position of the United States. The industry is pushing to keep up with technology demands by customers, as well as the use of technology to cut costs and offer new products such as electronic banking and electronic cash. Future trends, especially where financial services technology interfaces with other institutions as well as with the public, raise issues such as the privacy, security, and accuracy of financial transactions that directly affect the widespread acceptance and use of new and emerging technologies. The U.S. financial services industry is a leader in addressing the near-term Year 2000 (Y2K) issues. Finally, it is important to understand the industry's response to vulnerabilities inherent within new technologies, to competition from emerging economic powers and trading blocs, to global economic downturns, and to social security reform.

THE FINANCIAL SERVICES INDUSTRY DEFINED

The financial services industry encompasses the three primary segments of depository institutions, securities firms and exchanges, and insurance companies, and the separate regulatory agencies and governmental macroeconomic policies that surround them. The industry is evolving rapidly, however. Increased competition from nonfinancial institutions, new information technologies, rapidly declining processing costs, and new interpretations of regulations have accelerated the pace and scope of change.

The industry fulfills a number of key functions in the larger economy. The industry determines methods for making payments, pooling financial resources, transferring economic resources over time and distance, managing risk, and providing price information.[1] Due to its key role in the economy, the financial services industry is heavily regulated at both the state and the federal levels. The nation's financial system comprises a complex set of laws, accounting standards, exchanges, and clearing facilities, as well as the state and federal regulatory framework.[2]

A rapidly changing environment constantly buffets the industry. Domestic and international regulations, technological change, international currency flows, the trade environment, and large-scale

political changes all affect the financial services industry. The industry responds by adapting and introducing changes of its own. This circular cause-and-effect relationship has tremendous implications for the national security of the United States and its allies.

Depository Institutions

The classic financial institutions of banks, and savings and loans are depository institutions. As a result of increased competition from non-bank financial institutions, as well as new interpretations and implementations of regulations, consolidation within the banking sector has continued. In fact, the number of commercial banks, and savings and loan institutions has declined in each of the past 10 years. Depository institutions are regulated by the Office of the Comptroller of the Currency, the Federal Deposit Insurance Corporation (FDIC), the Federal Reserve Board, and state regulatory agencies. Unlike accounts in other financial and nonfinancial institutions, deposits in banks and savings institutions continue to be insured by the FDIC.

Securities and Exchanges

Securities firms mobilize corporate capital by helping corporations issue debt and equity securities and by selling these securities to individuals and institutions. Mutual funds pool financial resources from individuals and institutions and use professional management to select and purchase debt and equity investments. These pooled resources are then easily transferred over time and distance. Mutual funds have become an attractive way for individuals to invest in stock and bond markets, as they offer reduction of risk through diversification of assets and professional management of fund portfolios.

Venture capital firms and individuals also pool and transfer resources by providing equity financing to new and fast-growing companies. These firms are increasingly active overseas where they have assumed some of the roles traditionally performed by bilateral and multilateral donors, such as the World Bank.

The futures market consists of individuals and firms engaged in the offer, purchase, or resale of futures—or options—contracts for the purpose of managing risk and enhancing price stability. The futures market also includes exchanges, such as the Chicago Board of Trade and New York Mercantile Exchange.

The Securities and Exchange Commission (SEC) is the primary regulatory agency.

Insurance

The two primary types of insurance are life, and property and casualty (P/C). The insurance sector is composed of more than 1,700 life and 2,600 P/C insurance companies selling directly to the customer or through a designated agent or brokerage house.[3] Insurance companies are approximately half "mutual" (owned by policyholders) and half publicly traded companies. Many insurance companies are taking advantage of more lenient interpretations of the regulations to move into banking and services, however. The insurance industry is regulated at the state level.

Federal Reserve

The Federal Reserve (Fed) is the independent executor of monetary policy. In addition to its regulatory functions, the Fed focuses on monetary aggregates in an attempt to promote maximum employment, production, and purchasing power within the economy.

As the Fed gauges and interprets national economic data, it directs its open-market operations to achieve a federal funds target rate that it believes will adjust the volume of reserves in the depository system as necessary to optimize employment, prices, and interest rates. Because interest rates directly affect the cost of all financial instruments, the policies and actions of the Fed are of prime concern to the financial services industry. The Fed's recent lenient interpretation of regulations contributes significantly to the changes in the industry.

CURRENT CONDITION

The past century has been an economic success story for the United States. During this time, the gross domestic product (GDP) expanded more than 100-fold, from $56 billion in 1933 to more than $8.5 trillion today. International trade has reshaped the global economy, rising from 9 percent of the GDP in 1939 to 24 percent today. In the past 10 years alone, the world's total financial assets have expanded about 11 percent annually, to approximately $50 trillion. Since 1981, the average daily volume on the New York Stock Exchange (NYSE) has exploded, from around 40 million to more than 600 million shares traded daily.[4] In the last 4 years, the Dow Jones Industrial Average has soared from 4,000 to more than 11,000.[5]

The financial services industry is also going through profound changes, however. Banks have been merging and acquiring each other. Changes in technology have been producing economic effects that are felt in real time. Congress, state legislatures, and regulatory agencies have been changing and reinterpreting interstate and state banking laws. Businesses outside the traditional financial services industry have been entering the market. Recent examples include retailers getting into the banking and insurance business, banks offering mutual funds, investment firms functioning like deposit institutions, and insurance companies offering retirement packages through variable annuities invested in mutual funds. As a result, many institutions in the financial services industry no longer fit neatly within one of the three traditional segments of depository institutions, securities and exchanges, or insurance companies. Consequently, it is often unclear which regulatory agency is overseeing these hybrid institutions for the public good. This confusion often results in conflicting regulation or, worse yet, gaps and voids where no appropriate oversight is taking place.

The integration of services (banking, securities, and insurance) and the consolidation of financial institutions are taking place within and across national boundaries. In 1977, there were 14,671 commercial banks in the United States. Today there are fewer than 9,000. In 1998, in the largest corporate combination ever, Citicorp and Travelers Group merged, creating the world's biggest financial services company, offering banking, investment, and insurance operations in 100 countries. Subsequently, Deutsche Bank AG, Germany's largest bank, reached agreement to acquire Banker's Trust Corporation for about $9.7 billion, thereby surpassing the Citicorp–Travelers merger. Merrill Lynch recently acquired Great Britain's Mercury Asset Management Group, one of the premier securities providers in that country. The trend continues unabated; there are numerous U.S. and international mergers under discussion or awaiting approval.

The U.S. mutual fund industry has evolved into a significantly large segment of financial services. In 1980, the amount of financial assets controlled by mutual funds was $240 billion, but in the last 12 years it has grown over six times to $1.5 trillion.[6] In fact, at the end of 1997, only commercial banks had more combined assets than did mutual funds,[7] and that trend continues. Mutual funds in other countries have also flourished in recent years, and there remains significant potential for additional growth in this area, particularly in Europe. With the introduction of the euro (the single European currency) and recent

changes in European Union (EU)[a] laws, securities investment is on an exponential growth path.

Monetary Integration

The euro went into effect on January 1, 1999. As late as 1997, it did not appear that any of the EU countries would meet the strict convergence criteria. Despite all the naysayers, however, in less than 2 years the 11 countries of the European Monetary Union (EMU)[b] met the criteria and adopted the single currency.

Particularly noteworthy is the large trading bloc developed by this single currency union. The 11 current EMU members already have a larger size and population than does the United States. The EMU conducts 19 percent of world trade (exclusive intra-EMU trade), while the United States conducts only 16 percent and Japan conducts only 8 percent.[8] The dollar is currently used in about 83 percent of two-way foreign exchange transactions, however, and comprises 63 percent of official currency reserves worldwide. Central banks, governments, and private firms use reserve currencies worldwide as a long-term store of value and a means to meet their ongoing financial requirements. The United States enjoys numerous benefits associated with the U.S. dollar's being the world's reserve currency, such as high liquidity and extremely low transaction costs in foreign exchange markets, as well as low borrowing costs in financing the current account deficit. Given the EMU's preeminence in world trade, it is understandable that the EMU and the European Central Bank are pushing for the euro to become a major reserve currency; however, reserve currency status requires the establishment of global confidence in the stability of the euro. In the first 5 months since its introduction, the euro lost 7.5 percent of its value relative to the dollar.[9] A weak euro relative to the dollar does not necessarily preclude it from becoming a reserve currency, but it may be a few years before it reaches reserve currency status.

Another significant monetary trend is the linking of currencies to the U.S. dollar. Eleven countries, such as Panama and Liberia, use the dollar as legal tender.[10] Others, such as Argentina, have a bimonetary system.

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[a] The EU is a political body currently composed of 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, and the United Kingdom (UK).

[b] The European Monetary Union (EMU, also known as Euroland) consists of all the countries listed above except Denmark, Greece, Sweden, and the UK.

Finally, other countries, such as Mexico, are considering the possibility of linking their currencies to the U.S. dollar.

Financial Crises

The past year has been characterized by financial crises—the economic downturn in East Asia, Russia's debt default, the subsequent turmoil in Brazil, and the near collapse of the Long-Term Capital Management (LTCM) hedge fund.[11] Some of the emerging market crises were due to weak, badly supervised, and inadequately regulated financial systems. Firms, banks, or governments in these countries borrowed more short-term money than they could cover when the exchange rates later became unstable.[12] Other crises have been deepened by the speculative abuses of complex financial products, such as derivatives.[c] Financial mismanagement by government or private institutions also contributed to financial chaos.

The intervention of the United States has been a critical factor in stabilizing the world's economy. For example, in the case of LTCM, excessive use of leverage and the lack of collateral standards greatly increased its market risk and led to its demise when the market did not perform as expected. Although LTCM was registered in the Cayman Islands (and, therefore, not subject to U.S. regulatory control), the New York Federal Reserve found it necessary to organize a $3.6 billion bailout with the help of more than a dozen Wall Street firms. In fact, many huge companies have set up shop in the Caymans, due to the secrecy made possible by their lack of regulatory controls. Bank deposits alone on the islands now total more than $500 billion, making the Caymans the fifth largest financial center in the world (right behind New York, London, Tokyo, and Hong Kong)! Clearly, the removal of regulatory barriers is causing businesses to flock to the Caymans; their financial community consists of 575 banks and trust companies, and they charter more than 20,000 corporations.[13]

Another example of U.S. intervention being required in areas outside of U.S. regulatory control occurred during the Russian debt crisis. When the Russian economy failed in 1998, the United States, along with financial institutions in other countries, made it their business to provide multibillion dollar support packages to stem Russia's economic

[c] A derivative is a financial contract that derives its value from some other underlying financial instrument. Developed primarily to manage, offset, or hedge against the risks found in traditional financial instruments, derivatives have been of great benefit in this regard. They do, however, have risks of their own that need to be fully understood.

downturn. Otherwise, Russia would have defaulted on its loan payments and would have no foreign exchange to pay for needed imports.

Information Technology

It is clear that information technology has strongly influenced the performance of the financial market in the United States. Customer service has improved, transactions have become more precise, and markets have become more global in nature. But more importantly, the advances in technology have helped speed securities transactions, helped the markets efficiently deal with high volumes of securities, and facilitated the use of electronic currency. The NYSE has already experienced several days where more than 1 billion shares were traded and is installing technology to handle trading 1 billion shares a day on a regular basis. Additionally, some exchanges are completely automated, unlike the NYSE and others where there is some human intervention. For example, nine such electronic communication networks control 21.6 percent of National Association of Securities Dealers and Quotations (NASDAQ) shares and nearly one-third of NASDAQ trades.[14] The NASDAQ acquired the American Stock Exchange, and the European markets have become electronically linked. Online discount brokerages that provide faster service at a lower commission are challenging traditional providers. The trend is toward increased trading hours and further market consolidations.

CHALLENGES

As the world enters the Information Age with the new millennium, the U.S. financial services industry faces numerous challenges. Changes in banking and financial markets around the globe may have an impact on the preeminence of the United States in the industry. Economic globalization has brought greater prosperity as well as instability, with calls both for more regulation and for more deregulation. Cross-border megamergers raise sovereignty and security concerns. Pitfalls loom for the computer and communications technology that spurred the growth of the industry. Finally, with the aging of the U.S. population has come the challenge of how the financial services industry can and should participate in the financing of the "baby boom" generation's Social Security.

Finance and Banking Reform Measures and Proposals

In the aftermath of the Great Depression, the Glass-Steagall Act of 1933 curbed speculation by banks, separated commercial banking and the taking of deposits from investment banking, and created the FDIC. The Bank Holding Act of 1956 further prohibited the organization of diverse financial services firms under a single corporate umbrella. Since 1977, federally insured banks have been subject to the Community Reinvestment Act, which requires them to seek business opportunities in poor areas as well as in middle-class and wealthy neighborhoods.[15] Today's financial environment is considerably different from that of the 1930s and 1950s, however, when the majority of restrictive regulations were enacted. Current regulations prevent U.S. banking institutions from spreading risk over a larger area of services and sources of capital. Institutional diversification would lower the risk of bank failures, creating a stronger financial services sector.

Many are recommending deregulation of the industry, including a number of key economic decision makers such as the Secretary of the Treasury, the Chairman of the SEC, and the Chairman of the Federal Reserve. The restrictions and separations mandated by the Glass-Steagall Act have become outdated and outmoded, and, with the tacit approval of federal regulators, many are being ignored. New rules will position U.S. financial services providers to achieve additional growth in the global arena, while ensuring that federally insured bank deposits are not used in risky and unregulated ways. Without legislation that provides regulatory reform, soon all the major world financial markets outside the United States will allow equal competition among banks, securities firms, and real estate and insurance companies,[16] leaving the United States at a competitive disadvantage.

With this year's entry of the euro as the currency of the EMU, financial markets in the United States will face further competitive challenges. With its size, population, and large volume of trade throughout the world, Euroland has become a major trading bloc. In the next 4 years, it is likely that the remaining four countries of the EU will join the EMU, and the strength of the EMU will continue to grow as its membership increases. In a few years, when there is confidence in its stability, the euro will become a reserve currency. As a result, it is anticipated that the euro has the potential to hold about a 35–40 percent share as a reserve currency, rivaling the dollar as a close second and leaving only a 20 percent share for the yen.[17] A concern for the United States will be the potential of the euro to replace the U.S. dollar as the premier reserve currency. This would require the Fed to raise U.S.

interest rates in order to attract the necessary investors. At the same time, the ability of the United States to run large trade deficits would be greatly constrained.

The increasing rate of international financial crises since mid-1997 has led to a call for new regulations. The need to have sufficient regulation in place to keep the system supervised and cushioned, while maintaining the benefits of global capital markets, directly affects U.S. competitiveness. The United States would like to retain national sovereignty over its financial institutions. The three goals of capital market integration, global regulation, and national sovereignty are mutually incompatible, however, and have indeed been described as the "impossible trinity" in which only two of the three can be optimized at the expense of the third.[18] For example, it is possible to have global regulation and capital market integration, but only by forfeiting national sovereignty.

Economic Globalization

Defined as the increase of trade and investment linkages among all countries, economic globalization can result in the integration of national financial markets into an international financial market. Globalization brings forth many new challenges, such as more information leading to greater transparency, yet increased volatility; deregulation; and liberalization, as well as cross-border mergers, resulting in the need for changes in the traditional role and authority of national governments.

Technology, Private Capital Flows, and Destabilization. Ironically, the new technologies in computing and telecommunications that have been instrumental in globalization have also significantly facilitated market disruptions. Private capital is flowing to developing countries as new market opportunities with high-income possibilities have emerged. Some of these opportunities have also been high-risk. With new technologies, information about weaknesses—perceived or real—emerge quickly. Capital can be transferred out of these markets with a keystroke. Thus, aided by technology, investors can very quickly remove funds from countries or institutions perceived as being too risky relative to their potential returns.

Significant economic policy mistakes in one country can reverberate around the world and create "contagion" effects. The Asian economic "flu" that began in Thailand in 1997 quickly spread to South Korea, Malaysia, and Indonesia, which had similar flaws;[19] these flaws included banking systems with too much exposure to property loans, massive unhedged short-term foreign debt, and a general lack of transparency in

business and financial dealings. This problem also spread to the Philippines and Argentina, whose economic fundamentals were relatively sound. Further, the downturn in Asia has affected countries that export to Asian markets, as the ability of the affected Asian countries to import has been severely constrained.

The recent crisis in Russia illustrates another challenge with the unfettered flow of private capital to emerging markets. Underregulated and undercapitalized banks have gambled recklessly with depositor funds, since the bank managers feel that profits accrue to them while bank losses go to the government. Bailing out countries with undercapitalized banks has been a serious concern for the International Monetary Fund (IMF), as the IMF and its donor countries do not want to inadvertently create a "moral hazard" by subsidizing the risk of private investors. In the rush to liberalize capital flows, many countries paid insufficient attention to updating regulations for their banking industry.

Regulation and Economic Governance. Globalization has brought a sea change in the role of the nation state. On the positive side, globalization has been a catalyst for internationally agreed upon rules of behavior in trade, finance, and taxation, prompting the rise of the World Trade Organization (WTO) and other international organizations as the new bulwarks of a new and emerging international system.[20] With the March 1999 WTO General Agreement on Trade in Services (GATS), barriers that unfairly limit foreign participation and opportunity in domestic markets are falling. Many gray areas remain, however. For example, the Internet and electronic trade are growing in importance. Regulations are nationally based, but the Internet has no borders and hence remains largely unregulated. There is no authority to say whether an offering is legitimate or contains accurate information. Another issue concerns what level should have jurisdiction in disputes (e.g., state or region, national or international organization). Finally, advances in modern communication technologies have limited the power of governments to protect intellectual property rights and to restrict foreign borrowing.[21]

Impacts on National Security. The increasing tendency toward cross-border megamergers and acquisitions has exacerbated the issue of jurisdiction. The supranational characteristics of many of the world's leading corporations can muddy the waters of international politics and even national security. A big challenge for the United States, as well as for all nations, is to grapple with the new relationships between nations and commerce, and to minimize effects that may be counterproductive to national security interests.

Information Technology

In the financial services industry, where the time-value of money is of supreme interest, the Year 2000 (Y2K) problem figures prominently. Soon, millions of lines of code, if not corrected, will confuse the year 2000 with the year 1900. It may ultimately cost an estimated $300–$600 billion[22] to repair or replace global information technology systems solely to ensure that they can still function reliably at the turn of the century. Although the readiness for many industries within the United States is questionable, the banking and securities industries are in good shape due to extensive regulator-directed corrections that began several years ago. The impact is worse for international readiness. With Canada as the only clear exception—although possibly some of the EU countries are prepared—the remaining scope of awareness, assessment, planning, remediation, and testing necessary to support each nation's internal banking and securities transactions seems insurmountable in the time still available. The Y2K problem illustrates just one challenge of technology.

Many financial institutions have become completely dependent on computers and communications networks to meet business needs and to manage their daily operations.[23] Nearly 10,000 financial institutions use banking networks such as the Clearing House Interbank Payment System (CHIPS) and FedWire[24] to transfer approximately 86 million payments valued at nearly $280 trillion each year, or more than $1 trillion per day.[25] The 1997 Presidential Commission on Critical Infrastructure Protection categorized electronic system failures as a major current threat to the overall operation of the U.S. financial system. The merger of the Internet with the financial sector raises other security and privacy concerns. For example, the transmission of funds and other sensitive data "in the clear" on the Internet poses a significant risk to funds safety and consumer privacy. Encryption and other computer security techniques are being added to the basic Internet in order to secure it from potential abuse and to serve as a platform for increased use. Consumer privacy is in danger as the barriers break down among financial services providers. For example, life insurance medical records could be sent (without the consumer's knowledge) to a loan officer considering a mortgage application.[26]

The increased vulnerability of the financial services market was aptly demonstrated this year in the new "online trading" service of the securities industry. One of the Internet's brokerage firms, E-trade, suffered a 75-minute shut down on February 3, 1999 and a 2-hour shut down on February 4. Although a few hours should not seem like an eternity, it did for some 700,000 customers who wanted to trade during a

period when the stock market was in a decline. In the absence of any regulatory agency with purview over this new, hybrid industry, the Office of the New York State Attorney General launched an investigation into the online trading industry shortly after the incident.

Social Security

Social Security represents a significant economic challenge for the United States. As currently implemented, it faces bankruptcy by 2030,[27] despite a projected trust fund surplus of $835 billion at the end of 1999.[28] Today, the Social Security trust funds take in more money than they expend, thereby offsetting deficit spending in other areas of government. As payroll taxes are collected for Social Security, the government invests them in special U.S. securities that are used to finance government debt. The current budget surpluses are an aggregate of all U.S. revenues and spending—deficits in the spending budgets of government agencies are masked by the surplus in the Social Security trust accounts.

The population of the United States is expected to grow from 262 million in 1995 to approximately 400 million by 2030. The percentage of elderly citizens will increase from the current level of 13 to 20 percent or, in absolute terms, 80 million more people. Life expectancy will increase from 75 years in 1999 to 84 years in 2030. As a result, older people will collect Social Security benefits for 21 years longer than was the case when the fund first began making payments in 1940.[29] Compounding the issue is the declining fertility rate, despite an increase in population. Thus, with a greater number of older people and fewer younger people, the ratio of workers who support each recipient will decline to 2 workers per recipient from 3.4 today. If the Social Security system is not corrected in the immediate future, its bankruptcy will have far-reaching effects on U.S. national power. The issue is how the U.S. government can invest excess revenues from the Social Security system to maintain benefits and solvency for the future. A related issue is the extent to which the government should become involved in participating in and influencing the capital markets.

OUTLOOK

Despite the potential for continued volatility and vulnerability to global economic crises, the outlook for the financial services industry is extremely positive. The industry will continue to react to the added complexity brought on by the structural inadequacies found in emerging economies. Financial services providers in the United States will help

stabilize global economies by leading the global financial services industry with their prowess in providing solutions to significant challenges such as the Y2K issue and global economic contagion. In the long run, the United States, along with other established economies and international financial institutions, must remain leaders in global financial systems to ensure global economic stability and prosperity for all nations.

Short-Term Outlook

Within the next 5 years, the high costs and uncertainties brought on by the Y2K issue will be over, but the rapid pace of technological advancements will undoubtedly continue to affect the financial services industry dramatically. Technology improvements will make financial transactions through electronic commerce the norm. The old way of conducting financial services—face to face—will increasingly yield to virtual financial services. Customers will decide where and when they will conduct their financial business—be it from home, office, or recreational site, day or night.

Personal, as well as business, financing will increasingly be done from the customer's location, not from the financial intermediary's location. The premium that customers place on their time will encourage the financial services industry to exploit technology to its fullest to meet customer demands for variety, quality, and convenience. Industry mergers and acquisitions (domestically and internationally) will continue in response to the demand for increased competition and market share. Economies of scale brought on by these activities will strengthen the financial services industry.

These two trends (rapid technological advancements and increased competition) will continue to increase the velocity of capital movement around the world. Customers will increasingly expect to have access to their funds 24 hours each day, 7 days each week. Institutions need to adapt quickly to this demand or face extinction.

Globalization will spur international competition and result in international conglomerates and partnerships at unprecedented levels. The eventual reform of the Glass-Steagall Act and the Community Reinvestment Act will benefit U.S. financial firms by creating an opportunity for U.S. firms to expand their financial services in areas once prohibited. When this opportunity arrives, U.S. financial firms will be able to compete evenly with other international financial services institutions.

Governments and international financial institutions should work hard to implement transparent financial systems on a global scale, but the ever-present "impossible trinity" will make progress slow. Another hidden benefit of technology is that it can make the activities of central banks, commercial banks, and international investment firms more instantaneously transparent. Techenology can aid in the gathering and dissemination of data that can be the foundation of responsible global investment. Nationalistic economic objectives will still take precedence over desires for market integration, and calls for international financial accounting standards.

Long-Term Outlook

Beyond 2005, industrialized economies will cultivate stable financial markets around the globe—particularly in emerging economies—but not until after standard financial accounting practices and transparency take hold. Efforts by the WTO, the World Bank, and the IMF are beginning to show promise in some Asian markets, such as South Korea and Japan, but the effort to affect markets on a global scale will take longer. Many emerging economies will experience the pain of ebb-and-flow business cycles before they elect, or are forced, to use standardized accounting practices and open themselves to scrutiny. Like it or not, this transformation will occur, because industrialized economies will not continue to support bad business practices around the globe. Efficiencies in the financial services industry—and the increasingly higher bailout costs with no guarantee of success—will simply not allow it.

International efforts and economic interdependence will likely give rise to regional economies that will ultimately replace the now singularly dominating U.S. economic power. The EU is the forerunner of such regional economies, but it will be followed by an American bloc and, later, an Asian bloc. These regional economic blocs will develop as a result of regional interdependence, standardized financial accounting practices, and financial system transparency. The European Monetary Union (EMU) will flourish as a result of the likely addition of Great Britain and further regional integration. In the Western Hemisphere, the North American Free Trade Agreement (NAFTA) will likely give way to the Free Trade of the Americas Agreement. This increased financial interdependence among the Americas will probably result in an American bloc. Finally, the efforts of the Asian Pacific Economic Council (APEC) and competition from the other regional economic blocs could promote the formation of an Asian bloc. These regional blocs will not exclude international direct investments, but will primarily trade and

manage core currencies as economic partnerships, following the successful examples of the EMU, NAFTA, and APEC.

Ultimately, there will be strong incentives for countries and areas outside of these regional blocs (e.g., Russia, China, Africa, Eastern Europe) to join such blocs. Should any country or area elect to stand on the sideline and not participate, it will no doubt fall short of its economic potential. Those that fail to join in blocs will forego the economic growth and prosperity that regional economies of scale would yield and will exacerbate the regional and national disparities between the "haves" and the "have nots." Again, however, the desire for market integration and regulation as part of a regional economic community will come at the expense of economic sovereignty.

Meeting the Challenges

The United States will remain an active leader in the financial services industry because of its economic strength and technological prowess. In any event, the risks are too high not to be involved. Global interdependence among financial markets and the impact that volatile financial markets have not only on the U.S. economy, but also on emerging economies are too important to be left unsupervised. Governments and businesses around the globe are interconnected in a complex financial web. Economic isolationism is no longer an option.

The U.S. financial services industry stands to gain from fostering economic productivity in global markets. A more strategic benefit originates in global prosperity and stability, however. The United States will employ its full range of fiscal and monetary measures to aid financial markets at home and abroad. The U.S. objective remains to provide the economic leadership and direction necessary to ensure global economic stability and prosperity for as many nations as possible.

GOVERNMENT GOALS AND ROLE

As the pioneer of the largest, deepest, and most resilient financial system, the United States is the preeminent world leader in financial services and its economy serves as a model for the world. To champion economic growth and stability in the global financial marketplace, the United States needs to pursue a mix of domestic reform and international leadership.

Domestic Reform

On the domestic front, there are several appropriate government responses. First, Congress needs to allow freer and more open competition among all financial services providers. Increased competition will bring continuing innovation and enable U.S. firms to compete effectively in world markets. Banking organizations should be allowed to own securities firms and insurance companies, and vice versa. A delicate balance must be struck to protect against moral hazard, to safeguard the interests of underserved communities currently protected by the Community Reinvestment Act, and to provide stability and prosperity—all while remaining competitive.

Second, while these Depression-era regulations are eroded, new regulations, methods, and regulatory agency reform are needed to expose the hidden risks in nonstandard financial assets. Derivatives are being designed faster than the system can evolve to monitor them. Regulatory agencies organized around the traditional business areas of depository institutions, securities and exchanges, and insurance are creating dangerous opportunities for fast-moving hybrid companies to find gaps in regulatory coverage. Sophisticated information systems need to be established to quickly and precisely measure, manage, and report the risks of derivative investment activities. Better cooperation and coordination among state and federal regulators are needed to alert authorities to excessive speculation. Risk management and supervisory functions need clear authority independent of trading functions. Collateral standards are needed to limit levels of leverage. New standards should require derivative instruments to be valued at market price. Finally, safeguards must be adopted that prevent the use of insured deposits to bail out affiliates that are not depository institutions.

Third, the United States must stop alleging a budget surplus when, in fact, there is a deficit in major accounts that is being masked by the surplus in the Social Security trust accounts. Almost invariably since World War II, the U.S. government has spent more money than it has collected. The burden of servicing this accumulating debt has not been too great of late because of exceptionally low interest rates and the continuing desire of other countries to purchase U.S. debt. The large and growing current account deficit, however, and the euro's potential pressure on the dollar's position as the reserve currency of choice could drive up interest rates and increase the cost of servicing the debt, which would have adverse impacts on the U.S. economy. The first step in correcting these problems is to balance the budget—without the benefit of Social Security. The second step is to implement means testing and

prudent investments in the equities markets to increase Social Security trust fund reserves to preserve Social Security. Relieving Social Security of the burden of financing current government operations will set the stage for preserving the primary means of income redistribution that helps U.S. citizens avoid old age financial poverty.

Fourth, a combined industry and government effort is needed to guide the development of electronic commerce, electronic funds transfer, and e-cash. Direct government or industry control is not the solution, as the government is incapable of keeping stride with rapid technology advancements and the competing interests of industry require government supervision to enforce consumer protection and privacy rights. Government needs to maintain a low level of involvement while ensuring adequate competition and protection of free markets. In general, regulation of e-cash should equate to regulation of physical cash; there is a need for technology improvements in monitoring e-cash that can keep pace with its increased velocity.

Fifth, due to the poor Y2K preparation around the world, the United States needs to be prepared to isolate unproven institutions, corporations, agencies, and even governments from U.S. financial and business transactions, until such time as their systems' Y2K compliance can be confirmed. In addition, the United States must continue reaching out to international neighbors and agencies to assist with contingency planning and to provide information on ways to minimize the immediate and long-term impacts of the Y2K dilemma.

International Leadership

On the international front, the United States should pursue a policy of active cooperation to ensure continued leadership of the world's financial markets. Maintaining U.S. leadership not only will provide the economic stability and confidence needed in the emerging markets, but also will ensure that the United States has viable and healthy world markets for its goods and services. A policy of cooperation complements the U.S. strategy of engagement and will lead to greater political stability, as secure economies are a prerequisite for stable politics. There are two broad areas for U.S. cooperation: (1) building financial systems and encouraging sound economic policies, and (2) developing international standards and regulations.

Building Financial Systems and Encouraging Sound Economic Policies. The United States should work bilaterally through its various economic assistance programs and through multinational arrangements, such as World Bank financial sector programs or IMF conditions, to

improve financial systems and macroeconomic policies in developing and emerging economies. There should be continual pressure applied to those countries that appear reluctant to help themselves. Eventually, these countries will realize that the market is unforgiving and that their situation will continue to deteriorate until they introduce reforms such as a credible banking system in which their populace can have confidence. Efforts should be focused on moving governments toward privatization, open markets, common trade blocs, stable currencies with low inflation, and balanced budgets. After the groundwork is laid in improving worldwide systems, U.S. private sector financial services providers can further strengthen national systems overseas by their competitive business practices, capital, and expertise.

Developing International Standards and Regulations. The United States, along with other industrialized economies, needs to lead the way in establishing new standards and regulations that will enable the global financial system to handle today's crises. Such issues as financial disclosure and transparency, evaluation of risks associated with off-balance sheet activities, and the investment powers of universal banks all require U.S. leadership to develop accepted norms that will eventually evolve into de facto international standards. Either through formal bilateral and multilateral trade agreements or informal memorandums of understanding, U.S. cooperation can bring appropriate facets of U.S. national law into the international arena.

More comprehensive public disclosure standards, such as information about the nonperforming loans of a country's financial institutions, allow rational investment decisions. More disclosure will help reduce the sudden reversals of investors' positions once the true financial health status of a country and its banking system becomes apparent. More transparent systems will enable the free flow of timely and accurate information. Transparency standards will help distinguish between crises of liquidity and solvency, to determine the appropriate type of support required to stabilize the market. To help protect against liquidity crises, the United States needs to continue its support of the IMF.

In developing standards, the United States needs to reevaluate the G7 and its make-up in light of the development of the European Central Bank (ECB). While there have been efforts to expand membership into a G8 and G10, a superior path would be to constrict membership over time into a G3 with representation from the United States, Japan, and the ECB. This more comprehensive membership by the three regional economic blocs would provide better leadership for economic stability and growth.

Through the consensus-oriented, rules-based WTO, the United States can continue to build on the March 1999 international financial services agreement to further liberalize WTO financial services rules and policies. Specifically, U.S. policymakers should advocate expanding the WTO framework and developing new rules to enhance the safety and stability of international banking and securities markets.[30] The United States should initiate new WTO agreements to foster increased competition and allow additional foreign investment in financial services.[31] Finally, the United States should advocate structuring the WTO to enable financial services competitors to leverage new technologies without restrictions or artificial constraints imposed by foreign governments.[32]

Enforcement can be achieved through trans-governmental cooperation, involving the same officials who make and implement policy at the national level.[33] Supervision and crisis management will increasingly take place at the regional level to enforce those global regulatory standards that have evolved by accepted use.[34]

CONCLUSION

Never before has global interdependence been so critical to economic stability. The recent Asian economic contagion, the formation of a European economic bloc, the rise in international business acquisitions and mergers, and the increasing debate over open global markets are proof positive that economic globalization will be "business as usual" in the new millennium. Advanced communication and automation technologies will link global market activity in a complex patchwork of international financial systems in near real time; international financial activity will not rest. The strength of this global financial web will be only as strong as its weakest link. The weakest link in this system is its emerging economies, not its network architecture. Global economic stability and prosperity depend on the success of the weakest emerging economy. This complex financial web must be trustworthy to prevent economic turmoil due to lack of confidence.

The financial services industry must address economic turmoil created by rapid capital flight, poor investment strategies, crony capitalism, and inappropriate regulatory procedures. The potential for rapid economic swings—from prosperity to crisis—is only electrons away. The details about the origins of an economic crisis—who, where, how, and why—are not as significant as the impact on global stability and prosperity. A prudent and successful financial services industry reduces economic turmoil by creating fair opportunities for open markets to come together in a safe business environment.

Today's strong U.S. financial services industry, supported by its efficient use of information technology, serves as the principal enabler to future economic stability both at home and abroad. The U.S. financial services industry stands fully prepared to meet the opportunities that it faces by leading the call for transparency, financial regulation reform, and open markets around the globe. The main challenge facing the United States is how it can affect emerging economies to the same degree that it has been able to do at home. Pursuit of absolute U.S. economic objectives—economic isolationism—without concern for the impact on the global community is no longer a viable U.S. national economic strategy. It remains in the U.S. national interest to cultivate emerging economies, mirrored after its own, around the globe in an effort to diffuse economic prosperity to all nations.

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HEALTH CARE

ABSTRACT

While the U.S. health care system is world-class in many respects, its future is anything but bright. The financial resources consumed by the industry do not appear to benefit society in proportion to the investment. Millions of U.S. citizens have inadequate access to high-quality health care. Moreover, the industry eventually may not be able to meet the nation's needs in the event of chemical or biological attack. Thus, U.S. health care stands at a crossroads. The primary issue is whether to perpetuate a system that seeks ever more sophisticated and costly treatment in an attempt to treat the diseases of an aging population or whether to finance a more constrained system that promotes health for the entire population and provides individual treatment that is necessary, but perhaps less than that desired by patients. Whichever course is the ultimate choice, the collective decision will have profound economic, social, and security implications for the 21st century.

Mr. James M. Alderman, Dept. of State
Mr. Harold D. Bosse, Dept. of the Air Force
LTC Mark E. Collins, USA
COL Harry L. Dorsey, USA
LtCol Lloyd Phillip Edwards, USMC
LTC Jeffrey A. Elting, USA
Mr. Ivory J. Fisher, Office of the Secretary of Defense
Col Myron L. Hampton, USMC
Mr. Brian W. Hebbel, Dept. of Health and Human Services
Lt Col Anthony V. Levy, USAF
Mr. M. Ricardo McCrimmon, National Imagery and Mapping Agency
Lt Col Tommy T. Thomas, USAF
LTC Terry E. Trout, USA

LTC Dale R. Brown, USA, faculty
Dr. Faye R. Davis, faculty
Dr. William A. Knowlton, faculty

PLACES VISITED

Domestic

Allegiance Healthcare, Chicago, IL
American Medical Association, Chicago, IL
Baxter Healthcare, Chicago, IL
Cook County Hospital, Chicago, IL
George Washington University Medical Center, Washington, DC
Health Care Financing Administration, Department of Health and Human Services, Baltimore, MD
Hines VA Hospital, Chicago, IL
National Naval Medical Center, Bethesda, MD
Siemens Medical Systems, Chicago, IL
Uniformed Services University of the Health Sciences, Bethesda, MD
University of Pittsburgh Medical Center, Pittsburgh, PA
U.S. Army Medical Research and Materiel Command, Fort Detrick, MD
U.S. Naval Ship *Comfort*, Hospital Ship, Baltimore, MD

International

British United Provident Association, London, United Kingdom
Fresenius Kabi, Uppsala, Sweden
Headquarters, Swedish Armed Forces, Stockholm, Sweden
Headquarters, U.S. European Command, Stuttgart, Germany
Hoechst Marion Roussel, Frankfurt, Germany
King's Fund, London, United Kingdom
Royal Defense Medical College, London, United Kingdom
Siemens Medical Engineering Group, Erlangen, Germany
Swedish Emergency and Disaster Medical Center, Stockholm, Sweden
Tamro AB, Stockholm, Sweden
University of Heidelberg Hospital, Heidelberg, Germany

INTRODUCTION

A strong and healthy population is essential to the continued survival of the United States as a nation. It underwrites the national security. Little contributes more to the vibrant effectiveness of the military forces and the population as a whole than health care. The capability of the population is probably the single most important element of U.S. national power.

Those who live in the United States enjoy a high quality of life. By many measures, they have the best health care in the world. While its overall effectiveness may be debated, it is certainly the most expensive. Depending on the source, the U.S. health care industry consumes 13–16 percent of the nation's gross domestic product (GDP). Only the booming economy of this decade has kept the growth in check.

One of the problems with the U.S. health care system is that it is not really an industry as such. Although the mergers and acquisitions that have dominated business in the United States for the last few years are having an impact on the health care system, it remains largely a cottage industry of small and independent practitioners. There is little standardization, and neither providers nor consumers are collectively organized to get exactly what they want or feel that they need. The one thread that does run consistently and pervasively throughout the industry is cost containment. Concerns about costs are driving change throughout the industry.

This study group analyzed the health care industry by viewing three basic factors within a triangular framework in a state of constant dynamic tension. These three factors were quality, access, and cost of care. Quality, of course, is a universal concern, although its definition depends on perspective. Most providers define quality as the best science possible for each and every patient. To payers, quality is good science at a decent unit cost. Customers (patients) see quality in terms of access to the best treatment possible.

Experts throughout the industry are directly engaged in the great health care debate. All are looking to find the best outcome with the best service with the best cost for the most number of people.

THE HEALTH CARE INDUSTRY DEFINED

The health care industry includes a wide variety of individuals, organizations, and institutions—public, private, for-profit, and nonprofit. These individuals and entities in the industry exist to contribute to the

physical, mental, and social well-being of the nation, and increasingly the world.

Individuals

Providers. Medical care professionals, such as physicians, dentists, nurses, nurse practitioners, physician assistants, and pharmacists, are at the center of the health care industry and are the most directly involved with patients. While not as apparent or as recognizable as physicians and nurses, a diverse array of allied health care professionals, such as medical, radiological, and laboratory technologists; physical and occupational therapists; and behavioral scientists complement and supplement medical care provided to patients.

Consumers. Throughout Congress, state assemblies, and town hall meetings, health care discussions focus on costs, managed care, profit making in the pharmaceutical and medical supply sector, and the inability of hospital networks. Rarely does the discussion ask the question, What does the patient want? The public, the consumers of health care, are talking and forcing the industry to listen. In general, the issues and needs are divided along traditional social and economic lines—"the haves and the have-nots."

The "have-nots" are the roughly 43 million U.S. residents without health care insurance or access to adequate health care. According to the Department of Health and Human Services (DHHS), this group represents almost 18 percent of the nation's population. Most depend on government assistance for their health care needs, and they generally receive health care at hospital emergency rooms.

The "haves" voice a completely different set of concerns. Members of this group have health care insurance and, therefore, access to quality care, but they want flexibility in their coverage and treatment decisions. For the most part, they belong to managed care organizations, health maintenance organizations (HMOs), or similar organizations. In general, their argument is with the coverage provided by their health care plans. These consumers are not satisfied with the choices, options, and services offered by their insurers. They want flexibility to seek alternate health care providers and confidence that physicians will determine the level of care necessary (or reimbursable) rather than the insurance companies. Their focus is on a patient's bill of rights.

The central issue in the Capitol Hill battle about the patient's bill of rights is how legislation should redefine "medical necessity." Most of the patient protection bills before Congress contain provisions that

would compel health care plans to pay for all services and treatments that are consistent with generally accepted standards of medical practice.[1]

Patients' rights advocates notwithstanding, a 1998 pre-election poll of 2,000 adults by the Kaiser Family Foundation/Harvard School of Public Health found that voters placed protecting patients' rights in managed care at the bottom of a list of social issues. Protecting patients' rights came in behind improving education; dealing with crime; lowering taxes; and improving the economy, Social Security, and Medicare.[2]

A survey conducted by Public Opinion Strategies late in 1998 found that the problem of the uninsured ranked highest in voters' concerns about health care. Thirty-three percent said it was the most important health care reform goal, followed by 27 percent who said that making health care more affordable was the most important goal.[3] More than 47 percent of those surveyed said that government action should be taken on the issue of the uninsured even if new taxes were required.[4]

Organizations and Institutions

Medical Organizations. In the past, medical organizations or "advocacy groups" have played an important role in the delivery of services and development of legislation in the health care industry. These organizations have evolved over the years from membership and training organizations to organizations that primarily lobby Congress on behalf of their members. Patient advocacy no longer seems to be the primary objective.[5]

The American Medical Association, which once boasted that its membership included more than half of the physicians in the nation, has seen its membership drop significantly over the years to just over 30 percent[6] and appears more concerned today with the encroachment of other types of providers (e.g., physician assistants, nurses, pharmacists) on their practice than with patient advocacy. Many other organizations, such as the American Hospital Association (AHA), American Association of Health Plans (AAHP), American Academy of Family Physicians (AAFP), and the Health Insurance Association of America (HIAA) have all redirected their priorities to protecting the interest of their sector of the industry, too.

Health Care Facilities. Although the modern hospital is less than a century old, it has acquired a place of such centrality in modern medical

care that it is impossible for many people to conceive of medical care without the current dominance of the hospital.[7] While still critical to the delivery of health care, hospitals have become just one segment in a health care delivery system that also includes community health centers, nursing homes, home health care agencies, and ambulatory surgical facilities. The definite trend, however, is toward less use of inpatient care and more reliance on outpatient and/or home health care. Consequently, many communities have far too many hospital beds, and hospitals are straining under the financial pressure to merge, consolidate, or downsize to meet lesser need.

Third-Party Payers. Private entities may provide both reimbursement to the insured and/or coverage on a prepaid, managed care basis, as may government-sponsored programs, such as Medicare and Medicaid, U.S. Public Health Service Hospitals, the Indian Health Service, and various state and local facilities for worker's compensation, inpatient psychiatric care, and other kinds of long-term care. In the U.S. system, the primary payers for health care (e.g., employers, insurance companies) are not the consumers of the health care resources. Accordingly, normal market forces do not work to control costs or balance outcomes appropriate to assets expended. Rapidly rising health care costs have prompted third-party payers to take a more proactive role in determining what appropriate costs should be, for example, by restricting consumer care options and flexibility.

Managed Care Organizations. The health care industry includes many managed care arrangements—HMOs, preferred provider organizations (PPOs), and independent practice associations (IPAs). These organizations are effecting significant changes in the way that health care is delivered in the United States. The Health Maintenance Organization Act of 1973 encouraged and funded the development of HMOs, which serve as both providers and payers,[8] as a strategy to contain the rising costs of health care.

Medical Equipment and Devices Manufacturers. The 1976 Medical Device Amendment to the Food and Drug Administration Act describes a piece of medical equipment or device as an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article. Medical devices and equipment range from basic medical products to technologically advanced products costing millions of dollars, such as scanners for computed tomography (CT) and magnetic resonance imaging (MRI), hemodialysis systems, artificial joints, fiber optic endoscopes, and interocular lenses.

Medical devices are heavily regulated and very hard to develop. Because tolerance for error is very low, the development process is very expensive.

Pharmaceutical Manufacturers. Pharmaceuticals or prescription drugs have emerged as one of the fastest growing components of the U.S. health care industry. According to some analysts, the demand for new drugs for conditions such as depression, allergies, arthritis, hypertension, and an elevated cholesterol level is a major contributor to rising health care costs. Representatives of the pharmaceutical sector maintain that its products have positive effects on society at large and note that the industry spends a high percentage of revenue generated from sales on research and development (R&D). Given the patent and trademark laws of the United States and other nations, the relatively few products developed that ever become commercial, and the length of the approval process, pharmaceutical manufacturers charge high prices for new drugs to recoup their costs quickly and make profits before their patents expire.

Facilities for Research and Development. Much, if not most, of the health care R&D in the United States is medical school–based. Teaching hospitals both train new health care professionals and serve as test beds for new diagnostic and treatment procedures. The focus is on improving the ability to diagnose and treat injury, disease, and disability. Cost containment principles implemented by managed care organizations that pay only for necessary approved procedures threaten traditional cash flow systems in teaching hospitals and medical schools.

U.S. Public Health Service. Growing efforts by state and local governments in the United States during the late 19th and early 20th centuries centered on providing health care to the nation's neediest citizens. These efforts led to the development of public health as a separate and distinct component of the health care system. As public health departments grew, so did the opposition of organized medicine. Based on the contention that government was adversely affecting private medical practices, this opposition was generally successful in limiting public health department services to areas in which private physicians had little interest. Such services included the administration of preventive public health measures, such as disease screening, immunization programs, and communicable disease case discovery and treatment. For the poorest sectors of the population, public health departments sometimes filled the gaps for family planning, obstetrical care, well baby care, and both pediatric and adult medical care.[9]

Today, the scope of the public health care available varies widely. It can range from prevention-oriented programs (immunizations) to complete personal health care services offered through designated centers. Many public health care centers provide home health care services, usually through a nursing division. In some localities, public health provides school-based preventive services, such as vision screening, general physical examinations, and immunizations.

Despite the success of public health agencies in ensuring the safety of food and water supplies; control of epidemic diseases; programs for the care of infants, children, and adults with special needs, the nation has generally moved toward increased privatization and provides only relatively modest support for public health programs. The history of public health is marked primarily by struggles over the limits of its mandate.[10]

U.S. Military Health Service. Military medicine involves risk (threat) assessment, prevention, medical dispositions (evacuation), and the clinical management of the diseases and injuries that result from military occupational exposures. The U.S. Military Health Service is a $15 billion per year organization providing health care for more than 8 million members of the military, family members, and retirees through a worldwide network of 120 hospitals and 500 clinics.[11] Unlike the private health care system, military medicine emphasizes health promotion and preventive medicine. Also, there is still a need to reconcile the demands of providing health care in peacetime to service members, dependents, and retirees with the need to train and make preparations for the injuries and diseases of war.

TRICARE is the Department of Defense (DOD) response to the Congressional mandate to develop a health care delivery system based on the concept of managed care while maintaining readiness, containing costs, and improving access. It is an umbrella program bringing together the capabilities of the individual military services and civilian contractor preferred provider networks.[12] TRICARE is a regionally managed health care program consisting of three options that are designed to fit individual preferences and lifestyles, and to ensure the efficient use of military health care resources.[13]

Other Models

Canada. From early provincial efforts to provide funding for both hospital and medical services, health care in Canada has evolved into a

national system in which per capita block payments (with annual increases tied to the GDP) finance medical care costs. The Canadian Health Care System is not a socialized system. Ninety-five percent of physicians are self-employed; 90 percent of acute care hospitals are private, nonprofit corporations; and patients are free to select providers. Medical care providers bill the national health care plan rather than patients for insured services. All permanent residents have access to health care, regardless of their ability to pay.[14]

United Kingdom. When the National Health Service (NHS) of Great Britain was established more than 50 years ago, it consisted of three components: specialist care, primary care, and community-based care. Each was operated and administered as a separate entity. This structure did not work very well, primarily because of the lack of coordination between the three components.

A closely coordinated, multitiered, geographically integrated system designed to provide comprehensive health care to the whole community replaced the three-part health service structure in July 1973. The 1973 reorganization created the General Medical Service and the Hospital Service. The gateway to the NHS is through the patient's general practitioner. Depending on the medical care requirements, a patient may be referred to the hospital service, ophthalmic service, or pharmaceutical service. The NHS is an example of a health care system governed largely by non-price rationing.[15]

CURRENT CONDITION

The U.S. health care system is the most expensive health care system in the world. In 1997, the approximate cost of health care was $4,000 for each U.S. citizen. Projections indicate that this figure will rise substantially as the baby boomers become eligible for Medicare.

Domestic. Fifty years ago, the health care industry was characterized as groups of providers (e.g., physicians, hospitals, clinics) and patients with an emphasis on patient care. Now, as the 21st century approaches, the health care industry is considered a marketplace—one in which significant price increases and an aging population will boost the total consumption of health care significantly over the next decade.[16] Health care is now among the fastest growing, and most important, "businesses" in the United States.

The vigor of this industry is evident in its overwhelming contribution to domestic production. Since federally sponsored health

care began in 1965, the nation's health care expenditures have risen from $41 billion, or about 6 percent of GDP, to more than $1.1 trillion in 1996. This represents more than 15 percent of GDP[17] and is expected to grow to $1.2 trillion by the end of 1999 and $2.1 trillion by 2007.[18]

Since 1989, the public share of the total health care costs has been increasing rapidly, from 40.5 percent that year to 46 percent in 1996.[19] By 2005, officials of the DHHS estimate that total government spending on health care will reach 50 percent of the total for the health care industry. Not surprisingly, more than 75 percent of the expenditures, both government and private, are attributed to four sectors of the industry—hospital care, drugs and supplies, health care insurance, and physician services.

Driven primarily by the cost of operating health care facilities, hospital care expenditures represent the largest category of expenses in the industry. Many industry analysts describe the health care facilities portion of this industry as "a fragmented industry in transition,"[20] because it includes many different types of facilities, each of which provides for various health care needs. These facilities include 6,500 acute care hospitals, 85 percent nonprofit and 15 percent for-profit; rehabilitation hospitals; psychiatric hospitals; nursing homes; assisted living facilities; and home health care services. Pressure to reduce costs has come from many sources—large corporations, which have seen their employee health insurance costs rise dramatically in recent years; managed care companies, whose raison d'être is cost-efficient medical care; and the U.S. government, which pays for nearly 40 percent of the nation's health care expenditures.[21] In addition, the most expensive portion of this sector, acute care hospitals, has an estimated 40 percent oversupply of hospital beds.

The response of the health care industry to pressure to control costs focuses on reduced staffing levels and re-engineering projects to improve worker efficiencies. Spending on expensive medical equipment is expected to decline as facilities consolidate and merge, thus reducing the overlap of products and services.

While the size and the cost of the U.S. health care industry are staggering (and growing), there is a benefit: the health care industry is the leading employment sector in the economy. According to the Department of Labor (DOL), the number of employees in the health care system rose from 9 million people in 1990 to 11 million in 1997. This industry is helping to sustain the booming U.S. economy.[22] The DOL further projects that employment will continue to grow in all areas of the

health care industry. The most significant growth is expected in home health care, nursing, personal care facilities, and offices and clinics of physicians and dentists.[23] The highest rate of growth is in the home health care sector—approximately 60,000 jobs a year. The lowest rate of growth will be in acute care hospitals, but these facilities will continue to account for the largest share of employment.

Although the United States is projected to remain the largest and fastest growing among the world's leading pharmaceutical markets, many European countries are increasing the use of drugs in overall therapeutic formats.[24] In addition, the rising standards of living in Latin America, Asia, Africa, and Eastern Europe will provide opportunities for U.S. pharmaceutical manufacturers and companies, as consumers in these areas become able to afford drugs, even vanity drugs. In 1997, U.S. pharmaceutical companies accounted for more than 50 percent of worldwide drug sales (Table 1). Many U.S. drug manufacturers are opening factories, manufacturing plants, and distribution centers throughout the world. Industry analysts also predict that in the next few years, more mergers, acquisitions, and consolidations between U.S. and foreign drug manufacturers will occur.

The North American Free Trade Agreement (NAFTA) is expected to increase U.S. exports of pharmaceuticals to Canada and Mexico—currently 15 percent of the U.S. exports of pharmaceuticals. The European Union remains the largest importer of U.S. pharmaceuticals, purchasing nearly 50 percent of all U.S. exports.[25]

Table 1: Foreign Sales, Major U.S. Drug Companies

Company	Foreign Sales (MIL $)	% of Total Sales
Abbott	4,412	37
America Home Prod	5,917	42
Bristol-Myers Squibb	5,687	34
Johnson & Johnson	10,872	48
Eli-Lilly	3,106	36
Merck	5,874	25
Pfizer	5,637	45
Pharmacia & Upjohn	4,462	68
Schering-Plough	2,627	39
Warner-Lambert	3,710	45

Source: Annual Reports, Health Care Pharmaceuticals Industry Survey

International. The United States spends a significantly greater portion of its GDP on health care than does any other nation. More important, the United States spends twice as much on health care as the other 24 industrialized nations in Europe and North America.[26]

Industry analysts assert that the high health care costs in the United States make it harder for the other U.S. industries to compete in the global economy. In 1996, health care costs added more than $1,200 to the price of each car manufactured in the United States; Japan spends half this amount.[27] In 1990, General Motors spent $3.2 billion for medical coverage for its 1.9 million employees and retirees[28]—more than it spent on steel that year to build its cars. Perhaps the most troubling aspect of this comparative analysis is the fact that there appears to be too little quantifiable return on this tremendous investment. Life expectancy in the United States is not greater than in those nations that spend significantly less of their national wealth on health care, many of which provide universal access to care.

CHALLENGES

The numerous challenges facing the U.S. health care industry are unlikely to be solved in the short term. The most difficult challenge involves finding an ethical manner in which to apply finite resources (dollars, facilities, and personnel) to an infinite demand from individuals seeking health care. Determining the right mix of quality, access, and cost to satisfy each individual, as well as society as a whole, is difficult. Shifting the health care paradigm from disease treatment to health promotion will be a major undertaking. The infrastructure and ability of government agencies to handle large-scale emergencies resulting from natural disasters and terrorist incidents need to be bolstered. The nation's ability to quickly identify and control the spread of infectious diseases makes it necessary to improve health information flow and isolate problem areas. Finally, educating and training medical professionals who are morally and ethically committed to health care must continue to be a top priority.

In the not too distant future, individuals will be able to tap into a wealth of information on the Internet when they need to make health care decisions. Ready access to in-depth information will change the physician–patient relationship, as it will give consumers the clout and confidence to decide which health care plan to join, which physicians to see, which treatment alternatives to select, and which hospitals to use.

Also, employers may not be in the health benefit business, since companies may give their employees vouchers for the products and services that best fit their needs. These types of changes will be necessary because of the changing demographics of the country, the skyrocketing costs of health care, and the great leaps that health care technology is taking.

Physician–Patient Relationship. Recent changes in the health care industry have had a dramatic impact on the role of the physician. With the introduction of traditional business practices, economic principles, and government funding into medicine, priorities have shifted away from patient choice and access toward economic efficiency and treatment of the Medicare-eligible population. This transition has taken place largely at the expense of individual physician practices. Managed care organizations now routinely set limits on physicians' use of diagnostic tests and choice of prescription medicines. Non-physician administrators scrutinize medical decisions from the perspective of the terms of an insurance contract with the patient's employer. Physicians who resist these trends have been pressured to sell their practices and become employees.

Information and medical technology have also affected physicians' work. Physicians must work harder to keep abreast of medical advances. Moreover, while Internet access makes patients more knowledgeable, it has also threatened the confidentiality of their medical information. Additionally, practice rights for nurse practitioners and other alternative sources of medicine have encroached upon the traditional physician medical practice.

These changes strain the physician–patient relationship. Physicians lose long-standing patients because employers switch their insurance policies. Burgeoning administrative requirements increase physicians' practice expenses. Concurrently, their HMOs have slashed fees and placed caps on their practice. They are financially penalized for performing appropriate tests, as well as inappropriate tests. Personal income for physicians has declined in 2 of the past 4 years, despite the fact that they are more in debt after medical school, they are seeing more patients, and they are working more hours. Understandably, physician status and morale has declined.

Medical practice is becoming more business oriented. Physicians have formed group practices, employed physician extenders, and adopted best practice methods. Some are even organizing unions. Additionally, record numbers of them are obtaining master's degrees in

business administration, taking on leadership roles in civic organizations, and participating in politics (e.g., increasing numbers are successfully running for Congress).

Demographics. Because people are living longer, the demand for long-term care will increase dramatically. People 65 years or older numbered 34.1 million in 1997 and represented 12.7 percent of the U.S. population, about 1 in every 8 citizens. The Census Bureau estimates that by the year 2020, the nation's 80-and-over population will increase by almost 75 percent to 13 million. The capstone of this demographic change is the massive bulge of people in the baby boom generation (those born 1945–1964). Currently, there are 39 million beneficiaries entitled under Medicare to public health care in the United States. By 2030, there will be 80 million beneficiaries.[29]

The other side of this demographic trend is that the fertility rate and the number of younger workers are declining. Therefore, the number of workers supporting each elderly health care beneficiary will decrease from 4.5 workers today, to 1.7 workers by 2030. Health care industry sources project that expenditures for seniors will rise from the current level of $12 billion to about $18 billion in 2000, and $30 billion in 2005.

Payment and Funding. Private insurance rarely funds long-term care. Government-sponsored programs are the primary sources. The two major programs are Medicaid and Medicare. Medicaid is a federal and state government–funded program designed to provide medical assistance to eligible needy persons. Funded 50 percent by the states and 50 percent by the federal government, Medicaid is the largest public source of long-term care. Long-term care totals about 40 percent of all Medicaid spending and is increasing about 8 percent per year. Medicaid spending on long-term care is projected to grow from $33 billion to $73 billion by 2008.[30]

Medicare will soon pose a similar problem for the government. It is funded partially from federal tax revenues and partially from premiums withheld from Social Security payments. Traditionally, Medicare has focused on acute (hospital-based) care, but there is a growing consensus that it should also pay for long-term home health care. The Congressional Budget Office projects that, with current coverage limits, Medicare's share of the federal budget will increase from less than 12 percent in 1997 to 13 percent in 2002 and 16 percent by 2008.[31] This does not even take into account the possible addition of pharmaceuticals to covered care.

Fraud and Abuse. Nearly 800 million claims were submitted to Medicare for payment in 1998. The General Accounting Office estimates that 10 percent of all Medicare dollars are lost to fraud. The latest study by the Office of the Inspector General indicates that nearly $13 billion each year, 7 percent of Medicare payments, are inappropriate. The Clinton Administration has focused unprecedented attention on fraud and abuse of the health care system. Over the past 7 years, the Administration has increased the number of Department of Justice prosecutors and Federal Bureau of Investigation agents assigned to identify and prosecute health care fraud. Since 1992, the number of health care fraud convictions has increased by 241 percent.[32]

Cost Reduction. The growth of HMOs and managed care plans has reduced medical costs to some extent. Employers and insurance companies are limiting the choices of their employees and putting caps on payments for certain procedures and treatments. In addition, employers are shifting some of the costs for insurance to the employees, resulting in more out-of-pocket expenses for health care consumers. Many industry experts believe that managed care plans have reduced the cost of care at the expense of quality, however.

In their efforts to control cost, hospitals and medical facilities have placed greater emphasis on outpatient treatment and home health care. For the past several years, hospital admissions have been on the decline. Conversely, outpatient visits and surgeries have shown a steady rise since 1983. The number of staffed hospital beds has dropped approximately 18 percent from 1,005,718 in 1983 to 826,584 in 1998. All of this has resulted in a 10–20 percent reduction in inpatient expenditures.

Alternative Medicine. Many patients see alternative medical approaches as cheaper, more personable options than mainstream medical care. In addition to the lower costs that they incur with this type of care compared to conventional treatment, they feel that they are treated more as a whole person and have more of a voice in their treatment.

Alternative medicines (home remedies/folk medicine) are not widely taught in medical schools, practiced in hospitals, or reimbursed by medical insurance companies. Approximately 30–35 percent of the U.S. population has used one form or another of alternative medicine.[33]

Emergency Preparedness. The U.S. health care system faces significant challenges in preparing for state or national emergencies. Recent hurricanes and tornadoes throughout the Southeast of the United

States, floods along the Mississippi and Missouri Rivers, and earthquakes and fires in the West have all too often highlighted the need for health care facilities to be prepared to handle large volumes of patients. Furthermore, it is essential that health care facilities be ready to deal with the developing threat of biological or chemical warfare against the U.S. population.

Both local communities and government agencies are doing much to improve the initial response to such threats. Some large metropolitan areas, such as New York, already conduct daily analyses on health treatment figures to quickly identify trends that might be more sinister than readily apparent. Agencies and medical facilities are conducting drills and have developed standard operating procedures for certain scenarios. Teaming efforts have been established among government agencies, and the Federal Emergency Management Agency (FEMA) has been designated the overall coordinator for civil response.

To combat the problems that may occur, the nation must seek management and technological solutions that have dual use and multiple payoffs. Veterans Administration hospitals, National Guard units, and the military all possess core competencies that lend assistance to emergency preparedness.

Infectious Disease. Although there have been great strides in combating infectious disease, it remains the leading cause of death and disability in the world today. Whether infectious agents are cultivated and used as biological weapons or occur naturally, they remain a significant threat to the population and require extensive emergency preparedness.

A 1998 Yale medical study found four major reasons for the emergence or reemergence of infectious diseases: (1) the evolution of existing organisms, resulting in new infectious diseases; (2) the development of antimicrobial resistance in existing agents (e.g., those that cause gonorrhea or malaria) or a breakdown in public health measures for previously controlled diseases (e.g., cholera, tuberculosis, and pertussis); (3) growth of urban populations that has outpaced adequate housing, clean water supplies, and hygiene; (4) increased ease of travel around the world. Individuals can be infected in one country and become ill in a distant country, affecting all who have come in contact with them along the way.[34]

To address the problem and devise strategies and procedures to combat infectious disease, the Centers for Disease Control (CDC), the DOD, the World Health Organization, and numerous state and local

health care agencies regularly communicate and work closely to monitor, isolate, treat, and control infectious diseases as they become known.

Wellness Programs. With increased life expectancy and rising health care costs, more emphasis must be placed on preventing health problems rather than treating them. Wellness programs have demonstrated conclusively that implementing a physical fitness program for older citizens not only has helped them sleep better, feel better, and look better, but also has provided them with an enhanced self-image and self-concept. Disease and decline are not inevitable in the later years.

In addition to those for seniors, wellness programs for children are needed to help them begin a lifestyle of health and fitness. Studies conducted by the National Institutes of Health, the CDC, and others have concluded that wellness programs emphasizing physical activity in elementary school–aged youngsters have a significant influence on their capability to prevent coronary artery disease, Type II diabetes, and hypertension/depression. The studies acknowledge that behavioral patterns, such as drug/substance abuse, smoking, and unhealthy nutrition/diet, can also be prevented if youth are taught to appreciate the benefits of a healthy lifestyle.[35]

Although the total numbers are still low, some employers have begun to develop wellness programs for their employees to reduce the money spent on health care. The 8,334 employees who participated in Proctor & Gamble's health promotion program had significantly lower health care costs (29 percent lower total and 36 percent lower lifestyle-related health care costs) in the third year of the program when compared with nonparticipants. Similarly, participants had significantly lower inpatient costs, fewer hospital admissions, and fewer hospital days of care. Assuming a conservative reduction of health care costs of 25 percent, this equates to a saving of more than $290 billion (in 1998 dollars). The study noted, however, that results are not instantaneous. It was not until the third year of the program that actual health benefits were realized. The message is clear. Wellness programs are effective, but people need to start today in order to be healthy tomorrow.

Medical Education. The U.S. health care industry relies on teaching hospitals and their clinics for the clinical education of physicians and other health care professionals. In addition, teaching centers develop and refine new therapies, surgical procedures, and technologies to treat and cure patients. They also help the underprivileged and provide comprehensive and unique services for the general population.

Teaching hospitals perform five important functions: (1) provide more care to indigents than do their counterparts; (2) treat sicker patients; (3) provide specialized inpatient and outpatient services such as organ transplants, intensive neonatal care, and sophisticated reconstructive surgeries; (4) fund or provide resources for trauma centers and burn units, centralizing these costly services for many urban communities; and (5) offer the most comprehensive care for veterans who are otherwise uninsured. The Veterans Administration affiliates 132 of its 171 medical centers with medical schools.

More and more teaching hospitals are feeling the financial strain of changes in health care. An increasing portion of health care is delivered through managed care and reimbursement plans that generally do not support the education and research missions of teaching hospitals. Federal, state, and local economic pressures are constraining funding sources for disadvantaged patients. Medicare payments for education and higher costs of patient care in teaching hospitals continue to be targets in government efforts to control health care costs. Finally, physician payment reform, while geared toward the admirable goal of increasing reimbursement for primary care services, will affect medical schools more than other institutions because the faculty necessarily has a large portion of highly trained specialists.

Year 2000 (Y2K). The commercial segment of the health care industry has taken care of its internal business practices well in dealing with the Y2K computer software issue. The industry has not, however, taken a hard, systemic look at the internal processes of suppliers. It appears to be late for health care providers to begin "auditing" critical suppliers (i.e., actually checking components to see if they have problems), let alone fixing them. Self-certification and reliance on multiple suppliers form the primary basis for provider optimism. To reduce hoarding, suppliers have worked hard to keep their customers informed of their progress. While these efforts are commendable, there was little evidence of concrete plans to mitigate the impact of Y2K failure. Because the health care industry is committed to just-in-time logistics, there is little float in the supply systems of manufacturers or hospitals. If they occur, Y2K failures will be felt very quickly, with potentially life-threatening consequences for patients.

GOVERNMENT GOALS AND ROLE

Under its fundamental obligation to provide for the general welfare of the nation, the U.S. government has an implied goal to guarantee and improve the health of its citizens. The government faces a sobering reality in trying to balance access, quality, and cost. This may well make health care the dominant political and national security issue of the 21st century.

Population and National Will. Society's demographic changes and continuing high expectations are shaping the U.S. health care industry. The demographic trend in the United States is toward increased longevity and explosive growth in the elderly population. Life expectancy in the United States is already 78.6 years, and those over 65 years old will increase from 13 to 18 percent by the year 2005.[36] This cohort already consumes the bulk of U.S. health care. The impending baby boom generation's retirement will fuel the demand for health care even more.

The government's interface with the demographics of health care revolves around its role as a guarantor of health care for the nation. With the passage of the Social Security Act of 1965, Medicare, and Medicaid, the government made a commitment to the population. The challenge for the government is to maintain that commitment while simultaneously addressing the concerns of the other players in the health care industry. The other players include organized medicine (e.g., the American Medical Association, the American Hospital Association), HMOs, insurance companies, and the Congressional Budget Office.

The government's track record of fulfilling medical commitments (e.g., inadequate funding of the Veterans Administration) does not build confidence. Analysis of international health care systems demonstrates significant shortcomings there, too. For example, research and field studies revealed underinvestment in infrastructure in Canada and poor public access in the British National Health Service.[37]

The government has a major role in medical technology and education. It provides oversight of new pharmaceutical, medical equipment, and genetic engineering developments through the Food and Drug Administration, patent laws, and legislative restrictions. This involvement sets the rate of progress and determines the availability of the technological advancements.

Government subsidies of graduate medical education, the supervision of medical practice (e.g., via agencies such as the National

Practitioner Data Bank and licensing boards), and the regulation of information technology (e.g., confidentiality of electronic patient medical records) influence the practice of medicine at the provider level. The challenge for the government is to guard against the unbridled, and possibly harmful, proliferation of technological advancements and health care without stifling beneficial changes.

If properly cultivated, medical technology and health care have the potential to become prominent elements of U.S. diplomatic power in the near future. For example, if India continues to struggle with an increasing epidemic of acquired immunodeficiency syndrome (AIDS), access to advanced AIDS treatments and medicines may provide much needed diplomatic leverage in halting nuclear weapon proliferation in the region.

Defense and Domestic Security. The government is the only entity with the capability to take on the medical role of preparing a homeland defense against chemical and biological threats. The Nunn-Lugar-Domenici Domestic Preparedness Bill appropriating funds for this purpose was a first step. The federal funds that are dedicated to meet such a threat are increasing. To date, the government has sponsored educational orientation classes for medical providers and promoted the formation of disaster medical assistance teams as part of a medical strike force in 120 metropolitan areas. It has also set up a framework for a national disaster medical system and, through the DOD, expanded the role of the global emerging infectious disease surveillance program. Nevertheless, the government's medical response to these types of threats is still in its infancy.

Economics. At the bottom line, the government's role in health care all comes down to economics and the budget. Government-funded health care in 1997 was $507 billion, or 46 percent of the total.[38] Additionally, medical entitlement programs account for an ever-increasing portion of the national budget. For example, the Fiscal Year 1998 budget for Medicare was $302.5 billion; for Medicaid, it was $198 billion. Furthermore, hospital expenditures increased from $3.2 billion in Fiscal Year 1967 to $131 billion in Fiscal Year 1999.[39] The projection that Medicare alone will be 21–29 percent of the federal budget by 2030 is alarming.[40] This trend is economically unsustainable, and the national security opportunity cost is incalculable.

"The United States does not have a national health policy."[41] It needs one. Under the assumption that basic health care is a right, the government needs to start by morally, ethically, and politically

clarifying the limits within which it will structure the health care of the nation, while at the same time retaining concern for what seems to be forgotten too often in the business of health care—the patient.

The search for a national health care policy should involve five initiatives. First, the Constitution establishes certain inalienable rights for all people. Clearly, access to quality health care is a prerequisite to life and the pursuit of happiness. The fact that 43 million citizens must rely on emergency rooms and charity to obtain health care is inconsistent with the enduring principles of the United States, especially in a time of unprecedented national prosperity. Accordingly, the nation must establish a program for universal access to health care. This program should be built upon free market principles—for both provider and consumer—coupled with mandatory, portable, and uniform access to essential health care. This proposal blends the best features of U.S. managed care and European universal access systems.

Second, along with the increased demand for health care that will follow the implementation of a universal access policy, it is essential to curb concurrently the infinite demand for health care for disease treatment. Shifting the current paradigm from disease treatment to health promotion offers the best chance of achieving this goal. Accordingly, the incremental establishment and use of national measures to promote wellness and to avoid disease would be wise. For example, immunization and cancer-screening programs should be redoubled, public health programs reinvigorated, and financial incentives established for health care consumers, providers, and payers who implement aggressive health promotion programs.

Third, it appears that the current employer-provided health insurance structure is ill advised. This approach divorces the individual consumer from payment for health care. Under the recommended national standard program for health care coverage with mandatory participation in the program, individuals would be free to purchase supplemental insurance or to pay out of pocket for types of care in excess of the essential minimums.

Fourth, the U.S. health care system cannot afford the estimated 10 percent of total health care expenditures attributed to malpractice litigation. It is essential to end society's apparent love affair with the lawsuit and to destroy the notion that less than an optimal result for a given patient demands both punishment of the physician and overtesting of the population as a whole. Accordingly, it is recommended that punitive damages and contingent fee arrangements be ended and that a rule be established to require the losing party to bear attorneys' fees and

costs. These changes allow the recovery of actual damages caused by malpractice, thus promoting quality, but provide disincentives to frivolous lawsuits

Finally, just-in-time logistics concepts leave the health care industry vulnerable to the dramatic increases in demand for medical supplies, devices, and pharmaceuticals that would occur in a national medical emergency. The Federal Emergency Management Agency should purchase and manage a stock of essential materiel needed to respond to such an emergency. Although this rotating stock would be a part of the normal supply system, it would float. The major costs for this emergency stock level are in the warehousing of it and the administrative cost to manage stock rotation in order to ensure that perishable items do not expire. This float would allow immediate access in the event of an emergency and give manufacturers and distributors time to respond to dramatic increases in demand. The nation cannot afford to be without this safety net.

The proximity and magnitude of health care's impact on national security mandate that the government expand its role in this critical industry. The answer may be that it is worthwhile for health care to be 25 percent of the U.S. GDP, as long its product is outcome-based and enhances overall national security.

CONCLUSION

As the nation approaches a new millennium, society can look back and marvel at the advances that have been made in medical science and health care. The practice of medicine in the United States now faces challenges as great as any it has ever faced, however. On the one hand, medical science and technology have brought unimaginable benefits to a select portion of the U.S. population. On the other hand, these advances have contributed to the escalation of health care costs above what many people, or even society as a whole, can pay.

Providers are caught in the middle. Third-party payers are pressuring them to keep costs down while the public and their own professional standards are driving them to do everything that might benefit each and every patient. The ultimate, perhaps intractable dilemma of health care today is to choose between either pursuing optimum care for each individual or settling for the more utilitarian approach of practicing health care that provides the greatest good for the greatest number. We might not want the latter—but we can no longer afford the former.

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INFORMATION

ABSTRACT

Exponential growth, corporate mergers, and technology convergence continue to be the dominant drivers for the information industry, as the Internet becomes the pervasive force behind unprecedented information access and global interconnectivity. As the United States migrates from an industrial-based economy to one based on information and value-added services, corporations are leveraging internal knowledge and newfound interconnectivity to reinvent business models to improve their competitive advantage in global markets. Conventional government regulatory practices cannot keep pace with this rapidly changing environment. The government should resist overregulation of this market-driven industry. The government's legitimate role is to provide infrastructure security, enhance free and open global markets, and shape an information society. The cornerstone of this society will be an educated and trained workforce, capable of sustaining and expanding U.S. global leadership in this industry.

Col James Abel, USAF
Mr. Craig Baker, Dept. of the Army
Lt Col Michael Cardenas, USAF
Mr. Antonio Castrillo, Defense Finance and Accounting Service
CAPT Alfred Clark, USN
Mr. Leonard Daniels, Dept. of the Army
Mr. Michael Earnhardt, Defense Intelligence Agency
LTC Gabe Leyva, USA
CAPT Richard Marcantonio, USN
LTC Valerie Rasmussen, USA
CDR John Read, USN
LTC Robert Reyenga, USA
COL Serhii Shvets, Ukrainian Ministry of Defense
LtCol Scott Trout, USMC
LTC John Welsh, USA
Col Allen Wickman, USAF

COL (ret) Richard Altieri, USA, faculty
COL Robert Coxe, USA, faculty
COL Frankie Hoskie, USA, faculty

PLACES VISITED

Domestic

Advanced Micro Devices, Sunnyvale, CA
Bell Atlantic, Washington, DC
Cisco Systems, San Jose, CA
Computer Sciences Corporation, Fairfax, VA
Executive Office of the President, Office of Management and Budget
Exodus Communications, Santa Clara, CA
Foundry Networks, Sunnyvale, CA
Globalstar Corp., San Jose, CA
GTE Communications Systems Division, Taunton, MA
HCL James Martin, Inc., Fairfax, VA
Information Technology Association of America, Washington, DC
Jones Communications, Alexandria, VA
Lucent Technologies, Washington, DC
Microsoft and Autonomy, Inc., Washington, DC
National Cable Television Association, Washington, DC
Oracle Corporation, Redwood Shores, CA
Silicon Graphics, Inc., Mountain View, CA
Space Systems/Loral, Palo Alto, CA
Sun Microsystems, Menlo Park, CA
U.S. Dept. of Justice and U.S. Dept. of State, Washington, DC

International

Asian Technology Information Program, Tokyo, Japan
Center for Wireless Communications, Singapore
Economic Development Board, Singapore
Hewlett-Packard, Singapore
Hitachi and National Panasonic, Tokyo, Japan
Institute for High Performance Computing, Singapore
Kent Ridge Digital Labs, Singapore
Lockheed Martin; Lockheed Martin Global Communications, Singapore
Ministry of International Trade and Industry, Tokyo, Japan
Motorola Innovation Center; Motorola Excellence Center, Singapore
Motorola Manufacturing Plant, Singapore
National Computer Board, Singapore
Nippon Telegraph and Telephone (NTT), Tokyo, Japan
TECH Semiconductor, Singapore
Telecommunications Authority of Singapore, Singapore
U.S. Chamber of Commerce, Tokyo, Japan
U.S. Embassy, Singapore

INTRODUCTION

The information industry is like none other in its remarkable ability to shift rapidly from one technological breakthrough to the next while profoundly affecting U.S. national security in the economic, military, and social sectors. According to Federal Reserve Board Chairman Alan Greenspan, this industry is the key driver of the U.S. economy.[1] Information technology industries are responsible for over one-quarter of the total average real economic growth over each of the last 5 years.[2]

While technological breakthroughs continue at exponential rates, the commercialization of the Internet has set off a marketplace dash to capitalize on interconnectivity, mobility, and electronic commerce. Products and services are quickly converging to network environments. Web communication devices will become ubiquitous appliances, very similar to the telephone of today. Companies are merging and jockeying to provide consumers with bundled services that include conventional and cellular telephone, paging, Internet, and cable television. At the same time, transmission speed to the desktop is a top consumer demand, and industry initiatives are pushing technology to provide broadband transport mediums for voice, multimedia, and the growing stream of data via cable, telephone, and satellite technologies.

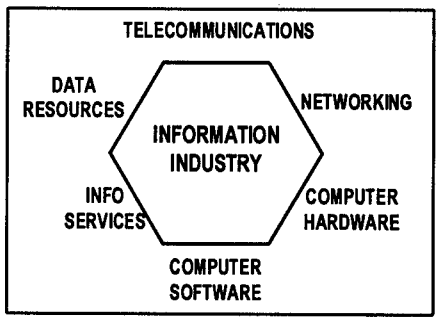
Technology convergence is also transforming the industry landscape. Single companies can no longer use innovation alone to sustain competitive advantage, but rather must look to new business strategies throughout their value chains to ensure long-term success. Large market leaders are under growing pressure from rivals and new entrants as the Internet promotes access and innovation. As a result, the levels of corporate acquisitions, mergers, and alliances to build the necessary synergy for market success have been unprecedented.

The rapid pace of change taking place in this industry presents the government with unique challenges to ensure free and open global markets, protect critical infrastructure, and deal with the social issues of the new information society. Security and privacy remain vital issues while "webtone," or universal access, is necessary to help eliminate the potential gap between the cyberspace "haves" and "have-nots." This will enable the United States to create a cyber-literate society, essential if it is to develop the trained workforce necessary to meet industry's demands and to remain the world leader in information technology.

THE INFORMATION INDUSTRY DEFINED

As companies reinvent their products and services to keep pace with new technology and the demands of the business community, the information industry is in a constant state of change. The emergence of the Internet as the medium for global interconnectivity has accelerated the rate of change as traditional transport mediums—such as voice, data, and multimedia—converge and more data resources, software products, and information services are distributed across public and private networks.

Although many information technology companies are extending their product lines across sectors, the industry today is best described by the six sectors shown in Figure 1. The sectors most likely to merge in the near future are the telecommunications and networking sectors into an "infocommunications" sector due to the convergence of digital voice and data technologies.



As boundaries between information sectors become increasingly blurred, companies are moving to integrate product and services lines vertically to provide one-stop shopping for consumers. Information sectors continue to be consolidated into fewer market dominators that purchase small start-up firms with emerging technologies as a strategy for innovation and convergence. The networking sector, which has seen the value of mergers grow from $6.9 billion in 1996 to nearly $640 billion in the first 10 months of 1998, characterizes the acquisitions and mergers exploding across the information industry.[3] Alternatively, information technology corporations are increasingly entering strategic alliances, sometimes with key competitors, on new technology development or to gain market share in one sector, while continuing to compete head-to-head in other industry sectors. This behavior is needed to survive in the rapidly changing information technology landscape.

CURRENT CONDITION

Networking

The most dynamic sector within the information industry is networking, as reflected by corporate profits and industrywide

investments. Network architectures are rapidly transitioning from client-server (centralized local and wide area networks) to Internet-based multiservice structures capable of multiple communications types. Voice, data, and video transit these virtual networks more efficiently and profitably than they could over the patchwork of yesterday's single-purpose networks. Business-to-business virtual private networks are growing at a rapid pace to link businesses in secure, electronic commerce marketplaces with global suppliers, distributors, and partners. Varieties of new services are offered via this multiservice network.

Internet growth has outpaced that of all other technologies preceding it—affecting the information business as well as virtually every other business area. Industry experts estimate that every 30 seconds a new user joins the Internet.[4] In 1994, 3 million people—mostly U.S. residents—had access to the Internet. In 1998, 100 million people around the world accessed the Internet. This drove dramatic increases in hardware, software, services, and communications investments.

As Internet use expands, users are demanding faster service, a function of more bandwidth. Internet service providers are investing huge amounts of capital to upgrade infrastructures with fiber optic technologies and fast, packet-switched networks. Analog dial up rates of 28.8 and 56 kilobits per second are quickly being outpaced by new technologies, such as digital subscriber line (DSL), Integrated Services Digital Network (ISDN), cable modems, and wireless applications. Data rates range from as high as 1.5 megabits per second downstream (toward the subscriber) and 512 kilobits upstream for DSL applications, to as high as 10,000 kilobits for cable modem applications.[5]

Two wireless technologies, in which communication companies recently invested $300 million for operating licenses, also provide ideal high-speed solutions for the last leg of the network to the user. The first is the multichannel, multipoint distribution system that operates in the 2-gigahertz range. The second is the local multipoint distribution system operating in the 26- to 30-gigahertz range.[6]

Telecommunications

The telecommunications sector continues to experience double-digit growth. Factors fueling this growth include an increasing need to transmit large volumes of information, increased spending by small and medium-sized companies, the convergence of voice and data onto integrated networks, falling prices, growing competition due to deregulation, and an expanding international market.

The United States is the dominant player in global telecommunications and is the leading telecommunications equipment exporter. Overall, the U.S. telecommunications market (equipment and services) grew by more than 11 percent in 1998, with revenues of $467.2 billion.[7] Despite the economic problems in Asia and Latin America, 1998 U.S. telecommunications products and services exports marginally declined to $20.7 billion.

Wireless communication constitutes a rapidly growing sector of the telecommunications market. The growing demand for enterprise and consumer mobile communications has fueled a 14.3 percent increase in spending on wireless services from $32.7 billion in 1997, to $50.2 billion in 1998. Industry experts project wireless communications spending will reach $81.8 billion by 2002.[8]

The U.S. telecommunications equipment market continued double-digit growth in 1998 by recording an 11.8 percent increase to reach $121 billion.[9] The fastest growing equipment categories in 1998 were computer–telephone integration (CTI) hardware and software (up 39 percent over 1997); groupware (up 29 percent); wide area network (WAN) technologies, such as asynchronous transfer mode, ISDN and frame relay (up 26 percent); and wireless handsets (up 25 percent).[10]

The largest dollar-value equipment category in 1998 was voice/data communications equipment, which totaled $65.9 billion, a 12.8 percent increase over 1997. As with virtually all other aspects of this sector in 1998 and in recent years, the fastest growing categories have been those that provide equipment primarily for high-speed data transmission. Servers, ethernet switches, and network and systems management equipment accounted for more than half of the 1998 total.[11]

Information Services

The United States dominates the information services sector, and U.S. companies are positioned to continue shaping both the global information environment and the process by which information technology is incorporated into other industries. Information services is one of the fastest growing sections of the U.S. economy due to its intrinsic link to an ever-changing technology base and the value-added knowledge needed by businesses to streamline processes in the globally competitive marketplace. International Data Corporation (IDC), a leading U.S. market research firm, estimates that the total worldwide computer services industry had revenues of $281.7 billion in 1997, with U.S. firms accounting for 47 percent, or $132.4 billion, of that sum.[12]

Professional services, constituting 70 percent of the sector, are in high demand by businesses that are constantly updating to stay competitive. The key player here is outsourcing services, which netted $44 billion in 1997 and is expected to continue strong growth at 11.6 percent, as 75 percent of businesses are forecast to outsource services by 2000.[13] Businesses that prefer to keep their information technology services in-house are increasingly looking to consulting and systems-integration services to re-engineer business methodologies and keep pace with the rapid improvements in the field. The fastest growing area is Internet/Intranet services, as businesses race to establish a web presence for competitive advantage or protection of consumer market share. Other services—such as training, disaster recovery, and facilities management and maintenance—will continue solid growth.

Electronic information services collect, organize, and provide users access to proprietary databases. The perishability of global business information keeps demand for services high, especially for marketing, financial, economic, and news retrieval. Consumer online services expanded from 9 million subscribers in 1995 to more than 62 million in 1997, propelled by the growth of the home personal computer market. Internationally, Asia is still far behind the United States and European markets for online services due to poor telecommunications infrastructures, regulatory costs, and sociopolitical issues, such as censorship, privacy, and intellectual property rights.

Data-processing services, estimated by IDC at $62.2 billion in 1997, continues steady growth fueled by vendors serving business and the financial market, especially in support of stock markets, banks, and insurance companies.[14] Firms in this segment profit from economies of scale to handle outsourced transaction processing or to offer time-sharing of mainframe capacity to businesses. As the business environment and employee compensation paradigms continue to become more complex, the market for payroll, employee benefits, and business tax payment processing—largely untapped by outsourced processing services—will continue to expand. Moreover, the stock market's increasingly heavy volume has been a bonanza for processing services that handle trades and financial information services.

Data Resources

Data and information have become strategic resources for businesses competing in the emerging digital economy. Clearly, those companies that synthesize the incredible volume of available information into usable

knowledge will gain a strategic business advantage over their competitors.

The rapid growth of the Internet and the surge in electronic commerce are driving growth in the database management market. According to IDC, sales in the database markets grew 15 percent in 1998, up from 11 percent growth in 1997. With only 20 percent of the world's business information stored on databases, continued growth in this sector is predicted, especially in international markets.[15] Recent efforts to incorporate the best features of relational database management systems and object-oriented products are creating hybrid databases that offer tremendous capabilities. The battle lines for the future of the corporate database have been drawn. On one side are the tried-and-true relational database management systems, used by corporations for decades; on the other side are new object-oriented database products—based on Java interoperability—which are beginning to be introduced into the market.

Computer Hardware

Personal computers account for more than 95 percent of the computers in the United States. The primary drivers of domestic and international demand for personal computers are price and performance enhancements. Since 1980, personal computer vendors have maintained a "typical" or mid-range system price averaging $2,000 by continuously providing more capability at about the same price. Ever-increasing functionality, such as image processing, speech recognition, and streaming video, have driven increases in performance. Storage capacity, processor speed, and data transmission speed have also increased, at a rate of 60 percent per year, doubling every 18 months. Despite these performance trends, however, lower component pricing and increased competition among vendors have reduced profit margins substantially, yielding average prices for home personal computers below $1,000.

While system prices drop, volume and worldwide revenues continue to increase. More than 92 million personal computers were shipped in 1998, and 1999 estimates exceed 100 million. Of these sales, IBM-compatibles overwhelmingly dominate, with Apple computers serving a niche market.

Network Computers. In 1997 and 1998, many U.S. companies aggressively pursued efforts to reduce total ownership costs of networked personal computers, conservatively estimated as $8,000 per year. In response to these cost-cutting demands, the information industry

released several products, such as network computers (also referred to as thin clients), NetPCs (Microsoft), and Windows Terminal Servers. Common to these products is reduced user workstation capacity and increased reliance on a centralized network server.

Supercomputers. In an attempt to increase the national security posture, the 1998 Defense Authorization Bill tightened export controls on the sale of computers capable of at least 2,000 million theoretical operations per second (MTOPS) to countries of concern for reasons of national security or their role in the proliferation of weapons of mass destruction. A modern desktop computer is capable of roughly 200 MTOPS, approximately the same level that was used to define a supercomputer in 1991. Current export restrictions vary by computer capacity (in MTOPS) and by region.[16]

Components and Peripherals. Microprocessors, random access memory (RAM), and other computer components continue to see steady growth, primarily because of the global personal computer demand. The United States enjoys a 42 percent market share in microprocessor manufacturing. However, manufacturing of less sophisticated memory chips has moved primarily offshore, where labor-intensive "commodity" manufacturing is cost-effective.

Peripheral devices, such as displays, modems, and other input devices, continue to be refined and improved. The introduction of flat panel displays, 56-kilobit feature-rich V.90 modems, touch screen technology, and digital workstation cameras illustrate the continual product improvement taking place. In addition, hand-held devices, which offer untethered access to the Internet, are available today.

Computer Software

Revenues for the worldwide packaged software market reached $122 billion in 1997, with projected annual increases of 12 percent. The U.S. packaged software market, valued at $54 billion annually, retained its place as the world's largest and most energetic software market. The Bureau of Labor Statistics reports that total software industry employment is growing at an annual rate of 9 percent, with salaries that are among the highest in the U.S. economy.[17]

The personal computer has continued to be the most widely used platform, with Microsoft's Windows 95/98/NT being the most popular operating system. Business applications software sold in "suites" continue to dominate the packaged software market.

In 1998, computer-aided design (CAD), engineering, and manufacturing software markets increased 13 percent over 1997 figures,

with revenues of over $2.9 billion.[18] This market should increase an additional 14 percent this year, reaching an estimated $3.3 billion in 1999 sales.

CHALLENGES

The emergence of the Internet, along with continued escalation of technology advances, is having a dramatic effect on society and traditional business paradigms, fostering rapid fundamental changes across all sectors. The government and the information industry face many challenges as the nation is transformed into an emerging digital society.

Technology Challenges

Intellectual Property and Standards. While technology advances in the laboratory continue to validate Moore's Law for the doubling of performance every 18 to 24 months, the information industry continues to innovate and produce new products to stay competitive. The sustainability of product innovation relies on the ability of companies to protect their intellectual property through patents and copyrights around the world. Enforcement of World Intellectual Property Organization treaties across international borders and legal jurisdictions is a critical challenge for sustaining technological leadership. Additionally, standards and protocols for hardware and software products are vital for competing in the global marketplace and for improving productivity through better interoperability. Fostering a cooperative environment for establishing standards in the United States and abroad is a shared challenge for government and industry.

Year 2000 (Y2K) Issue Challenge. In general, U.S. corporations in the information industry consider their internal systems well-positioned to handle the Y2K challenge. Extended efforts have been made to upgrade customer products, but some legacy systems—no longer tracked by warranty or service contracts—are difficult to fix proactively. Y2K is still a valid concern in developing countries and in small and medium-sized companies where limited financial resources have delayed fixes. The estimated Y2K global price tag is $300–$600 billion, and Y2K has boosted the demand for U.S. information services with nearly 55 percent of repair work being outsourced to information technology professional services.[19] An ongoing Congressional debate continues on the scope and limits of Y2K legal liability for corporations.

Social Issues

Skilled Information Workforce. The phenomenal growth of the information technology industry has created a growing need for information professionals in every sector of the U.S. economy. The Information Technology Association of America (ITAA) reports that the workforce will need to grow 7–10 percent annually to keep up with information-driven growth.[20] Nationwide, 24 percent of small business owners complain that a lack of qualified workers is a threat to their survival, up from 13 percent in 1993.[21] An ITAA-sponsored survey indicates that there are at least 346,000 vacant information technology positions nationwide—a 10 percent vacancy rate.[22] In addition, the lack of strong information technology educational curricula and the failure of the education system to produce enough qualified information technology professionals further aggravate the workforce shortfalls.

Universal Access. The Internet is quickly becoming the technology of choice for civic participation, commerce, employment, education, and daily communications. Those who have access will prosper from the Internet's social, educational, technological, and economic benefits, while those who do not will find it more difficult to compete. A "digital divide" is emerging between the information "haves" and "have-nots," especially in poor neighborhoods, because access to the Internet is not universally available. The U.S. economy may also be at risk if a significant segment of our society, denied equal access to the Internet, lacks the technological skills to keep U.S. firms competitive.[23]

Privacy. The automated collection and storage of personal information by public and private entities have grown with the expansion of the Internet. Current government policy supports private industry–led Internet regulation. A 1998 Federal Trade Commission survey showed that almost 85 percent of Internet sites collected personal information, however, while only 14 percent provided any notice of information practices, and only 2 percent provided a comprehensive privacy policy.[24] Consumers now consider the risk to privacy the number one reason to avoid the Internet.[25] In addition, more than 50 percent of respondents in a 1998 *Business Week*/Harris poll felt the government should pass legislation now to stem privacy violations.[26] How business and government resolve privacy issues will affect electronic commerce growth and criminal activity policing because of privacy protection

Information Security

Encryption. The security, protection, and assurance of sensitive information are critical issues to both government and industry. In a recent ITAA survey, 96.2 percent of respondents said global access to strong encryption (128-bit or higher) is essential to the growth of the Internet and electronic commerce. Encryption is an essential tool in providing security in the Information Age, allowing sensitive information to be stored on nonsecure computers or transmitted across nonsecure networks.[27] Strong encryption blocks law enforcement's ability to conduct electronic surveillance (particularly wiretapping) against suspected criminals, however. Software companies in the United States could lose up to $65 billion and many jobs if the government does not relax controls on encryption exports.[28]

A Ninth U.S. Circuit Court of Appeals ruling said the government's prohibition against exporting source code for strong encryption or posting it on the Internet is unconstitutional.[29] This ruling complicates the challenge for government and industry to find suitable trade-offs.

Critical Infrastructure Protection. The explosive growth of interconnected computers, which form the backbone of the national information infrastructure, can be traced to two key policy changes: the 1989 decision to open the National Science Foundation network (NSFNET) to corporate and individual users and the Federal Networking Council's 1990 decision to open the Internet to commercial ventures. Coupled with technological advances that enable workforce reductions through introduction of networked computing systems, these policy changes have acted as catalysts in the proliferation of interconnected information networks. All elements of the national critical infrastructure are becoming more reliant on information, especially transportation, finance, and energy. Just as these essential sectors are the backbone of U.S. economic growth, the military and the National Command Authority (NCA) are also dependent upon them for enabling rapid deployment and conduct of sustained operations.

The private sector owns and operates a major portion of the information infrastructure. Consequently, unless the corporate "bottom line" is affected, private industry may not appreciate the need to devote major effort and funding to protect their respective portions of the infrastructure, although it may be critical to national security interests.

Implementation of Presidential Decision Directive (PDD) 63, *Protecting America's Critical Infrastructures,* has progressed slowly

toward the goal of significantly increasing security of government systems by 2000, and developing a reliable, interconnected, and secure information system infrastructure by 2003.[30] The challenge for government and industry is the development of a viable strategy that refocuses efforts to create an effective and enforceable national policy for the protection of the information infrastructure.

Business Challenges

Antitrust. In recent years, federal courts have maintained that the most dominant companies can compete fiercely in the marketplace without violating the provisions of the Sherman Antitrust Act. The purpose of government regulation is to ensure the market is open to fair competition, on the premise that a monopolistic advantage attained by a single enterprise or consortium will result in anticompetitive practices characterized by wide profit margins and stagnation of innovation. Recent antitrust cases against Microsoft and Intel will have a profound effect on shaping the information industry because of their stature and the potential precedence that may be set in an industry where technology turnover and innovation are major factors in market share sustainability.

Taxation/Tariffs on E-Commerce. As e-commerce proliferates, federal, state, and local governments stand to lose tremendous amounts of revenue normally collected as taxes on traditional transactions. State and local authorities are increasingly demanding the right to tax e-commerce. However, the Clinton Administration and Congress, supported by industry, have placed a 3-year moratorium on Internet taxation to foster e-commerce growth. During the 3-year hiatus allowed under the Internet Tax Freedom Act,[31] state and federal taxing authorities must reach an agreement fostering fair business practices and continuing the move to a digital economy. A similar debate will occur over international tariffs.

Regulatory Agility. Government regulatory processes and practices are having trouble keeping up with the pace at which the information industry is changing. Whether predictable or unforeseen, the United States must transform government regulatory processes to accommodate rapid technology change while maintaining the ability to foster a business environment conducive to innovation and open markets.

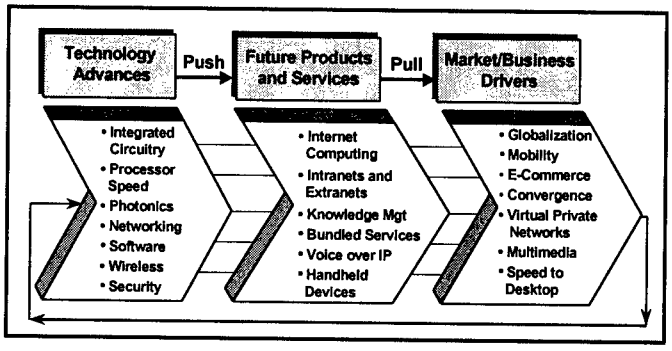
OUTLOOK

The United States will remain the global market leader in every segment of the information industry for the next decade. The

information industry is undergoing revolutionary change due to the dramatic advances in technology that are pushing the development of new products and services, while the marketplace continues to pull the sector toward innovative solutions for global competitive advantage.

The business environment will undergo similar Information Age change characterized by rapid global expansion, increased business partnerships, far-flung mobile workforces, and increasing availability of bandwidth for simultaneous support of data, telephony, multimedia, and video. Corporations must realign their structures to take advantage of the Internet to facilitate communication and data transport. The companies will need to exploit enabling technologies, such as knowledge management, data mining and warehousing, encryption, and broadband networks. Firms will integrate these new technologies into their business models to gain the maximum competitive advantage.[32]

Internet and E-Commerce. The overwhelming driver in the future marketplace will be the emerging Internet technologies (Figure 2). The Internet is projected to reach 1 billion worldwide users by 2005.[33] More important, it is driving rapid introduction of new products and services to capitalize on the migration to Internet computing and is driving network convergence of voice, data, and video. This revolution is fueling increases in information technology investments projected to grow worldwide from $750 billion in 1997 to nearly $1.2 trillion by 2002.[34]



Businesses are racing to the Internet because of the increased efficiencies, potential profits in the value chain, and new sales channels. By 2003, U.S. businesses are projected to reach $1.3 trillion dollars in e-commerce, or 9.4 percent of U.S. sales,[35] with more than 75 percent of the revenues in the business-to-business channel. The number of large companies with established e-commerce systems was estimated to jump from 20 to 65 percent by the beginning of 1999, led by computing and electronics firms, aerospace and defense, petrochemicals, utilities, and motor vehicles businesses.[36] E-commerce will foster competitive supply chain pricing, increased product customization, and further reduction of middlemen in the sale value chain. Additionally, new cyber-

intermediaries will take advantage of virtual private networks to cement and secure business partnerships and supplant traditional go-betweens.

Networking

The networking sector's explosive growth is forecast to continue at a 30–50 percent rate over the next several years, reaching $60 billion in global products by 2001.[37] Actual growth will be shaped by the worldwide level of acceptance of the Internet, the impact of e-commerce on network strategies, and the demand for new technologies for converged data, voice, and multimedia networks. By 2005, digital data traffic is projected to overtake voice as the dominant public network flow as a result of industry consolidation in the cable television, data and telecommunications segments, and the trend to offer consumers end-to-end multimedia communications networking.[38]

The overall trend toward increasing network bandwidth performance within the wide area network (WAN) and local area network (LAN) sectors should continue with the introduction of improved networking hardware and software technologies. Fast Ethernet, Gigabit Ethernet, and Asynchronous Transfer Mode will be the dominant competitors, with growth projected at 50 percent, 203 percent, and 37 percent, respectively, through 2001.[39] Advanced technologies for intelligent switching and bandwidth allocation hold promise for increased speed and efficiency needed for converged networks. Despite these anticipated improvements in bandwidth availability, it is still uncertain if bandwidth will keep pace with the burgeoning demand.

The next generation of networks will be Internet-based virtual private networks (VPNs), replacing centralized LANs and WANs. Virtual private networks use technologies that enable companies to extend their corporate networks (intranets and extranets) to their global workforce, suppliers, and business partners securely.[40] This business model will work only if the network supporting the information flow (data, voice, or video) is reliable, robust, cost-effective, secure, and flexible.

In addition to near-term networking improvements, Internet2 and the Next Generation Internet (NGI) Initiative research projects are developing revolutionary networking and application technologies that have throughput speeds 100 to 1,000 times faster than those offered by today's Internet.

Telecommunications

The United States enjoys the preeminent market position in the telecommunications sector. Key drivers for this position and future growth are increased market demand for bandwidth, worldwide liberalization and deregulation, proliferation of the Internet, and the introduction of low earth orbit satellite systems. Advances in silicon, optics, wireless communications, and software will drive a 250-fold increase in network capability by 2005.[41]

In the United States, competition and growth will continue as cable television, long distance telephone service providers, Internet service providers, and power companies compete to meet the requirements of both business and individual users. The telecommunication industry will expand bandwidth to meet the ever-increasing information requirements and applications, and will be shaped by technological innovations, such as Asymmetric Digital Subscriber Line and Internet Telephony.

Global wireless demand is expected to double to 600 million subscribers by 2001. Emerging markets in the Pacific Rim, Eastern Europe, Latin America, and—to a lesser degree—Africa have low teledensities and abundant populations, making them key future markets for wireless services. In the United States, wireless growth will occur predominantly in the data area. In 1995, traffic over wireless networks was 96 percent voice and 4 percent data. By 2005, data will comprise 70 percent of all wireless traffic. To meet this demand, satellite launches by commercial firms from sites around the world will continue to outpace government launches.

Information Services

The proliferation of Internet/Intranet technology will drive an increased worldwide demand for information services. International trade opportunities in information services will continue to increase rapidly due to the trusted expertise and market saturation of U.S. vendors. Information services are expected to continue at a compounded annual growth rate of 9.4 percent, reaching $403.2 billion by 2001.[42]

The demand for services will be driven by trends transforming all information technology industry sectors. These trends include the continuing migration to computer networking and client/server model, the powerful mass-market rush to the Internet and e-commerce, and a shift from product-focused to services-focused firms. Each of these growing trends will demand high-quality service to build, integrate, and

maintain new or existing architectures. Although the information services sector is dominated by several large vendors that use their size, expertise, and reputation to sustain competitive advantage, product-oriented information technology firms are extending their value chains into services sectors, while there is a growing niche for smaller vendors to service smaller, less complex businesses.

Data Resources

Data mining and knowledge discovery are in the top ten emerging technologies projected to have a significant impact on the future competitiveness of worldwide industries.[43] Data mining is the process of discovering a meaningful correlation, pattern, or trend by sifting through large amounts of stored data using pattern recognition technologies, as well as statistical and mathematical techniques.[44] Because of the tremendous size of these databases, mainframes and 64-bit platforms are the principal workhorses. The most important benefits of data mining and knowledge discovery are that they solve complex problems and are powerful business enablers.

Computer Hardware

The explosive growth of Internet and microchip advances heralds new growth potential for the computer hardware industry. Computer capacity will continue to increase; both Intel and AMD are poised to release processors with 64-bit architectures and 500-megahertz clock speeds in 1999. Intel demonstrated a 1-gigahertz chip in February 1999, with both IBM and Compaq announcing similar products.

The personal computer segment, the largest and most competitive, will reach $300 billion in sales by 2000, with 15–20 percent global growth over the next several years driven by continued price/performance improvements, Internet demand, and greater penetration in consumer and emerging markets.[45] As computer capability increases, lower end personal computers will challenge workstation and server segments, which in turn will challenge the mainframe/minicomputer markets. Cost competition in the value chain will continue to challenge the under-$1,000 personal computer market, particularly network personal computers, to lower the total cost of ownership. In the first decade of the next century, major advances will include multimedia interconnectivity, virtual reality, and flat panel displays to facilitate seamless interaction across diverse information media and geographical borders.[46]

Computer Software

The U.S. software sector continues to lead the world with nearly half the market revenues. Revenues are projected to grow at a compounded growth rate of 12 percent, surpassing $220 billion worldwide by 2002.[47] Although the United States and Western Europe account for 80 percent of the world packaged software market, there is real growth potential in many Latin American, Middle Eastern, and Asian markets. Networking software, groupware, e-mail, and telephone products will remain strong. Emerging applications—such as speech recognition, enterprise storage management, and e-commerce software products—also have significant growth potential.

While Windows products are projected to control more than 90 percent of the operating system market through 2001,[48] use of open-system products such as Linux and Java will gain momentum from alliances among major vendors such as IBM, Oracle, Intel, and Sun. Industry researchers predict that more than 60 percent of businesses will use Java by 2001, including more than 80 percent of the top 1,000 Fortune companies.[49]

The computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE) markets constitute 34 percent of worldwide software products. This market is forecast to grow by 12 percent in 1999, with revenues reaching an estimated $29 billion. Global market demands and new software vendor alliances in the development of new products will foster steady growth over the next 5 years. Three-dimensional CAD/CAM products will emerge to meet new virtual designs and production integration needs.

GOVERNMENT GOALS AND ROLE

> "The primary responsibility of government in the networked world is to establish and maintain a policy environment that promotes competition in the marketplace. Governments should focus their efforts on opening markets and, where necessary, ensure a level playing field for all participants."[50]

The rapid turnover of technology and the increasingly complex nature of convergence in the information sector have tested the government's ability to regulate new digital products and services effectively, especially with the emergence of the e-commerce marketplace. The traditional "command and control" approach to regulation is poorly suited because it demands timely government action

and thorough understanding of what is being regulated. More appropriate is a "cooperative regulation" paradigm where regulators establish goals for self-regulated organizations or associations to pursue, while providing an oversight framework of institutionalized problem solving and dialogue of experts in the private, public, and academic sectors.[51]

This model was used successfully to form a regulatory apparatus for the emerging and uncertain Over-the-Counter–Market securities market in the 1930s.[52] More recently, the Clinton Administration adopted a similar "non-regulatory, market-oriented approach" for the blossoming e-commerce market in the 1997 policy directive, *A Framework for Global Electronic Commerce*.[53] The information industry should pursue a cooperative regulation strategy, which leaves technical regulation and standards to the fast-paced private sector while government provides overarching guidance and oversight. The government has a legitimate role to intervene in criminal activity and certain other issues, such as free and open markets, infrastructure protection, and shaping of the information society.

Enhancing Free and Open Markets

The government's primary role should be to maintain a cooperative regulatory environment that fosters competition, innovation, and free and open global markets. The government should provide the negotiating muscle for industry in international forums for treaties and agreements and then pursue compliance by signatories. The Clinton Administration has been successful in negotiating several critical treaties in areas such as intellectual property rights protection and global telecommunications reform. Although many nations are beginning to liberalize their telecommunications markets, the government needs to continue to press foreign governments to ensure barriers or exclusionary practices do not preclude U.S. businesses from competing in free and open markets. Likewise, the cooperative international enforcement of intellectual property protection is vital to U.S. technology leadership.

Key to enhancing market access is the establishment of standards and protocols needed for global interoperability and greater networking capabilities. The government should be an advocate for the creation of such standards and protocols, particularly with other countries and international organizations, but should allow the marketplace and/or trade associations to determine which standards are adopted.

Competition and Antitrust. Government policies within information technology subsectors should be consistently applied without showing

favoritism to any particular individual, technology, or corporate entity. The telecommunications sector has a myriad of regulations and laws that treat different businesses unequally. While the former Regional Bell Operating Companies (RBOCs) are struggling to meet regulatory requirements to enter the long distance telephone market, cable television companies and long distance carriers are extending their services across the same spectrum of service without similar constraints. This approach has hindered the growth of broadband connectivity, especially over the "last mile" to consumers. Given the changes in technology, particularly voice-over Internet Protocol, government regulation must ensure that all technologies and market entrants receive fair treatment, particularly as cellular, Internet, telephony, and cable services converge.

Given the rapid turnover of innovation and technology that constantly reshapes this market, the government's antitrust intervention to address perceived information technology industry monopolistic practices should be tempered. Results from long, drawn-out antitrust cases may become obsolete because of the rapidly changing technology. Competitive monopolistic activity that results from industry convergence should not be targeted unless it exhibits predatory pricing practices or long-term, impenetrable market barriers. Government policy must consider that the marketplace is now defined on a global scale and the dominant U.S. market leaders enhance U.S. global competitiveness and allow the United States to continue to shape the information environment around the world.

Property Rights. The rapid digitization and dissemination of intellectual property is confronting software developers, writers, musicians, artists, and others with a myriad of problems, such as a loss of revenue. In practice, when copyrighted material is posted to a web site, it is assumed that the viewer has a "right to copy" without first gaining permission or remunerating the author. The lack of mechanisms for users to compensate intellectual property owners, disparate laws and regulations regarding owners' rights, and lack of enforcement further exacerbate the problem.[54] Therefore, some content owners are opting to withhold valuable information. While technological solutions for charging royalties appear to be on the horizon, these remedies must be coupled with enforceable copyright infringement mechanisms.

Taxation on the Internet. State, local, and federal entities that would receive taxes based on traditional transactions will continue to press for a new taxation methodology as e-commerce proliferates. The federal government, in cooperation with industry, must mediate this process to ensure the fair distribution across taxing authorities, a credible and

enforceable plan, and limits on tax burdens to avoid stifling the digital economy.

Protecting U.S. Information Infrastructure

The rapid proliferation of computer technology throughout the United States has resulted in the intertwining of the government, commercial, and private sectors into an unregulated information infrastructure. Although government and industry associations have been proactive in developing a baseline for critical infrastructure protection, the U.S. government has been unable to make significant progress in implementing a national policy. Reliance on private industry to finance and initiate protection measures has resulted in sporadic results. Corporations, especially large firms, are taking action on infrastructure protection when doing so protects profit margins or improves the bottom line. The infrastructure is only as strong as its weakest link, however, and many small and medium-sized businesses lack sufficient resources to squander on an ill-defined threat.

In this challenging scenario, the U.S. government has a crucial role to play. It must provide continued updates to help identify, isolate, quantify, and clearly define any threat, so scarce resources can be used efficiently to counter the threat. This role includes disseminating threat information in a timely manner while still protecting the sensitivity of the collection sources involved. Equally important is the maintenance of a cooperative environment for industry to share information with the government and competitors on threats and identified intrusions. In addition, the government must provide incentives to businesses and industry to pursue their own initiatives in Critical Information Infrastructure (CII) protection. The government must re-engage industry, work cooperatively to reduce U.S. vulnerability to CII attack, and mandate compliance to ensure that the United States has the necessary capability to survive an attack.

Encryption. The government must balance the needs of law enforcement and national security with those of Internet e-commerce users and software makers. As commercial encryption technology strengthens in response to heightened threats, U.S. software makers should be allowed to sell products that match or exceed the capabilities of offshore software makers. Law enforcement, in cooperation with industry, must find a cooperative way to access encrypted data that may be criminal in nature.

Shaping an Information Society

Privacy. The results of the 1999 follow-on survey to the Federal Trade Commission's 1998 online privacy study will have a profound impact on continuing the policy of industry self-regulation of privacy in the digital domain. If the results fail to show significant progress, the government has a legitimate need to protect citizens with legislation to establish guidelines for online privacy. However, the technical implementation must be left to industry to leverage emerging technologies and avoid stifling the growing digital economy.

Universal Access. Just as telephone services now reach virtually all U.S. residents, the government must work to make Internet services available to all. This must be a cooperative process between government and industry to foster innovative technology solutions, to ensure fair budgetary burdens, and to avoid heavy-handed regulatory implementation. Congress should pass legislation that outlines universal access goals while leaving the technical implementation to a cooperative forum of government and industry. The financial burden can be modeled after the recent Internet and telephone connections for schools and libraries (E-rate),[55] but should spread the rate burden across the converging network and telecommunications sectors. Universal Internet access will be an enabling medium to shape future generations.

Information Workforce. The greatest challenge to the dominance of the United States in the information industry is the inability of our educational institutions to meet industry demands for qualified workers. In the short term, the government must continue to support industry's demand for relaxed visa quotas of foreign information technology professionals. At the same time, government and industry must foster an environment of magnet innovation hubs and safe living communities that will continue to attract the international brain trust to the United States. The nation cannot sustain its technology leadership over the long term without making fundamental information technology investments in the education system now. The government must step up its funding to schools to expand information technology curricula while providing generous loans and grants to students. State and federal governments should offer tax incentives to businesses to encourage investment in schools, scholarships and internships for students, and expansion of work training programs.

CONCLUSION

Driven by the Internet revolution, the information industry continues to change dramatically—reinventing itself every 1–2 years. Driving global effects in all other major industry sectors, U.S. ingenuity and innovation are leading the charge on this unbridled growth. These changes affect virtually every aspect of U.S. government and business, resulting in direct and indirect impacts on business processes and global commerce.

The health of the information industry is excellent, and industry leaders forecast continued U.S. leadership well into the next decade. The government must adapt a cooperative regulatory strategy to keep pace with the information industry and foster U.S. competitiveness around the world. The major negative factor threatening this sector is the shortage of educated information workers to meet growing workforce demands. The government must act quickly to reverse this trend; it must support education initiatives to grow the mathematical and scientific minds that the U.S. information industry requires to advance aggressive, leading-edge technologies. These investments will pay dividends in future generations, not only for the information industry, but also for U.S. society as a whole as the United States leads the world into the "third wave" information-based economy of the next millenium.

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LAND COMBAT SYSTEMS

ABSTRACT

Existing ground combat platforms represent the most technically sophisticated, lethal, and survivable fleet of weapons systems in any military force, past or present. The land combat vehicle (LCV) industry, however, is in decline, characterized by low production rates, constrained demand, and uncertainty over new technologies. A high degree of global competition complicates market strategies. Corporate survival depends on seeking efficiencies through downsizing, expanding product lines, negotiating mergers and partnerships, and adapting current processes for low-rate, high-mix production. Despite these strategies, substantial, costly overcapacity remains, which could translate into monies for research and development (R&D). Current production contracts can sustain the industry for 5 years, but without a consensus for new vehicle manufacture or a robust modernization program, the industry may not retain a viable manufacturing capability in the future.

Brigadier General Bjorn Ruud, Norwegian Army
Lt Col Jorge Acevedo, USAF
Mr. Rick Azzarano, Dept. of the Navy
LTC Randy Corbin, USA
LtCol Mike Duva, USMC
LTC Michael Goodroe, USA
Mr. Dale Hanson, Dept. of the Army
COL Gary Knapp, USA
LTC David Mintus, USA
Lt Col Clada Monteith, USAF
CDR Dale Nees, USN
Ms. Linda Nordstrom, Dept. of the Army
COL Hernando Ortiz, Colombian Army
CAPT Frank Pagano, USN
CDR Renee Rodeck, USN
Lt Col Clarence Taylor, USAF

COL Sam Chappell, USA, faculty
Dr. Paul Needham, faculty
COL Paul Severance, USA, faculty
Col Russ Woody, USMC, faculty

PLACES VISITED

Domestic

AM General, South Bend, IN
Defense Advanced Research Projects Agency, Arlington, VA
Detroit Diesel Corp., Detroit, MI
General Dynamics Corp., Land Systems Division, Sterling Heights, MI
General Dynamics Corp., Woodbridge, VA
General Dynamics Corp., Tank Plant, Lima, OH
Letterkenny Army Depot, Chambersburg, PA
Oshkosh Truck Company, Oshkosh, WI
Tank-Automotive and Armament Command (TACOM), Warren, MI
Tank-Automotive Research, Development, and Engineering Center (TARDEC), Warren, MI
United Defense Ltd. Partnership, Chambersburg, PA
United Defense Ltd. Partnership, York, PA

International

British Aerospace, Royal Ordnance, Nottingham, United Kingdom
General Motors Canada, London, Ontario, Canada
Giat Industries, Roanne, France
Krauss Maffei-Wegmann Wehrtechnik, Munich, Germany
Steyr-Daimler-Puch Spezialfahrzeug, Vienna, Austria
Vickers Defence Systems, Armstrong Works, Newcastle Upon Tyne, United Kingdom

INTRODUCTION

Over the past 50 years, the United States designed and manufactured some of the finest ground combat systems in the world. Operation DESERT STORM was a global billboard for the quality of products produced by the LCV industry. During the last decade, however, reduced demand brought about significant change in the industry. This change has led to excess industrial capacity, inefficiency, and potentially costly procurement programs.

The existing LCV industrial base is a product of U.S. history. Arsenals, for example, trace their roots back to the War of 1812.[1] Depots were created in World War II to support the maintenance and repair of existing equipment, because private industry was totally consumed with the production of new equipment. After World War II, the government did not immediately demobilize the depots, because it was assumed that all future wars would require large-scale industrial mobilization just as World War II had. With the end of the Cold War, many defense planners no longer anticipate protracted global operations requiring a general mobilization. Rather, they foresee brief conflicts, following which the United States will refit ground forces with upgraded equipment from current inventories.[2] Consequently, there are questions about the sustainability of the LCV industrial base at current levels and about any need to preserve an industrial base for surge production of current generation armored vehicles.

The major challenges facing the industry are varied and complex:

- Substantial overcapacity in the industrial base
- Industry's capacity to surge production
- Health of subtier vendors
- Requirement for investment in R&D
- Maintenance of competition among remaining prime contractors

Growing technological obsolescence of current systems, the requirement for maintaining unique defense industrial capabilities, the effects of global competition, and an amorphous, asymmetrical threat to national security, compounds these challenges.

THE LAND COMBAT SYSTEMS INDUSTRY DEFINED

The land combat systems industry encompasses a spectrum of systems: tanks, infantry fighting vehicles, artillery and missile systems, tactical trucks, small arms, land mines, and command and control vehicles. The study group confined the scope of this report to tracked

vehicles, tactical wheeled vehicles, and the industrial base—including private industry, depots, and arsenals related to their production and maintenance (Table 1).

Table 1: LCV Domestic Industrial Base

Prime Contractors	Government Facilities
AM General	Albany Maintenance Center
General Dynamics Land Systems	Anniston Army Depot
GM Canada	Barstow Maintenance Center
Oshkosh Truck Company	Letterkenny Army Depot
United Defense Ltd. Partnership	Lima Army Tank Plant
Stewart & Stevenson	Red River Army Depot
	Rock Island Arsenal
	Watervliet Arsenal
	Idaho National Engineering and Environmental Laboratory

Tracked Vehicles

Designed to operate in almost any terrain, tracked vehicles can survive known and projected threats within reasonable risk limits. Today's domestic tracked vehicles are produced by two prime contractors: General Dynamics Land Systems and United Defense Limited Partnership. They include M1-series Abrams tanks, M2/3-series Bradley Fighting Vehicles, M109-series Paladin self-propelled Howitzers, M88-series Recovery Vehicles, Armored Combat Earthmovers, the M113 Family of Vehicles, the Multiple Launch Rocket System, and the Marine Corps' Amphibious Assault Vehicle (AAV). Future systems include the Grizzly Obstacle Breacher, the Marine Corps' Advanced Amphibious Assault Vehicle (AAAV), the Wolverine Heavy Assault Bridge, and the Crusader artillery system.

Tactical Wheeled Vehicles

In support of combat operations, tactical wheeled vehicles transport personnel, equipment, and critical supply items. They also provide mobility for command, control, and communications systems and serve as platforms for crew-served weapons, such as cannons, machine guns, and antitank missile launchers. Tactical wheeled vehicles include a number of platforms, which fall into three main categories according to load-bearing capacity. First, lightweight vehicles (less than 2.5 tons) include the High-Mobility Multipurpose Wheeled Vehicle (HMMWV) in production at AM General Corporation. Second, vehicles of medium weight (2.5–7 tons) include the Army's Family of Medium Tactical Vehicles (FMTV), which are produced by Stewart & Stevenson Corporation. Marine Corps' programs include the Medium Tactical Vehicle Replacement (MTVR), under contract with the Oshkosh Corporation, and the Light Armored Vehicle (LAV) produced by General Motors, Canada. Third, the heavyweight category (greater than 7 tons) includes the Heavy Equipment Transporter (HET), the Heavy Expanded Mobility Tactical Truck (HEMTT), the Palletized Load System (PLS), the Logistics Vehicle System (LVS), and a number of special purpose vehicles in production at Oshkosh Truck Company.

The wheeled fleet of military tactical vehicles, unlike its commercial counterparts, must traverse terrain and distances similar to those required of the combat forces that they support. Although survivability requirements for tactical wheeled vehicles continue to be less stringent than they are for tracked vehicles, load capacity, off-road mobility, reliability, and simplicity of operation and maintenance remain fundamental to their function of supporting combat forces.

In spite of this, tactical wheeled vehicles have more in common with commercial vehicles than do armored tracked vehicles. Their design is less likely to change with the evolving nature of threats and is more conducive to the use of off-the-shelf components and production technologies developed for commercial vehicles. Consequently, commercial options can sometimes satisfy military requirements with a degree of modification, and the production of tactical wheeled vehicles may lend itself more readily to integrated military/commercial production lines that can achieve economies of scale and contain an inherent surge capability for military requirements.

CURRENT CONDITION

Global Environment

The manufacturing industry for LCVs remains a profitable business in many sectors, but is an industry in decline. Many nations continue to reduce their defense budgets due to revised threat estimates or regional financial depression. Although some nations are still potential buyers for new or upgraded tracked and wheeled combat vehicles, competition for these markets is intense. The United States remains the largest aggregate buyer of land systems, and market projections indicate that the Middle East will remain the top importer, followed by Asia and the Pacific Rim countries, Europe, Latin America, and Africa.[3,4,5] Further, it appears that product sales will shift from heavy tanks toward infantry fighting vehicles and other light armored vehicles over the next 10 years.

Excess supply characterizes the current tank and tank-variant market. High-volume Cold War production rates and arms transfers generated by the Conventional Forces in Europe Treaty have created a market glut for much of the LCV market. Forecasted production over the next 10 years will exacerbate this problem.[6] Consequently, new tank sales have become particularly difficult, with cutthroat competition characterizing the market. For manufacturers, the surplus represents a potential market for retrofit and modernization in the inventories of less wealthy countries.

The future for new tanks will rest with two distinct customer groups. The first group consists of those countries wanting highly sophisticated tanks with prices in the $8 million range; the second group includes countries seeking a wider range of less expensive unit prices and technology options. Potential customers in this domain include Turkey, Greece, South Africa, Saudi Arabia, United Arab Emirates, Qatar, Argentina, and South Korea.[7]

The market for medium and light armored vehicles will decline slightly, but is still projected to be good for both mature and new systems well into the next century. Armored wheeled combat vehicles, in particular, remain an important asset in many of the world's military organizations due to the fact that they have lower unit and life cycle costs, reduced maintenance, and greater speed and mobility in most terrain than heavy tracked vehicles. Market projections for this class of vehicles remain positive, as France, Germany, and the United Kingdom

position themselves along with other nations to refit or upgrade their inventories.[8]

Forecasts for light and medium tracked vehicles for the next 10 years reach $17 billion, with the best sales opportunities in the Middle East, Asia, and Latin America. The trend in this market is the wholesale introduction of the "family of vehicles" concept, which is based on the use of a common chassis. The demand for these systems will bring additional competitors into the market, especially since the rapid technology transfer to developing nations has made it possible for them to produce light tracked combat vehicles. Additionally, the trend away from heavy tanks will introduce some nontraditional competitors looking for alternative sources of revenue. China, Russia, Pakistan, and Turkey are intent on becoming major suppliers in this market, for example.[9,10]

U.S. Industry Trends

Trends toward industrial consolidation, mergers, acquisitions, partnerships, and internal restructuring continue to characterize the post–Cold War LCV industrial setting. In response to flattening or declining defense procurement budgets and escalating global competition, LCV industries are clearly exploring every possible strategy to improve their competitive posture, expand market share, achieve a dominant market position, and cut costs.

As a result of reduced defense procurement budgets, companies that remain in this industry are reviewing and even redefining their core competencies and determining how they wish to position themselves in the market. In the past, firms operated generally in their own segments of the market (e.g., heavy tracked, light tracked, wheeled combat vehicles). Survival today depends on diversification of products and services, however. Consequently, several firms not only are seeking to expand operations beyond former boundaries and to penetrate the product lines of competitors, but also are examining new opportunities, such as total life cycle contracted logistic support.

Land combat vehicle companies are using both horizontal and vertical acquisitions to enter new markets. Some firms chose to concentrate solely on the defense industry, expanding their business through the acquisition of small defense product companies or subsidiaries divested from corporations exiting the industry. Other firms reduced their reliance on the defense dollar by acquiring commercial companies that complement their traditional product line.

Companies are also seeking partnerships and cooperative ventures to target new markets or expand existing ones. Various strategies have emerged, including collaborative efforts to market foreign products domestically and to co-produce U.S. products abroad. The U.S. government encouraged project partnering in the LCV industry to sustain manufacturing capability.

Firms are achieving internal efficiencies through cost-cutting initiatives, including relocation and consolidation of production operations, reduction of support staffs and suppliers, and outsourcing of non–core competencies where possible. With overcapacity running more than 50 percent across the LCV industry, extensive workforce reductions continue as well; this has created a highly skilled, but rapidly aging workforce—especially in manual production skill sectors, such as machining, welding, and the like.

Despite a reduction in the demand for the traditional hardware produced in the domestic LCV industry, all the competitors have managed to remain profitable by successfully implementing their diverse business strategies. With return on investment as the bottom line when books are balanced at year's end, companies in the LCV industry will continue to seek economies and efficiencies to remain competitive not only domestically, but also internationally as they vie for business with foreign producers.

European Industry Trends

The condition of the LCV industry in Europe is similar to that of U.S. businesses. In the short term, the firms will remain healthy, but they face questions about their economic viability as they approach the end of the next decade. Despite a European trend of nationally oriented, parochial land systems industries, European businessmen have recognized the problems associated with competing in a constrained international sales market and have finally begun to address the issue seriously. Although most European countries still aim to maintain an adequate defense industry capable of meeting their security and economic needs, many firms have begun to consolidate through mergers at the national level and to participate in joint venture projects at the international level. Thus, international mergers may be a long-term result of this trend toward industry integration.

As in the United States, most European LCV manufacturers are systems integrators who rely on subtier vendors to supply up to 80 percent of the components that make up the end item. Facing the

realities of declining markets and seeking business efficiencies, European companies, like those in the United States, have reduced their workforce and are closing redundant or unneeded production facilities. Further, most are seeking to broaden their product lines, to include new and diverse services, and to enter into international partnerships as a means to access new markets.

Unlike U.S. companies, European companies have avoided aging issues in many employee skill sectors. Active recruitment programs, coupled with training internships, have generally produced well-rounded demographic age profiles among those with production-associated skills. As in the United States, however, it remains difficult to recruit and retain engineering and information technology professionals in Europe.

Overcapacity

In the United States, other than the declining defense budget itself, underused excess industrial capacity remains the single greatest impediment to competitiveness in the land combat systems industry. Production facilities were built to mass-produce goods in support of large-scale Cold War requirements. With these requirements at an all time low, most facilities operate at 60 percent or less of their full capacity, and a few operate at only 10 percent of their potential. In commercial facilities designed for high-volume assembly lines, small workforces on limited shifts now produce individual vehicles and tanks on extended production schedules. Furthermore, government arsenals and depots draw off a portion of the production operations required by manufacturing components or refurbishing significant portions of the ground combat weaponry used by the services. Yet, in most cases, they do so with tremendous inefficiencies and at great overhead costs. For example, the government operation at Watervliet Arsenal in New York operates at only about 15 percent capacity. The sprawling Army tank plant in Lima, Ohio was designed to assemble more than 400 vehicles per year and manufacture major subassemblies for more than 800 vehicles, but it currently upgrades only 120 platforms annually, a rate expected to decrease to 24 platforms annually beginning in Fiscal Year 2001 and terminating in Fiscal Year 2005.

CHALLENGES

Significant challenges face the land combat systems industry in the foreseeable future. With military budgets drastically declining for most

of the 1990s, proposed budgets in the Future Years Defense Plan (FYDP) contain only flatline projections for procurement and development. Without significant increases in acquisition dollars generated by savings in other areas, the services' modernization plans will likely be unattainable. Since further reduction of land combat force structure or personnel entitlements appears unlikely, the only other potential source of funding is in the implementation of greater efficiencies and the elimination of political barriers to competitive operations in the industrial base.

Industrial Base

The opportunity to generate efficiencies lies in determining the mix of facilities that best meets the U.S. competing goals of maintaining an efficient, cost-effective, technologically innovative LCV industry, while providing the required capabilities for the military and ensuring adequate flexibility to deal with the uncertain defense requirements of the future. The existing redundancies and high costs of today's various production facilities impede efficiency in providing for the nation's future LCV requirements. The U.S. government must undertake a deliberate effort to eliminate wasteful production facilities consistent with the level of commercial vitality that it seeks in the LCV industry.

Further, reduction of overcapacities in government and commercial facilities would go far to enhance the competitiveness of U.S. firms in the international marketplace by eliminating expenditures on nonproductive overhead. Operators of most production facilities continue to justify costly overcapacity as a requirement to meet future surge capability. This problem is especially acute in the nation's government-owned, contractor-operated (GOCO) and government-owned, government-operated (GOGO) facilities. In spite of this, a current Department of Defense (DOD) viewpoint regards future wars as short-duration affairs for which there is unlikely to be a requirement for a surge in wholesale production in a full-mobilization scenario.[11] If that is the case, then the nation will continue to maintain an excess industrial capacity; this is both expensive and wasteful.

Surge Capability

The challenges to be overcome in maintaining an adequate surge capability for the LCV industry include a diminished threat, declining defense budgets worldwide, increased competition, limited production

rates, an aging workforce, and a more diverse product mix. With these challenges in mind, defense planners must evaluate the industry's surge capability to meet future needs under three sets of circumstances: (1) the plant's production line is currently up, running (warm); (2) the production line has been temporarily shut down (mothballed); or (3) the production line has been permanently closed and its infrastructure disposed of (cold). Evaluation of the opportunity costs of maintaining low land combat system production rates must be weighed against the advantages gained by investing in R&D with the attendant risk of incurring lengthy production start times in the event of a national emergency. In general, LCV surge capability is estimated at 10–12 months for a warm production line and 18 months or more for a cold line.[12]

Certainly, skilled production workers will migrate to other manufacturing enterprises, and engineers will apply their talents in other arenas. The industry will not lose the capability of building a tank or any other land combat system, however. It appears that there are sufficient inventories, if modernized, to replace critical systems until a potentially dormant manufacturing capability could be mobilized to meet a future national security threat through new production. This will require adequate mobilization planning to ensure that manufacturers meet the nation's LCV requirements with production lines that may not remain economically viable based on military requirements alone.

Subtier Suppliers

Almost without exception, LCV prime contractors are systems integrators who rely on subtier vendors for most system components. Consequently, suppliers of critical parts and key technical skills are vulnerable to closure or migration out of this industry sector if business is insufficient to sustain a profit margin. The disappearance of subtier vendors could lead to serious readiness problems in the event of a protracted conflict. Once the existing supply of critical parts is exhausted, the minimum timeline to resurrect a cold production line or to create a viable substitute can be up to 18 months.[13] Although the DOD does not predict a need for a surge capability in the foreseeable future, high-intensity, short-duration conflicts can generate immediate production requirements to support the existing force. For example, spare parts worth $150 million were taken off the M1A2 tank modernization line to fill requirements in the Persian Gulf during Operation DESERT STORM.[14] Without a warm production line,

reserve stockpiling, or at the very least adequate planning, the nation may find itself without the ability to satisfy a similar requirement in a timely fashion.

The U.S. ground forces have only a few LCVs in the design or early production stages. The Future Scout Vehicle, the Army's Crusader and Grizzly systems, and the Marine's AAAV and MTVR represent the only new programs. Remaining programs are modernization efforts for existing equipment that the land forces expect to keep for at least another 30 years. With only 20 percent of the fleet scheduled for modernization, most vehicles in the inventory will have no technology insertion for another three decades. Without production orders, the DOD should not expect the 700 parts suppliers for the Abrams tank to remain in business for another 30 years—producing parts for a 20-year-old system. The challenge will be in finding the parts, dealing with longer delivery times, and accepting the higher costs of limited production runs.

Research and Development

Continued R&D is the key to the revolutionary technological breakthroughs sought by defense planners for the military establishment in the 2030 time frame. Investment in R&D will be critical to success, but the reduction in government procurement spending has caused companies to back away from such investments. Although prime contractors are partnering with their subcontractors in R&D investment efforts, the DOD continues to fund most of the R&D in this industry. In most cases, industry development focuses on research applications targeted to take proven technology to a higher level of performance. Yet, given the state of the industry, there is little likelihood of any revolutionary technological breakthroughs for LCVs in the future without continued government sponsorship and R&D investment.

Maintenance of Competition

There are only two prime contractors producing tracked combat vehicles in the United States: United Defense Limited Partnership (UDLP) and General Dynamics Land Systems (GDLS). Both firms operate significantly below capacity because of the reduced government demand. The merger of these two companies could achieve production efficiencies, but would eliminate domestic competition in the tracked combat vehicle marketplace. The current environment of managed

competition, where no single firm receives all the business opportunities, reflects the government position that a noncompetitive environment is undesirable. The government's intent appears to be maintenance of the status quo through limited orders and threats of antitrust litigation.

This apparent policy does not, however, extend deeper than the prime contractor level. Both UDLP and GDLS are systems integrators that rely on a diverse base of second- and third-tier suppliers to provide needed components and equipment to produce their respective end items. Although the government will likely sustain both major firms in this industry, that same practice is not extended to the lower tier firms.

OUTLOOK

In the Short Term

The LCV industry will remain unchanged in the short term. Domestic production will continue to operate well below capacity. With few new production contracts on the horizon, competition will be intense for any and all business. In many segments, the industry is maintaining production lines through a combination of new production, system upgrades, and extended service life programs.

These system upgrades and extended service life programs represent the primary source of production for the LCV industry. The upgrade of the M1A1 Abrams tank to the M1A2 and the M1A2 System Enhancement Program (SEP) configuration will likely keep the Lima tank plant operating through 2005. The Lima facility is projected to build 465 Heavy Assault Bridges (HABs), using government-provided Abrams SEP hulls. Similarly, the upgrade of the M2 Bradley Fighting Vehicle to the M2A3 configuration will sustain production at UDLP's ground systems facility in York, Pennsylvania, through 2008. Low rate production will generate unnecessary overhead costs at production facilities, however.

The Army's 2.5-ton upgrade for National Guard units and the USMC's Logistics Vehicle System (LVS) programs reflect the emerging trend in the DOD to extend vehicle life through technology insertion, overhaul, and remanufacturing programs. The Army and the USMC have projected extended service programs for the HMMWV, the Medium Tactical Truck (USMC variant only), the 10-ton HEMTT, and the M772 Light Armored Vehicle. Original vehicle manufacturers view these programs as an opportunity to keep their production facilities operating. In the area of new procurement, both the Army and the

USMC plan to procure additional quantities of HMMWVs from AM General, FMTVs from Stewart & Stevenson, and MTVRs and HETS from Oshkosh, which will assist the firms in maintaining warm production lines.

The industry continues to aggressively pursue international sales for its systems, but overselling by domestic manufacturers after Operation DESERT STORM and increased global competition have saturated the marketplace. The expansion of the North Atlantic Treaty Organization (NATO) could provide new opportunities for U.S. and European Union manufacturers as new members upgrade their systems to NATO standards. Greece and Turkey are also in the market for a new main battle tank and associated support vehicles.

Further private industry consolidation may be on the horizon, but it appears that the DOD will attempt to ensure the continuation of adequate competition. Prime contractors should remain competitive, and existing contracts will enable them to survive for the next 9 or 10 years. The Army is the industry's primary customer, however, and its decision to postpone the identification of new LCV requirements dramatically affects the industry beyond the 2005 time frame.

In the Long Term

The long-range future of land combat systems remains ill defined. While the DOD and industry leaders await the results of current R&D and experiments with new force structure designs, they are unable to predict requirements beyond the current FYDP. A review of DOD programming documents revealed no new procurements or upgrades of the Bradley Fighting Vehicle and the Abrams tank beyond Fiscal Year 2008. The only certain major, long-term procurements are the projected purchase of 824 Crusaders, 1,013 AAAVs, and follow-on procurements of the FMTV. Incremental procurements of the Grizzly Obstacle Breacher, Heavy Assault Bridge, and Heavy Recovery Vehicle are also planned during this period, but these quantities are not by themselves sufficient to maintain viable production rates at either GDLS or UDLP. If these companies are to maintain a warm production line, they must continue to employ flexible manufacturing techniques to produce, upgrade, or rebuild small volumes of technically diverse systems at lower costs.

In the area of R&D, the United States began work with the United Kingdom on a Future Scout Combat System with a projected fielding date of 2010. Development contracts were awarded to two international

consortia, with UDLP and GDLS as subcontractors in the program.[15] In addition, government-sponsored research continues on advanced materials, armaments systems, and power train subsystems to support a future lightweight, mobile, and lethal combat system.

The challenges and the responses under consideration suggest the following long-term trends:

- Some U.S. firms are unlikely to survive if they must rely on domestic military requirements alone to keep them in production. A strong competitive position in the consolidated global market will determine which firms lead the industry in the next century.
- Without government support, production and development efforts appear inadequate to sustain the base of the two major domestic tracked vehicle producers. Without an increase in government demand, foreign military sales, subsidies, or a major merger or partnership with a foreign competitor, the United States could lose one of these firms in the next 30 years.
- GOCO and GOGO facilities continue to struggle for production opportunities, contributing to the burden of considerable excess capacity and associated overhead costs. An efficient and competitive structure for the next century will not evolve without further restructuring and downsizing of these facilities.
- If new technologies fail to materialize, the land force planners will probably revert to developing block upgrades to current systems.
- Corporate executives will remain reluctant to make capital investments in new manufacturing technology without a financial incentive to do so.
- Foreign military sales may provide an economic incentive to maintain otherwise underused production facilities. Keeping a competitive advantage in the international marketplace will require efficient manufacturing operations, continued commitment to future product development, aggressive global marketing, and some form of cooperative partnerships, however.

GOVERNMENT GOALS AND ROLE

Government shapes the defense industry not only through statutes that regulate commercial operations at home and abroad, but also through its role as the only domestic consumer of the product. In addition, government rigidly controls the issue of profit, either through acquisition and trade regulations, or through price negotiation. The combined influences of a complex regulatory environment and dramatic

reductions in federal spending have caused a deliberate consolidation of the defense industry under a few first-tier corporate giants supported by hundreds of smaller, lower tier companies.

Given the complex operating environment, how can the U.S. government best sponsor or support manufacturers to become more competitive in the world market? The government has the following avenues of support:

- Continue to support R&D by funding government research laboratories, giving tax incentives for industry-sponsored research, and expanding opportunities for cooperative industrial R&D initiatives.
- Provide incentives to recapitalize plant property and incorporate robotics, automation, computer design and processing, and other advanced technologies into the production process where feasible.
- Encourage contractors to provide life cycle systems support to help stabilize the industry and reduce the service support infrastructure.
- Support the defense industry by encouraging the sale of technologically tailored defense systems throughout the world market as a replacement for flagging domestic sales to the government.
- Encourage the development and exploitation of dual-use technology as a commercial advantage for business.
- Seek joint venture partnerships for future vehicle development.
- Review the statutory requirement for 50 percent of depot maintenance to be conducted in military depots.
- Continue to pursue acquisition reform, especially in the area of cumbersome government cost-accounting requirements.

CONCLUSION

The LCV industry is trying to preserve business viability while coping with dwindling production orders, flat procurement budgets, and a sole domestic customer relationship with the DOD. Against this backdrop, the LCV firms have developed a number of creative strategies to cope with uncertainty. The long-term decline in DOD procurement dollars precipitated an industry response consistent with collapsing markets. Domestic and international manufacturers have been participants in horizontal integration via mergers and acquisitions that resulted in a smaller number of larger, more globally oriented firms. Similarly, to ensure control of profitable elements in the subvendor base,

some companies have responded by vertically integrating the production of subcomponents into their own processes.

To maintain a warm production base and sustain ongoing business operations, the LCV industry is waging a three-pronged strategy. First, manufacturers have adapted their manufacturing processes to accommodate low-rate production of high-mix end items. This action preserves plant capacity and a highly skilled workforce. Second, firms pursue unit cost reduction programs aggressively at every opportunity to sustain returns on investment and position themselves for future competition. Third, the industry is attempting to develop new business enterprises that capitalize on existing and expanded core competencies.

On balance, the LCV industry is managing the stressful transition from a Cold War growth posture to the complex realities of post–Cold War frugality. This "holding action" is successfully preserving the LCV industrial base for the near term. Without either a consensus for new vehicle manufacture or a robust modernization program of legacy fleets, however, the industry may not retain a viable manufacturing capability in the future.

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[1] Watervliet Web Page, http://www.wva.army.mil, May 12, 1999.

[2] Jacques S. Gansler, *Defense Conversion* (Cambridge, MA: MIT Press, 1998), p. 10.

[3] "The Market for Tanks," *Forecast International/DMS,* May 1998, p. 2.

[4] "The Market for Light Tracked Vehicles," *Forecast International/DMS* , July 1998, p. 1.

[5] "The Market for Light Wheeled Vehicles," *Forecast International/DMS*, February 1999, p. 2.

[6] "The Market for Tanks," p. 2.

[7] "The Market for Tanks," p. 4.

[8] "The Market for Light Tracked Vehicles," p. 1.

[9] "The Market for Light Tracked Vehicles," pp. 1–2.

[10] "The Market for Light Wheeled Vehicles," p. 2.

[11] Transforming Defense—National Security in the 21st Century, National Defense Panel Report to the Secretary of Defense, December 1997, p. 77.

[12] Based on interviews with various industry representatives. Depending on the lead-time to stockpile raw materials and subassemblies, recruitment, and training of workers, and assembly or expansion of design and production supervisory teams, estimates to restart end-item production range from 6 months to upwards of 2–5 years.

[13] Based on interviews with various industry representatives.

[14] Douglas Menarchik, *Powerlift—Getting to Desert Storm: Strategic Transportation and Strategy in the New World Order* (Westport, CT: Praeger Publishers, 1993).

[15] "Ministry of Defence: Britain and United States in Joint Battlefield Reconnaissance Programme," *M2 Communications Ltd, Coventry*, July 9, 1998, *Proquest*, June 8, 1999.

MEDIA

ABSTRACT

The news media serve an important role in society as distributors of news and information. The news media industry is increasingly complex and dynamic while experiencing double-digit growth. It is an industry that is experiencing tremendous consolidation in traditional news outlets and simultaneously becoming more fragmented with the emergence of new media channels, such as the Internet. The effects of globalization and technological change are perhaps more evident in the news media than in any other industry. It is an industry that is facing many challenges, such as declining credibility and public mistrust, increased emphasis on profits and ratings, and pressure to continually update news to feed 24-hour formats. This industry has a special relationship with the national security team—almost a love–hate relationship and one that is a critical element of national power.

COL David R. Apt, USA
Lt Col Toni A. Arnold, USAF
COL Michael U. Atherly, Guyana Army
Ms. Kristina M. Erickson, The Boeing Company
Col Lorene T. Hill, USAF
Ms. Nancy J. Hill, Office of the Secretary of Defense
Col John J. Karns, USAF
Mr. Gregory L. Kee, Dept. of the Army
Mr. Matthew J. Keough, Office of the Secretary of Defense
Mr. Stephen A. Kramer, National Security Agency
Mr. Paul T. McMahon, Defense Systems Management College
CAPT Nori Ann Reed, USN
LTC Thomas J. Richardson, USA
CAPT Stephen W. Rochon, USCG
Ms. Pamela A. White, USAID

Dr. James T. Currie, faculty
Ms. Pamela G. Kruzic, faculty
Col Stephen P. Randolph, USAF, faculty

PLACES VISITED

Domestic
ABC News, New York, NY
AeroBureau, Washington, DC
Army Public Affairs, Washington, DC
Brill's Content, New York, NY
Cable News Network (CNN), Atlanta, GA and Washington, DC
David Sarnoff Research Center, Princeton, NJ
Freedom Forum, Arlington, VA
Gannett News Service, Washington, DC
National Public Radio, Washington, DC
Newseum, Arlington, VA
New York Stock Exchange, New York, NY
The New York Times, New York, NY
Office of the Secretary of Defense Public Affairs, Washington, DC
Pew Center for Civic Journalism, Washington, DC
Project for Excellence in Journalism, Washington, DC
USA Today, Arlington, VA
U.S. News and World Report, Washington, DC and New York, NY
Washington Bureau, Hearst Newspapers, Washington, DC
The Washington Post, Washington, DC
White House/National Security Council Public Affairs, Washington, DC
The Wall Street Journal, New York, NY

International
BBC World News Television, London, England
British Ministry of Defense Public Affairs, London, England
The Economist, London, England
ELTE University Media Center, Budapest, Hungary
The Guardian, London, England
Hungarian Defense Force, Budapest, Hungary
Hungarian Ministry of Defense, Budapest, Hungary
Hungarian Ministry of Foreign Affairs, Budapest, Hungary
Hungarian National Defense University, Budapest, Hungary
Hungarian Radio, Budapest, Hungary
Independent Television News, London, England
Magyar Nemzet Newspaper, Budapest, Hungary
Nepszabadsag Newspaper, Budapest, Hungary
Nepszava Newspaper, Budapest, Hungary
Sky News, London, England
Slager Radio, Budapest, Hungary
The Times, London, England
TV2, Budapest, Hungary
U.S. Embassy, Budapest, Hungary
U.S. Information Service, U.S. Embassy, London, England

INTRODUCTION

The news media inform, challenge, question, and aggravate. They affect the way the public looks at domestic and foreign policy, and they shape both the public's view of the world and their national will to address the problems of the world. The media are part of the national security structure of the United States, without being part of the government.

THE MEDIA INDUSTRY DEFINED

Because the media industry has a few industry-dominant firms, it is considered a classic oligopoly. In the broadcast television segment, for example, the "Big Four" (ABC, CBS, NBC, and FOX) networks reap more than 50 percent of broadcast television revenues. There is a potential danger, of concern both in the United States and abroad, of so few owners having such widespread control over the news that is presented to the public. "We don't have any real government controls [content] since the only people who might be inclined to challenge the media giants are those who depend on these very powerhouses to communicate with their constituents. Politicians and the media have always had a love/hate relationship, but there is no doubt that they need each other to survive."[1] According to Tom Schatz, a prominent media analyst, "In a global media culture unified by rituals of entertainment and patterns of consumption, those who cannot afford to consume are likely to be factored out of the cultural and political equation. And those social and political issues which cannot be rendered in sufficiently entertaining terms are likely to be either ignored or relegated to the far reaches of the 500-channel universe."[2]

The news media's job is to inform their readers, viewers, and listeners of events in the world around them. So how does the industry reach its audience? The four primary means that the news media industry uses to communicate its message are television, radio, print, and electronics.

Television

The U.S. television market is the largest market in the world. Television markets are served in one of four distribution channels: national television networks, independent commercial television stations, cable television services, and direct broadcast satellite (DBS), primarily for those viewers unable to receive broadcast television. For the near

future, broadcast television will continue to lead in number of viewers and advertising.

Consolidation has been a major trend in this industry. The top 25 owners of television stations, as a group, controlled 36 percent of the stations in the United States as of early April 1998, which is an increase from only 25 percent in 1996 and 33 percent in 1997.[3] A trend toward more vertical integration has appeared since the Telecommunications Act of 1996 removed the national ownership limit of 12 stations. Owners now may acquire as many stations as they want, provided that they reach less than 35 percent of the nation's homes. There is also a trend toward horizontal integration as networks acquire other media, such as cable (regulated) and Internet access providers (not regulated).

According to the National Association of Broadcasters and 1998 Nielsen Media Research, 98.3 percent of U.S. households own a television set. Seventy-three percent of them have two or more sets. Sixty-three percent of the sets have 30 channels available to them. The average household views television for 6 hours and 57 minutes per day.

Radio

The radio broadcast market structure includes commercially based entertainment and sports, educational, news, and talk magazines; noncommercial news/talk public radio (e.g., National Public Radio); and transnational radio (e.g., Radio Free Europe, Voice of America, the BBC World Service).[4]

Of every 100 U.S. households, 99 have a radio. The average number of radios per household is 5.6, with a nationwide total of 560 million (including 144 million vehicular radios). According to the Radio Advertising Bureau, 96 percent of radio owners listen at some point during any given week. The typical listener tunes in for 3 hours and 18 minutes every weekday, and 5 hours and 45 minutes a day on the weekends. Unlike most other media, a radio can go just about anywhere that a person can. Radio reach is enormous and frequent; thus, if orchestrated appropriately, it can be used to inform and affect national will in a short period of time.

In 1992, the Federal Communications Commission (FCC) relaxed ownership limits, permitting one company to own up to 20 FM and 20 AM radio stations. This loosening of radio station ownership regulations provided a powerful boost to radio fortunes. Companies that owned several stations could centralize office functions such as sales, billing, and marketing.[5] Furthermore, the Telecommunications Act of 1996 has exerted a profound effect on radio broadcasting in the United States. The

1996 changes meant that one company could own as many as eight radio stations in a single major market. There is no question that radio has experienced a seismic shift in paradigm since the passage of the 1996 act.[6]

Print Media

In the United States alone, the print media contains more than 30,000 publishers. There are currently more than 1,500 daily newspapers, with the 20 largest papers accounting for 23 percent of average daily circulation. Consolidations have been taking place over the past few years as the industry struggles to maintain its strength. The top 10 newspapers own more than 370 others. Gannett Company alone owns 89 daily newspapers, which have 10 percent of the nation's daily circulation. Other leading newspaper companies include Knight-Ridder, Inc., the New York Times Company, Advance Publications, Times Mirror, Dow Jones and Company, Tribune Company, Cox Enterprises, McClatchy Company, and the Hearst Corporation. The need for publishers to remain competitive to maintain their share of the average U.S. citizen's time drives advancements in technology. The average person currently spends 28 minutes each day reading newspapers. With the growing popularity of other forms of media distribution such as television, the Internet, cable, and DBS, it is likely that the print media market will continue to consolidate for survival. Many of the print media are now scrambling into the Electronic Age with television, CD ROMs, online services, and the Internet.

Electronic Media

The media have capitalized on the enormous growth in the Internet market. For example, two of the more predominant news Internet sites—CNN and MSNBC—have seen their usage double. CNN sees the Internet as one of its fastest growing markets and is expanding its Internet sites to other languages to capitalize on the growing global Internet market. Disney, Time Warner, and NBC are buying portal Internet companies to expand their market availability. The Internet includes all forms of traditional media. One advantage of the Internet for the news is that it is not limited to a predetermined number of pages, a weekly publication schedule, or sound bites.

CURRENT CONDITION

Economic Trends

U.S. Economic Trends. For the television and radio segments, product differentiation is a substantial consideration in setting advertisement prices and winning viewers in designated market areas (DMAs). The use of quality news programming, enhanced by diverse content and celebrity associations, syndication programming, and DMA rating shares, will determine product differentiation achieved in three prime advertising categories—network, national spot, and local. Internet reaches out to a worldwide customer base.

Growth is expected to continue in television, radio, and Internet segments of the industry. Advertising produces more than 75 percent of revenue for U.S. newspapers and 50 percent for U.S. publishers. In 1997 alone, newspapers generated $41.25 billion in advertising revenue.

The 1991 industry decline, the first since the 1970s, was caused by the federal ban on cigarette ads on television, perhaps by the impact from the Gulf War, and by economic recession. In 1992 and 1993 revenue grew by 5.3 percent; it surged to 14.5 percent in 1994 because of political and Olympic advertising. The sharp increase to 18 percent in 1996 (Table 1) and the 14 percent estimated for 2000 (Table 2) is attributed to the heavier advertising done in presidential election and Olympic years.

Table 1: U.S. Television Advertising Expenditures ($ billion) 1995–1998[7]

Source	1995	1996	1997	1998
Broadcast	27.91	31.27	32.46	34.79
Cable TV	5.11	6.44	7.50	8.70
DBS & Others	3.00	4.90	6.50	8.60
Total	36.02	42.61	46.46	52.09
Growth		18%	9%	12%

Global Economic Trends. International economic trends are similar to U.S. domestic trends, with exceptions generated by varied media-financing models such as the BBC subsidies for British news consumption and the public-owned media in Hungary. In these two countries, the growth expectations in electronic media and decline in newsprint appear consistent with those of the United States. Television is

Table 2: U.S. Television Advertising Expenditures Projected by Standard & Poor's[8]

Source	1999	2000	2001	2002	2003
Broadcast	37.20	41.43	43.60	46.23	50.19
Cable TV	10.40	12.70	15.00	17.70	20.80
DBS& Others	10.10	11.70	13.40	14.40	16.70
	57.70	65.83	72.00	78.33	87.69
Growth	10%	14%	8%	9%	12%

rapidly playing the same sort of dominant cultural role in Europe, Asia, and worldwide that it has played in the United States for more than three generations.[9] A higher reliance on DBS appears to be the case in Hungary, where satellite dishes seem to glitter throughout the countryside.

Before the 1990s, media systems had been primarily national; however, due to evolving technology and globalization of a more integrated capitalist economic system, a dominant international commercial media system is rising. It is primarily an extension of the U.S. system, because U.S. firms dominate the global system. As happens in the United States, firms compete in aggressive oligopolistic markets, supply each other in other markets, and are partners in yet others that dominate the global media market. There is fierce competition for the English-speaking rolling news market (24 hours per day).

Impact of the Media

Impact of the Media on the National Will. One function of the mass media is political persuasion—the direct effort to change people's attitudes and behavior through communication. The relationship between changes in attitudes and the subsequent changes in the way people behave is extremely important. Perhaps the best examples of the media impact on the national will have occurred during times of war. In this century, the United States has fought two world wars that its leaders explained were for the purpose of making the world safe for democracy. All forms of media played a major role in mobilizing the national spirit, which eventually resulted in overwhelming support for U.S. involvement in both wars. Conversely, when consistent negative media coverage turned the national will against U.S. involvement in the Vietnam War, the war could no longer be sustained.

Interestingly enough, the Hungarian media do not feel that they have much impact on the national will in their country. They note very little public reaction, even when scandals are reported in the press. This may be attributed to the legacy of biased reporting and the lack of experience in public expression of individual views in Hungary.

Current leaders successfully affect the national will by using all forms of media. The challenge for future leaders is to orchestrate a plan to reach all of the fragmented audiences with a common message (or messages) that appeals to each of the audiences—while remembering that the message appeal should not be confused with determining the message.

Sheila Tate, former press secretary to Nancy Reagan, suggested that "the relationship between the President and the press is an arranged marriage, based on mutual need and convenience. The President must depend on a free and unfettered press to communicate with the citizenry, and the degree to which citizens can trust the media is the degree to which democracy works."[10]

Future news media will be able to inform, influence, and mobilize the national will with the speed of the Internet, the fidelity of multiple forms of media messages, and the power of communication coordination across all these media forms.

International Impact of the Media. Instantaneous coverage of events across the world affects political groups, leaders, and the public at large, driving some of them to respond immediately. Remote events such as the battle for control of the Russian parliament in 1993, the Gulf War in 1991, and the fall of the Berlin Wall in 1989 were reported in real time across the world by CNN. The media have, in fact, provided an alternative channel for the conduct of diplomacy,[11] as they lend themselves to the peculiar needs of international dialogue.[12] CNN, Sky News, and BBC World, to name a few, struggle to be objective reporters of international news, without favoritism toward any one nation state. For example, all of these organizations have sought to report the war in Kosovo from the perspective of both Serbia and the North Atlantic Treaty Organization (NATO).

The freedom with which the news media in the United States can practice their craft is the envy of the world. Journalists in England and Hungary have spoken with great respect of the protection that the First Amendment accords U.S. journalists.

CHALLENGES

The media industry is witnessing a time of major changes, including new developments in the way that news is promulgated and its ability to mobilize the national will. The ever-increasing speed of computers and the rapid growth of the Internet, hallmarks of this Information Age, continue to expand the volume of news and the number of people who have access to it. Challenges that warrant attention include the public mistrust of the media, sensationalism, and media–military relations. Both domestically and abroad, the industry faces issues about its funding and the effects of funding on content. Additionally, technology continues to reshape the environment within which foreign policy and national security decisions are made.

Public Mistrust of the Media

One of the most significant challenges facing the news media today is public cynicism and a growing mistrust of the information that the media provide to the public in all news formats. Gone are the days when people tuned in the radio or television to hear an Edward R. Murrow or a Walter Cronkite, trusted to provide all the news the public needed to know in a professional, soothing manner and with unquestioned accuracy. Enter Geraldo Rivera, Matt Drudge, CNN's Tailwind scandal, the *Boston Globe's* Mike Barnicle, and the Starr Report on the Web. While every news organization visited, both in the United States and abroad, professed to be dedicated to providing objective news, the public is skeptical. According to a remarkable survey recently performed by Scripps-Howard News Service and Scripps Survey Research Center, less than 15 percent of U.S. citizens believe that newspapers are reliable; more than 75 percent believe that reporters are biased, inaccurate, and prying; and more than 40 percent have lost all faith in the media.[13]

People have high expectations for depth and seriousness as well as balance and fairness in news reporting, but they are increasingly concerned that they are getting only one side of the story and that reporters' personal biases are creeping into their work. In 1985, more than half of U.S. citizens thought that news organizations "got their facts straight." By 1999, the number had declined to 37 percent.[14]

Perhaps fueling much of the public cynicism is the concentration of the news media in large horizontally and vertically integrated corporations, leading to further charges of profiteering, bias, commercialism, and censorship. Almost two-thirds of the U.S. public pointed to the "profit motive" as "improperly influencing" news

reporting, and more than half of the public cited corporate media owners and advertisers as the source of this improper influence. There are growing instances in which the business interests of the corporations have sullied or have appeared to sully the journalistic intent of the news media. For example, one *Time* magazine issue, entitled "The Future of Medicine," had as its only advertiser the huge drug conglomerate Pfizer. In another case, a charge of censorship was leveled at ABC when ABC News refused to air a negative story on its parent corporation, Disney. How critical can or will a news organization be of a parent company?

The international news media are not immune to such problems. The BBC believes that it is able to have great flexibility and maintain its unbiased news reporting without corporate interference, because it subsists on the television licensing fees paid by the British public. But how much longer will that last? As their access to more news sources via the Internet, satellite, and cable increases, the British people may be less willing to continue to subsidize the BBC. The BBC has reacted to this possibility by branching into commercial broadcasting with the advent of BBC World, which offers news programming shown outside Great Britain. In Hungary, when the state-owned media were privatized, most were bought by large corporations from outside Hungary.

Part of the lowering of journalistic standards stems from the demand on the media to be first with a story in this day of instantaneous Internet news and the 24-hour news stations. As a result, there is less time for verification and a greater possibility of providing inaccurate stories to the public. Thus, the media are quick to report allegations until the counterallegation is issued. Furthermore, although information is available in many forms, it may not be accurate. The media use other members of the media as "experts" and/or sources, rather than finding people who actually have the expertise to comment intelligently. The public is hearing more "news," but in a very raw manner, which leaves more room for manipulation of the information. This phenomenon strongly contributes to the perception in the United States that the media are not to be trusted and cannot be relied on for accurate reporting.

An approach called "civic journalism" takes into account a message's tone and method of presentation in order to determine its impact. For example, the news message need not represent one of only two extremes, but instead can provide all sides—including the common ground of understanding. Civic journalism also suggests that the media should be participants in the community, advocating the social good and providing a forum for ideas and improvements. This form of journalism may increase faith in the press and, therefore, the believability and understanding of the message.

Crises in Ethics, Standards, and Values

Although the news media have not established a set of values applicable across the profession, the growing sense among serious journalists is that there is a crisis of ethics. This awareness ensures that journalists will continue to explore various ways of establishing ethical standards for the profession. Some have suggested the establishment of certain minimum standards that news organizations could voluntarily agree to uphold and could advertise. Another possible option is the establishment of local or even national news councils that would review the news media and study possible cases of journalistic malpractice. The majority of the news media have not received these suggestions warmly. Many of the most influential journalists and news organizations are concerned that these options could lead to regulation and infringement of First Amendment rights, and they are not willing to support such initiatives. In the meantime, publications such as *Brill's Content* have a certain "watchdog" effect. The news media are an incredibly powerful force in the United States and abroad, and there should be at least some means for highlighting their problems and issues.

Media's Role in Democracies

In democracies (mature and emerging), the degree to which the press is "free" can determine the growth and strength of the democracy. As Harold J. Laski stated, "A people without reliable news is, sooner or later, a people without the basis of freedom." The European news media differ from the U.S. model in that they are not afraid to blur the line between editorial comments and hard news, with newspapers openly admitting a particular political frame of reference. Nonetheless, the media in both models believe that they provide reliable and responsible news by being independent, making every effort to be factually correct, employing a standard of ethics, and not pre-judging the consequences of publishing the facts.

Infotainment

The fine line between "news" and "entertainment" disappears more and more with each passing day. With their desire to capture the viewing public, for example, the television networks have crossed the fine line between journalistic reporting of world events and exploiting them for the entertainment value. It is obvious in examining just a few of the headline "news" stories of recent years—the O.J. Simpson case, the

death of Princess Diana, and of late, "Monicagate." According to *The New York Times* columnist Frank Rich, "The 10-month saga [Monicagate] has solidified for good a 20-year trend in which the media—especially the electronic media [television and radio], by which the vast majority of Americans get the news—have steadily replaced journalistic standards with those of show business."

Not only is the content of the news stories becoming more sensational, but also there has been an explosion in the number of nominally news-oriented television "newsmagazines" such as *20/20*, *Primetime Live,* and *48 Hours.* This format is the networks' answer to the loss of about half their audiences in the last two decades. Thirty years ago, more than 50 percent of U.S. residents watched the evening broadcast every night, but today less than one-third does.

In a 1998 Gallup poll, 1 percent of respondents listed "media/television" as the most important problem facing this country today. This is significant in view of the fact that Gallup had never seen media mentioned in response to such a question. Moreover, the media came up not just once last year, but twice, in two separate Gallup polls.

The media themselves recognize these issues, but appear to be at a loss in dealing with them. Part of the dilemma is related to the news media's need to make a profit. To do so, television, for example, must provide programs that viewers want to watch. The difficulty is that what viewers say they want for news does not follow what they actually watch. In recent focus groups that have addressed the issue of journalistic credibility, the public identified the following as what they want the media to do: (1) write for the public instead of writing for themselves—focus on what is important for the community; (2) give context, depth, and meaning rather than headlines and "fluff" pieces; (3) provide perspective, but allow the reader to draw the conclusion; and (4) demonstrate responsibility for mistakes by acknowledging them in the same manner and importance as the original story.[15] Yet, one has only to hear the demographics of the Monica Lewinsky news coverage to realize that the public wants to hear the "dirt," even if it is unsubstantiated.

The Military–Media Relationship

Both in the United States and internationally, the military–media relationship continues to be a challenge. Military–media relationships in the United States have been contentious since Vietnam. The media need access to news sources, but total access to report the news story during military operations is not always practical or feasible. The fact that reporters' knowledge of the military is declining, because fewer reporters

today have military experience, complicates the relationship even further. During World War II and Korea, the war correspondent shared the foxhole with the soldier for long periods of time and had firsthand knowledge of the situation—although censorship and the primitive means available to communicate the story limited the reporting. Now, however, reporters may instantaneously broadcast troop movements, weapon launches, and other issues of concern to military commanders. Additionally, no longer are reporters forced to wait until U.S. or allied forces enter an area before they are permitted to enter; many times they are on hand to greet the military as it arrives. The military wants to limit the number of reporters, both for the reporters' safety and for control of their access. Reporters fight against being placed in the public affairs/press "pools." Most news organizations express distaste for these pools, but they tacitly concur on the need for them under certain circumstances. Pools should be utilized only as a last resort, however.

The independent coverage tier system permits guaranteed access and support to the media, but also allows military commanders to determine how many media members can be accommodated on the battlefield.[16] The military should expand its training in media relations for its own people at all levels. It should offer educational opportunities to the media as well. Training sessions at war-gaming and live exercise sites may help both sides understand the other under sometimes chaotic conditions. The media must be willing to educate themselves on military issues.

The military–media relations philosophy of the British press differs from that of the U.S. press. The British press consistently support military operations. One reporter has suggested that media and public support for the military could be attributed to the fact that there is no Vietnam casting a shadow over the military–media relationship in England.

Although Hungary has no Vietnam, both the media and the military are emerging from an era of Soviet dominance that clouded military relations not only with the news media, but also with the public. The news media are generally supportive of the military in this emerging democracy. The Hungarian government and the news media worked together to mobilize the national will for support of Hungary's admission to NATO. Voter turnout (49 percent) was far greater than had been anticipated, as was the 85 percent support for NATO admission. Hungary's NATO membership and its concern over ethnic Hungarians living in Serbia, however, challenge the government and the news media in ways not normally faced by a nation involved in armed conflict.

Ultimately, in all countries, the military has an important story to tell, one that it owes the public that it serves. The military must concentrate on helping, not hindering, the media in properly and honestly telling it.

Technology Expansion and Innovation

News broadcasting can be a highly effective medium for shaping the national will and influencing public policy and national security. Television has the power to affect auditory and visual senses simultaneously, thereby appealing to a greater audience mix. Broadcast journalism is also vulnerable to manipulation, however, as has been seen in Yugoslavia, where Serb television broadcasts World War II movies that were corrupted. Images of U.S. leaders were superimposed on Hitler's body, and those of U.S. military personnel were superimposed on Nazi soldiers. The message was clear—the United States is evil. The movie *Forrest Gump* demonstrated this technology when the main character was inserted into scenes with historical figures. The David Sarnoff Research Center demonstrated that real-time, undetectable, low-cost manipulation of video and speech (insertion and deletion) is technically possible today. Options to protect or determine authenticity include encrypting or digitally inserting a watermark into the image. Additionally, in the not too distant future, the Department of Defense must be prepared to address the impact on the military and on the national will of high-fidelity commercial imagery release to private subscribers (i.e., global and national news agencies), military adversaries, and non-governmental organizations (NGOs).

The future expansion of radio is very promising, with numerous requests for low-power (1–10 watt) FM stations. The purpose of these stations, if approved, is to give a voice to more people and to provide more diversity in the voices heard. The future leadership challenge is to organize a plan that will, in the event of an emergency, permit a common message to a diverse audience. Radio is also in the process of digitizing, which will require minimal equipment and will allow less skilled workers to record and edit the message. Eventually, digital recording, editing, and filing will be done on the telephone lines or put directly onto a web page on the Internet. Digital radio is vulnerable to manipulation, just as is digitized video, and the same precautions (encryption or electronic watermarking) can be used for digital radio transmissions.

A rapidly growing market, the Internet is shaping the way people get information in the future. The "dot.com generation" may rely on the Internet as its primary source of information, be it radio or video. The

Internet can also give the news media access to markets that they cannot traditionally penetrate because of government intervention. For example, when President Slobodan Milosevic expelled journalists from Yugoslavia and allowed only state-run news to be broadcast, the Internet provided unprecedented access because people were e-mailing their personal accounts of the war to relatives and other interactive web sites. And when radio station B92's over-the-air broadcast was shut down, it continued to broadcast over the Internet. Consequently, in order to shape Yugoslav public opinion against President Milosevic, the President of the United States sent his personal message via the Internet. These examples demonstrate the adaptability and flexibility of the Internet in conveying information. The Internet will provide governments and NGOs with the ability to inform people and possibly change/develop their will to support governments and/or policies. The Internet—as a dissemination tool—is the future bridge to globalization and freedom of information.

Despite its advantages, there are some concerns about the Internet. There are no filtering mechanisms or standards applied to Internet "information." Originators are not guaranteed, nor are sources of information verified. Therefore, data on the Internet are vulnerable to corruption, fraud, and devious influence. The challenge is to find a way to disseminate the truth when false information is disseminated via e-mail, web sites, or other methods on the Internet. One challenge, for example, is to determine who received the false message and where/to whom they forwarded the false information.

In 1970, some 77.6 percent of adults (18 and older) were daily newspaper readers. That figure has dropped to 58 percent in 1997, and future projections for newspaper readership predict further declines to 48 percent among 18- to 24-year-olds. Despite these figures, the influence of print media should not be ignored. With the U.S. population expected to increase to more than 280 million people by 2002 and with more than 80 percent of persons aged 25 or older holding high-school diplomas or the equivalent, the market for print media remains attractive. The challenge for the print media is in coping with the near–real-time access to information that people now have. Most major newspapers, both in the United States and abroad, are on the Internet in an effort to meet those challenges. Additionally, special focus magazines that cull through the multitude of information being presented to the general population have great potential for the future. Even general interest magazines are participating in the segmentation trend by producing special editions and theme sections to promote readership. Print media will continue to influence the national will of future generations.

In short, over the next two decades, current and future technology will affect the news media in the following ways:

- Growth in the global number of people able to access each medium (e.g., more broadcast, print, and especially Internet users)
- Growth in the global number of people who will expand the forms of media that they access (e.g., more people using more than one form of media, such as television and Internet access for their personal and professional decision-making)
- Increase in the speed with which all forms of media will reach the people around the world (i.e., the Internet is fastest, but television, radio, and print media's speed will increase because of the use of the Internet to accelerate their forms of media distribution)
- Integration among these forms of media so that media suppliers will be better able to coordinate their strategic communications (i.e., people will read it in print, see it on television, hear it on the radio, and access it on the Internet)

In summary, the four key forms of media—television, radio, print (e.g., newspapers, magazines) and electronic (Internet) will experience sustained growth in each media form. Content integration across media forms will require coordinated and strategic communication planning (e.g., print media with web sites, broadcast media with web sites).

The greatest challenge facing the news media is ensuring that information is accurate and reliable, no matter what the form of dissemination might be. That will require a concerted effort by the news media to police themselves throughout the various forms.

GOVERNMENT GOALS AND ROLE

The U.S. government and its executive branch realize that the media have and will continue to have immense impact on mobilizing the national will. The British and Hungarian governments also understand how the news media shape national opinions. Although there is some friction between these institutions, the government agencies appreciate the power of the news media and try to enlist the power of the press to support their programs.

Government officials do not like critical news coverage stories. The news media in the United States, England, and Hungary believe that it is their duty to serve as a government watchdog. Occasional conflicts may result in government pressures to control the content of the information available to and reported by the news media. The approaches used by the government agencies differ in each nation.

Access to Information

Free societies face the dilemma of maintaining a free and open government with unencumbered access to information on the one hand, while striving for strong national security on the other. The U.S. legislative system attempts to regulate the flow of information and news through laws designed to balance First Amendment requirements with the need to protect national security information. The Freedom of Information Act (FOIA), for example, is based on the proposition that a properly functioning democracy requires a knowledgeable population capable of making informed decisions. In general, this law affords people or institutions, including the news media, the right to access government records as long as such records are not protected from disclosure by one of nine exemptions.

Both the British Ministry of Defence and the British news media are preparing for their version of the FOIA to take effect. The process, as described in the law and implementing guidance, seem similar to the process employed in the United States and British Commonwealth nations. The British media believe that the FOIA should give them greater access to information that has traditionally been withheld under the Official Secrets Act. The FOIA may make more government-controlled information available to the news media.

Roles of the Courts

The U.S. news media believe that the First Amendment is the lifeblood of the free press in the United States. The British and Hungarian news media have a genuine appreciation for the First Amendment. Although the press is free in all three countries, the First Amendment provides greater protection to the U.S. news media against censorship that emanates from libel lawsuits and laws designed to control or censor news content.

First Amendment Protections. When the author of the U.S. Bill of Rights wrote, "Congress shall make no law...abridging the freedom of speech, or the press..." he clearly established the intent for this nation to have a free press. The Founding Fathers understood that the U.S. political system rests on the sovereignty of the people, not the power of the government. The U.S. Supreme Court understood that the system could work only if the people and the press were free to question or criticize the government. Therefore, the Court developed a body of case law based on the First Amendment that protects the press from various threats of censorship.

The New York Times v. Sullivan (1963) marked the beginning of a new era for freedom of the press in the coverage of public figures and public officials. Before this case was decided, truth and the privilege of fair comment were the only defenses to protect the free press against self-censorship of true, as well as marginal, material. The Supreme Court interpreted the First Amendment's free press clause to require a public official plaintiff to prove knowledge of falsity or reckless disregard for the truth in order to recover damages against the news media. This standard makes it nearly impossible for a public official or public figure to prevail in a libel action against the news media.

The British courts do not distinguish among classes of plaintiffs. The British libel standard for the news media is similar to the pre–*The New York Times* standard in the United States. Truth and the privilege of fair comment are available as defenses to allegations of libel. The courts also assess the motives of the news media when determining liability, however. This standard improves the likelihood of public officials and public figures prevailing in libel suits against the news media.

Hungary is an emerging democracy with an evolving free press. The news media there face unique challenges. They do not have constitutional provisions or a body of case law to protect them against libel suits or laws that control content. Hungary has only a complicated media law written in 1989 by politicians who were concerned about the potential power of a free press in their emerging democracy. The media law abolished the monopoly of state broadcasting and established the procedures for the creation of publicly owned news media. Neither the Media Law nor the Hungarian constitution provides the news media with the type of protection afforded by the First Amendment of the U.S. Constitution. Eventually, common law will evolve and define the rights and limitations of the Hungarian news media. This process can be tedious, and until the common law develops, the press may exercise self-censorship to limit its potential liabilities.

Restrictions on Subject Matter. The U.S. Supreme Court recognized the power of legislators to restrict subject matter content and thereby restrain a free press. The Court developed a strict scrutiny test, however, to assess the constitutionality of laws and regulations that control subject matter content and to ensure that statutes do not limit protected speech in the news media. Lawmakers have the burden of establishing the constitutionality of any law that controls subject matter content. Legislation that infringes upon freedom of the press must use the least restrictive means to do so, even when the legislative purpose is legitimate and there is a substantial government interest. Under the strict scrutiny

test, any law that regulates subject matter content is presumptively invalid.

The courts in England and Hungary take an opposite approach to the validity of laws that control subject matter content. These courts presume that laws written to control subject matter content have a legitimate purpose and that they are valid. British and Hungarian news media have the burden of convincing the courts that the laws unreasonably limit their ability to acquire or report information. Although the news media are free in both countries, they do not have the same ability as the U.S. news media to successfully challenge laws that control subject matter content. This soft form of censorship can hamper a free press.

The U.S. Supreme Court's interpretations of the First Amendment largely unshackled the U.S. news media from the chill of libel litigation, as well as government control of subject matter content. The Court placed the burden of proof for defamation lawsuits or content regulation squarely on those who would limit the power of the press and gave the benefit of the doubt to those who seek to expand it. The First Amendment gives the U.S. news media unmatched levels of protection to collect, distill, and publish information about public officials and figures. These principles of freedom of speech and press set the U.S. news media apart from the free press in other nations.

CONCLUSION

Globally, the news media have a major role in the determination of a nation's will and make up a critical element of national power. There is no question that they influence the environment within which foreign policy and national security decisions are made and implemented. Yet, the media industry is facing major changes, both in technology and corporate structure. It must cope with the ever-increasing speed of access to news, but it must ensure the accuracy of that news in order to remain a credible source of information. At the same time, it is a profit-driven industry and is drawn more and more to sensationalism to capture market share. Because it can be so profitable, corporations seek to consolidate news markets through horizontal and vertical integration of the various forms of the media. This consolidation has created oligopolies, perhaps not the most desirable way to provide objective news coverage, but definitely the trend for the future, both domestically and abroad.

In the United States, the media industry is the industry most protected by the Constitution; abroad, there is not that protection. As

media corporations expand internationally, they will have to deal with the laws and strictures of each country in which they operate. In both the United Kingdom and Hungary, individuals and government entities have greater protection from intrusions by the press. Even in the United States, however, there are cries for protection of an individual's right to privacy. It may still be difficult to sue for libel in the United States, but the giant media corporations do not have the same leverage in other countries.

Domestically, the federal government, especially the Department of Defense, must overcome its traditionally antagonistic view of the press. Any operational plans must include from the beginning a consideration of press coverage, and the military must be prepared to address any press issues that may arise on topics such as budget, weapons technology, and personnel issues. The news media can be a positive force for the military, for they represent an opportunity to inform the public and strengthen their support.

The global news media must come to grips with the technological challenge of providing timely, accurate information while resisting the lure of sensationalism if they truly desire to combat the public's growing mistrust of the news media. They will need to determine how to set and achieve standards, as well as how to show the public that they are complying with those standards.

The news media's impact on the world cannot be overemphasized. Without their "watchdog" role, even democratic governments striving for good can go awry. The news media have the ability both to inspire people and to focus people's minds on salacious scandals instead of real issues. The news media must continue to strive toward providing objective and factual information, for when it does not achieve that goal, all nations and all people must inevitably suffer.

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MUNITIONS

ABSTRACT

The munitions industry's precision guided munition (PGM) component is a key tool for bringing the military element of U.S. national power to bear. This is an industry segment whose health is variable, with limited capability to "surge" production. Surge is a capability especially pertinent in an era of "cruise missile diplomacy," where PGMs serve as force multipliers for a smaller military. Risk aversion in product development characterizes both the Department of Defense (DOD) and defense contractors. Surprisingly, risk in offshore component sourcing may be unknowingly accepted due to lack of visibility in the practice. Suppliers in the United States will be challenged by competition from many smart, proactive defense firms around the world and will not be protected by their current high market share and what are today the best products in the world.

Lt Col Henry L. Andrews, Jr., USAF
Lt Col Mark P. Brown, USAF
Lt Col Ronald R. Colunga, USAF
Col Allen Coulter, USMC
COL Walter L. Hawkins, USA
COL Nabil M. Ibrahim, Egyptian Army
Mr. Terry J. Jaggers, Dept. of the Air Force
COL Albert N. Love, USA
Mr. C. J. McEntire, Dept. of the Air Force
Col Gary D. Proctor, USAF
CDR Gary R. Windhorst, USN
Mr. William E. Youngstrom, Dept. of the Navy

COL Kenneth H. Clevenger, USA, faculty
Dr. Thomas C. Hone, faculty
Col Barry H. Smith, USAF, faculty

PLACES VISITED

Domestic
Air Armament Center, Eglin Air Force Base, FL
Atlantic Research Corp., Gainesville, VA
Bulova Technologies LLC, Lancaster, PA
Intercontinental Manufacturing, Garland, TX
Litton Electro-Optical Systems, Tempe, AZ
Lockheed Martin Vought Systems Co., Dallas, TX
Naval Surface Warfare Center, Dahlgren Division, Dahlgren, VA
Radford Army Ammunition Plant, Radford, VA
Raytheon Systems Co., Tucson, AZ
Talley Defense Systems, Mesa, AZ

International
Aerospatiale Missiles, Bourges, France
Delegation General pour l'Armament (DGA), Paris, France
Elbit Systems, Ltd., Haifa, Israel
Alenia Marconi Systems, Borehamwood, Hertfordshire, United Kingdom
GIAT Industries, Bourges, France
Israel Aircraft Industries, Ltd., Ben Gurion International Airport, Israel
Matra BAe Dynamics, Stevenage, Hertfordshire, United Kingdom
Office of Defense Cooperation-France, U.S. Embassy, Paris, France
Rafael, Haifa, Israel

INTRODUCTION

A 5-month study of the munitions industrial base (MIB) has shown that the economic health of the conventional (i.e., unguided) munitions manufacturers has declined in the years since the Cold War ended. Some conventional munitions makers have already stopped producing explosives, weapons, and fuses for the DOD. Others are considering dropping their defense products and moving completely into the manufacture of goods for the civilian market.

The situation is quite different for the precision guided munition (PGM) manufacturers: their concern is for future business. They are confident that the market for PGMs is secure in terms of the demand for such weapons by the DOD. Less certain are the particular technologies in which the DOD will want to invest and the level of that investment. For example, PGMs can be divided into two broad classes: self-propelled weapons, such as the Navy's Tomahawk cruise missile, and guided bombs, such as the GBU-28 laser-guided bomb. Self-propelled weapons, especially those with long range, are significantly more expensive than guided bombs. If the technology within these self-propelled weapons and the technology of the production process become progressively less expensive, however, the DOD may shift its purchases away from laser-guided bombs and other, similar weapons toward missiles.

Firms in the United States are not the only ones attempting to anticipate future military demand. Foreign firms, such as Aerospatiale and British Aerospace, are in the same position, but they lack the ready access to the DOD that their U.S. competitors have. In short, there is a great deal of uncertainty about the future, even within the part of the munitions industry that produces PGMs. Manufacturers are trying to hold on to or enlarge their market shares at a time when the technology of PGMs is changing rapidly, government spending on research and development (R&D)—to say nothing of procurement—is declining, and firms are merging.

THE MUNITIONS INDUSTRY DEFINED

The MIB is continuing to evolve, reflecting military downsizing since the end of the Cold War. The MIB includes both private and government-owned facilities, and there are numerous advances and experiments under way in various types of munitions—specifically, directed-energy weapons and offensive information warfare. These weapons could have a vast and far-reaching impact on the total MIB. Some of these implications are the lower cost of weapons operation

(including the cost per kill rate), the potential to reduce force structure, and greatly simplified logistics support.

For the purpose of this study, only the portion of the MIB that deals directly with the production of PGMs will be discussed. PGMs are typically made up of five components:

- Guidance: radar, infrared (IR), television, inertial navigation system (INS), and global positioning system (GPS)
- Propulsion: solid rocket motor, turbofan jet engine, or ramjet engine
- Warhead: typically, blast fragmentation or penetration
- Ordnance and electronics: fuses, power supplies, and safe and arm devices
- Flight controls: vented thrust and maneuvering control surfaces

Few contractors in the United States make these systems, and no U.S.-fielded PGM has all five systems made by a single contractor. In fact, although U.S. PGMs are dependent on several manufacturers, the number of available manufacturers has shrunk significantly due to defense budget declines and limited munitions procurement. In the face of this trend, munitions experts have continually pushed technology to provide increased accuracy in weapons delivery, achieving greater combat power, economy of force, and few casualties.

Despite persistently low procurement, some contractors have successfully penetrated the market and have had success integrating dual-use technologies. This enables the MIB to achieve economies of scale and allows the production of commodities used in the private sector. Given this mingling of technological resources, the DOD has to remain vigilant in the management and understanding of the MIB to ensure that the United States is not lacking in munitions resources during times of crisis.

While the national military strategy is clearly focused on PGMs, the traditional munitions part of the MIB, an essential component of this nation's ability to produce PGMs, is undergoing the same type of transformation as the PGM industry and facing even larger drops in demand. While the nation weathers this turmoil, it is vital not to lose sight of the constant need to provide warfighting capability through efficient use of resources resident in the conventional MIB. Accordingly, subsequent munitions industry studies must monitor this part of the MIBs.

CURRENT CONDITION

During the next 6 years, the DOD plans to invest about $15.2 billion to procure PGMs.[1] Clearly, the DOD is betting on the power of PGMs as

the most cost-effective way to deliver victory with low friendly casualties and minimal collateral damage. However, the technological superiority and high development costs of PGMs all but relegate the production of these weapons to the nation's few remaining major defense contractors: Raytheon, Lockheed Martin, and Boeing. With PGMs increasingly called upon to counter tyrants such as Saddam Hussein and Slobodan Milosevic, the PGM industrial segment is in a sound position to take advantage of the continuing shift in warfare to precision weapons.

The demand for munitions began to decline dramatically during the 1980s. Many production lines were discontinued or slashed to "misery rate" production levels. Early in this process, the munitions industry hoped international demand would keep domestic munitions production lines operating at steady and profitable levels. Unfortunately, this vision faded quickly as our allies also dealt with mixed global economic conditions, a greatly diminished (or at least uncertain) threat, and an increased desire for indigenous munitions production to keep their own industrial base as robust as possible. As a consequence, a number of companies have dropped from this volatile business base, while others are barely hanging on at greatly reduced production volume.

Precision Guided Munitions Defined

Precision guided munitions are produced for surface-to-air, surface-to-surface, air-to-air, and air-to-surface targets. A cursory examination of the major PGM programs under way in the United States is necessary in order to identify the market niches being aggressively carved out by the major defense contractors.

Surface-to-Air. The Raytheon System Company's 1997 acquisition of its two primary competitors, Hughes and Texas Instruments, has resulted in Raytheon's emergence as the dominant contractor in the domestic missile industry.[2] Raytheon is now responsible for all three major U.S. surface-to-air missile systems: Stinger, Hawk, and Patriot. Only Lockheed Martin competes in this arena—as the prime contractor for development of the Theater High Altitude Area Defense (THAAD) system in the theater ballistic missile defense mission area (although it has teamed with Raytheon, which provides the radar systems).[3]

The growth in short-range air defense systems, better known as man-portable air defense systems (MANPADS), will continue to flourish. Here, the Stinger missile has enjoyed robust sales. In the medium-range air defense systems arena, sales have virtually dried up over the past decade. However, they are expected to rebound over the next few years.[4] This is principally due to the recognized requirement for an extended

medium-range air defense system for ground maneuver forces in the United States and Europe. However, the greatest potential for growth is clearly in high-altitude air defense systems.

Surface-to-Surface. The crown jewel of surface-to-surface PGMs is the Tomahawk. In December 1998, more than 300 Tomahawks were fired at Iraq and an undisclosed number were launched at Serbia during Operation ALLIED FORCE. However, the use of Tomahawks exemplifies the PGM dilemma. Because of their high cost, few are purchased; thus, when they are used, the inventory is rapidly depleted. "The Navy's inventory stands at only around 2,900 missiles, set against a requirement of 3,500, and of that total, only about 1,500 are the more capable Block III version. The rest primarily are older Block Is that lack the accuracy and faster mission planning systems of the Block III Tomahawks."[5] Presently, the Navy is aggressively pursuing the next-generation Tomahawk, recently awarding Raytheon Systems Company a fixed-fee contract for 1,343 of these new and less expensive "Tactical Tomahawks." Engineering and manufacturing development on this version is expected to be complete in 2001, with production from 2002 to 2007 and with many predicted sales beyond 2007.

Although the Army may not be known for employing PGMs, some firms believe that the Army "offers the biggest market for precision bombs and missiles for tactical fire support in land combat."[6] For example, the Advanced Tactical Missile System (ATACMS) Block I missile is in the inventory and the Block IA is under production. The Army expects 97 INS/GPS-guided missiles to be delivered by Lockheed Martin at the end of July 1999. The total buy of ATACMS Block IA will likely be more than 600 missiles at a cost of approximately $1 billion. Lockheed Martin is also developing follow-on versions of the ATACMS, the primary difference between the two missiles being the number of submunitions carried. The follow-on Block II and IIA program will cost more than $4 billion and produce 1,800 missiles.

Air-to-Air. Raytheon controls the domestic air-to-air PGM market. The primary missiles in the inventory are the AIM-9 Sidewinder, AIM-7 Sparrow, AIM-54 Phoenix, and the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)—Sidewinder and AMRAAM being in production. These missiles have been in the U.S. inventory for some time and have spawned generational improvements on the original missile design. Raytheon is developing the AMRAAM Pre-Planned Product Improvement (P3I) Phase 3, the AIM-9X, and a new Future Medium-Range Air-to-Air Missile (FMRAAM) based on the current AMRAAM. Other than a new short-range air-to-air missile (the AIM-9X), the domestic demand for air-to-air missiles appears to be stagnating

due to the existence of sufficient inventories and a perception of U.S. dominance in air-to-air warfare. In fact, the small number of air-to-air missiles fired in the Persian Gulf War attests to the reluctance of any foreign air force to truly challenge U.S. air superiority. Further, the crisis in the Balkans did not strain the U.S. air-to-air missile inventory, since Yugoslavia did not pose a robust air threat.

Air-to-Surface. This portion of the PGM market includes laser-guided bombs, the Joint Direct Attack Munition (JDAM), the AGM-130/GBU-15, the Joint Air-to-Surface Stand-off Munition (JASSM), and the Joint Stand-off Weapon (JSOW). The expenditure of air-to-surface PGMs in Kosovo and vicinity bodes well for the prime contractors.

The Paveway series of laser-guided bombs, now produced by Raytheon, includes guidance kits and fin sections that can be attached to the currently available arsenal of 500-, 1,000-, and 2,000-pound bombs. The bomb tracks a laser beam operating at a particular frequency that is less susceptible to spoofing by an adversary and can be transmitted from the launch aircraft or an independent laser designator.

The JDAM functions by the attachment of low-cost INS/GPS guidance kits to BLU-109, MK-84, MK-83, and BLU-110 bombs. Currently under low-rate production, the total buy of JDAM kits will exceed 83,000 and extend late into the first decade of the 21st century.

The Boeing AGM-130 weapons program is rather expensive, but accurate. Functioning at the 15- to 40-mile stand-off range, this all-weather system uses INS and GPS to guide a 2,000-pound MK-84 bomb to its target, with final course corrections made possible from the aircrew via data link. Although the program is still active, the procurement profile has been small due to the $300,000 price tag and the fact that AGM-130 was always intended as a "bridge" capability prior to the JDAM's fielding.

The JASSM is in the engineering and manufacturing development phase with Lockheed Martin. This PGM is the next generation of low radar cross-section, stand-off weapons for Air Force use.

The Raytheon JSOW is a glide system designed to strike targets from outside the range of air defense. Equipped with INS and GPS, JSOW combines accuracy with lethal payloads in a number of variants. Currently under low-rate production, the total buy is projected at more than 10,000 at a cost of nearly $3 billion.

The State of Play Today

The increasing use of PGMs to reduce friendly casualties and minimize collateral damage was clearly exemplified by events in the

former Yugoslavia. Thus, this market is very promising for those contractors able to produce PGMs in large quantities at low cost. In light of the inherent accuracy of PGMs and their higher costs, larger production rates, similar to those associated with traditional munitions, are unlikely. Today, high production rates equate to thousands rather than millions of end items.

Within the DOD, PGMs continue to compete against other warfare areas for scarce dollars. The number of PGMs under development and the projected buys of these weapons exceed the anticipated level of funding. Furthermore, with the DOD's budget stalled at about 3 percent of the U.S. gross domestic product (GDP), it may be unrealistic to believe that permanent support exists for continuing meaningful increases in the DOD procurement budget's foreseeable future. This is despite the fact that the enormous use of PGMs in the Balkans following so closely behind the December 1998 Operation DESERT FOX was clearly straining existing inventories. Although this pressures the DOD to replenish expended PGMs, this upward spike in demand is difficult for industry to satisfy quickly, given the long production lead times. If the Serbian conflict taught any lesson, it is that the United States has a valid need for larger inventories of PGMs to deal with world uncertainties, while minimizing risk to national security.

Prime Contractor Tier

While some overlap of product lines exists, many PGMs are "sole source" items produced by one of the three prime suppliers: Boeing, Lockheed Martin, or Raytheon. These prime contractors appear to have been healthy through the 1990s and there is reason to believe this condition will continue, since the funding for PGMs is projected to be $15.2 billion through the current Future Years Defense Plan.[7]

Generally, the remaining "Big Three" firms, as well as other key industry players, rely on four factors for success: (1) increasing international demand for PGMs; (2) a renewed focus on national and theater missile defense systems; (3) cost efficiencies gained through mergers, consolidations, and productivity improvements; and (4) a strong civilian aerospace economy that offsets the cyclical nature of PGM sales. Additionally, most firms have sharpened their customer-focused, quality-oriented vision and have been certified to ISO 9000 Quality Management System Standards. Collectively, these characteristics represent the diversity and strength of the large firms involved in the PGM market and have proven to be assets supporting the MIB.

Research and Development. In this era of small-quantity purchases of PGMs (as well as many other munitions), R&D has frequently been viewed as a luxury that only prime contractors could afford. Funding for research by domestic firms comes primarily from government-authorized overhead paid through existing procurement contracts (typically providing 4 percent of contract value as an expense allowed for research funding). Thus, only those companies with large contracts can afford to improve their existing programs or other technology applications. Clearly, this situation helps perpetuate continued market domination by a select few firms. Although some companies claim to use corporate money (e.g., profits) to invest in R&D, most have discontinued this practice, offering as their rationale the poor financial performance of the mid-1990s. For many companies, the main issue is the basic commitment to their shareholders. They prefer to invest shareholder money as a "buy-in" to a more lucrative program rather than in attempts to push technology in multiple arenas.

Acquisition Reform. The DOD's acquisition reform programs were viewed as having the potential to curtail the DOD bureaucracy and lower costs while delivering better products faster. To date, however, contractors have witnessed few tangible benefits. Many did acknowledge a better working relationship with their resident Defense Contract Management Command plant representatives and applauded those individuals who have made a conscious effort to streamline processes. Integrated product teams (IPTs) were viewed as aids to progress, but only when the program being worked was technical and overarching and government participants were technically competent and empowered to make decisions.

The main factor in the success of acquisition reform is the time to develop, demonstrate, produce, and field a new product. In almost every case evaluated, there was little or no appreciable acceleration. The acquisition process appears to be as lengthy today as it has been throughout recent history.

On the other hand, "single-process initiatives" have recently been pushed by the contractor base as a method by which to gain acceptance of a standard set of best industrial practices. Interestingly, while many of the best practices appeared to streamline processes for the prime contractors, second-tier contractors criticized these initiatives as just another layer of bureaucracy with accountability, due in this case to an industrial customer.

In summary, efforts to reduce acquisition bureaucracy have had mixed results, although ISO 9000 and customer-oriented practices are often viewed as major steps in the right direction.

Supply Chain for Manufacturers and Integration Agents. In the 1980s, prime contractors had the luxury of many component suppliers, although much of this depth was forced by government requirements for contractors to qualify second sources for critical components. Today, this has changed substantially, as the prime contractors are working closely to develop close customer–supplier relationships with their vendors. Foreign suppliers are not common, because they are not generally necessary for satisfying current production requirements. It is necessary to view this issue with caution, however, because many of the vendors' products contain foreign-supplied items purchased through U.S.-based distributors. Further, the prime contractor is often unaware of the actual source of the part obtained by the subcontractor, meaning the DOD is also blind to sources.

Prime Manufacturer Problems. The integration of disparate workforces necessitated by repeated corporate consolidations and downsizing presents prime manufacturers with a multitude of new problems. Among the biggest challenges facing PGM producers is the fact that many talented employees do not feel compelled to follow the PGM business lines that are often relocated to other plant locations. Consequently, many companies have found growing shortfalls in their requirements for technical employees.

Thus, today's climate finds prime contractors offering generous relocation packages to persuade their seasoned employees to follow the company's fortunes as production lines move across the country. Additionally, in an effort to offset the growing shortage among experienced staff, contractors are offering unprecedented starting salaries and signing bonuses to new engineering graduates, even with the knowledge these employees require 2 years of training to become a contributing member of design teams.

Despite these efforts, many employees are choosing not to relocate. Other high-technology jobs are available in most metropolitan areas, and most do not entail the impediments of cyclical government procurement and PGM manufacturing. Couple these problems with an aging workforce, a decline in the skills base, and limited general process know-how, and PGM manufacturing becomes somewhat unattractive to all firms save those that are effectively diversified.

Subsystem Contractor Tier

The subcontractor business base has also undergone major downsizing and consolidation. Additionally, many of the subsystem manufacturers have changed their long-term vision. Instead of

manufacturing across a product line, many have found niche markets in which they can employ flexible manufacturing concepts to adapt for either commercial or military production.

The subsystem contractors that appear to be struggling are those that maintain older, less efficient manufacturing lines in anticipation of multiyear procurements. Also afflicted are those that have not diversified their skills or carved out a niche in the business base.

Meanwhile, many subtier contractors have successfully responded to these imperatives and are thriving. In some cases, these smaller firms actually serve as a prime contractor, but more often they team up as a subsystem vendor. As with the prime contractors, most all the subsystem contractors either were ISO 9000–certified or had plans to gain this certification.

Despite being affected by the same budget constraints, not all subtier munitions manufacturers are tackling the problem in the same manner, and in some cases they are not tackling it at all. Management and employee attitudes toward meeting future challenges vary widely. Some companies appear to have no plan to make their situation better by either diversifying or drumming up business elsewhere. Conversely, other companies in similar situations seem positive about their future and are actively seeking new, non–defense-related markets at home and abroad. These firms are also exploring mergers as a means to aid in diversification and are striving to stay ahead of the power curve in terms of technical performance.

CHALLENGES

It is fairly clear from the description of the U.S. munitions industry's current state that the challenges to be overcome are great. It may not be as obvious, however, that the challenges may be insurmountable for some companies that are presently key members of the industry. These possibly insurmountable challenges may lead to gaps in a critical aspect of the nation's defense industry and ultimately have an adverse impact on the national security.

The dichotomy between these companies makes it difficult to assess the industry as a single entity. While current challenges to the munitions industry are numerous, they are not necessarily impediments that affect the entire industry or even an entire tier thereof. Some of the deepest concerns are rooted in the realms of low production rates endemic to PGMs in general and the increasing difficulties in managing a changing workforce.

Production Rates. Procurement rates vary by munition across the industry. The DOD's strategy of maintaining rather small inventories of PGMs while enhanced follow-on versions are developed has contributed to low-quantity production contracts. Production rates are also greatly affected by any current operations in which the military finds itself (e.g., NORTHERN and SOUTHERN WATCH, ALLIED FORCE). In fact, prior to DESERT FOX in December 1998 and the operations in Kosovo, procurement rates for cruise missiles were low. Today, though, as a result of what some pundits call "cruise missile diplomacy," the United States finds itself in critically short supply of cruise missiles and is now asking the industry for a surge in their production. In fact, a recently signed emergency spending bill provides $644.3 million to modify 322 Air Force conventional air-launched cruise missiles and 624 Navy Tomahawk cruise missiles, and allows for the procurement of additional JDAMs.[8] These cyclical procurements, as well as the ever-increasing trend toward PGMs, have wreaked havoc on the munitions industry as a whole, and not all companies are faring well under these conditions.

Low production rates as a result of declining procurement budgets require decisions that literally affect a company's life. Many options are available to companies saddled with low production rates, including staying in business while scaling back production, merging with other companies while the company is still an attractive acquisition, or attempting to diversify by expanding into commercial and international markets. Because profits generally determine a company's strategy, low production rates affect the strategic health of the company and may result in a production line going cold or, at the very least, the layoff of many experienced employees.

Today, both high and low production rates require sound inventory, supplier, and subvendor management. Companies must be able to place orders that take advantage of economical order quantities and provide a sufficiently steady demand to let suppliers keep employees and their own production capabilities "warm." Annual government budgeting generally precludes this option, however, and forces contractors to assume all the risk. While managing their suppliers, contractors often need to use creative means to obtain high-quality products in a timely manner. In this context, many companies are looking overseas for component parts critical to particular munitions. Those companies dealing with preferred munitions (e.g., cruise missiles, JDAMs) must have the capability to deal with the challenges of both the high and low ends of the production cycle, sometimes within the same budget year.

As a mitigating measure, there are times when the government allows procurement "stretch-outs" for those munitions deemed essential

to keeping critical expertise in the industry. The fundamental quandary in these instances is picking the correct "essential" munitions at the right time.

Maintaining an Experienced Workforce. One fallout from declining procurement and production rates is a slow exodus of industry expertise. Production lines stopped for lack of government procurement require extensive time to reopen. A key factor is the extensive training period required for new employees. Because the previously employed, experienced workers have often found other work when their line closed, there may be a large void in the industry. In general, it takes at least 18 months to start up a line that has gone cold.

Also, as mentioned earlier, there is no assurance that experienced workers will want to move with a production line when it is consolidated at a new location following a merger or acquisition. Again, this creates an obvious void and training dilemma. Minimizing this loss of expertise in the munitions industry could well be the most difficult challenge to overcome.

The challenges facing the munitions industry are many, but they can be met successfully with vision, insight, and the right attitude. With DOD procurement expected to retain its cyclical nature for the foreseeable future, companies in the munitions industry must find their own niches or be willing to diversify, and they must seek opportunities for commercial expansion into both domestic and international markets.

OUTLOOK

Insight into the outlook can best be gained by reviewing the forecast domestic and international demand for PGMs, the current and future capacities of the U.S. industrial base to meet this demand, and those external factors that will continue to shape this market during the coming years.

World Demand

International demand for PGMs is expected to increase in the coming years. A report prepared by the Columbia International Affairs Office (CIAO) for the U.S. Under Secretary of Defense for Acquisition and Technology suggests an increasing demand for "advanced munitions and electronics." The report states, "Air forces are increasingly viewing standoff precision weapons as a cost-effective way to destroy targets while reducing losses and using fewer aircraft...the demand for such equipment is expected to increase." Given this trend toward high-

technology weapons, the total global arms trade during the decade of the 1990s was valued at $291–$330 billion (in constant Fiscal Year 1991 dollars). In this market, the United States will remain the predominant supplier, with a market share of 53–59 percent.[9] This U.S. market dominance stems principally from the following factors:

- Many countries seek interoperability with the United States (as does the United States with them).
- DESERT STORM and more recent events continue to prove U.S. products are the best in their categories.
- It is perceived that the United States continues to perform R&D to maintain superiority.
- The prices established by U.S. firms are competitive.
- The United States provides training and support.
- The United States has long-standing buyer–seller relationships.
- Overseas defense industry consolidations and mergers are proceeding at a slow rate.

In Israel, France, and the United Kingdom, healthy, vibrant companies were fully engaged in developing and marketing PGMs on the world market. Universally, each company's foreign sales exceeded its domestic sales, demonstrating the potential for significant competition with U.S. manufacturers. Thus, the U.S. government should not count on foreign sales to sustain U.S. industry.

Each country exhibited unique, but understandable traits. Israeli companies and their government maintained a much higher level of R&D spending. In both the United Kingdom and France, contractors were actively seeking to manage industry downsizing smoothly through their domestic and international mergers. British Aerospace is now the fifth largest defense contractor. While other foreign companies have not completed their consolidations, they are following similar paths and experiencing problems akin to those of U.S. firms in like situations. It may be concluded that well-managed, world-class companies are all vying for a smaller PGM pie.

The CIAO report goes on to forecast strong PGM sale prospects in Europe, the Middle East, South Asia, and East Asia.[10] Despite this rosy view, international sales for U.S. companies have their share of impediments. Among these are

- Export licensing, wherein the Department of State is viewed by countries and companies alike as a severe bottleneck
- The foreign military sales bureaucracy with which many countries are growing increasingly impatient

- Purchasing country demands for offsets and technology transfers, accompanied by intellectual property right disputes among prime contractors and U.S. government agencies
- Biased competition from host countries' domestic manufacturers
- Foreign competition that brings other highly sophisticated PGMs to the market

While encouraged by the DOD, partial foreign ownership or other partnering ventures have not provided a competitive advantage in foreign markets to U.S. munitions makers, and thus there is little incentive for further industry participation. With this in mind, it is appropriate to explore the industry's international imperatives, which offer challenges in three primary areas: international sales, offshore suppliers, and international mergers.

International Sales. In an effort to fill production gaps induced by the DOD's cyclical procurement, U.S. companies look to overseas markets. While this tactic may solve some of a company's problems, the remaining challenges are many. Where once a company may have been an insulated sole source in a robust U.S. market, the firm is now forced to learn the rules of international sales and compete in a broader marketplace. This involves intimate knowledge of the releaseability and licensing process as it pertains to the foreign customer in question. There is also the inevitable "red tape" involved in dealing with the bureaucracy and the length of time required to complete foreign sales. Collectively, these are major challenges to a company in the international market.

Offshore Suppliers. Subtier companies faced with declining profits often shut down their underutilized production lines, leaving the prime munitions contractors wanting for components. In the increasingly open world economy, prime contractors may find the components that they need at lower prices from overseas vendors. The first challenge for the DOD is to ensure unfettered access to these critical components and to confirm that the quality of these items and their support are as needed to meet overall system requirements. Another challenge is to prepare for the inevitable influence of politics on the availability of critical components when needed and to find ways to avoid leaving the United States short of critical munitions.

International Mergers. Once engaged in an overseas market in an attempt to either diversify or help ensure access to critical foreign-made components, U.S. companies may seek to merge with foreign firms. Once again, licensing and technology release, not to mention the possible loss of U.S. jobs, pose major challenges.

Market Drivers

Industry Restructuring and Globalization. The munitions industry continues to restructure at the subtier level, undertaking globalization initiatives in an effort to compete successfully in the world market. Today, this globalization represents an essential course of action to retain industrial competitiveness in all sectors of the U.S. economy. Though globalization of the defense industry has been occurring for several decades, never has there been such an imperative to ensure survival of the companies in question. Competition for a slice of the smaller defense pie is especially keen among the few remaining domestic suppliers.

Among the lower supplier tiers, where "buy American" rules become fuzzy, prime vendors are searching out suppliers at home and abroad that offer the best products at the best price in order to reduce costs. In some cases, subtier vendors overseas are chosen because there are no domestic component suppliers. More often than not, offshore suppliers win the day due to their better and cheaper products.

At the prime contractor level, there is increasing pressure to slash corporate overhead costs in order to compete successfully at home and abroad. These cost efficiencies have been achieved to one degree or another through domestic mergers and takeovers. Chief Financial Officer of Raytheon Peter D'Angelo, in reference to his firm's recent takeovers made in an effort to better compete against Lockheed, said, "the market [has] redefined what it takes to remain a top player; you must adapt or suffer the consequences."[11] Cost efficiencies can also be gained through international mergers and takeovers, though existing law would likely prohibit the remaining prime contractors from competing for defense business in this arena. Regardless of restrictions on the prime contractors' globalization desires, it is imperative that neither law nor policy restrict further globalization among the lower tier providers. Such restriction would simply keep the prime contractors' (and ultimately the DOD's) costs high and needlessly limit product innovation.

A common theme among defense contractors is that the U.S. PGM market is essentially closed to foreign suppliers. This is not likely to change substantially in the near future. However, with the continuing trend toward globalization, international consolidation and cooperation, and coalition warfare, protected markets on both sides of the Atlantic may begin to break down over the long term. Mergers, cooperative development of systems, and technology sharing are most likely within countries of the North Atlantic Treaty Organization (NATO). Asian countries will, in due course, join this web of interdependence, provided

they remain closely allied with the United States or with another NATO nation.[12] The most likely mergers are between countries with existing, strong government-to-government ties. At the top of this list would be firms in the United Kingdom. Current U.S. Under Secretary of Defense for Acquisition and Technology Jacques Gansler supports United States–United Kingdom industrial cooperation because he believes both nations should have compatible hardware.[13]

Technology Push. The leadership of the United States in the application of information technology for both the mission and business systems will continue to provide better PGMs at lower costs. As manufacturers incorporate information technology into target location and tracking by PGMs, weapon lethality will increase and collateral damage will decrease, further fueling worldwide demand for PGMs. In addition, as industry continues to leverage information technology in business practices, the cost of producing PGMs will decline, also bolstering demand. Additionally, new weapons technologies on the horizon may well challenge traditional munitions like PGMs. Even though PGMs are in the growth phase of their product life cycle, developments in directed energy may offer an alternative to today's PGMs.

Foreign Military Sales. As European consolidation continues and Russian industry completes restructuring, international competition will increase. Affordable systems with recent technology will likely be preferred by developing countries to the leading edge systems fielded by U.S. forces. In addition to some European companies, Israeli industry will compete favorably in this market. Conversely, systems used by U.S. forces are often preferred (when affordable), due to their inherent interoperability and future supportability.

Many defense firms believe bureaucracy in foreign military sales and export licensing are causing many countries to pursue direct contract sales, vice foreign military sales, if they even choose to continue to buy from a U.S. source. This trend is expected to continue.

GOVERNMENT GOALS AND ROLE

As discussed previously, the PGM industry has experienced tremendous consolidation. The results have led to significant industry stratification: Raytheon, Boeing, and Lockheed Martin dominate the precision munitions industry and, for the most part, compete only with one another. Lockheed Martin, for example, has more than $28 billion in sales and a workforce of 290,000 employees. By comparison, Litton Industries, although ranked as one of the top 10 U.S. defense suppliers,

has sales of only $4 billion and survives by leveraging its core competencies and supplying components to the "Big Three."

Contractors in the United States readily admit that R&D spending is almost universally limited to government dollars. With returns on investment at seldom seen lows, contractors believe that they are unable to "invest" their own dollars in promising R&D projects. Additionally, when contractors elect to expend research dollars, they prefer to do so on products that offer the potential for large paybacks—usually those associated with high production runs. Unfortunately, new weapon programs leading to large production runs are the exception rather than the rule. Thus, the contractor typically directs the bulk of the R&D investment toward preplanned product improvements of current weapon systems.

The outcome of this strategic decision by the contractors tends to lead to small, incremental technological advancements and reduces competition even further within the industry, since any given system's present prime contractor is most likely to win the P3I (i.e., pre-planned product improvement) program on a given system. From a national defense perspective, this acquisition cycle hinders rather than fosters significant technological innovation. The cycle minimizes the possibility of technological leaps because of limited R&D investment and will generally beget only marginal increases in performance rather than the major scientific leaps previously enjoyed by the United States

The present industry stratification will likely keep the current level of competition steady and may even result in less competition. Subtier contractors are almost universally forced to accept firm fixed-price contracts from the three prime contractors—even on developmental work—while the prime contractors themselves successfully negotiate cost and award fee contracts with the government. The result is that prime contractors share risk with the government, while the subtier firms absorb substantial development risk at their levels. The result to the government is either higher component prices or an ever-narrower supplier base as contractors voluntarily leave the PGM business.

While acquisition reform is resulting in a shift toward performance-based rather than technical specifications, this change at the subtier level is slow to take hold. Interestingly, though, this change is probably good for the DOD, because performance specifications at the subtier level allow the contractor to almost freely substitute component parts as long as performance remains the same. In view of the lack of awareness by prime contractors of the actual sources for their subtier suppliers, the possible complications are clear. In many cases, the prime contractors admitted that they were unaware of, and even unable to determine, the

quantity of overseas components within their products. However, they expressed confidence in PGM procurement practice based upon first-article testing and the time-tested relationship between prime contractors and subcontractors.

The government must have a clear, strategy-to-task relationship from the national security strategy through the national military strategy to all the implementing plans as a way to confirm that procurement policies effectively support the capstone strategy documents. However, these policies cannot be made or executed in a vacuum; some form of open, candid, regular feedback must be obtained to permit decision-makers to understand the ramifications of their policies and procurement decisions for industry as a whole and, in some cases, even individual suppliers.

A core requirement enabling effective support of the national security strategy is needed to maintain technological superiority. After all, while international competition is an interesting concept, it has practical limitations when the United States buys a foreign-produced system rather than developing a superior system domestically. Given the likelihood that this system is also available to other nations, it is not hard to conceive of a decline in U.S. military preeminence.

Today, the DOD chooses to fight with existing stockpiles and rely on the defense industry to restock depleted supplies following what is posited to be a short war. Hence, the DOD has staked national security on a munitions policy decision that may not have involved full consideration of the attendant risks. To aid in determining if the current course is sound, government acquisition policy and management of the PGM industrial base should be modified in the following ways:

Require records of all component sources. An acknowledged reliance on single-source suppliers, a shift toward performance-based specifications, and a globalization of the world economy create a potentially vulnerable component supply chain. The DOD should leverage the recent developments in the Information Age and pay the prime contractor to maintain awareness of the actual component sources, not simply the mailing address of the supplier in question.

Insist on competition for high-value components. The government should determine what constitutes "high value" in terms of the percentage of overall system cost, the reliability of the component source, and other factors, and the government should be willing to reward the contractor for the establishment and maintenance of a second source for these components, particularly if the primary source is an overseas supplier.

Immediately make an assessment of the MIB's true surge capability for critical, high-value munitions in the U.S. war-reserve stocks. This

assessment must be conducted at the component level to validate delivery times of the final product.

Institute a periodic assessment of the subtier suppliers. This effort should determine if there are "critical" sole-source suppliers about to go out of business and should develop a formal policy to provide some level of production to prevent this, where necessary.

Review government R&D technology investment policy in both the private sector and government laboratories. Current policy leads to marginal improvements of existing systems rather than dramatic innovations or entirely new weapons systems. With world competition being high, R&D spending must be more broadly based to ensure competitive products that provide the warfighter dominating capabilities on the battlefield.

Evaluate whether the current profile of low-volume, high-value munitions provides sufficient return on investment to contractors. The information derived will be key to determining if contractors at all levels will survive over the long term at projected procurement levels.

Encourage cooperative efforts between government and industry. Efforts such as those performed under the JDAM program by the Air Force's Air Armament Center and development contractors have fostered key technological and performance enhancements and significantly benefitted the warfighter.

Assess the implications of the trend toward contractor logistics support. Clearly, the positive developments resulting from the shift to performance-based specifications will lead to increased use of these specifications. To minimize the risk of departure from MILSPECs, the government must ensure that these specifications are closely coupled with lifetime warranties, leading to lifetime contractor logistics support. The questions that must be answered by the government are the following: What will be the wartime implications of such a shift? How many contractors will be on the battlefield, and how far forward will they be? How will they get there? How will their proprietary logistical tail be supported? What is the extent of the government's obligation to support the contractor?

Streamline the foreign military sales process. Include in ongoing DOD efforts in this area a specific focus on improved export licensing procedures to facilitate direct commercial sales. Most domestic companies reported extensive administrative requirements that could be streamlined through a government–industry team approach.

In the end, it is clear the DOD has benefitted from the changes in the PGM business. However, these changes have been the result primarily of good fortune and market forces rather than planned causes and effects,

and they have been economically motivated rather than oriented to specific security needs. Therefore, it is time for government to assess the nature of the playing field and make required changes to policy in an effort to influence future directions, not simply catch up to them.

CONCLUSION

The health of the munitions industry is variable. The prime contractors are sound, but low production volume has led to spotty subtier viability among PGM component suppliers and "traditional" bomb and bullet makers. There is limited capability to surge PGM production, a capability especially pertinent in an era of "cruise missile diplomacy" when there are often significant lead times to replenish expended PGMs. This can contribute to shortfalls in major theater war (MTW) planning, calling into question the wisdom of sizing war reserve munitions requirements based largely on postulated MTWs with all munitions types typically employed in smaller scale contingencies as lesser *included* cases. Exacerbating this dilemma is the purchase of small quantities of PGMs to take advantage of incremental technological gains, leaving few preferred munitions on the shelves.

Adequate supplies of valuable PGMs must be an everyday concern because of the PGM's role as a force multiplier, the same force multiplier that has allowed the United States to reduce force structure because the remaining systems are so much more effective. Without a robust PGM supply, however, the United States cannot expect this simpler force structure to be as effective as the nation needs it to be.

Risk aversion characterizes the DOD and defense contractors, leading to a preference for evolutionary capabilities instead of revolutionary advances. It is critical to ensure that mere preplanned product improvements do not deprive U.S. fighting forces of the best technological edge possible. While the United States may have no problem with offshore component sourcing by PGM manufacturers, component tracking in this area is inadequate; the United States cannot have a viable policy about a condition that it knows little about, meaning that the DOD and prime contractors must achieve higher component source awareness.

Finally, the world market is an increasingly competitive place to do business. Suppliers in the United States are beset with competition from many smart, aggressive, proactive defense firms around the world that are gaining on them. High market share and the best products in the world today are no guarantee of success in the future.

[1] "U.S. Defense Budget Forecast," *Forecast International/DMS*, February 1999.
[2] "U.S. Defense Industry: And Then There Were Three," *Defense and Foreign Affairs*, August 1997, p. 18.
[3] Michael A. Dornheim, "THAAD Program Future Tied to Test Results," *Aviation Week and Space Technology*, March 3, 1997, p. 64.
[4] "U.S. Defense Industry: And Then There Were Three."
[5] Robert Holzer, "U.S. Navy Strives to Boost Inventory of Tomahawks," *Defense News*, September 28–October 4, 1998, p. 4.
[6] "Companies Finding Precision Munitions to be a Growing Market," *Global Positioning & Navigation News*, November 18, 1998, p. 1.
[7] "U.S. Defense Budget Forecast."
[8] Paul Mann, "White House Likely to Accept Doubling of Kosovo Funds," *Aviation Week and Space Technology*, May 24, 1997, p. 36.
[9] "World-Wide Conventional Arms Trade (1994–2000): A Forecast and Analysis," December 1994, *Columbia International Affairs* Online (CIAO), p. 2.
[10] "World-Wide Conventional Arms Trade," p. 2.
[11] Charles Grant, "Land of the Giants," *The Economist*, June 14, 1997, p. 2.
[12] Grant, "Land of the Giants," p. 2.
[13] Sandra I. Erwin, "Industry Globalization Looms Large in Pentagon Agenda," *National Defense*, February 1999, p. 14.

SERVICES

ABSTRACT

Traditional definitions of the "services industry" no longer capture the enormous range of non-manufacturing and non-agricultural activity occurring in the global economy. Fully 75 percent of the U.S. economy is now service-based, and 7 of every 10 employees are defined as service workers. Services are not restricted to any industry, but occur in all industries. They are anything that adds value, improves responsiveness, reduces cost, allows risk taking, and increases competitiveness. Global economic and quality competition, stockholder demands for increased profits, and pressures to reduce government spending have caused the service phenomenon. As corporations and government entities concentrate on core competencies, service providers perform those necessary services that are outside of core areas. A large segment of the services industry already supports the Department of Defense (DOD), and this will continue to grow. There are still significant challenges to the DOD in defining core competencies and overcoming a culture that is grounded in ownership, and in command and control of people and assets.

CDR Mark Brown, USN
Col Pamela D. Carter, USAF
Col Gabriel Dassanou, Senegalese Air Force
Mr. Thomas H. E. Drinkwater, Dept. of the Army
CDR Kathleen Dussault, USN
COL Don Hart, USA
COL Rocky Hills, USA
Mr. Jeff Levine, Dept. of State
Mr. Gene Peterson-Beard, Dept. of Commerce
LTC Jack Scherer, USA
Col Chuck Snavely, USAF
Ms. Janet Walton, Dept. of the Navy

Dr. Gerald Berg, faculty
Mr. Donald Briggs, faculty
CAPT Scott Ensminger, USN, faculty

PLACES VISITED

Domestic

Chamber of Commerce, El Paso, TX
Dallas Airmotive, Dallas, TX
Defense Logistics Agency, Ft. Belvoir, VA
Dyncorp, Ft. Worth, TX
EDS, Plano, TX
Fitting Out & Supply Support Assistance Center, Norfolk, VA
Marriot, Washington, DC
Military Traffic Management Command Transportation Engineering Agency, Hampton Roads, VA
Southwest Airlines, Dallas, TX
Westat, Rockville, MD

International

Baltic Exchange, London, England
Bloemenveiling Aalsmeer (Flower Auction), The Netherlands
CGU Insurance, London, England
Damen Shipyards, Gorinchem, The Netherlands
Dutch Ministry of Defense, Amsterdam, The Netherlands
European Union, Brussels, Belgium
GM Delphi, Juarez, Mexico
Lloyds, London, England
Logistics Information Systems Agency (U.K. Army), Bicester, United Kingdom
Oxford Economics, Oxford, England
Phillips Electronics, Juarez, Mexico
RAF College, Cranwell, England
RAF Training Group, Cranwell, England

INTRODUCTION

Traditional definitions of the services industry no longer capture the enormous range of non-manufacturing and non-agricultural activity occurring in the global economy. Fully 75 percent[1] of the gross domestic product (GDP) in the United States is now service-based, and 7 of every 10 employees are defined as service workers.[2] Of the 20 industries studied by the Industrial College, 8 fall completely within the service sector, and the remaining 12 have large service components.

Exact definitions of service work are probably not important. Current workplace trends are almost certain to continue, regardless of terminology. The role that services play in economic productivity has forced a corporate restructuring, so the way that companies organize themselves to conduct business is undergoing a dramatic transformation. Corporate America, as well as government, is spending considerable time and resources determining what they do best, where they are most competitive, and how they add value to their activities.

The classic benefits derived from functional specialization and economies of scale only partially explain the incentive for this restructuring. Computerization and telecommunications are the new technology multipliers, leading to, until recently, unimagined levels of productivity and return on investment. The simple historical division of business activity into manufacturing and services categories is no longer adequate to capture the essence of a company's activities. Focused networks of specialized skills are the modern paradigm. Today, the concept of "core competency" defines a company. Activities that one company does not consider part of its core are outsourced to form the core of another company. Yet the various cores remain interlocked in a flexible, synergistic network that allows each to respond to the needs of the other. The sum of these new parts is greater than the original whole. In the broadest possible terms, the group of activities that enables this synergistic phenomenon is attributable to the services industry.

The services industry includes various sectors, such as problem solving, insurance, logistics, and base-operations support. Problem solving captures the consulting and research fields and is key to improved productivity through better operating processes. Insurance, generally defined as part of the financial services industry, serves as an economic stabilizer and can be viewed as the "outsourcing of risk." Logistics involves traditional supply chain operations and companies that serve as facilitators, bringing supply and demand into contact, and adding value to their processes through logistics services. Like base-

operations support, each of these areas constitutes an independent multibillion dollar industry sector.

These diverse sectors have common threads. Most pronounced is the strong and continual focus on defining and redefining core competencies and the subsequent use of mergers and outsourcing to create synergies that result in more efficient, productive organizations. Today's competitive environment almost forces outsourcing. Any service is likely to be available from a specialized firm that can provide better value at a more competitive cost than an in-house operation. The more specialized the product, such as research capability, process re-engineering guidance, or tax law advice, the more likely a candidate for outsourcing. Neither corporate walls nor national boundaries serve as restraints. Organizations relying on the services industry are increasingly demanding the highest level of services at the most competitive price.

The same forces pushing private industry toward service reliance affect government. It, too, is struggling to define its core competencies while finding the right synergistic mix of public and private sources to best meet its responsibilities. Senior government leaders recognize the changes occurring within industry and understand the need to compete in productivity and quality. Toward this goal, legislative and executive initiatives clearly seek a stronger public–private partnership.

THE SERVICES INDUSTRY DEFINED

The traditional U.S. Standard Industrial Classification defines *services* as the construction, transportation, communications, utilities, wholesale, retail, and public administration sectors, in addition to the specific *services industries* of amusement, personal services, social services, education, health, lodging, engineering, management, and legal services. The breadth and diversity of these classifications quickly demonstrate the need for a more focused view of the services industry if meaningful conclusions are to be drawn. The larger definition is primarily of interest to those concerned with the diminishing role of the manufacturing sector in the economy. Even within the traditional manufacturing sector, services such as human resources, product development, design, and marketing contribute substantially (85 percent in microchips) to the value added.

The services industry includes both traditional service providers and the portion of the services sector that is a direct outgrowth of core competency and outsourcing decisions. Companies are analyzing what they do best, calling the results of that analysis their core competencies. Functions that are not a part of their core, but are still needed to support

operations are outsourced to a "service provider." Through this dynamic process, the services industry is in a continuous process of growth and change.

CURRENT CONDITION

Industry

The services sector is a dynamic element of the U.S. economy and has grown in recent years to account for 75 percent of the GDP. Fiercely competitive, the sector is better developed in the United States than anywhere else in the world. Markets for U.S. services are especially strong in Europe, and they are growing in other regions.

As *Business America* noted, "Service industries have become the engine of growth for the American economy, fundamental to the health and prosperity of almost every business, large or small....Companies engaged in every type of commercial activity—manufacturing, transportation, energy and utilities, retail and wholesale trade, finance and government—rely on the edge that services firms offer to be integral to their business success."[3]

More than 72 percent of jobs, and approximately 90 percent of new jobs, fall into service categories; these jobs continue to provide employment for workers displaced from the diminishing number of manufacturing positions. Thirty percent of U.S. exports (as compared to 20 percent of total world trade) come from this sector.[4] The service sector's importance to the economic element of national power cannot be overstated.

Many converging trends have fueled the growth of services, but the information revolution is the dominant enabler. Alan Greenspan, the Federal Reserve Chairman, recently stated that the "leap in [information] technology is primarily responsible for the nation's "phenomenal" economic performance."[5] The explosion of information and its access has transformed virtually all business processes, allowing much greater span of control, productivity, accuracy, flexibility, and customized operations. Greatly increased international competition, investor demand for high returns, and the balanced budget movement have also pushed both the private and public sector to improved levels of efficiency and subsequently higher growth.

Another key force influencing both the growth in services and improved efficiencies is outsourcing. When done correctly, outsourcing offers superior technology and better trained personnel. According to James Brian Quinn of Dartmouth College, "If you are not best-in-world

in doing something, and you're doing it in-house, you are giving up competitive edge. You could outsource to the best in the world, up the value and lower the cost."[6]

Studies indicate that outsourcing not only can result in improved efficiencies and/or effectiveness, but also can "free up the time and energies of management to focus on companies' core competencies."[7] Outsourcing has progressed over time from physical activities such as cleaning, maintenance, and transportation support to "intellectually based service activities like research, product development, logistics, human relations, accounting, legal work, and marketing."[8] The bottom line is that identifying non–core areas and then maximizing the effectiveness and efficiency of these areas through outsourcing increases profits and promotes business in the private sector. This same approach is available for public use.

Government

While accelerating under the pressure of reduced federal spending and the National Performance Review, streamlined and cost-effective government services are not new goals. In 1955, the Eisenhower Administration issued Bureau of the Budget Bulletin 55–4, which declared that the federal government "will not start or carry out any commercial activity or provide a service for its own use if such product or service can be procured from private enterprise through ordinary business channels." Although often ignored, this bulletin established an executive branch policy mandating a bias in favor of the private sector. This policy has led to extensive use of private contractors in meeting federal goals, particularly among agencies created in the past few decades, such as the Department of Energy, the National Aeronautics and Space Administration, and the Environmental Protection Agency. Contractors also have almost completely replaced federal employees in some functions, such as cleaning services, travel management, and personnel security investigations. As an indication of the degree to which the federal government uses the private sector, total civilian personnel costs for Fiscal Year 1997 were $113 billion, as compared with $110 billion that federal agencies spent on commercial service contracts.[9]

The issue of contracting out federal functions has always been challenging, contentious, and emotional, especially for agencies with existing workforces. In an effort to help standardize the decision-making process, the Office of Management and Budget (OMB) issued Circular A-76, which requires federal agencies to identify commercial activities

and then, with some exceptions, conduct competitions for the management and performance of these commercial activities.[10] The Circular and its supplement provide a formal process for evaluating the cost-effectiveness of outsourcing. To win a competition, a private sector bid must be at least 10 percent lower than the public sector bid. In March 1996, the OMB revised the Circular A-76 process, providing for streamlined cost comparisons, a fixed 12 percent overhead rate for in-house estimates, and work descriptions in standard terms (i.e., full-time equivalents [FTEs]). While these revisions were intended to facilitate the use of Circular A-76 within the executive branch, Table 1 indicates that, with the exception of the Department of Defense, executive policy calling for reliance on the private sector continues to be largely ignored.

Table 1: Number of FTE Staff Years Studied under A-76[11]

Fiscal Year	Total FTEs	DOD FTEs	Civilian Agencies FTEs
1988	17,249	12,000	5,249
1989	8,469	6,100	2,369
1990	9,547	6,989	2,558
1991	2,026	1,243	783
1992	564	496	68
1993	509	441	68
1994	1,691	1,623	68
1995	2,386	2,128	258
1996	5,267	5,241	26
1997	25,255	25,255	0

The reluctance of executive branch agencies to pursue public–private competitions has run counter to the general mood in Congress, which supports significantly increased levels of outsourcing.

In 1998, Congress passed the Federal Activities Inventory Reform (FAIR) Act based on its concern over the lack of governmentwide progress in Circular A-76 compliance. The FAIR Act directs agencies to submit a list to the OMB each year of all their non-inherently governmental activities and to review the lists within a "reasonable" time to decide whether to outsource the jobs. Similar lists have been compiled in the past, but the FAIR Act requires, for the first time, public disclosure of these activities and allows anyone, federal employees or private firms, to challenge agency decisions on what can be outsourced.

Although it is too early to predict the outcomes of this legislation, it is likely that the legislation will create a new battlefield as headlined in the May 10, 1999 *Defense News*: "U.S. Industrialists, Unions Clash Over A-76 Contract Process."[12]

Department of Defense

As reflected in Table 1, the DOD remains the government leader in outsourcing. Although the DOD has broad experience in outsourcing work, it has never attempted the magnitude of outsourcing under consideration today. Even after contracting for 200,000 work years, the DOD is still a target-rich environment for additional outsourcing opportunities. Several independent commissions and private sector advocates have asserted that additional outsourcing within the DOD would save billions annually. The Commission on Roles and Missions of the Armed Forces (CORM) identified approximately $120 billion per year that could possibly be outsourced. Using both the DOD and private sector experience, the Commission estimated potential savings from outsourcing these activities as high as $36 billion per year.[13] The Defense Science Board asserted, in September 1996, that the DOD had 640,000 federal workers involved in commercial activities (a term generally considered synonymous with outsourcing candidates).[14] Recognizing the need for change, the DOD leadership in the mid-1990s began in earnest a series of reform efforts that included increased outsourcing.

An understanding of the DOD's current outsourcing strategy requires a cursory review of its overall defense strategy. The DOD laid out its overarching strategy in the May 1997 Report of the Quadrennial Defense Review. The strategy requires the DOD to help shape the international security environment in ways favorable to U.S. interests, respond to the full spectrum of crises, and prepare now to meet the challenges of an uncertain future. These three elements—shaping, responding, and preparing—define the essence of the U.S. defense strategy between now and 2015.[15] To ensure the DOD's ability to execute this strategy, the Secretary of Defense established the following as one of six strategic goals: to "fundamentally reengineer the Department...by reducing costs while maintaining required military capabilities across all DOD mission areas." To achieve this goal, the DOD implemented a program entitled the Defense Reform Initiative (DRI).

The DRI requires action, vice studies or planning, aimed at adopting business practices that U.S. industry has successfully used to become leaner, more flexible, and highly competitive in today's global market.

Industry has used and continues to use outsourcing extensively to streamline operations and allow increased focus on core business processes. Private sector studies indicate companies often save 10–15 percent or more, in functions outsourced.[16]

This potential for significant cost savings resulted in outsourcing (called competitive sourcing within the DOD, since DOD teams can compete against the private sector under Circular A-76 procedures) and privatization as significant parts of the DRI program. Under the DRI, the DOD established the following competitive sourcing objectives:

- Evaluate all positions by 1999 to identify which functions are commercial in nature and could be opened to competition with the private sector.
- Conduct competitions for 229,000 positions between Fiscal Years 1997 and 2005 under the Circular A-76 process. This target represents more than one-third of the federal workers in the commercial activity area. The level will remain roughly equal, about 25,000 per year, during this 9-year period.
- Seek permanent legislative authority to privatize family housing construction.
- Initiate privatization of all utility systems by January 1, 2000, except those needed for unique security reasons or when privatization is uneconomical.

Within the DOD, the Services project that competitive sourcing saves an average of 20–30 percent. The General Accounting Office (GAO) reviewed these projections and concluded that "sourcing competitions are likely to produce savings." Although the GAO warned against overestimating the magnitude of the savings likely to be achieved, it projected that "initial savings from recent competitions are expected to be substantial." Currently, the DOD projects savings from Circular A-76 competitions will total approximately $11.2 billion by 2005, whether they remain in-house or convert to contractors.[17]

CHALLENGES

The services industry faces a host of challenges as it operates in the private and public sectors. Some challenges are shared across these environments, while others are unique to particular sectors. Their impact on national security is manageable. Linked to jobs and education, however, the services industry takes on a more important role in sustaining the vital economic instrument of national power.

Private Sector

The top three challenges to the services industry in the private sector are "staying focused on the core business," resolving the deficit of skilled information technology workers, and creating measurement tools that can demonstrate how much value is added by service providers in the synergistic environment of the industry.

Service firms report "staying focused on the core business" as an ongoing challenge. Core competencies for service firms often include the functions of communication, logistics, transportation, travel, information assurance, knowledge management, health affairs, network support, finance and insurance, and energy. The enormous growth rate of the services industry is due largely to the expanding capabilities and expertise held by the firms in the industry.

The services sector in the United States is projected to sustain steady job growth through 2005. Nearly two-thirds of new jobs worldwide will require the use of information technology. The scarcity of individuals skilled in information technology continues to be an issue in the industry. The demand for workers with leading-edge skills is so great that there is a worldwide deficit of 885,000 positions. Of the information technology positions available today, 10–20 percent are unfilled.

In the United States and abroad, job trends are moving toward those jobs that require knowledge workers. Furthermore, knowledge is now viewed as a resource that can be applied to many different jobs. This knowledge is constantly evolving through the frequent advancement of technology in three classes of knowledge work that have value: (1) creative knowledge work, which is based on innovation; (2) portable knowledge work, which is based on widespread, immediate utility; and (3) specialized knowledge work, which is based on narrow, but high-utility knowledge learned for specific products. Knowledge workers in all classes are required in the services sector to protect the political, economic, and military instruments of national power. Without a concerted effort to educate its citizens on the changing requirements for success in the job markets of the new millenium, the United States cannot remain competitive. The impact of services on elements of national power such as jobs, unemployment, and education demand the attention of decision makers.

There is a synergistic effect to business partnering that is responsible for the expanding growth of the services industry. The challenge is recognizing that synergy and putting it to use in decision making. Firms network for increased business opportunities as they partner and associate with one another. Some firms use a technique called "co-

sourcing," which allows them to benefit from the process improvements that they secure for their customers to the extent that improvement increases productivity and revenue growth. The use of metrics that prove how service firms add value to their customers can be a helpful marketing strategy.

Public Sector—Specifically DOD

In order for the DOD to realize the projected outsourcing savings without harm to readiness, capability, identity, and morale, it must first overcome challenges created by its culture, the Circular A-76 process, and defined core competencies.

Within the DOD, the military services are the primary stakeholders in department-level outsourcing initiatives. Savings can be used to improve funding prospects for modernization and readiness, primary goals of each of the military services. Yet the Defense Science Board defined one of the primary impediments to outsourcing in the military as the "resistance of the military to fundamental change."[18] There are valid reasons to support cautiousness by the military services, but the biggest impediments appear to be military culture and past experience.

Military culture teaches its leaders that carrying out the mission comes first and taking care of their people is a close second. In the words of one senior officer, "Our job is to kick ass and not lose people!" The underlying belief is that effectiveness should not be risked for the sake of efficiency. Ironically, retired, high-ranking military officers lead many of the major service firms seeking DOD contracts. Now in the corporate world, some freely admit their opposition to outsourcing while on active duty. One former base commander acknowledged slow-rolling an A-76 study for his entire 2-year command. He cited the frequently raised concerns, such as loss of control of the workers, contractor incompetence, displacement of the current workforce, and morale problems. His service had provided no incentives to promote greater cooperation at the base level. Now pursuing DOD contracts, this former base commander rebuts each point. Senior leaders need to set the tone and establish a clear direction on the efficiencies that can be sought without affecting combat effectiveness.

The military's distrust of private sector practices is rooted in past experience, especially during the Vietnam War. Robert McNamara and his civilian Whiz Kids were determined to reform the DOD and force private sector business practices on the military. Their roughshod efforts to impose efficiency on the military and disastrous attempts to apply Ford Motor Company style systems analysis to the war all worked to

reinforce the military's impression that private sector business practices are grossly inapplicable to armed forces.[19]

The impact of culture and experience is hard to decipher, but is reflected in the concern most commonly raised by commanders—loss of control, especially in a combat situation. Despite the fact that non-military personnel have been on the battlefield since the nation began, concern about their presence also arises frequently. Commanders fear that contractors may refuse to deploy as required or otherwise hinder readiness and/or capability. Industry again has its rebuttal. Just as retired military leaders head many of these firms, most of their employees are retired soldiers, sailors, and airmen. They are experts in the military environment and provide needed augmentation in the field. Although this may be true, the doctrinal aspect of contractors on the battlefield warrants further development to address both the real and imagined problems. Some of the known issues include physical protection, legal protection/status, tax status, and benefits. In addition, the DOD must include contingency requirements in outsourcing and privatization contracts that address deployment and emergency needs. Anticipation is as important to contractor-provided logistics as it is to military logistics in general. Consideration must also be given to the role of contractors in Status of Forces Agreements.

Organizational cultures can be changed, but require strong vision and leadership. Improvements to the Circular A-76 process, which has received universal criticism from both government and private sector sources, can facilitate cultural change. The outsourcing process has numerous problems, starting with the lack of accounting systems that capture the true cost of an activity. This information is vital in making outsourcing decisions and determining true comparability between proposals. Education and training on the Circular A-76 process are also inadequate. While the DOD has conducted numerous cost studies, few installations have conducted more than one or two. As a result, well intentioned individuals at the installation level are struggling through the complex process of developing a sound performance work statement and objectively evaluating proposals. Furthermore, poorly designed requests for proposals, especially those that do not allow bidders to benefit from economies of scale, can reduce competition by discouraging contractor interest. Finally, the process also creates an organizational conflict of interest in that one of the competing parties (the government) is also responsible for conducting the cost comparison. Several firms have recommended outsourcing the outsourcing process itself, handing the analysis, statement of work preparation, bid process, and possibly even the award decision to specialized consultants.

Although Circular A-76 attempts to establish an objective evaluation and decision-making process, these competitions may evoke a variety of emotions. Affected commanders fear a degradation of their workforce; workers fear displacement or reduced compensation, and private industry resents spending millions of dollars on contract proposals in competitions that they believe are often unfair. Winning contractors have sometimes found an in-place workforce that they must assume has been poisoned against them during the competitive process. These challenges all significantly reduce the potential for real savings, the original objective.

In an attempt to avoid the pitfalls of a Circular A-76 cost comparison, DOD organizations have struggled with definitions of "core competencies." The reality is that the determination of a core competency is greatly influenced by one's interest in the task examined. Politicians are influenced by their constituents and their political agendas. Private businesses are influenced by the desire to increase their profits. As a senior military leader observed, ensuring combat effectiveness and protecting soldiers on the battlefield equal profits for the DOD.

OUTLOOK

Private Sector

Consolidation is ongoing in the services industry. Companies consolidate to improve the economy of scale, increase market access, improve quality or service to their customers, widen the span of control, and spread expertise or best practices. Larger size gives service providers greater cost leverage with suppliers. Knowledge of business conditions or the market is also an important reason to consolidate.

Cultural fit is an important aspect of consolidation. This fit includes geographical position, finances, and management style. Differences in the corporate approaches to servicing customers impede the consolidation of those corporations.

Process improvement in the services industry affects productivity, cost, and quality of service to the customer. In the short term, much of process improvement will be the result of continued consolidation, the spread of existing technology, and the adherence to best practice. A basic characteristic of services is that they are people-oriented. If process improvement reduces the personal touch without adding personal assurances in other ways, there is significant risk that the customers will not accept the improvement.

In the short term, niche business in the services industry will continue to thrive. More niches will be found and exploited for competitive advantage. The danger of niche business is that it can be self-limiting.

International Sector

Clearly, the United States leads and will continue to lead its competitors in the services industry. Liberalization of the international services market began with the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) talks, and further negotiations are scheduled to begin next year in the World Trade Organization. As national restrictions on service-providing firms end, firms in the United States will be well-positioned to enter these new markets, especially in the fields of commercial consulting, information technology, and telecommunications. These firms will likely enjoy a short-term competitive advantage over European Union–based competitors because of more advanced development, but competition will be intense. Service opportunities in the Far East are more limited than in Europe due to different business philosophies; Asian businesses appear less willing to split support requirements from their core functions and prefer to control all aspects of production or establish very close association with support/supplier firms.

The global marketplace will continue to push world-class firms toward global presence. The result will be a series of linked individual operating units located wherever a competitive advantage can be found. For example, the concept of *maquiladoras* (i.e., offshore assembly or service activities) in Mexico is not new and initially offered lower wages with proximity to the U.S. market. As more and more maquiladoras were established, however, their comparative advantage diminished. They instead became a necessity to remain competitive, and only those able to improve upon the concept enjoy an advantage.

Some firms focus on taking care of their employees to achieve better results. Maquiladora benefits already offered include bonuses for longevity, transportation to and from work, two meals daily, and housing assistance. Many processes are still labor-intensive, even though additional automated or robotics-based assembly could also add quality, perhaps at a lower long-term cost. Good local managers earn competitive salaries in Mexico. Some firms are developing managers internally, but the increasing competition (with higher salaries) can draw these managers to other firms. As the full provisions of the North American Free Trade Agreement (NAFTA) take effect, the economics and resulting

roles of maquiladoras will change. The current benefit is a competitively priced assembly of U.S.-produced parts with resulting low tax on the added assembly value. Assembled goods must return to the United States or Canada for sales. Phillips, for example, makes television sets in Mexico for the United States and Canada, and it relies on televisions produced in Brazil for its share of the Mexican market. As the full provisions of the NAFTA are implemented, taxes will increase, but the restriction on end destination will disappear.

In the United Kingdom, the Thatcher government introduced a significant outsourcing effort called "contractorisation." Efficiency (cost savings) and best industry practice remain the goals of this program, which also recognizes increased flexibility in levels of support. The U.K. outsourcing effort includes diverse areas such as information technology, base operating services and support, and government office space. Displaced employees are protected by Transfer Undertaken (to) Protect Entitlements (TUPE), which provides protection against loss of job, pay, benefits, and conditions when functions are outsourced. This program is continuing to expand and should improve as contract scopes and bids are fine-tuned to reflect actual needs more closely. Unfortunately, there has been a negative impact of outsourcing within the U.K. military services. Commanders report that outsourcing has led to a loss of espirit de corps. The team-building processes so vital to unit cohesion have suffered at many bases where there are no longer sufficient uniformed personnel to participate.

Department of Defense

Both reduced federal spending and the private sector's demand for more DOD service contract opportunities ensure that the outsourcing trend will continue. Competitive sourcing efforts are an important part of the DOD's strategic goals to re-engineer the department and generate savings to fund critical modernization requirements.

The DOD is in a unique position to benefit from the services industry and already has a number of successes that can be exploited. Verification of DOD savings through the Logistics Civil Augmentation Program (the outsourcing of contingency logistics—LOGCAP) and similar contracts should be convincing, as should lesser known successes such as U.S. Army Europe's outsourcing of helicopter engine rebuild, Anniston Depot's cooperative re-manufacturing of armored personnel carriers, and the public–private aircraft maintenance operation at Kelly Air Force Base.[20] In April 1997, Thomas G. McInerney, representing Business Executives for National Security, recommended outsourcing

several functions to the National Defense Panel.[21] These functions included travel claims processing, military and civilian payroll administration, military family housing, inventory management, and defense depots. Contractor maintenance for weapons systems, including the Apache helicopter, Palladin and Crusader artillery systems should be considered. The expansion of transportation outsourcing (such as delivering repair parts or provisions from supplier to the user or maintainer) is already under way in the Defense Logistics Agency (DLA), Air Force, and Navy. The potential benefits are enormous and include more rapid delivery, improved operationally ready rates for supported weapons systems, drastically reduced cost, and less wear on strategic aircraft.

Efforts to further refine the Circular A-76 process will continue. Recently, the Deputy Under Secretary of Defense for acquisition reform indicated that the DOD will soon ask Congress to change the law governing public–private competitions to allow best value to replace best cost as the determining factor in job competitions.[22] Other refinements will most assuredly be debated, and more radical changes may be possible.

With the reduction of weapons systems research, development, and acquisition, many defense contractors will continue to pursue opportunities to compete in the defense services sectors. Creative teaming arrangements are emerging within the private sector. An optimum outcome will see the lines between the public and private sectors continuing to fade, with greater use of partnering and other mechanisms that leverage competitive efficiencies and blend the strengths of industry and government in support of U.S. national objectives.

While a leader within the federal government, the DOD is behind the private sector, and behind state and local governments, in utilizing outsourced expertise. The bottom line—undoubtedly threatening to some in the DOD—is that others can do much of what the DOD currently does better and cheaper. Barring catastrophic world events, budget limitations will drive the DOD to more efficient approaches. Political opposition is declining, and the DOD has new authority to privatize installation utilities and family housing. The smoothness of the transition depends on the leadership commitment, not only with the DOD bureaucracy, but also at the military service level.

GOVERNMENT GOALS AND ROLE

Clearly, the DOD must improve its business practices as it moves forward with outsourcing and privatization. Best value must be the basis for contractor selection. True partnering must be the DOD's attitude toward its contractors. To achieve leverage and economy of scale, DOD agencies must seek joint ventures, both within and outside the department, and must consolidate needed services to take advantage of the full range of services available from a class of contractors. Contracts must also be written to require and facilitate transitions...transition to a new contractor, transition between contractors, and transition back to the government if necessary.

The following specific recommendations will help to smooth the transition to private sector service providers within the DOD and optimize potential cost savings. To ease the cultural change:

- Congress should pursue legislation to ensure portability of benefits for government employees facing privatization/outsourcing.
- Congress should authorize and/or DOD leadership should establish financial incentives to installations to outsource when it makes sense to do so. For example, installations could be allowed to retain 25 percent of the first 2 years' savings. This approach ties some positive incentives to outsourcing, countering what are now considered at the local level all negative incentives.
- The DOD should establish doctrinal guidance on the treatment of contractors in combat environments to remove existing fears of nonsupport and to guide commanders on their responsibilities to contractors while educating them on contractor limitations.
- Service Secretary and Chiefs should more aggressively commit to and support a transition to a greater reliance on the private sector.
- The DOD should develop and implement a commander's awareness program on their rights under contracts to ensure that commanders understand the considerable control that they retain over contractors.

To improve the Circular A-76 process:

- The OMB should eliminate the mandatory requirement for in-house bids for functions involving more than ten positions. Instead, a make-or-buy decision based on best value/best industry practice should be allowed, similar to the approach taken by the U.K. Royal Air Force.
- Competitions should be managed at a centralized level, such as the Major Command level. Learning will accelerate, improved performance work statements will result, and organizational conflicts of interest will be avoided.

- Competitions should cover multiple functions (vice single functions) to gain the advantage of economy of scale, to match capabilities of best practice contractors, and to reduce the turmoil on installation personnel.
- Regional outsourcing should be encouraged, when appropriate.
- Joint ventures with other government agencies can be used to achieve economy of scale regionally when appropriate.

To define the core business:

- The DOD should establish common, specific guidelines on what functions are considered core.
- The DOD must prepare for an environment of continuous change and ongoing process improvement.

CONCLUSION

The services industry will continue to grow as a strategic element of national economic development and power. As corporation and government employees concentrate on performing core competencies, service providers will continuously emerge to provide those services that are necessary, but lie outside the core areas.

A large element of the service industry already supports the DOD, and it continues to grow as DOD downsizes. For the time being, former or retired military personnel who are familiar with outsourced tasks often perform these functions for services industry firms. These tasks are performed at a savings to the taxpayer and allow the DOD to concentrate on maintaining national security, even with a downsized workforce. It is essential to ensure that the mechanisms to obtain the services required to support the national strategy and objectives will be available when and if required.

Careful government reliance on segments of the services industry will not jeopardize the national strategy. The challenge for the DOD will be defining core competencies and overcoming a culture that is grounded in ownership and command and control of people and assets.

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SHIPBUILDING

ABSTRACT

The U.S. shipbuilding industry continues to lead the world in the design and construction of advanced military vessels. The United States is not now, nor has it historically been, a major producer of commercial passenger or cargo ships, however. There will be no significant growth in the commercial market for U.S. shipyards, and protectionist policies, such as the Jones Act, are not effective in sustaining the industry. The U.S. shipbuilding industry has capacity well in excess of the need for military ships. As shipyards merge and the U.S. Navy reaches its 300-ship standard, military vessels will become increasingly expensive. One means to expand competition and to bring to bear advanced business processes is for major systems integrators to team with shipyards to produce the military vessels required in the 21st century.

LTC Dennis Baldridge, USA
Ms. Sally Darner, Dept. of the Navy
Mr. Marc Gorelick, Dept. of State
LTC Mark Henscheid, USA
CDR Thomas Holman, USN
CAPT Mike Howard, USN
CAPT Ljubomir Kranjc, Slovenian Navy
Lt Col David Lawson, USAF
Mr. Wayne Marhefka, Raytheon
LTC Morris McCoskey, ARNG
Mr. Mike McDonald, Dept. of the Navy
LTC Kathleen Meehan, USA
Mr. Gay Mount, Dept. of State
Ms. Renee Roman, Defense Logistics Agency
Lt Col Robert Shofner, USAF

CAPT Michael Brown, USCG, faculty
Dr. Nedra Huggins-Williams, faculty
Dr. Mark Montroll, faculty

PLACES VISITED

Domestic

Avondale Shipyards, New Orleans, LA
Bollinger Shipyards, Lockport, LA
Central Gulf Lines, New Orleans, LA
Electric Boat, Groton, CT
Halter Marine Group, Gulfport, MS
Ingalls Shipbuilding, Pascagoula, MS
Naval Surface Warfare Center, Carderock Division, Carderock, MD
Newport News Shipbuilding, Newport News, VA
Northrup Grumman Corporation, Annapolis, MD
Portsmouth Naval Shipyard, Kittery, ME
Swift Ships, Morgan City, LA
Textron Marine & Land Systems, New Orleans, LA
U.S. Navy Supervisors of Shipbuilding: New Orleans, LA; Pascagoula, MS; and Newport News, VA

International

Australian Defense Industry, Sydney, New South Wales, Australia
Australian Defense Industry, Newcastle, New South Wales, Australia
Daewoo Heavy Industries, Ltd, Koje City, Kyungnam, Korea
Daewoo Heavy Industries, Ltd, Seoul, Korea
Depot Support Activity-Far East, Seoul, Korea
INCAT Tasmania Pty, Ltd, Hobart, Tasmania, Australia
Royal Australian Navy, Canberra, Australia
Samsung Heavy Industries Company, Ltd, Changwon, Kyungnam, Korea
Samsung Heavy Industries Company, Ltd, Koje City, Kyungnam, Korea
Tenix Defense Systems Pty, Ltd, Williamstown, Victoria, Australia
U.S. Embassy, Canberra, Australia
U.S. Embassy, Seoul, Korea

INTRODUCTION

The United States is the preeminent naval power in the world. No other country has a navy with the technology, range, and lethality of the U.S. Navy. The United States is not a major shipbuilding nation, however. First-tier U.S. shipyards are generally unable to compete successfully in the global commercial and military marketplace, although some second-tier shipyards are internationally competitive in small, specialized vessels. The United States ranks 14th in the world with just 1 percent of the world's gross tonnage of new construction.[1] This country's position as a minor player among shipbuilding nations is not a new development. The U.S. shipbuilding industry has been in a slow, but steady, decline since before the Civil War (although surges in production for combatant, support, and supply ships during World War I and World War II, and the requirements of a superpower navy during the Cold War, have interrupted this decline). This country's major shipyards are now almost totally dependent on the U.S. Navy not only for new construction, but also for repair, maintenance, and overhaul.

In the post–Cold War period, the United States faces the difficult task of sustaining a modern, technologically advanced, and flexible navy in the face of a declining fleet, changing threats, competing demands in the defense budget, and a shipbuilding industry increasingly marked by consolidations and mergers.

THE SHIPBUILDING INDUSTRY DEFINED

The facilities and shipyards that construct, convert, repair, and overhaul government and commercial ships, barges, other watercraft, and offshore oil drilling and production platforms make up the U.S. shipbuilding industry. Included in the industry are four public naval shipyards—Portsmouth, Norfolk, Pearl Harbor, and Puget Sound—that perform only ship repairs. The commercial shipbuilding industry is a multitier business. The largest, or first-tier, shipyards have launching facilities for vessels of 122 meters (400 feet) or more in length. As of 1999, there are 18 active shipyards within the first-tier. Second-tier yards, producing ships and other vessels less than 122 meters in length, number several dozen.[2]

Six major shipyards produce the bulk of the U.S. Navy's aircraft carriers, submarines, surface combatants, sealift, and combat logistics ships. General Dynamics owns three of the "Big Six": Bath Iron Works, Electric Boat Corporation, and National Steel and Shipbuilding Company (NASSCO). Ingalls Shipbuilding, Inc. belongs to Litton

Industries. Two yards, Newport News Shipbuilding and Avondale Industries, are independent corporations; however, Newport News has negotiated the purchase of Avondale, pending approval of the stockholders. In addition, Litton Industries recently made separate unsolicited bids for Newport News and Avondale.

A number of second-tier shipyards, such as Halter Marine; Swiftships, Inc.; and Bollinger Shipyards, construct small vessels for the Navy and Coast Guard, as well as commercial vessels. The shipbuilding industry also includes numerous subcontractors and suppliers—what might be called third- and fourth-tier companies—that provide engines, fire control, habitation, command and control systems, and a myriad of other systems for Navy and commercial vessels.

CURRENT CONDITION

Current and Projected U.S. Shipyard Work

The current U.S. shipyard commercial order book has 6 tankers under construction worth $619 million; 2 cruise ships worth $800 million; and 159 offshore supply vessels (OSVs), barges, rigs, ferries, tugs, pusher boats, crew boats, tour boats, and other miscellaneous vessels worth a total of $2.3 billion. The pending commercial orders (e.g., options, Letters of Intent) include 13 tankers worth $1.4 billion and $3.1 million in such vessels as OSVs, tugs, barges, and rigs.[3] The increase in tanker orders results from the requirement for double-hulled tankers and the Jones Act requirement for U.S.–built tankers for trade. Newport News has pursued commercial work; however, in March 1997, they decided to leave the commercial shipbuilding business and concentrate solely on Navy shipbuilding. The company also canceled the construction of 3 tankers. Extensive losses in their commercial tanker construction program are responsible for this decision.

The ship repair and conversion section of the U.S. shipbuilding industry is vigorous and has been successful in competing for work in both domestic and foreign markets. The firms involved have parlayed location, timeliness of repairs, and competitive prices into an edge over many foreign repair yards. The work obtained from foreign markets has been critical for their survival because of the decreased amount of Navy repair work. There has been a great deal of industry consolidation within the Gulf Coast for smaller scale shipbuilding and repair, as well as an expansion of shipyard capabilities through investments in capital equipment, such as production facilities and dry docks. In fact, the demand is so high in the Gulf Coast yards that the area has a continuing

labor shortage despite the downturn in offshore oil market. Outside the Gulf Coast area, Navy repair work continues to make up a major part of the market. In 1997, the Navy spent $959 million on repairs in private yards; in 1998, it spent $697 million. A significant part of the Navy repair budget (48 percent in 1997 and 61 percent in 1998) is spent in the four remaining public yards.[4]

The second-tier shipyards that build small and medium-sized vessels for inland waterway and coastal operation have seen a surge in orders for dry cargo barges, tank barges, tugs, and OSVs. A number of these yards are active in the international market. The 1998 exports included crew boats, small water plane area twin hull (SWATH) research vessels, patrol vessels, tugs, and tank barges. The recent downturn in the offshore oil market has dampened the OSV construction, but the other segments are expected to remain strong.

The Big Six shipyards employ 90 percent of all workers engaged in construction of ocean-going vessels. These yards rely on the Navy for 9 of 10 revenue dollars. Most of these dollars come from larger warship construction programs, auxiliary vessels, and sealift vessels. These shipyards are overwhelmingly focused on military work and have not been able to build commercial ships competitively without government support. The last container ship made in the United States was built in 1992 at a cost of $129 million. A similar ship built in a foreign yard would cost $25–$30 million.[5] Predictions that the U.S. flag carriers in the Jones Act trade will build ships in U.S. yards to replace their aging fleet of 23 container ships appear unrealistic when the cost differences are recognized.

In April 1999, 34 combatant ships and 15 amphibious, auxiliary, and support ships were on order or under construction in private yards. This order book covers ships as diverse as attack submarines, nuclear aircraft carriers, and a Coast Guard icebreaker. There were nine different types of ships being built in seven yards. Newport News in Virginia builds nuclear aircraft carriers. Submarines are built at Electric Boat in Connecticut and Newport News. The guided missile destroyers (DDGs) are split between Bath Iron Works in Maine and Ingalls Shipbuilding in Mississippi. Ingalls also builds the amphibious assault ships (LHDs). Halter Marine in Mississippi is building two oceanographic ships, (TAGS) and Avondale shipyard in Louisiana is building amphibious transport ships (LSDs), an icebreaker, and sealift ships (LMSRs). NASSCO is the only West Coast private yard building Navy vessels; they are building LMSRs. The military sealift construction program, which has accounted for 13 ships since 1993, is scheduled to end when the last ship is delivered in 2001.[6]

Economic Health of the U.S. Shipbuilding Industry

At least as represented by the Big Six shipyards, the U.S. shipbuilding industry appears financially strong. Newport News has a current backlog, or order book, of approximately $6 billion, all based on current and prospective orders for Navy ships. In 2007, Newport News is expected to construct the next generation of nuclear aircraft carriers (CVN 77), and the *Virginia*-class nuclear submarines (with General Dynamics as the lead shipyard for the submarines), as well as to refuel 10 nuclear carriers. Despite its unsuccessful attempt at commercial shipbuilding, Newport News increased its revenues by $155 million to a total of $1.86 billion. General Dynamics has strengthened its position in Navy shipbuilding with its 1998 purchase of NASSCO for $370 million and assumption of $45 million in corporate debt. General Dynamics' other major shipyard, Bath Iron Works, has a major commitment to the DDG 51 destroyer program that is expected to run through 2010. Avondale has a current order book of approximately $2 billion for amphibious landing platforms, logistics ships, and tankers. During 1998, Avondale's cash position was strong enough to repurchase 8.6 percent of its common stock. In 1997 and 1998, the industry invested more than $500 million in upgrading and expanding facilities. Commercial yard improvements included new pipe and fabrication shops, dry-dock extensions, and automated steel process facilities.[7]

Future Navy Shipbuilding Programs

The U.S. Navy shipbuilding plan from 2000 to 2005 includes construction of 47 ships and conversion of 17 others, including 2 nuclear refuelings and 15 service life extension programs (SLEPs). This program represents an average of 8 per year. This is an increase from the current 6 per year, but still far less then the 19 per year during the 1980s. This Navy construction plan includes 1 nuclear aircraft carrier (CVN 77), 5 *Virginia*-class attack submarines, 12 guided missile destroyers , 4 DD 21 land attack destroyers, 10 amphibious transport ships, 12 auxiliary dry cargo (ADC[X]) ships, 1 amphibious assault transport ship, and 2 joint command and control (JCC[X]) ships. The final *Nimitz*-class aircraft carrier is scheduled to start production in 2001; after that, the Navy will begin making the transition to the next-generation nuclear carrier. Research and development (R&D) will start on that program in 2002.[8]

The land attack destroyer program is billed as the first of a family of ships for the Navy's 21st century surface forces. The current plan is to

procure 32 of these ships, beginning in 2004. For the first time in a half-century, the design and engineering of U.S. Navy warships are not focused on countering threats from the former Soviet Union. In the mid-1990s, Navy planners began developing operational requirements based on threats envisioned for the coastal operating environment and 21st century war-fighting capabilities.

The new *Virginia*-class attack submarine, designed as a lower cost follow-on to the *Seawolf*-class, will provide an affordable replacement for the *Los Angeles*-class submarines, which will retire after the turn of the century. The Navy plans to spend $64 billion over the next 18 years to acquire 30 *Virginia*-class submarines. This new class incorporates technology improvements from the *Seawolf* program and will have enhanced capabilities for coastal operations. Electric Boat and Newport News will build different modules and systems. The yards will alternate assembly throughout the production run. The first submarine is slated for completion at Electric Boat in 2004; the next, at Newport News in 2005.

The latest Navy project is the ADC(X) ship, which will replace the aging Navy Combat Logistics Force ships that transport ammunition and dry cargo to battle groups at sea. The Navy will seek innovative designs of both the ship and cargo-handling gear to reduce costs in all aspects of construction and operation. The ship will be commercially designed and built to American Bureau of Shipping (ABS), Coast Guard, and Safety of Life at Sea (SOLAS) standards, instead of Navy specifications. This ship design is expected to involve industry teams and include a re-engineering of the ways that ships are replenished at sea.

Industry Consolidation

The 1990s have been a period of intense consolidation in the shipbuilding industry. This trend continued into 1999 when senior leadership at Newport News and Avondale planned to combine their shipyards in a $470 million deal. This merger would create a powerful combination of maritime resources that could be perceived as a deliberate business move to secure future marketable deliverables to Navy and Coast Guard customers, above and beyond the future intended deliveries to the military by General Dynamics, the primary competitor of the merged company. The Department of Defense (DOD) reviewed this case with respect to the competitive shipbuilding industry and the country's national interests; they endorsed the proposed Newport News and Avondale merger. In response to this tactical move, General Dynamics made an unsolicited $1.4 billion bid for Newport News.

Newport News was cool to the offer, and on April 14, 1999, the Secretary of Defense announced that the DOD opposed the General Dynamics bid for Newport News. General Dynamics immediately withdrew its offer. The DOD concluded that the proposed savings of several billion dollars did not outweigh the potential competitive disadvantages of a proposed company that would have controlled 70 percent of all Navy shipbuilding and 95 percent of the Navy's overall R&D funds for future vessels. The DOD also announced that it had agreed to cost reductions of more than $350 million for Newport News through 2003. Three weeks later, Litton Industries announced a $1.8 billion bid for Newport News and Avondale; the DOD is reviewing the proposal.

To maintain the shipbuilding industrial base, the Navy intends to keep at least two sources for each ship class—with the exception of aircraft carriers. There are two sources for nuclear submarines and surface combatants, and three sources for complex amphibious ships. To maintain at least two sources for each class, contract awards have required a partnership arrangement among shipbuilders to divide the workload. Although the division of the workload among the shipyards does indeed maintain the sources for the Navy, it also adds to the cost of the ships. This added cost is reflected in terms of duplicate setup costs, reduced learning curve benefits, and increased overhead costs for multiple yards working at reduced capacity. Failure to make such an arrangement, however, would ultimately lead to a sole supplier with the consequent risks.

In addition to partnerships among the yards, significant teaming between the shipbuilders and ship system integrators is now taking place. For both the Navy's DD 21 and the Coast Guard's Deep Water Program, major system integrators, such as Lockheed Martin and Raytheon, are linking up with first-tier shipyards to compete to design, construct, and eventually maintain new classes of ships. The result has been the formation of industry teams as full-service contractors that have a full spectrum of required capabilities, ranging from design through construction to in-service logistics. Full-service contractors will need to team with the government because not only does the government have much of the detailed knowledge of ship and weapon system design, but also it owns the ranges required for testing the designs.

This new consortia approach to ship design, construction, and maintenance has a number of advantages over traditional shipbuilding. It brings innovation to the shipbuilding team, ties cost to performance as an independent variable, and should lead to lower operating costs since the team responsible for the life cycle support will design the ship. This

approach also raises a number of questions, however. The requirements for design and maintenance may result in a contractor infrastructure redundant to Navy capabilities, and the long-term contracts with shipyards may prolong an industrial base with excess capacity. In addition, with respect to the contractor–government, the Navy needs to work out an efficient means to make its expertise in ship design and systems testing available to the private sector.

Shipyard Workforce

With their reliance on U.S. Navy and Coast Guard requirements for their shipbuilding and repair work, the large U.S. shipyards face the challenge of attracting and retaining sufficient qualified workers to build and maintain the fleet.

In the United States, most shipbuilding involves large, complex, and technically sophisticated naval ships. Overseas, much ship construction involves either large carriers (dry cargo or oil) or cruise ships. Between 35 and 60 percent of U.S. ship cost is labor related, while labor constitutes only 20–30 percent of the cost of foreign-built ships. Workers in U.S. shipyards receive an average of $18.26 per hour, compared to South Korean hourly wages of $8.32 and Japanese hourly wages of $23.39. In comparison with other skilled workers in the United States, shipyard workers receive lower pay and experience relatively high cyclical layoff rates. These two factors, combined with the relatively high skill requirements of naval ship construction, make it difficult to attract and retain skilled workers.[9]

Shipyard unions have played a significant role in the industry for well over 100 years. Because the industry's employment has declined, total union membership has declined. In addition, a number of major shipyards are non-union or are located in states where union membership cannot be required for employment. Union membership in shipyards peaked in 1954 at 35 percent and is now only 14 percent. Shipyard unions are concerned with increasing hourly wage rates, but they also attend to health, safety, and training standards, and seek improved stability in employment levels.

The downsizing of the U.S. Navy fleet has had an impact on the repair and maintenance portion of the Navy's shipyard work. This downturn in work affects both the large yards and the second-tier yards, which do relatively little new construction for the Navy. Repair work is also complicated by the statutory requirement to guarantee a set amount of work each year for the four public naval yards.

The commercial shipyards have undertaken a number of initiatives to sustain workloads and maintain their workforces. These include Flyaway or Tiger Teams, public–private shipyard partnerships, and apprenticeship programs. Tiger Teams are specialized, highly qualified groups of skilled workers who are able to travel to a ship virtually anywhere in the world and provide quick, efficient repairs. These teams can also provide technical and refresher training to ship crews. Under an innovative partnership, Electric Boat, the Portsmouth Naval Shipyard, and the New London Submarine Base distribute the maintenance workload based on each facility's expertise. The three partners even share their skilled employees to a limited extent.

A number of shipyards, including Newport News, Ingalls, and Portsmouth, have developed 4-year apprenticeship programs with local vocational/technical schools or community colleges. The programs combine academic instruction, trade technical training, and periods of on-the-job training. Participants in the programs usually receive an associate degree and, in some cases, Department of Labor and Department of the Navy Certificates of Apprenticeship.

Technological Trends

MARITECH Advanced Shipbuilding Enterprise (ASE). The shipbuilding industry, along with various government agencies, established MARITECH ASE as a follow-on to the federal MARITECH program, which operated from 1993 to 1995. The purpose of MARITECH ASE is to foster the continuous product and process improvements in ship design, construction, and repair necessary for the U.S. shipbuilding industry to become internationally competitive. The MARITECH ASE major initiatives are shipyard production process technologies, business process technologies, product design and material technologies, systems technologies, facilities and tooling, and crosscut initiatives. Its ultimate aim is to leverage technology in order to meet the nation's sea power needs at the lowest attainable cost; provide a cost-effective, responsive industrial base for building and maintaining ships; and improve the U.S. shipbuilding and repair industry's competitiveness in the global commercial ship market. A 5-year strategic investment plan focuses cooperative R&D efforts on the most important needs of the shipbuilding industry. Unlike the results of the earlier MARITECH program, the R&D results of the MARITECH ASE will be nonproprietary and are to be shared among participating members. Most major shipbuilding companies actively support the program.

Modular Construction. Used extensively in the shipbuilding industry, modular construction has a number of clear advantages over traditional construction methods. First, major sections are fabricated indoors, free from the weather. This is particularly critical during the process of welding and the application of coatings and paint. Second, workers have free access to the entire section because the modules are open at both ends. Workers do not have to run up and down ladders and passageways carrying tools and materials, and they work in less constricted space. Third, workers are adjacent to their shop areas with ready access to their entire set of tools and specialized parts. Fourth, the modules can be rotated for ease of work, which makes for much more consistent work and reduces worker fatigue and injury. Fifth, all crafts and trades can work in the same shop area, which greatly facilitates communication and problem solving.

Another advantage of modular construction is "zone outfitting," a process in which the various subsystems (e.g., power; electronics; heating, ventilation, and air conditioning [HVAC]; fire safety) are incorporated into the modules as they are built. In traditional construction, the hull portion is constructed, launched, and then tied to a pier for outfitting. It is possible to accomplish much of this additional work through zone outfitting with the inherent benefits of indoor work, close proximity to shop areas, and ease of access to open-ended modules. Combining modular construction with zone outfitting can reduce time, increase quality, and improve quality control.

Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM). The challenge of shipbuilding information technology is to keep design and test engineers, contractors, suppliers, and customers linked with visible, retrievable, and readily updated information on millions of parts and on the designing, testing, analyzing, assembling, machining, and outfitting of a single structure. Management teams, possibly at geographically separate locations, need accurate data simultaneously so that they can execute timely and cost-effective resource and marketing decisions.

Computer software with virtual reality/simulation–based CAD products are undergoing exponential growth and development in volume, accessibility, and sophistication. Despite the potential of CAD/CAM, savings in costs and developmental time were realized only with the advent of interactive systems. These systems not only establish connectivity among product development phases, but also extend into the business processes (management for finance, marketing, resources, and logistics). Another improvement, virtual prototyping and testing (VPT) technology, reduces or eliminates the need for physical prototypes or

initial units from limited production quantities to demonstrate design integrity and performance. Mechanical, physical, visual, functional, and environmental characteristics of a design can be attributed to a prototype for "virtual testing," and engineering data can be exchanged between designers/testers and robotic cells in the manufacturing process. By increasing work standardization on finished products and reducing personnel hours, this approach translates to cost savings. However, U.S. shipyards are among the last segments of manufacturing industries to relinquish homegrown CAD/CAM systems for commercial-off-the-shelf products, which limits their data exchange and the benefits of partnerships between shipyards.

Unless concurrent investments in business processes accompany the use of CAD/CAM, these technology innovations cannot guarantee U.S. shipbuilders a competitive edge, nor can they transform the industry into one operating on the margins of efficiency. The U.S. shipbuilding industry appears oriented on technology insertion. In most cases, however, integration of significant CAD/CAM will require firms to reshape their structure and demonstrate flexibility to absorb change before they will see a significant return on this capital investment. Over time, the integration of CAD/CAM will assist in establishing an ingrained, forward-looking, upstream orientation in all aspects of their operations.

World Shipbuilding Industry Trends

Serious overcapacity and sharp, cutthroat competition between East Asia and Western Europe/U.S. shipyards characterize the world merchant shipbuilding situation. A glut of merchant ships plying the oceans and on the market is compounding the problems. With shipbuilding companies in the United States and Western Europe consolidating and downsizing, there is increased pressure from shipbuilders in Eastern Europe and Asia. For example, shipyards in China are using the advantages of cheap resources and labor to expand their order books and become a world leader in shipbuilding and repair.

Countries worldwide tend to consider shipyards as strategic assets, icons of national prestige, and sources of jobs; therefore, they will prop up unprofitable yards. Many countries subsidize their shipyards through direct and indirect payments, covert investments, or tax breaks. Countries are also investing in technology to make their shipyards more competitive internationally. In this buyer's market, the price of ships has been driven down so that many yards cannot compete without subsidies.

A number of countries have developed market niches by leveraging specialized designs and technology (e.g., Australia with its fast ferries) or by exploiting favorable geography (e.g., Turkey and Singapore with their proximity to established shipping lanes). For example, Australia's INCAT has captured 40 percent of the world fast ferry market with its lightweight aluminum catamaran designs. South Korea and Japan have leveraged their long-term investments in technology to retain their dominant positions in the merchant shipbuilding market with just under 70 percent of the gross tonnage of merchant ships on order. As of April 1999, the total world order book was 2,635 ships at 57.4 million gross tons. The South Korean order book was 20.3 million gross tons, and the Japanese order book was 19.7 million gross tons. The United States is near the bottom of the list. In 1998, only one new large merchant ship was ordered from a U.S. yard, and only five new ships, totaling 113,345 gross tons, were built.[10]

The commercial shipbuilding and repair industries are entirely dependent on the commercial shipping industry, which is, in turn, entirely dependent on world trade. Three types of vessels operate in the deep-sea trade: liners (including containerships) offering scheduled service; nonliners, which carry dry bulk cargo on demand; and tankers, which carry liquid cargo. The trend in commercial shipping has been to build larger ships to carry more cargo at reduced cost. The steady growth in ocean trade in recent years is expected to continue through 2002, but the growth in the world ocean-going fleet has already outstripped the need for merchant ships. This overcapacity in the world's merchant fleet, as well as an overcapacity in the shipyards, has made ship trade a buyer's market. New tanker ships, which once sold for $50 million, are being sold for half that by Asian yards.

Despite the overcapacity in merchant ships, several factors drive new ship construction. First, the growth in world ocean trade, which is projected at 3.2 percent annually through 2002, will generally exceed world merchant fleet growth of 1.6 percent per year and improve earnings for ship owners. Second, new vessels are being built to replace old ones; tankers are serviceable for 20 years, and right now, much of the world's tanker fleet is past due for replacement. The need to comply with double-hull regulations imposed by the United States and the International Maritime Organization (IMO) is also affecting tanker construction. For example, South Korean yards are building only double-hulled tankers. Third, petroleum product tankers are being built to service the expansion of refinery capacity in the Middle East and South East Asia. The average size of these tankers is expected to increase in response to long haul shipping requirements. New ship

construction is primarily for extra-large, fast containerships in the main liner trades and for intraregional trade container vessels. Finally, the IMO Safety of Life at Sea (SOLAS) Convention requires significant changes in ship design and structure. These requirements are likely to accelerate the construction of newer passenger ships and the removal of older vessels from service.

The global trend in warship construction is for smaller, cheaper, versatile vessels with significant weapons power. Sales of these types of vessels are expected to increase. However, U.S. first-tier yards make large, complex, specialized platforms that most countries neither need nor can afford.

CHALLENGES

Although an integral part of national security, the U.S. shipbuilding industry faces various competitive challenges that affect military companies and the commercial markets unevenly. The DOD has concluded that the industry cannot further consolidate unless the action leaves at least two sources for each ship class. Even though DOD statements point to the goal of maintaining competitiveness between these sources, the builders of naval vessels are past the point where real competition exists. The government's approach will result in competition for some aspects of ship construction, such as design or systems integration, but the actual vessel construction will be parceled out to ensure the preservation of the industrial base and the continuity of a skilled workforce. In an environment where competition is muted for construction and protection is tacitly guaranteed for the survival of selected sources, the inherent challenge for government and industry becomes how to motivate a workforce and efficiently produce quality products so that defense funds are not used for corporate welfare.

The segment of the shipbuilding industry that builds small ships is more competitively motivated than the segment that builds large ships. The successful firms sought to expand their order books with more diverse product lines, as well as with repair and conversion work. They aggressively developed niche markets, such as tugs, OSVs, and megayachts, and they actively targeted customers who are nongovernment—including overseas buyers. Most companies draw some benefit from or support Title XI and the Jones Act. If that protectionism were reduced and/or eliminated, individual firms would emerge as subsequent winners or losers; even so, the small ship segment of the industry is much more solvent overall and is far better prepared to function and profit in an increasingly competitive environment than the

large ship segment. The challenge to the commercial segment is to gain government support in reducing protective barriers for better access to global markets and more opportunities to develop competitive alternatives.

OUTLOOK

The maritime strategic policy of the United States now focuses on power projection, and current scenarios envision smaller regional conflicts. Large-scale, World War II–type mobilization efforts in U.S. shipyards are not likely. Thus, maintaining an extensive just-in-case infrastructure, with its attendant workforce is undesirable. It is necessary, however, to maintain a skilled workforce to sustain current U.S. capabilities. Projections in the 1992 and 1995 DOD Mobility Requirements Studies indicate that those ships on hand or scheduled for delivery by 2001 will meet the needs of the two major regional conflict scenario. As such, the future planning focus of U.S. shipyards must be on replacement shipbuilding and maintenance capabilities, rather than on massive mobilization efforts.

After several years of considerable downsizing, overcapacity, and industry consolidation, the shipbuilding industry appears to have reached a level of relative stability. Since Spring 1998, mergers have reduced the number of major shipbuilders from four (i.e., General Dynamics, Newport News, Avondale, Litton) to three or even two (assuming the completion of the Newport News/Avondale deal and the Litton/Newport News/Avondale merger). The remaining companies are also consolidating and pursuing a number of initiatives to improve their efficiency and competitiveness. Investments in digital design and engineering tools, adoption of commercial standards and practices, long-term teaming among yards, and public–private partnerships will continue. The near demise of large commercial vessel domestic construction, subsidies, and protectionism in most of the foreign naval markets means that the big U.S. yards will serve primarily the U.S. Navy shipbuilding needs.

Although the U.S. shipbuilding industry represents just 1 percent of the world market for ocean-going commercial vessels, it builds the most complex, sophisticated combatants in the world. No other country builds vessels as versatile as the *Nimitz*-class carrier, Aegis guided missile destroyer, or nuclear attack submarine. The government practice of allocating ship construction programs among states as a way of satisfying political constituencies will continue; therefore, the recent wave of mergers is unlikely to result in the closure of any of the Big Six

shipyards. The possible competitors for most ship types have evolved to a series of duopolies covering all of the Big Six yards.

Historically, the second-tier shipyards have not depended on the U.S. government for the majority of their work and income. With the downsizing of the Navy, these yards are even more aggressive in pursuing nongovernment work to include Jones Act vessels (i.e., vessels engaged in U.S. domestic trade) and foreign military sales. Many of these second-tier companies have competed effectively on the international market. The United States will continue as a world leader in small boat and yacht construction.

The future health of the large ship industry is based on maintaining a 300-ship Navy in support of national objectives and the current national security strategy. Any significant reduction to the current Navy ship requirement would most likely cause the closing of several shipyards.

A firm's ability to reduce production costs via better business practices, to gain efficiencies by moving along the learning curve, and to team with international industries, as well as with the federal government, will determine its ability to overcome the barriers of entry into the commercial marketplace. Lastly, with the increased complexity of the communication and weapons systems on Navy vessels, the role that system integrators play is more important than ever. This is particularly true in determining life cycle and total ownership cost. Partnerships and alliances between the shipyards and system integrators will become the norm in the 21st century, in both the commercial and the military shipbuilding markets.

GOVERNMENT GOALS AND ROLE

The U.S. government plays a major role in maintaining the national shipbuilding industrial base. The government's goal for this industry is given in the Merchant Marine Act of 1936, otherwise known as the Jones Act. This act states that it is necessary, both for the nation's defense and for the nation's commerce, that the United States have a viable merchant marine service that serves on ships constructed in the United States and owned by U.S. citizens and is supported by efficient facilities for shipbuilding and ship repair. To this end, the government helps the industry by imposing various trade protection measures, as well as by providing industrial loan guarantees and technology enhancement programs.

The Jones Act requires that all vessels transporting cargo between two U.S. ports be built in the United States, crewed by U.S. mariners, and owned by U.S. citizens. Likewise, the Passenger Services Act

requires that vessels carrying passengers between two U.S. ports be built in the United States, crewed by U.S. mariners, and owned by U.S. citizens. The stated purpose of these acts is to maintain a shipbuilding and ship repair industrial base, a trained merchant mariner personnel pool, and assets to respond in times of national security emergencies. Protection under these acts can be credited with providing U.S. shipyards a limited number of orders for double-hulled tankers and cruise ships for the Hawaiian Islands that otherwise would have been placed with foreign yards.

The protections increase the costs for U.S. ship owners and shippers to the extent that companies are motivated to circumvent the restrictions of the acts whenever practicable, particularly for large ships where the added costs can be substantial. Indeed, so few large commercial ships are being constructed under the acts that it can be questioned if they are continuing to fulfill their purpose of maintaining the industrial base. By invoking these acts, the United States is joining other nations in the restriction of free trade for maritime products, which, in turn, limits the foreign sales of its more competitive small craft. Given these costs, it is recommended that the acts be reviewed to determine if they are doing more harm than good to the overall U.S. shipbuilding industry.

Title 10, Section 7309 of the U.S. Code restricts the DOD to the acquisition of only U.S.–built military vessels by stating that "no vessel to be constructed for any of the armed forces, and no major component of the hull or superstructure of any such vessel, may be constructed in a foreign shipyard." A careful reading of this statute indicates that it does not preclude the purchase of a vessel that had already been constructed in a foreign yard at the time of purchase. Although this interpretation has been used to purchase a limited number of vessels from foreign sources, the intent of the law is clearly to protect the domestic builders of Navy vessels and to maintain the industrial base. This restriction limits competition and results in higher costs for a ship's hull, which is not even its most critical component.

The government allocates work between shipyards to keep them viable and to maintain domestic sources for ships' hulls and at least the possibility of competition. Ships of the U.S. Navy are the most complex ships in the world, but their complexity lies in their design, in their integration, and in their electronic suites, which are the products of the highly competitive, domestic technology industry. For the hull requirement, advances in CAD/CAM now allow modular construction at remote locations, to include competing yards, and then transshipment to a single site for final assembly. Allowing foreign yards to compete for the construction of the hull could result in significant cost savings.

Indeed, this approach could allow the United States to partner with allies on future ships; the United States could provide the more lucrative design, integration, and complex electronic suites, while allies could compete for the basic ship's hull.

In other areas of government assistance, on October 1, 1993, President Bill Clinton submitted a report to Congress entitled "Strengthening America's Shipyards: A Plan for Competing in the International Market." This report served as the basis for the Administration's efforts to assist the U.S. shipbuilding industry. In the report, the President listed a five-part plan to ensure fair international competition, eliminate unnecessary government regulation, assist international marketing, finance ship sales through Title XI loan guarantees, and improve commercial competitiveness with MARITECH. This plan envisioned a two-step process to improve U.S. shipbuilding competitiveness. First, foreign governments should stop subsidizing their shipyards, and second, U.S. shipyards should adapt to the demands of the international commercial market.

As part of the first step, the United States, Japan, South Korea, the European Union, and Norway reached an agreement in December 1994 under the auspices of the Organisation for Economic Co-operation and Development (OECD) to eliminate shipbuilding subsidies and other trade-distorting practices. The builders of small ships and barges in the United States, which are competitive in the world markets, strongly support the OECD initiative. Due to pressure from large U.S. shipbuilders, however, the Senate has never ratified the treaty.

As noted, the second step involves industry adaptation to international competitiveness and calls for government assistance through MARITECH, reduced government regulation through acquisition reform, the updating of ship construction standards, and the broadening of the Title XI Ship Loan Guarantee Program. Established pursuant to the Merchant Marine Act of 1936 to promote the growth and modernization of the U.S. merchant marine and U.S. shipyards, the Title XI Ship Loan Guarantee Program provides a government guarantee on a commercial loan for the construction of commercial ships in U.S. shipyards for domestic and export customers. The act permits guarantees in an amount not exceeding 87.5 percent of the actual vessel cost over a 25-year period. (If the OECD initiative were adopted, the loan percentage would be reduced to 80 percent, and the repayment period would be reduced to 12 years.) The program is an extremely popular program and has been credited with furnishing a number of orders to U.S. shipyards.

The initiatives in the President's plan represent the proper role of government in maintaining the domestic shipbuilding industry. The government should work with the industry to make it internationally competitive and then work with international trade bodies to lift trade restrictions and eliminate government subsidies to promote international competition. The United States should work for adoption of the OECD initiative.

The government also plays a role in the shipbuilding industry in the operation of the public shipyards. The Navy originally had nine shipyards: four on the East Coast—Portsmouth, Philadelphia, Norfolk, and Charleston; four on the West Coast—Bremerton, Mare Island, Hunters Point, and Long Beach; and one in Hawaii at Pearl Harbor. The yards were set up basically to construct Navy ships, but they have not constructed a ship since the 1970s. Five of the shipyards have now closed under infrastructure reduction initiatives. Of the remaining four public shipyards, Portsmouth is limited to submarine maintenance, which consists primarily of nuclear reactor work. There will no longer be a need for this service after 2005 when all Navy submarines will be equipped with life-of-the-ship reactors. Norfolk and Puget Sound are both full-service shipyards capable of all repair requirements. Puget Sound is the only nuclear-capable facility on the West Coast. Finally, the Navy shipyard at Pearl Harbor provides submarine maintenance and Pacific Fleet support. Its location can be considered critical for providing mobilization support in the event of a national emergency.

Except for the nuclear capability at Puget Sound, these facilities provide a ship repair and maintenance service that is readily available from the highly competitive domestic ship repair market. Government use of these facilities represents a clear contradiction between its policy not to compete with private industry and a statutory requirement[11] that the Navy spend no less than 50 percent of funding appropriated for ship repair in a Navy shipyard. Where private industry competes with these shipyards, private industry should be the preferred choice. The General Accounting Office has noted that the public yards are not price-competitive with private yards.[12] Furthermore, closing the public yards will result in both direct benefits (e.g., cost savings to the Navy) and indirect benefits (e.g., more work for private yards). This would be particularly helpful for those shipyards, such as Newport News, that do both ship repair and ship construction for the Navy. Also, the current Navy policy to award total life cycle support contracts to the shipbuilder will limit the public shipyard's role in future maintenance requirements. For all these reasons, the Navy should carefully consider working with Congress to repeal the statutory requirement mandating the use of Navy

shipyards and to close those shipyards that do not provide a critical unique capability or a needed surge capability.

CONCLUSION

The U.S. shipbuilding industry today meets the nation's security requirements. The industry has sufficient capacity to build the necessary naval combatants for peacetime and contingency requirements. In fact, the nation's shipbuilding industry clearly produces the finest, most complex, and largest warships ever built and sustains the most capable naval force in the history of modern warfare by means of repair, nuclear refueling, and overhauling. This facet of the industry's superiority comes at a great premium, however. Without government support, the industry would clearly be in extremis; the current low global position of 14th, which is in terms of annual gross tonnage produced, would most likely continue to decline.

The six primary shipbuilding companies have sufficient capacity to meet current U.S. military requirements of sustaining a 300-ship Navy. The construction of at least eight new ships annually is necessary to sustain this number of ships, as indicated in the Future Years Defense Plan (FYDP) budget. Approved funding allows for only six new ships annually, however. This level of production will be insufficient to sustain the 300-ship naval force into the new millenium. Production increase decisions will be difficult, given the decline of the Soviet threat and the continued ambiguity of other threats that are typically politically and economically driven.

Surprisingly, the industry retains the ability to support a much larger naval force, one equivalent to those levels found during the height of the Cold War. It is doubtful that the industry can retain this unique capability into the distant future, however, given the low numbers of anticipated government contracts, its lack of flexibility to shift to successful large commercial shipbuilding, and the increasing trends toward consolidation and streamlining.

The protection that the government affords the industry increasingly occurs through the distribution of contractual work. This method fosters the maintenance of the industrial base by ensuring that the unique shipbuilding skills and workforce remain within at least two different yards, yet it limits real competition in the short run. The result is a premium cost that the United States pays for its warships. In short, the United States pays a little more now to prevent facing a monopoly in the future and paying a lot more later. Both basic steel hull construction and systems integration come at high cost; whereas, in a more robust

competitive environment, the less complex and technically common hull construction would be less costly. As it is, the protection of the industry and the meeting of national security requirements by this industry are mutually inclusive. There is a question about how long this arrangement will continue to work effectively, although not necessarily efficiently.

The industry has clearly recognized the dynamics of this new arrangement and is applying a self-preservation strategy quite aggressively in an attempt to ensure reasonable affordability of products. Contractual "teaming" is becoming commonplace, and contractors are constantly expanding their approaches to better systems integration. These efforts are noteworthy and will prove key to the sought after affordability levels.

The U.S. shipbuilding industry does not compete internationally in the commercial large vessel shipbuilding market. This fact does not appear to be of much significance, given the current sustaining level of work afforded by the government. Other nations are far outpacing the United States in terms of commercial gross tonnage shipping produced annually. Most nations—and the trends bear this out—are finding a specialized market that they tend to dominate. For example, Australia and the Republic of South Korea dominate the large aluminum ship fast ferry and steel-hulled tanker markets, respectively. China, European countries, and other nations are emerging as key players in this international niche market, which will characterize the world shipbuilding industry of the future.

Perhaps the U.S. shipbuilding industry needs to recognize and better capitalize on its position in this new, international niche market system. As the premier warship builder, the United States may need to find more competitive and affordable ways to produce these highly effective and sophisticated ships. This approach may be the key to sustaining the shipbuilding industry domestically, as well as perhaps expanding its role in the international market.

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[1] "Outlook for U.S. Shipbuilding and Repair Industry 1998," *MARAD,* June 1998, p. 2.

[2] "Outlook for U.S. Shipbuilding," pp. 19–20.

[3] "Marine Log, April 1999," *Shipyard Contracts*, 42–46.

[4] "Outlook for U.S. Shipbuilding," p. 24.

[5] "Open a Jones Act Window," *The Journal of Commerce,* March 31, 1999, p. 12.

[6] "Marine Log, April 1999," 42–46.

[7] *Jane's Corporate Analysis*, 1999, pp. 1–4.

[8] "Outlook for U.S. Shipbuilding," pp. 18–22.

[9] Bureau of Labor Statistics, http://www.coltoncompany.com/index/shipbldg/wages.htm.
[10] "Shipbuilders Orders/Deliveries," *MARAD,* 1998).
[11] Title 10, U.S. Code, Section 2466.
[12] "Shipyard Competition," *GAO Report 94-184*, May 25, 1994, p. 3.

SPACE

ABSTRACT

Few industries have shown as much growth in recent years or as much potential for increased activity as has the global space industry. Space touches our daily lives through applications such as telecommunications, remote sensing, surveillance, and navigation. Despite a series of launch failures, the long-term outlook for the U.S. space industry remains strong. However, government investment in research and development (R&D) is dwindling at a time when major trends for the industry include globalization, deregulation, and privatization. The demand for low-cost launch has stimulated the creation of innovative launch services. Yet, market uncertainties highlight the continuing maturation process of the space industry. Government's role is to provide enlightened export policy, superior infrastructure, and strategic direction to stimulate continued growth.

Lt Col Kevin Gamache, USAF
Mr. Tom Girz, Dept. of the Air Force
Lt Col Jim Haywood, USAF
Col Hidetoshi Hirata, Japanese Air Self Defense Force
CDR Dave Hough, USN
Mr. Ed Jackanowski, Dept. of the Navy
LTC Ted Johnson, USA
Dr. Walter Jones, Dept. of the Air Force
Mr. Brian King, Dept. of Transportation
CDR Wayne Radloff, USN
Lt Col Jeff Shivnen, USAF
LTC Charlie Smithers, USA
LTC Hal Walker, USA
Ms. Kathy Weilnau, National Imagery and Mapping Agency
Lt Col Jack Weinstein, USAF
Lt Col Joe Zeis, USAF

Dr. Bob Hughes, faculty
Col Bill Humphreys, USAF, faculty
Col Mary McCully, USAF, faculty

PLACES VISITED

Domestic

45th Space Wing, Patrick AFB, FL
Applied Physics Laboratory, Johns Hopkins University, Baltimore, MD
Assistant Secretary of Defense, C3I, Washington, DC
Astrotech, Titusville, FL
Boeing-North American, Space Systems Division, Huntington Beach, CA
Boeing Sea Launch, Long Beach, CA
Cheyenne Mountain Air Station, Colorado Springs, CO
Evolved Expendable Launch Vehicle Program, Los Angeles, CA
Hughes Space and Communications, El Segundo, CA
Iridium LLC, Washington, DC
Kelly Space and Technology, Inc., San Bernadino, CA
Lockheed Martin Astronautics, Denver, CO
Motorola Space and Electronics, Inc., Arlington, VA
National Aeronautics and Space Administration, Washington, DC
National Space Development Agency of Japan, Washington, DC
Northrop Grumman, Baltimore, MD
National Reconnaissance Office of Architectures, Assessments, and Acquisition, Washington, DC
Orbital Sciences Corporation, Dulles, VA
SPOT Image, Reston, VA
Teledesic Corporation, Washington, DC
TRW Space Park, Redondo Beach, CA
U.S. Department of Defense Space Architect, Alexandria, VA
U.S. Department of Defense Spectrum Management, Washington, DC
U.S. Space Command, Peterson AFB, CO

International

Aerospatiale, Les Mureaux, France
Arianespace, Kourou, French Guiana
Alcatel Espace, Cannes and Toulouse, France
Centre National d'Etudes Spatiales (CNES), Toulouse, France and Kourou, French Guiana
European Space Agency, Kourou, French Guiana
Office National d'Etudes et de Recherches Aerospatiales (ONERA) Centre d'Etudes et de Recherches Technologiques (CERT), Toulouse, France
Snecma - (SEP), Vernon, France
SPOT Image, Toulouse, France

INTRODUCTION

The U.S. space industry is now over 40 years old, very much a child of the Cold War. In its infancy, the industry's sole customer was the U.S. government. At conception, it was an instrument of national security, power, and prestige, rooted in ballistic missile technology. The end of the Cold War freed the industry from its government nest, and it started to spread its wings in the commercial sector. Once an offspring, the space industry is now a partner with government in seeking to expand the global economic competitiveness of the United States.

As early as 1955, USAF Chief of Staff Thomas D. White declared, "The United States must win and maintain the capability to control space in order to assure the progress and pre-eminence of the free nations."[1] For more than 40 years, space has been home to a variety of U.S. military and civil operations—reconnaissance, surveillance, warning, command and control, weather, science, and navigation. Space applications are as appealing to commercial interests as to the military, largely because they allow for the exploitation of markets in all corners of the globe and do not require an extensive ground infrastructure. In 1996, commercial launches exceeded military launches in the United States for the first time, marking the transition from a government-dominated industry to a more classic market-driven orientation.[2] As a space-faring nation, the United States should have a space policy that focuses on how to best integrate economic and government space interests. Access to space remains a vital national interest.

THE SPACE INDUSTRY DEFINED

Generally, the space industry is defined as those activities that depend on or directly relate to having a satellite or other assets in orbit.[3] This industry has displayed the technological strength of the United States, embodied in space industry giants building the Mercury, Gemini, and Apollo spacecraft and developing a lunar-lander that propelled the United States into an age of exploration that only Jules Verne could imagine. Emphasis has gradually shifted from government-sponsored, manned space systems to an industry dominated by unmanned commercial satellite constellations. The global positioning system (GPS) unlocked the concept of dual military–civil use. This naturally evolved toward purely civil systems supported from space and, ultimately, to an opening of international commercial markets. Traditional military applications have converged with commercial applications of imagery, entertainment, communications, and consumer electronics.

Space is emerging as a military and economic center of gravity for information-dependent forces, businesses, and societies.[4] The convergence of traditional military, civil, and commercial capabilities in space is improving the quality of life for people around the world. Significantly, the use of space allows underdeveloped nations to catapult past conventional infrastructure. It is not an understatement to suggest that space affects essential aspects of modern society—mobile communications, navigation, agriculture, and entertainment.

Julian Gresser defines a strategic industry as the primary cause of economic growth in a given time and place.[5] Since space is inextricably linked to everyday life, its importance as a strategic industry cannot be neglected. Gresser's theory of strategic industries suggests a government role both nationally and internationally in shaping economic growth.[6] A country that bypasses growth-inducing strategic industry for short-term benefit of comparative efficiency risks a drop in long-term productivity and standards of living.[7] According to this theory, a strategic industry has worth beyond book value.

It appears that the U.S. space industry no longer enjoys considerable comparative advantage. The impact of this shift requires careful government attention. An emphasis on government–commerce partnerships reflects the symbiotic relationship evolving in the U.S. space industry.

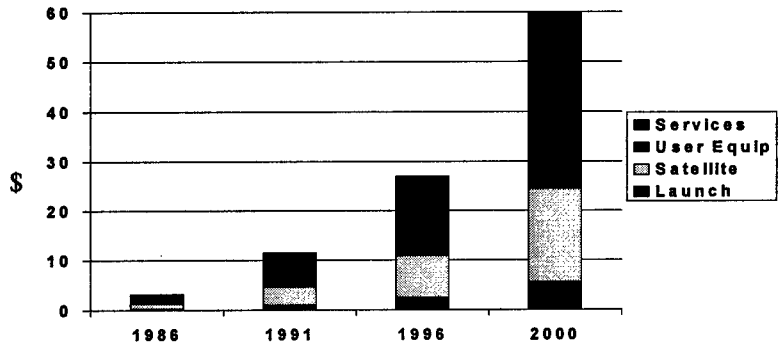
CURRENT CONDITION

Space may be the final frontier of tomorrow, but today it is the leading edge of global commerce. The space industry now embraces the global aspirations of newly expanding telecommunications, broadcasting, and remote-sensing industries. It has enabled unparalleled growth in capabilities and information available to consumers at home and work. The year 1997 marked a telecommunications industry milestone: for the first time, the number of commercial satellites in orbit exceeded the number of government satellites.[8] Because of the space industry's phenomenal growth, its size is difficult to quantify. There is no general agreement; economic estimates range anywhere from $44 billion[9] to $100 billion worldwide (Figure 1), and estimates of jobs generated, 960,000,[10] half of those in the United States.[11] The space commerce era is at the forefront of U.S. technological and economic innovation.

While the global space industry is vibrant and poised for long-term growth, the U.S. launch industry outlook is not as positive. Indeed, the short-term health of the U.S. space launch segment is questionable. Six failures of U.S. Delta III, Athena, and Titan IV launch vehicles over the

past 9 months, coupled with recent uncertainty in the financial strength of major telecommunications constellation companies, brings into question the ability of the U.S. space industry to recapture significant market share from European countries.

Figure 1: Commercial Space Market Growth[12]



Launch

"I think this is probably one of the worst times in the launch history of the country," said retired Air Force General Howell M. Estes, III, former head of U.S. Space Command. "Even the old rockets aren't working. That's the concern, and it comes at the very time we most need to get the launch costs down and assure access to space."[13] Three distinct U.S. launcher types have failed six times in the last 9 months, at a cost of more than $3 billion.[14] Forty years into the space age, the United States still does not have reliable access to space.

The Air Force is the Department of Defense (DOD) agent for space launch. As an aerospace force, the Air Force concentrates on fighting and winning the nation's wars through missions that are a part of its core competencies. According to Brigadier General Robert C. Hinson, Air Force Space Command (AFSPC) Director of Operations, "Our core competencies are concentrated in operating in space, not in getting to space. We operate satellites, provide missile warning, monitor space weather, ensure global communications and navigation, and track space debris—and integrate it all with the warfighter and other agencies who need it."[15] Government typically performs functions that have no competent or comparable actors in the civilian sector. If a function relates directly to warfighting, it is called a mission. A space launch,

however, is no longer viewed exclusively as a mission; it is also a commodity that can be purchased.

Commercial space launch activity in the United States began in earnest when the Air Force awarded Atlas and Delta launch contracts after the Challenger tragedy, allowing commercial launch providers to use Air Force infrastructure to build, process, and launch vehicles at marginal cost. Since 1989, the DOD has continued to provide extensive financial support for U.S. commercial operators, all on a marginal cost basis as directed by national policy and law.[16]

The DOD supports every U.S. commercial launch, using range assets that cost nearly $240 million per year to operate and maintain.[17] In 1996 alone, $30 million per year in Air Force funding was spent just on the operations and maintenance segment of the government Atlas and Delta programs.[18] Yet, most of this upkeep also benefited commercial activities that used the same processing facilities and launch pads. Until recently, the Air Force alone employed 5,300 people at Vandenberg and Patrick Air Force Bases.[19] These employees provided weather, security, safety, communications, and other support functions for national security, civil, and commercial missions.[20]

As civilian contractors have acquired core competency in the service, space launch has become a service to be bought. The civil part of government has recognized this trend. The National Aeronautics and Space Administration (NASA) has turned over operation of its space shuttle fleet to United Space Alliance (USA), a Boeing–Lockheed Martin joint venture, formed to conduct space flight operations. The Alliance performs shuttle launch and landing activities at the Kennedy Space Center in Florida and flight operations for the Johnson Space Center in Houston. With Congressional approval, USA could begin launching commercial payloads next year.[21] Further, the company wants to convert the shuttle fleet to a privately run spaceline by 2002.[22] The core competencies of NASA rest in R&D, reusable launch vehicles, and exploration.

Government subsidy alone does not guarantee successful market partnerships, however. First, at the European launch base in Kourou, French Guiana, the customer is king. Commercial satellite builders rate Kourou number one.[23] The same builders rate Cape Canaveral second to Kourou because of the lower priority of military missions, and despite the Cape's superb rating for facilities and location.[24] Second, commercial operators report difficulties in working with the Air Force accounting system, particularly the slow billing process.[25] Third, commercial users consider range safety requirements antiquated. At Kourou, man-in-the-loop command destruct goes out to 750 miles and

then automation takes over, while at the Cape it carries out to 1,500 miles.[26] Antiquated downrange instrumentation further complicates the man-in-the-loop concept employed on all launches from Cape Canaveral. Thus, as space becomes more commercialized, customer satisfaction becomes more important, and Kourou has the distinct, measurable advantage over existing U.S. launch sites.

Spacecraft

The demand for satellite services will continue on an upward trend, given that the vast majority of the world does not have access to basic telephone services. Low earth orbit (LEO) satellites, in conjunction with geo-synchronous earth orbit (GEO) satellites, are forming an integrated communications system that provides seamless global coverage. Although global economic growth has slowed recently, trends toward commercialization, increased business demand, and the need for faster and more powerful communications in developed and developing countries are driving an increased demand for satellite-based services.

Over the past 5 years, the number of commercial launches has increased by an average of 41 percent.[27] This launch increase has been driven by the commercial communications industry's need for GEO and LEO satellites. Launch demand is projected to increase with the expected launch requirements for the LEO systems that provide broadband satellite services for voice, video, data transmission, and global Internet access. Orbital Sciences Corporation's Communications Company (ORBCOMM) paved the way as the first LEO communications constellation. Iridium is the first operational "big LEO" system with a 66-LEO satellite constellation, and Globalstar is entering the space launch phase for its 48 planned satellites.[28] Teledesic's planned 288-satellite constellation will continue to drive launch demand.[29] A European, 64-satellite constellation system, Skybridge, is poised to break into the emerging communications market as well.[30]

Satellite production is likewise transitioning to a commercially based marketplace. Prior to the commercial constellation boom, satellite production was based on unique, government-specified requirements. This led to large, one-of-a-kind spacecraft to fulfill military or civil missions, with lower priority given to the cost of development or deployment. While federal budget tightening has forced more constraints on government sector spacecraft, the commercial satellite market has been able to significantly reduce the size and cost of its spacecraft. With the maturation of the telecommunications industry, an individual firm or government can go to any satellite manufacturer and

order an off-the-shelf model. This reduction in cost enables large LEO constellations populated by standardized satellites.

Block purchases of launch services by satellite manufacturers have altered the launch market. Two dynamics are tightening the relationship between satellite manufacturers and launch vehicle providers: (1) the satellite manufacturer is beginning to buy launch services in bulk for reduced cost, resulting in long-term launch supplier arrangements and thereby stabilizing the market; and (2) launch providers are moving toward selling satellite manufacturers a complete "service-to-orbit" package, which includes the rocket and all launch services rather than the satellite manufacturer purchasing specific rockets that must be accepted, adapted, and launched by a third party. The term *space commerce* identifies this trend: "To gain guaranteed access to launch slots, satellite manufacturers have altered this demand pattern by purchasing a number of launches at once and then selling a customer a satellite and a launch as a package. In effect, the satellite manufacturers have become the new brokers of commercial launch services around the world."[31]

Operations

While launch continues to be a singular, uncertain "event" characterized by a perceptible chance of failure, on-orbit operation of satellite constellations has become routine. It is no longer the sole domain of engineers and orbital physicists. Satellite command and control has been simplified and standardized through the use of high-speed computers. The impact of this normalization of operations has been dramatic. The Air Force has shifted satellite command and control tasks from officers to the enlisted ranks. Likewise, commercial industry is able to take advantage of the normalization of satellite operations. This earth-bound revolution in space operations has resulted in smaller commercial control centers and ground stations directing multimillion dollar constellations. Industry has taken this concept one step further and has fully automated some satellite ground stations, thus reducing the overhead infrastructure costs passed to the customer. A visit to a major commercial satellite operations center revealed only three controllers on duty during normal operations. While emergency augmentation is always available, the reduced costs and requirements of normal operations are immediately apparent. European satellite manufacturers operate in a similar manner. Satellite services have become economically attractive as operational costs decline.

Applications

Government is no longer the majority shareholder of space assets—profitable commercial applications drive the entire space industry. Ventures in space will succeed only if they make good business sense for their corporations and public shareholders. This arena has become the critical barometer of the health of this industry.

The total revenues of the global space industry now surpass $88 billion,[32] making it one of the largest industries in the world. Driven mainly by rapidly growing commercial applications, total industry revenues are expected to surpass $117 billion by the year 2001.[33] Likely to lead this tremendous growth from 1997 to 2001 are mobile telecommunication services (784 percent), precision navigation systems (222 percent), and remote-sensing and geographical information systems that permit such activities as precision farming (77 percent), for a total industry growth projection of 48 percent.[34] Analysts generally agree that the commercial space sector has been growing by at least 20 percent annually for the past several years, with no signs of slowing. This growth translates to over 70,000 new U.S. jobs each year, providing an increasingly large segment of U.S. industry employment. In 1996, for the first time, commercial launches exceeded government launches, and private investment in the space industry surpassed government investment. Reductions in both NASA and DOD budgets, together with restructuring in the European Space Agency, have allowed the commercial space sector to become approximately 53 percent of the total investment.[35]

Space has enabled the continued growth and prosperity of many other industries. The growing need for telecommunications capacity fuels the rapid expansion of the space industry. In addition, space is the enabler of services such as direct-to-consumer radio and television applications, mobile telephony services, precision navigation, inventory control, in-transit visibility, and financial services.

CHALLENGES

The industry sees space as the high ground of profit and has applied the necessary vision to exploit its commercial potential. There are, however, numerous impediments. The primary challenge is coordinating a vision with a realistic business case and end product. Although projections highlight a growing space industry, promised target dates for various space products and services have not been met. In most cases,

consumer end products have not reached the same level of commercial maturation as has the space-based portion of the system.

Launch

In the last 5 years, there has been an explosive and unanticipated growth of the LEO constellations. It was vision and a very aggressive approach that put these constellations in orbit by the end of 1998. The sudden growth of satellite customers inspired a surge of upstart launch vehicle companies; six companies are now vying for these LEO customers. In the view of Marco Caceres of the Teal Group, "If only half the proposed launch vehicles actually get built and enter the market, we will have at least 30 launcher programs with some 60 available models to address a market of 1,700 payloads or just over 800 launches to reach orbit."[36] The risk is that delays or major reductions in both constellations and satellite numbers will not support that many launchers. The challenge for the upstart small launch vehicle companies is one of head-to-head competition against large companies with established launch infrastructure and secure capital investment. Some will not obtain the financing required if market projections do not provide the anticipated number of customers.

A second challenge to the U.S. launch sector is getting market share from increasingly competitive foreign companies. The United States is designing the Evolved Expendable Launch Vehicle (EELV) program to partner with industry in developing a national launch capability, which both satisfies the government's requirements and is commercially marketable. This program is expected to reduce the cost of space launch by at least 25 percent over existing systems.[37] This partnership can benefit government and industry alike and can fundamentally alter the way that launch services are provided in the future. The EELV is still 2–3 years away and will have to provide a significant edge to the commercial customer over the highly successful European Space Agency's Ariane series of boosters. Its established launch provider, Arianespace, has a 60 percent share of the current geo-stationary transfer orbit (GTO) market. In 1998 alone, Arianespace launched 13 out of 21 satellites to GTO.[38]

A third challenge is the aging U.S. launch infrastructure. Ground operations at Cape Canaveral and Vandenberg Air Force Base are expensive and personnel-intensive. Turnaround time and cost-consciousness were not key performance parameters during the golden era of U.S. space exploration. The U.S. government launch facilities were developed for one-of-a-kind space operations, while today's

environment emphasizes lowered costs through standardization. Although the government effectively subsidizes all U.S. commercial launch operations, the antiquated Western and Eastern Range safety and tracking procedures and systems are at a disadvantage compared to commercially operated spaceports such as Kourou. It is in the interests of both the U.S. government and the commercial launch customer to improve range capabilities.

The recent series of U.S. launch vehicle failures has placed a question mark on the ability of the United States to capture market share from a highly reliable overseas space industry. Since 1987, U.S. civil, military, and commercial launches have totaled 226. Of those, there have been 16 failures, with 6 occurring in the past 9 months.[39] Reporting on the most recent Delta III launch failure, a May 5, 1999, Associated Press report said, "For the third time in less than a month, a botched rocket launch has left a satellite in the wrong orbit."[40] Over the first half of 1999, U.S. industry performance has not generated the confidence required to compete successfully with its international competitors.

Spacecraft

One of the largest challenges for satellite builders is partnering with government to resolve the sensitive technology transfer issue. Every satellite builder visited during this study considers this issue a major obstacle to continued global growth. The sale of satellites to foreign customers requires approval from the Departments of Commerce and State. Launch of certain satellites is restricted to U.S.-only launchers, which can increase costs and reduce competitiveness. The impact of a flawed technology transfer policy is overwhelming. In the 1970s, U.S. protectionism of the satellite industry during France's commercial communications program "Symphony" spurred the development of the Ariane series of launchers[41] and the subsequent creation of Arianespace, the nation's greatest launch service competitor 25 years later. Continuing with our outdated export laws risks a similar fate in the commercial telecommunications market.

While space offers many advantages, terrestrial systems can effectively challenge space industry markets. Fiber optic cable initiatives and new compression schemes are offering unforeseen capacities that threaten the competitiveness of broadband satellite systems.[42] Nevertheless, this market is growing fast enough that the two systems can complement each other. The space industry points to an inherent advantage over fiber systems in that satellites can reach customers directly, while fiber can only expand bandwidth between networks.[43]

Sustained production efficiency represents a further challenge, as LEO constellations, such as Iridium, ORBCOMM, and Teledesic, are fully populated. Planned obsolescence and expendable on-orbit systems can provide continuing opportunities for growth, while government laboratories, making one-of-a-kind satellites, can provide much of the R&D for sustained commercial innovation and production.

Operations

Government and private sector infrastructure costs remain high. Much of routine satellite control has been divested to commercial organizations. Further personnel reductions and outsourcing will reduce training and other costs. Small numbers of contractors will handle commercial and civil satellite operations. Although certain functions should be performed only by the DOD, government satellite operations could be outsourced or streamlined. For example, GPS control centers are now staffed mostly with enlisted personnel compared with only officers a few years ago.

The heavy reliance on commercial systems for government purposes introduces a risk in the U.S. infrastructure. Vulnerable ground station nodes have become the center of gravity of space operations, both military and commercial. This challenge requires committed government–industry cooperation to counter a growing asymmetrical information warfare threat.

Applications

Vision has lead to the burgeoning application of space products and services; however, vision alone is not going to expand the physical limits of the radio frequency (RF) spectrum. Short of a breakthrough in physics, global competition for bandwidth will challenge space services and governments alike. The International Telecommunications Union has sliced the RF spectrum into more than 450 separate bands to serve customers.[44] Frequency allocation has become a premium, global commodity. Most satellite systems strive to operate in the upper half of the RF spectrum, where more information can be transmitted per unit bandwidth. Managing the RF spectrum is a problem of significant proportions, and spectrum issues will only increase with the expected proliferation of new commercial satellite systems in the next decade.

Marketing lags have had a significant impact on potential space services, such as telecommunications, remote sensing, and navigation. Two companies involved in the creation of satellite constellations have

fallen short of their business goals through mid-1999. The Iridium network lost $500 million during the first quarter of 1999.[45] In the same quarter, ORBCOMM lost $15.9 million with its global data and messaging constellation.[46] While the long-term health of the industry is not dependent on the immediate success of two domestic firms, their recent financial performance indicates technical and marketing problems. Communications constellations are still in their infancy, awaiting market development and maturation. Consequently, launch predictions through the next decade must necessarily carry a degree of uncertainty.

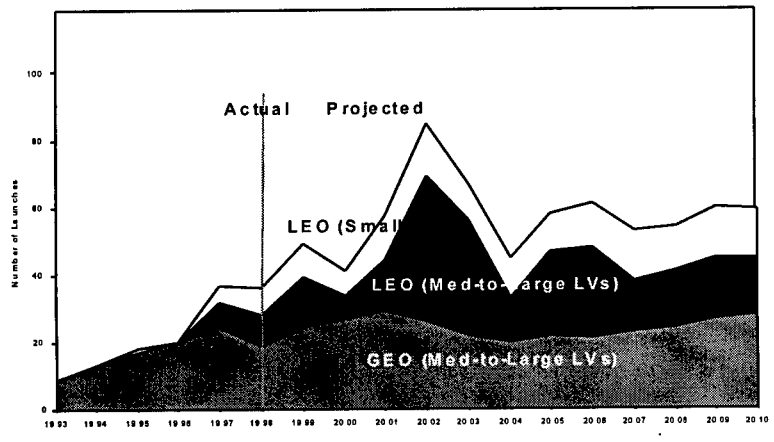
OUTLOOK

Launch

The launch sector is witnessing two interesting phenomena: the proliferation of launch companies and new infrastructure development.

The commercial space launch industry is projected to experience continued high growth through 2003, when demand for communications satellites begins to level off.[47] Nevertheless, launch requirements will continue with the need to replace LEO and GEO satellites.[48] (See Figure 2.) This demand is feeding worldwide competition in the launch industry.

Figure 2: Commercial Launch Projections[49]



Arianespace is the market leader in international commercial launch services, controlling 40 percent of the commercial launch market in 1999.[50] With the introduction of the Ariane 5 heavy-lift booster, the

Europeans have laid the framework for continued dominance in the launch segment of the space industry. The Russians have established teaming arrangements with Lockheed Martin (International Launch Services) to launch their Proton rocket and are teaming with Europe with their Soyuz rocket on the STARSEM venture.[51] Likewise, the Ukrainians are teaming with Boeing and others on the Zenit/Sea Launch enterprise in partnership with Russia and Norway. Sea Launch's first launch was successfully completed March 27, 1999. Other emerging launch providers include China with the Long March rocket, Japan with its H-2A rocket, India with its Polar Satellite Launch Vehicle,[52] and Brazil with its VLS-1 rocket.[53]

International competition is driving U.S. launch providers to develop innovative partnerships. The U.S. market is characteristic of the traditional oligopoly, with only two large corporations, Boeing and Lockheed Martin, dominating the industry. Boeing absorbed McDonnell Douglas and produces the Delta series, while Lockheed Martin produces Atlas and Athena rockets. Both are under contract with the DOD to produce versions of the EELV. This situation continues to make it difficult for small launch companies to gain significant U.S. market share, while trying to develop innovative technology to reduce costs.

The reusable launch vehicle (RLV) market is witnessing a surge of government and private investment. NASA is co-funding development of RLVs. Lockheed Martin is developing the X-33, with the first suborbital flight scheduled for July 1999.[54] The X-34 effort, led by Orbital Sciences, is also targeting a summer 1999 first flight. Several other commercial launch vehicles are being developed: Kistler Aerospace is developing a reusable K-1 rocket to carry payloads into LEO; Kelly Space & Technology is developing a manned, tow-launch vehicle called Eclipse; Pioneer Rocketplane Corporation is developing an RLV called Pathfinder; and Rotary Rocket Company is developing a reusable single-stage rocket called Roton RLV.[55] These new efforts offer possibilities for increased competition and reduced future costs.

The commercial launch sector is exploding with the growth of new spaceport facilities around the world. There are more than 30 spaceports proposed or in development[56] with 17 already in existence.[57] The principal commercial facilities are Cape Canaveral, Florida; Kourou, French Guiana; Baikonur, Kazakhstan; and Xichang, China. The most interesting development is state efforts in the United States to attract a piece of the global commercial launch business.

The DOD has been the initial up-front investor via the U.S. Air Force Dual Use Space Launch Infrastructure Grant Program, which helped finance the current crop of state spaceports. In addition to the

refurbishing of older sites in California and Florida, Alaska, New Mexico, and Virginia are entering the commercial space launch business.[58]

In 1989, the Florida State Legislature created the Spaceport Florida Authority to attract aerospace business.[59] Last year, the Authority received $5.3 million from state, federal, and private sources.[60] Spaceport Florida's biggest success so far is converting a Navy missile test site at Cape Canaveral Air Station into a commercial launch base for small rockets.[61] The Authority has invested $22 million in facilities and is looking to renovate a second launch pad to attract more business for the Athena and Taurus rockets.[62] Florida has contributed $4 million to help build a hangar for a next-generation RLV as part of an effort to fly such vehicles from the Kennedy Space Center to ensure the spaceport's future after the space shuttle fleet is retired around 2012.[63]

New Mexico may also pursue the RLV market. The state legislature is debating on whether to spend $344 million to build a spaceport by 2006, which would exclusively serve these rockets through three pads on the White Sands Missile Range.[64]

An interesting alternative is the $25 million Alaska Launch Complex on Kodiak Island.[65] Its northern location is ideal for launching small satellites into polar orbit. Advocates of the Alaskan site say that it is competitive because existing launch facilities are high on both red tape and costs. Alaska Aerospace Development Corporation feels that its pricing will be similar to Spaceport Florida's, but with the advantage of not having to schedule launches around the Air Force schedules.[66]

Virginia is entering the market with a commercial spaceport at NASA's Wallops Island facility. With $10 million in state and federal money, the center is designed to launch small to medium-sized rockets carrying payloads for NASA, universities, and cellular telephone companies into near-polar and polar orbits.[67]

In California, a consortium of aerospace companies called Spaceport Systems International is spending $100 million to build the California Spaceport, a commercial launch complex on 100 acres at Vandenberg Air Force Base.[68] Proximity to some of the world's largest satellite producers, such as Hughes and TRW, will enable customers to reduce transportation and personnel costs. In addition, the site will offer a new launch pad and a payload-processing facility originally built for the space shuttle.[69] It will accommodate small rockets, Delta launchers, and Minuteman ballistic missiles converted into space launchers.[70]

Nevada is hosting Kistler Aerospace and its reusable K-1 rocket at the Department of Energy's former nuclear weapons test site north of Las Vegas.[71] The company has plans to build a launch facility to handle

its large $100 million contract with Space Systems/Loral to launch ten communications satellites.[72] Vehicle tests are planned later this year.[73]

The result of this expansion is a glut of launch sites, geared to an uncertain LEO market. Additionally, there are numerous small launch companies based on limited capital, forming the basis for these localized facilities. This rapid growth is a response to market demand for economical customer service in the LEO niche. Questionable satellite forecasts, given Iridium's recent scalebacks[74] as an example, place these entrepreneurs in a precarious position for the next 5 years.

Spacecraft

The space commerce era is here, an era that is at the forefront of U.S. technological and economic innovation. The next 10 years will see the launch of more than 1,700 satellites worldwide with commercial satellites contributing more than 70 percent of the total.[75] Motorola alone plans 500 satellite launches in that period.[76] The telecommunications industry is expected to grow to $2 trillion by 2010.[77] The growing commercial market for communications satellite services is driving demand for affordable launch services. Over the past 5 years, more than $20 billion has been invested in the space industry, and it is estimated that an additional $55 to $75 billion will be invested in the next 5 years.[78]

Space-based telecommunications are projected to grow exponentially. Despite the slow start of Iridium and ORBCOMM, the continued crowding of the usable LEO space with constellations such as Teledesic and Skybridge will likely continue. Projected dates of operation have already been pushed back 18 months by Teledesic.[79] Overall, the advantages to Internet in the sky may generate the financing needed, but at a high cost. Financial institutions estimate the proposed investments to develop broadband systems could exceed $50 billion dollars through 2005.[80] By 2010, broadband satellites could serve 16 million customers globally, generating $77 billion in annual revenues.[81]

This giant potential market with the high cost of space access may force mergers in broadband telecommunications services. Already, Motorola merged its planned Celestri constellation with the Teledesic constellation, providing an impressive array of partners, such as Motorola, Boeing, Craig McCaw, and Bill Gates.[82] In 1997, more than a dozen organizations petitioned for international frequencies in the Ka and V bands so as not to be locked out of future frequency needs.[83] Among the dozens of planned systems, two to four proposals may

actually launch, with mergers and joint ventures reducing risks and financial exposure.[84]

Operations

According to an AFSPC report, Eastern Range safety and instrumentation obsolescence is draining national resources.[85] A plan to modernize the range for $1.2 billion over 6 years, or about $200 million per year, has been extended, with completion now set for 2007.[86] This would include GPS upgrades to instrumentation. While range upgrades must occur if the U.S. industry is to remain competitive in the world market, tight budget priorities have delayed any implementation. The Western Range at Vandenberg has a similar, bleak outlook.

Applications

Space is expanding beyond telecommunications and into high-resolution satellite imagery, precise positioning, navigation and timing using GPS, and geographical and geological information products. The commercial remote-sensing satellite market is projected to reach $1 billion by 2000, and the provision of GPS goods and services has become an industry in itself with projected revenues of $8 billion in 2000 and $16 billion in 2003.[87] These applications link the developed and developing worlds as transportation and communications become transnational. Just as telecommunications, broadcasting, and imaging are remaking themselves into space industries, traditional industries will transition into space industries, such as package delivery, public travel and tourism, manufacturing and processing, mineral exploration and mining, and power generation.[88] One could conceive of the development of yet unimagined industries, just as the Internet and broadband telecommunications were not envisioned at the beginning of this decade.

GOVERNMENT GOALS AND ROLE

The U.S. government must take an active role in creating a climate that fosters government–commerce partnerships, both domestically and internationally. Specific government actions can start with reforming the approach to technology transfer. Export laws that favor allied and especially trans-Atlantic business environment start with the Congress and the Department of Commerce. In addition, U.S. ground infrastructure for space should be commercialized to the extent that it fosters U.S. leadership in launch capability. Government should partner

fully with industry in launch development, encouraging the lead role that the commercial sector has earned. Finally, the United States should foster global standards in telecommunications, navigation, and remote sensing to enhance commerce on a worldwide scale.

Launch

The government can foster U.S. launch capability by improving both the investment climate for launch vehicles and the U.S. ground infrastructure. Significant government investment in R&D is needed to reduce the technical risk of new launch technologies. Under the President's policy, NASA and the Departments of Defense and Commerce are working in partnership with industry to create new technologies and systems that will develop the next generation of space transportation systems. Government must work with industry to create a climate that encourages private sector investment in new space transportation systems. Loan guarantees, advanced purchase agreements, cooperative R&D agreements, and tax incentives should be explored.

Finally, the government should improve the overall investment climate for launch services through policy stability, regulatory streamlining, predictable certification, and appropriate indemnification. For example, the Department of Commerce has already been engaged in a number of specific efforts aimed at improving the competitiveness of the commercial space transportation industry, including industry–government round tables; collection, analysis, and dissemination of statistical information about the commercial space market; coordination on space transportation policies; discussion with state and local officials involved in spaceports and space transportation issues; and a coordinated outreach effort by the Office of Air and Space Commercialization.

A greater government–industry team concept is recommended. It is time to competitively source space launch operations. Industry will be able to relieve the pressure on the U.S. military infrastructure and allow the DOD to spend resources within its core competencies. In an AFSPC report, Lieutenant General (ret) Richard C. Henry said, "Ranges exist to support a dangerous test environment where performance is measured, but space launch is no longer a test mission. We ought to have a long-term objective to divorce space launch from the ranges."[89]

The greatest growth in space continues to be commercially based, and by 2010, military launches will account for only 6 percent of the total.[90] A transition to contractor launch operations for both military and civilian launches lends itself to a spaceport concept where operations are handled much like those in a professional airport authority. As space

launch moves from a singular "event" into the realm of routine operations, military presence during launch and on the ranges should transition to a regulatory organization, much like the Federal Aviation Administration (FAA). As the nation moves away from derivative ballistic missiles and toward new commercial launch services, concepts, and vehicles, military oversight of a majority of the U.S. domestic launch infrastructure is becoming obsolete.

A new way of thinking along business lines makes this transition to commercial leadership easier. The EELV demonstrates a successful military–industrial partnership. With a $1 billion investment each by Boeing, Lockheed Martin, and the Air Force, the nation should have two new-generation commercial launchers, meeting both commercial and military needs in just 4 years.[91] This investment will reduce the DOD's launch costs by $6 billion for planned launches between 2002 and 2020.[92] Industry has stepped up to the plate with its investment. In turn, government should continue to broaden its business approach, outsourcing launch operations. The government thus becomes a customer procuring commercial launch services, not launch vehicles.

This partnership will require a two-step process. First, the ranges need infrastructure improvements. The U.S. government should bear these costs as an investment in the nation's space infrastructure, placing it on an equal footing with modern competitive ports, such as Kourou. The government must accept this transition cost as contractors take over the launch business, but the long-term benefits of commercial launch services to U.S. competitiveness outweigh the short-term expenditures.

Second, the facilities at Cape Canaveral should be leased long-term as planned to EELV contractors Boeing and Lockheed Martin. Recovery of range upgrade costs should be amortized over a very long period with very modest leasing fees. Contractors pay about $75 million per year for use of government facilities for commercial launches. Once expired, these leases would be open for competition.

Charging user fees as part of a U.S. government–controlled launch operation could drive up launch costs relative to those of overseas competitors. Kourou's operational costs are roughly the same as those at the Cape, about FF1.5 billion ($250 million) per year with 950 government and 250 contractor employees.[93] While trying to capture market share, increasing launch costs are mutually exclusive paths. If the national space strategy hinges on U.S. competitiveness through partnership, government must become an equal partner with the space industry. It starts with launch.

Space launch that the military purchases as a commercial service may be just the beginning of other commercially available space

alternatives. In the future, the military may purchase more and more communications, remote sensing, surveillance, meteorology, and navigation services from a commercial provider rather than purchasing and operating its own satellites.

Spacecraft

According to the U.S. Air Force Scientific Advisory Board (SAB), commercial space services "will have an aggregate capacity early in the next century that is about 1,000 times that of even the most ambitious military satellite communications structure."[94] Military communications must continue to migrate to the commercial sector except for unique capabilities, such as nuclear command and control. All other communications requirements provide large potential market niches for communications constellation providers. In exchange for government investment in the development and deployment of advanced civil communications constellations, industry provides a Civil Reserve Air Fleet–like capability to augment U.S. government command and control capabilities in an emergency situation.

In addition, imaging can be outsourced for all but the highest resolutions inherent in national assets. Expending resources for commercially available government imagery wastes precious funding that could be allocated to higher priority operations. Congress supports this migration to commercial sources. In 1998, Congress passed the Commercial Space Act of 1998,[95] which among other things called for improved licensing regulations for remote-sensing satellites.

Operations

In a manner similar to launch operations, routine satellite command and control must be competitively sourced. The GPS constellation, with its myriad civil and commercial applications, provides a superb opportunity to test this service concept. The Air Force satellite control network is already contractor-operated, and it seems prudent to take the next logical step and competitively source GPS command and control. The commercial space industry becomes stronger, more diverse without non-essential government control.

Applications

A broader partnership of commercial and civil functions within the military sector is proposed. The convergence of military, commercial,

and civil space sectors offers national security synergies. With the United States setting standards for space products and services, first-mover innovation can create global partnerships with the United States as the senior partner. This can imply even passive global security capabilities. For example, denying access to global standard systems, such as GPS, would be devastating to potential adversaries. Given the cost of deploying a GPS constellation and the fact that usage is free, the global standard so far has been accepted. Civil oversight of the GPS constellation might ease fears of a global navigation standard totally run by the U.S. military.

The United States should support selective sharing of the limited RF spectrum. Exclusionary trade practices spurred Ariane development. The United States must compete by openness and technological superiority, not protectionism. Worldwide acceptance of the GPS provides a prime example of successful competition through technological achievement. Sharing of the RF spectrum is no exception; it is a scarce global commodity to share wisely.

Perhaps even more innovative than the technology itself is the effort to create interdependence through foreign investment. Several countries have invested in Iridium, and negotiation of access licenses throughout the world by both Iridium and Teledesic shows global commitment. By giving everyone a stake in the global economy, U.S. industrial pioneers have given everyone a stake in peaceful access to space.

CONCLUSION

The study of the space industry reveals several trends. First, U.S. launch infrastructure and vehicles remain a problem. Infrastructure costs are high in the United States, compared to those of international competitors. The U.S. space industry is still locked into government launch facilities and burdened by antiquated range capabilities. This has limited the ability of the U.S. commercial industry to compete with international launch providers. Given initial government investment in this strategic industry, outsourcing space launch and on-orbit operations to the commercial sector provide market stimuli to develop cost-conscious, globally competitive operations. Additionally, the mediocre success of U.S. launch vehicles over the first half of 1999 does not stimulate foreign or domestic investment in the U.S. industry. Reliability can move the U.S. industry toward capturing a majority of the launch market in the future. The EELV program provides a key ingredient to this future strategy. Indeed, the move away from launch vehicle sales toward launch services provider is pivotal.

Second, there is a potential glut of launch vehicles in the next decade. Short-term uncertainty in LEO satellite requirements due to financial and market issues can only worsen the predictions. Only reliable, well-positioned launch providers will succeed in such a flooded market.

Third, it is the role of government to ensure that the U.S. market is in position to compete on the international stage against strong, reliable international competition. This competition need not be adversarial, but should be coupled with partnerships in satellite systems. The United States needs to amend its export law to acknowledge a global market with global partners.

Fourth, as commercial and military activities have migrated to space, their operations have often become routine. As the commercial sector has gained core competencies in space, the migration of operations to this sector should continue with diminishing government roles.

Finally, the commercial potential of space has led to the expansion and creation of whole new markets. As the potential of space makes commerce truly global, growth will continue. Direct-to-consumer applications, such as mobile communications, television, precision farming, expanded bandwidth for data and Internet services, and precision navigation, add to the growing potential of space commerce. Space applications furnish the ideas that push the evolution of launch, satellites, and operations.

While the state of the international space industry is strong, the nation's short-term domestic outlook is uncertain. However, U.S. innovation and financial strength can easily balance this short-term uncertainty in the industry with incredible long-term opportunities for market growth.

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STRATEGIC MATERIALS

ABSTRACT

This is a comparative study of national strategic materials policy from the perspective of U.S. national security and, therefore, contains a certain bias. The Committee concentrated on the traditional material of steel and aluminum and on the advanced materials of ceramics, polymers, composites, and the "smarts." The findings fall into three broad categories. First, The United States, Canada, and the European Union still have the remnants of the Cold War's (1945–1989) strategic materials policy.[1] Second, Belgium, Poland, and Spain are conscious of the strategic nature of selected materials, but appear unsure as to "who" in their country or region can be the most reliable provider of strategic material products. Third, there is a general recognition that the return of the "global commons;" the occasional natural disasters; the apparent world climate changes; the pollution of the habitat; and the growth, urbanization, and migration of the world's population directly affect all aspects of the entire life cycle of minerals, metals and materials, both traditional and advanced.

CAPT Tom Barns, USN
Dr. Rudi Boone, Dept. of State
LTC Steve Brooks, USA
Mr. John Bukoski, National Imagery and Mapping Agency
Ms. Mary Carlisle, Defense Information Support Agency
LTC Walt Davis, USA
Mr. Hilliard Haynes, Dept. of the Army
Mr. Rob Innocenti, Dept. of the Navy
Lt Col Janice Kinard, USAF
Ms. Bonnie Phelps, Defense Intelligence Agency
Mr. Thom Revay, Dept. of the Army
Mr. Jeff Roberson, Dept. of Energy
Mr. Al Starnes, Dept. of the Air Force
Col Tom Travis, USAF
CDR Zdenka Willis, USN

COL Dave King, Canadian Armed Forces, faculty
Mr. Rich Shivar, faculty
Dr. John Starron, faculty

PLACES VISITED

Domestic

Aluminerie de Becancour, Inc. (ABI), Becancour, Quebec, Canada
Army Research Laboratory, Aberdeen, MD
Bombardier, Inc., Mirabel, Quebec, Canada
Canadian Institute of Mining and Metallurgy, Ottawa, Ontario, Canada
Canadian Space Agency, Saint-Hubert, Quebec, Canada
Defense Industrial Supply Center, Philadelphia, PA
Embassy of the Republic of Poland, Washington, DC
Goddard Space Flight Center, Greenbelt, MD
ISPAT SIDBEC, INC., Contrecoeur, Quebec, Canada
National Research Council Industrial Materials Institute, Ottawa, Ontario, Canada
U.S. Consulate, Montreal, Quebec, Canada
U.S. Embassy, Ottawa, Ontario, Canada

International

Aceralia Planos, S.A., Spain
Asociacion Tecnica Espanola de Fundicion (ATEP), Spain
Asturiana del Zinc, Spain
Atlantic Copper, S.A., Spain
European Commission, Brussels, Belgium
Huta Katowice, S.A., Katowice, Poland
Ministry of Agriculture, Madrid, Spain
Ministry of Economy, Warsaw, Poland
Ministry of Environment and Resources, Poland
Ministry of Industry, Madrid, Spain
Ministry of Labor, Poland
North Atlantic Treaty Organization HQ, Brussels, Belgium
Polish Aviation Institute, Poland
SIDMAR NV, Ghent, Belgium
Spanish Association of Standardization and Certification (AENOR), Spain
Union Espanola de Explosivos, SA (UEE), Spain
VIZ, S.A. , Poland

INTRODUCTION

In its comparative study of strategic materials, the Committee took the national policy approach. National policy is composed of five interrelated components: (1) a statement of national goals and objectives; (2) a strategy or means for achieving the goals; (3) a set of national priorities to guide the allocation of financial and personnel resources; (4) a set of criteria by which to assess the progress toward goal achievement; and (5) the designation of the individual or agency fully responsible for the success of the policy and its supporting programs and projects.[2]

Associated with the domain of strategic materials, both tradition and advanced, are 13 major policy issues:

1. Funding basic research in the material sciences and technologies.
2. Educating material scientists and engineers.
3. Developing design standards and product reliability criteria.
4. Protecting intellectual property rights and trade marks.
5. Maintaining worker health and safety standards in mining, metal processing, manufacturing, and disposal.
6. Collecting essential data and information on mining and material industries, such as iron ore and bauxite, steel and aluminum.[3]
7. Transferring defense material sciences and technologies to the civil sectors.
8. Depending on offshore sources for strategic materials and associated technologies, trading blocs included.
9. Accessing seabed material and energy resources.
10. Recovering, reclaiming, and recycling used metals and materials.
11. Stockpiling selected strategic materials and precursors.[4]
12. Controlling the export of selected strategic materials and associated technologies.
13. Substituting advanced materials for traditional materials in high performance systems.

Accomplishments in most of these material policy issues involve the United States and other countries in a host of arrangements and regulatory program at the federal government level with such multistate agencies as the Food and Agriculture Organization (1945; Rome), the International Labor Organization (1946: Geneva), the International

Organization for Standardization (1947: Geneva), and the International Bank for Reconstruction and Development (1947: Washington).

The national policy perspective, the attending material policy issues, and the requirement to participate in and comply with a host of regional and world regulatory regimes demonstrates the need for a national materials policy based on the security interests of the United States and its Allies.[5]

DEFINITION OF THE STRATEGIC MATERIALS INDUSTRY

Over the years, during national emergencies, wartime, or economic depressions various materials have become "strategic." The strategicness of a material is in part a function of it essentially and its availability. As an example, as of 30 September 1997, the National Defense Stockpile was composed of 88 materials in five material types valued at $5.4 billion. Of the five material types 22 percent were minerals, 8 percent were agriculture products, 20 percent were ores, 36 percent were metals, and 14 percent were classed as "other." Among the metals were aluminum, cobalt, nickel, silver, tin, and zinc. Included with the agricultural products were natural rubber and tannin extract. Each of these 88 materials constitutes the raw material for or a product of an "industry."[6]

In 1995, the Office of Science and Technology produced a list of "national critical technologies." This list includes 11 subareas of materials characterized functionally: (1) alloys, (2) ceramics materials, (3) composites, (4) electronic materials, (5) photonic materials, (6) high energy-density materials, (7) highway/infrastructure materials, (8) biocompatible materials, (9) stealth materials, (10) superconductors, and (11) aircraft structures.

CURRENT CONDITION

This section will be a sketch of the broad features and factors related to the steel industry and to the advanced materials industries.

The Steel Industry

A contemporary description and the current data and information are available from the American Iron and Steel Association (Washington) and from the International Iron and Steel Association (Brussels).[7]

The U.S. steel industry has been and continues to be a solid pillar in the foundations for U.S. commercial prosperity and national power. The

apparent national requirements for steel and steel products in order to update, repair, and modernize the U.S. transportation, energy, communications, housing, and appliance industries are substantial, and the requirements exceed domestic capacity. The U.S. steel industry should be given recognition for its successful efforts to modernize its mills, comply with environmental standards, reduce worker safety and health risks, and meet the needs for high-quality steel at reasonable costs.

During the course of the Committee's study, foreign producers (located in Brazil, Japan, China, and Russia) managed to dump steel and steel products into the U.S. market. According to U.S. law and international trade agreements, dumpling is illegal. The American Iron and Steel Institute, the Congressional Steel Caucus (both House and Senate), the United Steel Workers of America, and others "alerted" the Administration. Members of the 106th Congress introduced legislation, such as the proposed Fair Steel Trade Act and held committee hearings before the "problem" was resolved through public exposure and diplomatic exchanges.

With the creation of the North American Free Trade Agreement, a trade bloc including Mexico, Canada, and the United States, Canadian-made and U.S.–made steel and steel products continue to move across the common border via ship, barge, truck, and train, but on a much larger scale. For the most part, this movement is based on cost, quality, and schedule requirements.

The classical vertical integration model of the steel industry has gone through a dismemberment process in part. Public incorporation, private ownership, proprietary processes, financial accountability, pollution standards, labor compensation, and investment returns are some of the factors contributing to the restructuring of individual transnational corporations. However, even today, each transnational corporation seeks to have ownership of or direct control over the following resources, agencies, and capabilities:

- The land and mines, which produce the iron ore, limestone, coal, and special alloys, used to make steel.
- The transportation systems (ports and ships, barges, trucks, and trains) to move the raw materials from the mines or storage to the steel mills and then the finished steel and related products onto the manufacturing sites.
- The sources of electrical and other energy types to operate mills and to make steel.
- The factories to role, shape, bend, and weld to make steel products, such as plate, beams, and rails.

- The centers to collect and process primary and secondary steel scrape.
- The research and engineering capabilities to maintain currency with the latest mining, metallurgical, manufacturing, and recycling processes.
- The financial institutions to acquire funding and investments for plant modernization, new technologies, and raw materials.
- The executive, administrative and scientific cadres who "know steel" and who can work with all the stakeholders in the "common interest."

Advanced Materials

A number of Washington-based associations, such as the Suppliers of Advanced Composite Materials Association, plus the National Institute of Standards and Technology (Gaithersburg), the Defense Advanced Research Projects Agency, and the Congress' former Office of Technology Assessment, are excellent sources of data and information, domestic and foreign, on the state and development of the advanced materials industries.[8]

This category includes thousands of ceramics, polymers, and composites that are created and designed to meet unusual performance requirements (e.g., speed and endurance, fatigue and radiation, stealth and weight) for manned or unmanned, civil or military, operational systems in the lithosphere, hydrosphere, atmosphere, biosphere, or space. Most of the basic ingredients and material precursors for advanced materials are readily available. However, the science and technology with the associated creativity, invention, innovation, and transfer processes, the individuals and scientific teams, are critical in order to obtain the desired "fix, form, and function." Much proprietary work is associated with advanced materials development and usage.

While each advanced material has peculiar research and development protocols and arrangements, there is a general scheme for advanced materials development. Eight broad, interrelated stages have been identified:

1. An expression of the desired performance requirement stated often as a hypothesis or as an actual need.
2. The "organization" of a team of those scientists and engineers who are interested in the "problem."
3. A systematic search of the scientific and technical literature to identify similar or like problems and their apparent "material"

solutions. (Note: Advanced material conferences and workshops are important.)

4. Use of a laboratory to fix, form, and function potential advanced material candidates and for extensive testing and evaluation.
5. The testing of the "solutions" in the operational environment (such as the hydrosphere) to ascertain the actual performance of each candidate material. Select the "solution."
6. Design a prototype factory for either the batch production process or the continuous production process of the selected advanced material. Conduct an operation test of the factory with attention to worker health and safety, pollution of the environment, and consistency of product quality.
7. Obtain the necessary patent rights, trademarks, and technical agreements.
8. Build a factory, purchase and store precursors, hire and train a workforce, and go into production.

Much of the basic research and development work outlined in the preceding is done in governmental, academic, and small commercial laboratories because of the length of time normally to go from the "problem" to the patents. The European Union appears to have taken a more consistent and comprehensive approach to organizing and supporting the "seeds" for future advanced material industries. The leadership of the European Union is conscious of the continent's dependence on offshore sources (especially from Africa and South America) for more traditional materials, and therefore it seeks to have alternatives (synthetics and substitutes) on line or in hand.

The three major policy issues that deal with advanced materials are:

1. The most effective legal means to protect intellectual property, such as the use of patents, trademarks, and proprietary agreements.
2. The large investment and extended time period needed to do the research, development, testing, evaluating, and manufacturing of new advanced materials.
3. The importance of a yeasty and viable home-based research capability in the broad material sciences arena, not only to foresee and handle the "problems," but also to conceptualize the proved "solutions:" the fixes, the forms, and the functions.

CHALLENGES

There are numerous security and commercial challenges confronting the United States and its Allies. The Committee was in Europe while there were undeclared wars under way in the former Yugoslavia. Also, during its study, both India and Pakistan exchanged nuclear "bomb" detonations in South Asia. Generally, all the challenges can be summarized under three broad sets.

One set of challenges deals with access to materials. This includes such major issues as the many conflicting territorial claims in the South China Sea, the unresolved issue as to who now owns the mineral sources of the Republic of South Africa, the safe storage and sure accounting of spent nuclear fuels, the future implications for the many regional trade blocs, and the developing shortages of potable drinking water. Imagine the problems, prospects, and challenges when fresh drinking water becomes a strategic material.

Another set of challenges deals with the acts of Nature, such as regional droughts, hurricanes and typhoons, volcanic eruptions, earthquakes, and regional floods.

A third set of challenges involves human problems. Throughout the world there are terrorist organizations, ethnic conflicts, criminal corporations, extensive poverty, and something called "kleptonomics."

GOVERNMENT GOALS AND ROLE

Over 200 years ago, the federal government got the tasks to "provide for the common defense and insure the general welfare." The federal government has had and will continue to have a vital role to play in the traditional materials as well as the advanced materials areas. The lessons of the Great Depression (1929–1939), the Second World War (1939–1945), and the Cold War Period (1945–1989), including the Berlin Airlift, the Korean Conflict, and the Vietnamese War have not been forgotten. "Preparedness" is the watchword. In this day and age, preparedness means to build "national power." Clearly, common material resources (e.g., wheat, soybeans, tar sands, water) in general and strategic materials (e.g., steel, aluminum. cobalt, titanium, and guayule rubber of Aztec origin) in particular are vital factors and components in both the foundations and then instruments of national power.

As well known, the components of national power include (a) extensive territory, (b) natural resources, (c) large population, (d) advanced technology, (e) social cohesion, (f) national will, (g) sufficient

provisioning, and (h) effective government. In turn, the natural resource component consists of (a) typography, (b) hydrography, (c) climate, (d) minerals, (e) flora, (f) fauna, and (g) soils. From the most simple tasks of issuing patents and trade marks, upholding standards of weights and measures, enforcing the mining laws, regulating the polluters, and ensuring labor safety standards to the far more complex activities of funding material research programs and promoting material advancements in construction, transportation, communications, and health care, the federal government will continue its role in the promotion, development, and application of strategic and advanced material resources in the national interest.

Perhaps the thrice themes of "awareness," "preparedness," and "responsibility," for the United States are captured and demonstrated by the many acts passed by the Congress, signed by the President, and implemented by a federal agency. Some examples of these acts in chronological order include the Mineral Lands Leasing Act of 1920, the Reconstruction Finance Corporation Act of 1932, the Strategic Materials Act of 1939, the Defense Production Act of 1950, the Mining and Minerals Policy Act of 1970, the Strategic and Critical Materials Stockpiling Act of 1979, and the Critical Materials Act of 1981. On June 6, 1994, the Administration issued Executive Order 12919, "National Defense Industrial Resources Preparedness," which continues this thrice thematic approach.

RECOMMENDATIONS

Recommendation One. Within the United States alone, there are many stakeholders in the materials arena writ large: individual inventors, colleges and universities, local and state governments, labor and professional associations, and commercial companies, as well as Congressional committees and federal departments and agencies. Given the ongoing global political conditions and regional commercial disruptions, the time has come again for all the stakeholders (read: representatives of the citizens) to gather in a series of annual conferences to reformulate a national materials policy to serve the national interest. The five components of national policy and the 13 material policy issues, as outlined, could well serve as an agenda. This will not be an easy task, but it is an essential task.

Recommendation Two. There is a "politics of global resources." The center stage is the United Nations, which has some 185 members. The main thrust of most of these members is to restore the "global commons." Through a series of international and regional arrangements

and conventions, there is the effort to "manage" global resources in the interest of humankind as a whole. The time has come again for the United States to take the lead to attempt to formulate a global materials policy in the interest of humankind, now and in the future. The Antarctic Treaty (1961) and the United Nations Convention on the Law of the Sea (1994) are a start, but more needs to be done on the mining, metals, and materials resources areas.

CONCLUSION

The world is and will continue to be a hostile environment for the United States and its Allies. The primary task is to think and reason strategically, meaning the survival of the United States and security of its citizenry. The only practical approach to achieve this political condition is to build national power whose instruments will guide the regional and global forces of change toward a more peaceful and sufficient sustainable development process. One of the key foundations of national power is material resources. Minerals are where you find them. Minerals are nonrenewable resources. Everything is made of something. Organizing and managing the foundations of national power (as listed earlier) and in turn forging and employing the instruments of national power (diplomatic, technological, military, and commercial) do not happen by chance. There is now and will continue to be an essential role for the federal government in the materials arena, as well as in the other foundations of national power.

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[5] A good benchmark study which is permeated with material policy issues and the role of participating agencies, at home and abroad, is Office of Science and Technology, *1995 Federal Research and Development Program in Materials Science and Technology* (Washington, DC: The White House, December 1995).

[6] The data are from U.S. Department of Defense, *Strategic and Critical Materials Report to the Congress, Fiscal Year 1997* (Washington, DC: USDOD, 1998).

[7] Two recent studies of the American steel industry are U.S. Department of Energy, *Energy and Environmental Profile of the U. S. Iron and Steel Industry* (Columbia, MD: ENERGETICS, Inc., July 1996); and U.S. Department of Energy, *Steel Industry Technology Roadmap* (Washington, DC: USDOE, August 1997).

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TRANSPORTATION

ABSTRACT

The transportation industry serves to mobilize the U.S. economy and provides critical links to the rest of the world. Transportation has undergone a major transformation, with speed, in-transit visibility, and value-added logistics highlighted as the hallmarks of the revolution. Air carriers have globalized through code sharing, and container shippers have responded by creating their own alliances. The increasingly international nature of the industry has created challenges for the U.S. government, which relies on contractual links to the transportation industry for surge sea and airlift capacity. Transportation is a thriving sector, one in which the United States faces world-class competition. The United States has an edge in many areas, but chronic underfunding in surface infrastructure has dulled the advantage.

CDR Andrew C. Boening, USNR
LTC Larry S. Bolton, USA
CDR Gregory S. Cruze, USN
Mr. Srecko Domljanovic, Croatian Defense Ministry
Ms. Jennifer I. Greene, Dept. of the Army
Lt Col Michael R. Helms, USAF
Mr. Gregory P. Kuechler, Dept. of the Air Force
Lt Col Samuel Lofton, III, USAF
Mr. Gerald J. Loftus, Dept. of State
CDR Patrick W. Menah, USN
Mr. James P. Papageorge, Dept. of the Navy
LTC Steven R. Perry, USA
Lt Col Janice M. Stritzinger, ANG
COL Constantine S. Vakas, USA
Ms. Belinda C. Ward, Dept. of Agriculture
CDR Robert D. Wilson, USN

CAPT Mark M. Benson, USN, faculty
Mr. James Tarrant, faculty
COL Jonathan White, USA, faculty

PLACES VISITED

Domestic

Alameda Corridor Transportation Authority, Long Beach, CA
American Airlines, Fort Worth, TX
American Presidents Line, Port of Los Angeles, CA
AMTRAK, Washington, DC
Burlington Northern Santa Fe Railway, Fort Worth, TX
Burlington Northern Santa Fe Railyard, Alliance, TX
Defense Distribution Center, Chambersburg, PA
Long Beach Port Authority, Long Beach, CA
Maryland Port Authority, Baltimore, MD
Union Pacific Railroad, Long Beach, CA
United Parcel Service, Louisville, KY
U.S. Naval Ship *Antares*, Baltimore, MD
U.S. Naval Ship *Comfort*, Baltimore, MD
USTRANSCOM, Scott Air Force Base, IL

International

Baltic Exchange, London, England
British Airport Authority, Heathrow Airport, England
British Airways, London, England
Caterpillar Logistics Services, Brussels, Belgium
DHL Global Opns & Hub, Brussels, Belgium
European Transport Systems, Moerdijk, The Netherlands
EURO-Tunnel, Folkestone, England/Calais, France
GE/SEACo, London, England
Maersk Lines, London, England
Military Traffic Management Command (USA/MTMC), Rotterdam, The Netherlands
Ministry of Transportation & Public Works, Barendrecht, The Netherlands
Rotterdam Port Authority, Rotterdam, The Netherlands
Royal Nedlloyd N.V., Rotterdam, The Netherlands
Sea-Land Delta Terminal, Rotterdam, The Netherlands
U.S. Embassy, London, England
Van der Vlist Special Transportation, Moerdijk, The Netherlands

INTRODUCTION

The transportation industry touches virtually every aspect of daily life. Its tools—jet airplanes, high-speed trains, container ships, buses, and trucks—transit the globe to facilitate the commerce underpinning the U.S. economy. As an integral part of the U.S. economy in its own right, the transportation industry accounts for more than 15 percent of the gross domestic product (GDP). Government recognition of transportation's centrality has been the impetus to regulatory reforms leading to industry consolidation and revitalization. Transportation is central to the economy and to national security.

National security relies on transportation assets. The U.S. military owns an impressive array of air and sealift equipment, including such world-class transportation assets as the C-17 Globemaster aircraft and the purpose-built Large Medium Speed Roll on/Roll off (LMSR) ships. Crucial to U.S. mobility in the event of war is a set of voluntary partnerships with private industry. Civilian air and sea assets are ready for call-up in the event of an emergency through the Civil Reserve Air Fleet (CRAF) program, the Voluntary Intermodal Sealift Agreement (VISA), and the Maritime Security Program (MSP). Though firm commitment to strategic airlift is vital, these agreements with private industry give the United States a unique surge capacity to handle the transportation requirements associated with a major regional conflict.

Beyond moving people and things from point to point, there is the growing field of value-added logistics or supply chain management—that is, moving material from the point of production to the customer. Increasingly, companies are focusing on core competencies and are divesting themselves of support activities, such as transportation, order processing, inventory control, and customer service. The goal is to be more efficient in serving the customer. The Department of Defense (DOD) has also started to re-engineer logistics management—replicating the business world, where immediate service and pinpoint accuracy are routine. This philosophy has far-reaching implications for military logisticians and requires mastery of the best civilian practices.

The transportation industry and the infrastructure supporting it are critical to the continued economic growth and to the mobility that those in the United States have come to expect. The transportation industry, perhaps more than any other, is essential to the U.S. ability to project military power around the world in order to protect and defend U.S. national interests. It is the transportation system—the ability to move things and people—that truly brings together all of the elements of U.S. national power.

THE TRANSPORTATION INDUSTRY DEFINED

Transportation is a system. It deals with moving people and goods from a point of origin to a point of destination. The medium in which transportation takes place influences the type of vehicles to be used. The vehicle, along with its means of locomotion, is the mode. Although vehicles (e.g., trains, ships, planes) are its most visible aspect, thinking of transportation as simply an aggregation of vehicle movements would be to underestimate the complexity of the industry.

The information revolution has transformed the transportation industry and has made possible the growth of just-in-time delivery systems, which are fast becoming the state of the art for U.S. industry. Indeed, the case can be made for redefining the industry, moving away from categorization by vehicle and stressing the intermodal nature of transportation. Intermodalism derives from containerization, whereby standardized steel boxes flow through the system in a seamless circuit. Containers are filled at a factory loading dock, trucked to a railhead, put on a transcontinental freight train, off-loaded at a purpose-built container port, shipped across an ocean . . . and the process continues. All the while, the container is tracked via the latest satellite positioning technology or radio frequency tags.

As the lifeline of U.S. commerce, the transportation system boasts 4 million miles of highways and roads; more than 250,000 miles of rail and rapid transit lines; 190,000 miles of petroleum pipelines; 26,000 miles of navigable waterways; and more than 2,000 commercial airports, seaports, and intermodal terminals. This enormous and diversified transportation system serves 260 million people, 6 million business establishments, and 87,000 governmental units scattered over the 3.7 million square miles of the United States. In 1994, the system carried more than 4.2 trillion passenger-miles of travel and 3.7 trillion ton-miles of freight.[1]

Until recently, all ships of a nation, whether for war or for commerce, were considered part of the nation's navy. Because the U.S. commercial fleet is much smaller and much of the U.S.-owned fleet uses foreign registry and crews, the United States now separates the two. The nation continues to rely on transportation by sea for the bulk of its commerce (fully 98 percent of world trade is by sea.) and to rely on its mastery of the sea to protect that commerce. Despite the formal separation between the U.S. Navy and the U.S-flagged merchant fleet, it is only a partnership between the two that ensures the country's ability to meet the requirements of a national emergency.

Just as public–private cooperation is vital to sealift, so too are partnerships across all modes of transportation. The advent of just-in-time manufacturing has given rise to (and has in turn been facilitated by) the growth of cargo integrators (e.g., FedEx, UPS, DHL). These integrators not only use their own fleets of air cargo planes, but also use other modes (recently Amtrak has turned its scheduled passenger train service to advantage by contracting to carry integrator parcels).

The cargo integrators and a bevy of other firms have gone beyond mere transport service, moving parcels from point to point. Under a system called "value-added logistics," transportation firms will provide customers with a smorgasbord of services to enhance products. Hence, a computer manufacturer may produce components in several countries and award assembly and customer delivery contracts to a cargo integrator. An Asian construction equipment firm may ship sections of massive dump trucks to Rotterdam, where a logistics firm will weld the pieces together and transport the vehicle (by rail, truck, or canal barge) to the customer. Value-added logistics has tended to blur the lines between transportation and the services formerly performed by manufacturers or their agents. Indeed, carried too far, it can mean a company might take on more than it can handle by trying to be all things to all customers.

Pipelines accomplish what transportation is supposed to do—get the goods to the customer. They could be a metaphor for the goal of all transportation modes: fast, efficient, continuous, automated movement of product. The "pipeline" employed by air cargo integrators is nothing other than an attempt to make the delivery process a seamless "flow." Where pipelines do not exist, transportation companies try to mimic the concept. Wherever bulk cargo is involved, be it rail or sea (75 percent of all ocean cargo is of the bulk/tanker variety), the pipeline concept of large volume flow is applicable.

CURRENT CONDITION

The booming U.S. economy has had its effect in the transportation industry. Because transportation is not a purely domestic industry, however, the state of the world economy affects the transportation sector more quickly than it affects other sectors. Phrases such as "before the Asian downturn" permeate briefings by port officials, who see the immediate effects on traffic from fluctuations in imports and exports.

Air Industry

The airline industry is basically a service industry. With its extensive fleets of airplanes, support equipment, and related infrastructure, it is highly capital-intensive. Aviation is a high cash flow industry. Its inherently physical nature makes it labor-intensive as well, with a highly trained (and unionized) workforce. Outside factors (e.g., economic downturns, oil prices, weather) mean operating on thin profit margins.

Airlines in the United States have made progress in restructuring their balance sheets after suffering enormous losses in the early 1990s. The profits of the past 3 years have been applied to reducing capital debt. As a result, total long-term debt decreased from $17.6 billion in 1994 to $15.5 billion in 1997. Retained earnings increased from $2.2 billion to $12.8 billion, and stockholder equity more than doubled from $13.2 billion to $27.8 billion. The airlines have now reduced the percentage of capital generated from debt to 46 percent. While this figure is still higher than the 40 percent average for all U.S. corporations, it is significantly improved from the more than 65 percent level for the airlines in 1993 and 1994.[2]

The U.S. airline industry is composed of four air carrier categories: (1) the major airlines, such as United, Delta, and American, which have annual revenues of $1 billion or more; (2) the national airlines, which are scheduled airlines with revenues between $100 million and $1 billion; (3) the regional airlines, which have service limited to a single region of the country, but represent the segment of the market that has been the fastest growing and the most profitable; and (4) the cargo carriers, which are divided into combination carriers (i.e., cargo on one level of the aircraft and passengers on the other) and cargo-only carriers (e.g., FedEx, UPS, and DHL).

Significant increases in traffic and continued strong demand for air travel resulted in some overdue airline cost increases. Not only did the airlines add 22,000 new employees, but also average wages increased. The average annual compensation per airline employee, including wages, insurance, and pension benefits, increased from $62,092 to $63,223, as compared to a U.S. industry average of $40,100.[3] Labor is the industry's largest single cost, representing 34 percent of total operating expenses for passenger airlines.

A significant portion of labor costs goes to retain the highly trained pilots needed to operate modern aircraft. The U.S. airlines hired a record 12,000 pilots in 1997, which was the fourth year of a hiring boom that could last well into the next decade. The rosy job outlook is taking shape

amid record passenger loads and robust earnings. New hires are needed to operate growing fleets and to replace thousands of pilots who earned their wings in the Vietnam-era military and are nearing retirement. The competition for qualified pilots could mean trouble for small airlines unable to match major airline salaries. Regional airline pilots stay with one carrier an average of 5 years, but if predictions hold, the average stay will be only 2–3 years by 2002; the result will be increased training costs and, possibly, higher salaries.

Jet fuel costs, airlines' second largest expense, decreased from an average price per gallon of 66.4 cents in 1996 to 64.5 cents in 1997. With U.S. airlines requiring 18.5 billion gallons of fuel annually, total cost of fuel reached $11.9 billion. These costs do not include the 4.3 cents per gallon federal deficit–reduction tax imposed on the airlines since October 1995.[4] Clearly, increased fuel efficiency is a top priority for the industry. During the past two decades, the airlines have increased fuel efficiency nearly 50 percent by

- lowering cruising speeds
- using computers to determine optimum fuel loads and to select altitudes and routes that minimize fuel burn
- increasing the use of simulators for pilot training
- using only one engine to taxi

Most important, airlines have continued to invest billions in new aircraft and cleaner-burning, fuel-efficient engines.

Railroad Industry

Today's railroads have increased efficiencies, improved infrastructure, and are in the best shape since the mid-1960s. The foundation for this success lies in the mergers permitted by the 1980 Staggers Act, which deregulated railroads. The number of class one railroads has dropped from 25 to 6. Mergers, spin-offs of low-profit rail lines, the selling of regional rail networks, and the abandonment of branch lines significantly increased efficiency and created some very strong class one railroads. Megamergers of railroads significantly reduced shipping costs to customers. After Union Pacific acquired the Chicago Northwestern Railroad (CNW) in a merger acquisition, "through" cars from Los Angeles to Chicago go direct and have to pay only one railroad for moving the load. With competition now setting freight rates, average rail freight costs to railroads between 1988 and 1997 (in constant 1988 dollars) dropped from 2.72 cents to 1.85 cents per ton-mile. These cost reductions helped the railroad business, primarily

from increased coal hauling and intermodal (container and truck trailer) traffic.[5]

To ensure that rail system capacity and customer service capabilities meet these increasing demands, class one railroads have heavily invested in infrastructure—retracking mainlines to double and triple railsets, as well as adding long passing sidings. Railroads are working with two U.S. "motive power" producers in designing, building, and producing more powerful locomotives capable of moving greater loads more efficiently. New diesel locomotive designs have increased the efficiency of fuel consumption between 1980 and 1997 from 235 to 377 revenue ton-miles per gallon of fuel consumed. Another dividend from infrastructure investment is that derailment/accident reductions dropped from 11.4 accidents per million train miles in 1980 to 3.5 accidents per million train miles during 1997.

Maritime Industry

The U.S. shipping industry has had to adapt to the intermodal revolution. Break bulk cargo ships simply cannot compete with large-capacity container ships, which are increasingly integrated into intermodal systems. Though the U.S. commercial shipping industry has lost much of its shipbuilding capacity to foreign flag carriers, shipping remains vital to the U.S. economy. Some 90–95 percent of U.S. import and export volume travels by sea. Seaports are faced with daunting infrastructure modernization requirements to accommodate larger, faster ships. In 1999, the intermodal container traffic saw intense competition between the ports of Baltimore and New York, with the latter retaining the loyalty of the major shippers. Faced with the loss of government subsidies, U.S. shipyards must compete in a market characterized by oversupply. In Europe, economic integration has not eliminated port overcapacity, where Rotterdam must face competition from nearby Antwerp and Bremen. Strategically, shipping is vital to national security; the United States must travel up to 8,700 sea-lane miles in order to protect its interests abroad and respond to international crises. During a major theater war, more than 93 percent of all the equipment and supplies needed to sustain the U.S. military would be carried by sea.[6]

In the aftermath of the Persian Gulf War, Congress ordered a mobility requirements study that led to major improvements in U.S. sealift capacity. The Future Years Defense Plan (FYDP) now contains $20 billion for 19 LMSRs, 14 smaller Roll-on/Roll-off (RO/RO) ships, and improved ready reserve readiness. The studies have revitalized the

Military Sealift Command (MSC) and moved logistic requirements higher on budget priority lists.

Trucking Industry

Trucking accounts for more than 62 percent of freight transportation tonnage in the United States, and it dominates local and regional freight. The trucking industry is more specialized than the other modes. Trucking companies tend to segregate their services into distinct categories or industries: long distance versus regional/local; private versus for-hire; dry van versus tanker; and general cargo versus specialized cargoes, including hazardous cargo. The trucking industry shipment services are broken down into three segments: truckload (TL), less-than-truckload (LTL), and package express carriers. The TL carrier hauls the goods of only one customer from the point of origin to the final destination. The LTL carrier hauls the goods of many different customers from numerous points of origin to their final destinations. The operating cost of the LTL carrier is usually much higher than that of the TL carrier, partly because the LTL carrier requires facilities to consolidate and distribute the freight before a shipment can reach its final destination. The operating cost of the distribution center (both the original construction and the maintenance) is layered on top of the operating cost of the trucking equipment. The final segment, the package express carrier, has an operating cost similar to that of the LTL carrier because it is servicing numerous customers at numerous locations. This diversity, versatility, and flexibility has enabled the trucking industry to remain highly competitive with other modes of transportation.

In 1996, the number of people employed by the trucking industry increased 26.4 percent to more than 9 million people, and the number of truck drivers increased 23.1 percent. There are 442,695 interstate motor carriers, of which 69 percent operate 6 or fewer trucks and 78 percent operate 20 or fewer trucks. This equates to more than 19 million trucks used for business purposes on U.S. highways. A direct result of the increase in motor carriers was truck tonnage growth, which grew well over 40 percent between January 1994 and December 1998. The estimated $345 billion spent for truck freight dominated the freight transportation market in 1996 at 82 percent of the nation's freight bill. By 1998, 92 cents of every U.S. transportation dollar was paid to a trucking company.[7]

Mass Transit

Those who live in the United States depend on mass transit. More than 32 million senior citizens are coming to rely on public transportation as their driving ability decreases with age. Nearly 24 million people with disabilities need mass transit to maintain their independence. Almost 37 million people who live below the poverty line and cannot afford a car, rely on mass transit to reach their jobs. Some 56 million children under driving age travel farther to schools than ever before, and they use mass transit. In many metropolitan areas, mass transit continues to grow. Systems such as California's Bay Area Rapid Transit (BART) are including state-of-the-art passenger transport systems and pioneering systems, such as electronic display boards for subway platforms, video monitors, and "talking signs" for the visually impaired. The National Passenger Railroad Corporation (Amtrak) is perhaps the best example of the federal government's involvement in mass transit. Recent performance figures indicate that Amtrak is exceeding ridership revenue and cost reduction projections, lending some hope to Amtrak's plan to be independent of most federal operating support by the year 2002.

OUTLOOK

By its very nature, the transportation industry is confronted daily by worldwide competition. Cross-border alliances are now the norm in the air and maritime sectors. As the new millennium arrives, the momentum for change will only accelerate.

Air. Paperless documentation created online by the shipper is the way of the future. Airfreight will move significantly faster through a combination of improved data sharing, reduced red tape, faster and more efficient aircraft, and partnership agreements linking the complementary strengths of air carriers. The C-17 is a proven national asset, and the program could grow due to documented strategic airlift requirements. The Pentagon is studying development of a heavy-lift airship for long-distance sustainment. In Europe, plans for a pan-European future large aircraft (FLA) for troop transport remain on the drawing board.

Maritime. The 1960s worldwide container revolution has affected all transportation modes. The transportation industry standard by which all conveyance means are measured is the 20-foot equivalent unit (TEU) trailer; today's container ships can carry up to 6,000 TEU trailers. Tomorrow, even larger and faster ships will dominate the high seas, and world ports will have to invest to match their capabilities. The ocean

shipping industry, in an effort to capitalize on this revolution of new technology, introduced container ships and specially designed terminals, cargo-handling cranes, and container trains and tractor-trailers to provide commercial shippers with more expeditious origin-to-destination "intermodal" transportation. Today's ocean transport industry trend toward containerization has created a shortage of commercial sealift ships with military applications capable of carrying combat equipment, however. The MSC works continuously with private industry to find ways to make commercial resources more compatible with military sealift needs and is identifying areas where the MSC can more efficiently and safely use containerization to transport military cargo, particularly ammunition. Looking ahead, December 1999 will see the final handover of the Panama Canal to the Panamanian government. Now carrying only 14 percent of U.S. maritime trade, the canal has lost much of its significance—thanks to the growth of intermodal port/rail networks across the North American "land bridge."

Railroads. Tomorrow's transportation customer will be more demanding and will require specialized service. Evidence of what lies ahead is seen in the recent agreement of Burlington Northern and Santa Fe Railway (BNSF) and Wal-Mart, where BNSF will be Wal-Mart's primary rail transportation provider. Alliance Yard, BNSF's $150 million multimodal transfer hub, is a global commerce center. As the largest transport center in the Southwest—575 acres with 50 miles of railroad track and an adjacent airport—it is a model distribution center for the 21st century.

The search for efficiencies may lead to remote-controlled engines. In Cargill's fertilizer plant in South Park, Florida, one operator has taken the place of several employees by using remote controls to manage the entire loading operation of hopper cars for shipments. Although this experiment is going well, the Federal Railway Administration ordered the Wisconsin Central to refrain from using remote-controlled equipment in its rail operations, citing concerns over safety.

Recruitment remains problematic. Railroads cut crews due to reduced traffic loads in the 1980s. Unanticipated increases in traffic during the early 1990s put a strain on the availability of qualified personnel. Today, the average age of a train crewman is 50, and many enter the retirement window each year. Railroads scramble for qualified personnel and have had to turn to nontraditional personnel resources, including human resource companies and college training programs.

Trucking. The largest issue for motor carriers is safety. In 1995, commercial trucks logged 369 billion miles. The number of miles traveled by motor carriers has continually increased while the number of

fatalities has decreased drastically, thanks to drug- and alcohol-free drivers. In 1996, only 1.4 percent of commercial truck drivers involved in fatal crashes were intoxicated. Of the nearly 42,000 road fatalities in 1996, trucks were involved in only 12 percent of cases—a remarkable record, given that large trucks accounted for 161 billion miles traveled.[8] Driver fatigue remains one of the leading causes of accidents, however. The American Trucking Association (ATA) is aggressively working with the Department of Transportation (DOT) to reduce the hours-of-service in a 24-hour period to help alleviate driver fatigue. The Federal Highway Administration (FHWA) is conducting research to evaluate hours-of-service regulations.

The trucking industry will continue to be capable of meeting U.S. economic and defense needs in the 21st century. The most important challenges that it will face will be an aging infrastructure, congested road conditions, adequate supply of truck drivers, new and emerging technologies for intermodalism, identification and development of markets for intermodal freight transport, and compliance with federal and state safety and environmental requirements.

Mass Transit. Emerging technologies are having a positive impact on the nation's mass transit system. For the past 20 years, the Department of Energy (DOE) has been developing alternative fuel technologies in partnership with industry. Though many conventional vehicles using alternative fuels are on the road today—used by the public and in fleet applications—much work is still needed to improve the technologies and reduce the cost. The key to making electric vehicles practical, for example, is the development of batteries that can provide power to operate the vehicle at costs comparable to those of operating conventional vehicles. This would be an improvement over today's limited range lead-acid batteries. Finally, in 1999 Amtrak is on the verge of unveiling a train set service that features state-of-the-art "tilt" technology, which is designed to operate at high speeds and to enhance passenger safety and comfort.

Pipelines. Economic uncertainty in energy markets has caused most companies to trim plans for pipeline construction. The data show that plans for petroleum and natural gas pipeline installation in 1999 will decline by 28 percent. These statistics should be seen as an indication of a cooling down period while the industry reevaluates the domestic and global energy picture. Most companies planned their long-term strategic pipeline projects before they understood the full effects of the weak energy economy. The sagging energy markets have affected the petroleum side of the pipeline industry the most; in fact, the natural gas sector shows some promise of growth. The most extensive development

of new pipeline capacity is primarily the result of growing demand for natural gas as fuel for electricity-generating plants that are replacing their coal- and oil-fired units. Total U.S. natural gas consumption has increased by 17 percent since 1990, marketed production has increased by 6 percent, net imports have nearly doubled, and the interstate pipeline system has increased in size and capability.[9] Overall growth of the pipeline network has occurred in both its deliverability and usage levels. The Energy Information Administration projects that the natural gas market will grow steadily into the next century, prompting the pipeline industry to plan extensive capacity additions.

Information Technology. Like most other industries, the transportation industry is dependent on the national information infrastructure. The transportation industry in the United States, as in most other industrialized nations, has a sophisticated network of government agencies to protect critical information technology and other infrastructure through safeguards and regulations. The United States has yet to assemble an information technology working group of government and industry specialists to develop a national strategy for coping with information technology intrusion and catastrophe, however.

Peculiar to this year's industry study is the Year 2000 "millenium bug" phenomenon, better known as Y2K. The transportation industry has received considerable attention during discussions of this issue, given its safety and economic considerations. The success of U.S. efforts to minimize or abate the Y2K problem rests with the industry's early acknowledgment of the problem and willingness to dedicate considerable assets to a robust effort to fix it. Generally speaking, industry officials agree that the United States is relatively secure in its efforts to remedy the problem. No one can guarantee with any degree of certainty how the interaction with other countries and their systems will affect the transportation infrastructure. Industry groups believe that they are prepared. The question remains whether the customer base and foreign concerns will be ready.

Efficiency in any industry, achieved primarily by cutting inventory and using the Internet, requires reliable transportation. Just-in-time delivery of parts, a practice yielding efficient inventory management and reducing supply chain costs, is dependent upon electronic data systems. Transportation is the common denominator and link to the integration of the supply chain.

Logistics Management. For the private sector, information about a shipment—where it is and where it is going—is just as critical as its safe delivery. The DOD acknowledged the overarching importance of information and logistics management with *Joint Vision 2010*,[10] which

has far-reaching implications for military logisticians. *Joint Vision 2010* provides a conceptual template for the way in which U.S. armed forces will use technological opportunities to achieve new levels of effectiveness in joint warfighting. A central pillar in this framework is focused logistics.

Focused logistics is best described as minimal inventory, minimal logistics footprint, and minimal response time. It includes total asset visibility, including in-transit visibility. It is intended to yield joint forces that are more mobile and versatile. The idea is to support rapid crisis response; to track and shift assets even while en route; and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical levels of operation. Focused logistics will be the logical extension of industry best practices to the U.S. military.

GOVERNMENT GOALS AND ROLE

Government is a major consumer of transportation services, a supplier of parallel services (largely in the military sphere), and the regulator of the industry. Government at all levels, both domestically and internationally (through membership in specialized international and regional organizations), fundamentally shapes the transportation industry.

Safety and Security. Of all the issues in the transportation industry, safety and security have the potential for catastrophic impact. They affect the public image of the industry and even future transportation modes. Safety is a matter of government regulation and is an especially challenging task in this age of asymmetrical threats by terrorists, rogue states, organized crime, and drug cartels. The United States and other industrialized nations have sophisticated networks of government agencies with transportation safety and security responsibilities. In the United States, the DOT serves as an intermodal umbrella for a number of modal-specific agencies.

On the international level, regulatory organizations tend to follow similar modal lines. The National Transportation Safety Board (NTSB), charged with investigating transportation accidents, is linked to other national transportation investigative agencies through the International Transportation Safety Association (ITSA). The Federal Aviation Administration (FAA) and the Department of State provide U.S. representation and support to the International Civil Aviation Organization (ICAO). The network of international cooperation is vital

to transportation security, as transportation links do not end at a country's border.

Deregulation. As the United States prepares for a new millennium, deregulation and the resulting mergers set the stage for even greater efficiencies and service improvements in the transportation industry. An exception to greater efficiency and improved service has arisen in the rail industry, however. Major disruptions in service, costing customers hundreds of millions of dollars in lost revenues, occurred immediately after the merger of the Union Pacific and Southern Pacific railroads. Fortunately, these service disruptions were relatively short-lived, less than 18 months, and customers should start seeing benefits from this merger in the very near future. Only a deregulated railroad industry allows the flexibility to meet the demands of future customers.

Infrastructure. In 1997, the trucking industry paid $27 billion in federal and states taxes and an additional $16 billion in fuel taxes to the government. There is a question, however, as to whether this tax base is adequate to fund the roads, bridges, and highways that are the lifeline of the trucking industry. The American Society of Civil Engineers (ASCE) released a 1998 "Report Card for America's Infrastructure" that gave letter grades for the nation's public infrastructure and environment. The roads in the United States received a grade of D-. More than 50 percent of the roadways are in poor, mediocre, or fair condition, and more than 70 percent of peak-hour road traffic occurs in congested conditions. It will cost $263 billion to eliminate the backlog of maintenance and repair needs, and another $94 billion for modest new improvements for a total bill of $357 billion. Bridges rated a little higher at a C-. Nearly one of every three bridges is rated structurally deficient or functionally obsolete. It will require $80 billion to eliminate the current backlog of bridge deficiencies and maintain repair levels.[11]

TEA-21. Congress and the President have moved in the right direction with the passage of the Transportation Equity Act for the 21st Century (TEA-21), which authorizes highway, highway safety, transit, and other surface transportation programs for 6 years (1998–2003). The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) was the last major authorizing legislation for surface transportation, and the TEA-21 builds on its initiatives. Significant infrastructure features of TEA-21 include assurance of a guaranteed level of federal funds for surface transportation through Fiscal Year 2003, strengthening of safety programs across the DOT, continuation of the proven and effective program structure established for highways under the ISTEA legislation, and investing in research and its application to maximize the performance of the transportation system.

In a major change to the federal budget rules, highway programs are now guaranteed a minimum level of spending under TEA-21. Highway guaranteed amounts are keyed to actual Highway Trust Fund (HTF) Highway Account receipts and can be used to support projects eligible under federal highway and highway safety programs. This historic legislation was a major breakthrough for the American Trucking Association and the trucking industry. For the first time, all highway and fuel taxes collected under the HTF are designated for transportation infrastructure expenses. The HTF establishes the floor that may be spent on eligible projects. The DOT estimates that TEA-21 will increase federal spending for highways from $23.8 billion in Fiscal Year 1998 to almost $31 billion by Fiscal Year 2003. Total spending for federally funded highways during the 6-year authorization period is $171 billion, an average of $28 billion annually.[12]

TEA-21 also includes $41.4 billion for improvements in public transportation. Specific mass transit earmarks include $150 million for transit enhancements, such as improved pedestrian access and landscaping, and $20–$25 million per year in discretionary grants to metropolitan planning organizations and local governments to research, plan, and integrate strategies. The $41.4 billion allocated for mass transit is enough only to maintain the current system, however.

Highways for National Defense. By Directive 4510.11, "DOD Transportation Engineering," the DOD has established the operating responsibilities between U.S. Transportation Command and the military services. Through the Highways for National Defense Program, the Military Traffic Management Command (MTMC) has established continental U.S. (CONUS) highway systems, which represent the minimum networks required to meet DOD surface movement needs in peace and war. The responsibility to administer the highway systems portion of this program has been delegated to the MTMC Transportation Engineering Agency (MTMCTEA), which works closely with the FHWA, states, services, and installations to identify key sections of the highway system that are important to the DOD and to ensure their continued viability to meet the national security needs of the nation.

The most important network defining the DOD's highway needs is the Strategic Highway Network (STRAHNET), which was developed in the 1970s. STRAHNET is 61,000 miles of highway, plus an additional 2,000 miles of connectors, that link important power projection platform installations and strategic ports. It provides defense access, continuity, and emergency capabilities for movements of personnel, supplies, and equipment in both peace and war. In January 1991 and again in July 1997, STRAHNET was updated to take into account quantifiable DOD

highway requirements. The evaluations addressed the DOD's peacetime, wartime, strategic interest, and oversize/overweight highway demands. The MTMCTEA has been the driving force, emphasizing the need for a timely nationwide highway status reporting system, which is critical to meet future time-sensitive transportation demands and detailed surface deployment planning requirements.[13]

Through efforts with the FHWA, the MTMCTEA was successful in incorporating STRAHNET into the requirements for the National Highway System. In November 1995, the National Highway System legislation became public law—the first time that legislation designated important defense routes. This legislation gave the DOD a platform to ensure the maintenance of the interstate system, and other roads important to the nation's defense and mobility. TEA-21 identifies a separate authorization line item for the National Highway System, with a funding level of $28.6 billion over 6 years. This level of investment makes it possible to improve bridges to take heavy loads and to have adequate underpass clearance on roads to and from key military installations. The focus will be on connectors to forts, bases, and the deployment ports. Cooperation between the federal and state governments on the DOD's highway needs should give funding priority to STRAHNET to ensure the readiness of these important strategic highways and roads to support the nation's defense deployments well into the 21st century.

Railroads for National Defense. The Strategic Rail Corridor Network (STRACNET) is a system of U.S. rail lines designated by the DOD as important to move military hardware and commercial products critical to national defense in the event of mobilization. Thanks to the 1980 Staggers Act, greater volumes of freight flowed over single rail networks, and railroads started putting money back into the physical plant to increase both speed and capacity. The upgraded infrastructure also improved reliability. The DOD requires track to be maintained at a level allowing freight trains to travel at an average speed of 22 miles per hour across the system.

The recent growth in the railroad industry has been primarily in bulk movement and container traffic. Railroads sought efficiencies for moving this type of cargo in new railroad cars capable of carrying longer truck trailers and double-stacked containers. Although these more efficient railroad cars helped make intermodal traffic profitable, railroads have had little use for general purpose flatcars. Of concern to STRACNET is the ability of the railways to handle oversized military hardware such as M1 tanks, which require flatcars. A flat car inventory study conducted by the MTMC revealed that the fleet of commercial and

government-owned flatcars is capable of meeting military needs until 2002.

CONCLUSION

The U.S. surface transportation infrastructure has been deteriorating after years of Band-Aid solutions. The FHWA has deemed 182,000 bridges (31 percent of the nation's total) functionally obsolete,[14] with many subject to weight limitations. Years of neglect mean that major investments from all levels of government are necessary.

Competitive pressures lead to pushing on the safety envelope, hence the trucking industry's call for longer trailers and younger drivers. Locked in a cost struggle with the rail industry, truckers lobby for bigger trailers and higher weight limits. Despite their rebound over the past several years, the railroads are still suffering from equipment and crew shortages, severe service disruptions, and erosion of customer confidence. Railroads in the United States struggle to achieve a 90 percent on-time rate, which is still not good enough for manufacturers and retail operators. Improved service is a key goal; the future is in intermodal transport of containerized cargo. Progress is being made with the establishment of hubs, alliances, and shared track use. Of note is the Alameda Corridor at Los Angeles/Long Beach, scheduled for completion in 2002. This ambitious project will allow the rapid offload of containers from ships, their immediate placement on railcars, and their rapid transport out of the city to main lines.

A strong economy, coupled with a competitive environment, meant record profits for U.S. airlines in 1997 and 1998. Not only are U.S. carriers continuing to hire thousands, but also they have more than 1,400 new aircraft on order, representing a $140 billion commitment to the airline industry and, by extension, to national security through CRAF. Profits in the late 1990s have helped reduce the capital debt incurred earlier in the decade, and earnings are being used to fund the newer aircraft. In 1997, the cost to move a passenger or piece of cargo increased by less than 1 percent as compared to a 2.3 percent increase in the consumer price index (CPI).[15] The balance sheet is promising.

Research on the transportation industry suggests that the United States should

- remain committed to strategic lift procurement plans, both in sealift and in airlift
- continue its efforts for regulatory reform, particularly in the maritime sector

- reduce military service-unique standards and adopt commercial standards—especially in the highly developed transportation sphere—where possible

In sum, the transportation industry has effectively reinvented itself to meet the needs of the U.S. military and the economy as a whole. Globalization means sleepy routines cannot survive, and the confluence of best practices across borders means world-class vehicles, systems, and procedures are here to stay. Infrastructure needs constant mending, however. Further, deregulation, while generally positive in instilling the discipline of the market, is not a panacea and will not replace government action in areas where national security is at stake.

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