Information Superiority and Geographic Information Systems: Where is the U.S. Army?

A Monograph
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AY 02-03

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

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Title of Monograph: Information Superiority and Geographic Information Systems: Where Are We?

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Abstract

Information Superiority and Geographic Information Systems: Where is the U.S. Army? by Major Judith M.R. Price, PE, United States Army, 43 pages.

The Joint Staff published Joint Vision documents in 1996 and 2000 to provide the joint conceptual framework for the transformation effort. The United States Army embarked upon its own transformation towards its Objective Force in conjunction with the Joint Vision. Both initiatives depend upon realizing the potential of information age technologies and exploiting the information superiority to which those technologies contribute.

Geospatial information provides the foundation for information superiority, which in turn supports the initiatives embodied in Army transformation and the tenets of Joint Vision. Geospatial information references locations on the surface of the earth incorporating the domains of land, sea, air and space and, as such, becomes the foundation upon which all other battlespace information is integrated. Geospatial information provides the basic framework for battlespace visualization, planning, decisions and actions. Without geospatial information, information superiority and subsequently decision superiority cannot succeed.

While significant progress has occurred technologically, challenges remain with systems interoperability, training and support agencies. Part of the challenge rests in changing the experiential mindset – “but this is the way we have always done it” – in ensuring the United States Army’s acquisition systems develop interoperable technological applications based on a sole common geospatial information baseline and revising the education and training systems that support the military and its support agencies. In conclusion, geospatial information is a relevant enabler but still requires continued refinements to meet the demands of Joint Vision and Army transformation in developing current and future requirements.

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INTRODUCTION

Geospatial information is the information derived from remote sensing, mapping and surveying technologies that identifies the geographic location and characteristics of natural or constructed features and boundaries on earth including statistical data. Geospatial information contributes extensively to visualization. It is the power of visualization that enables the commander to see problems innovatively, thereby increasing the chances of arriving at a successful solution. Because visualization is the link between reality and a decision maker's cognitive processes, it is a crucial element of information superiority.[1]

The relationships among information superiority, the Army's transformation initiative and Joint Vision share a common thread – geospatial information. Geospatial information provides the foundation for information superiority, which in turn supports the initiatives embodied in Army transformation and the tenets of Joint Vision. While the information age is within its youth globally, it is racing towards maturity in the United States military and its support agencies. This has not been without challenges however. These challenges have presented themselves organizationally, technologically, and as resistance to adaptation of new concepts and capabilities.

The Future is Now

Futurists Alvin and Heidi Toffler contend that the way societies wage war mirrors the way they accumulate wealth. Each "wave" of social revolution (agricultural, industrial and informational) produced profound changes in society and military technologies. Those changes have produced armies that reach further, faster and with greater effect than ever before. With the

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[1]James C. King, Director, NIMA, Keynote address to the American Society for Photogrammetry & Remote Sensing 2000 DC Annual Conference, available from http://www.asprs.org/asprs/publications/pe&rs/2000journal/september/king.html, Internet, accessed 17 February 2003

advent of the 21st century, a revolutionary new economy is rapidly developing based on knowledge, rather than conventional raw materials and physical labor. This remarkable change in the world economy is ushering along a parallel revolution in the nature of warfare – the dawning of information age warfare.[2] Information age warfare requires information integration at every level of command to ensure vital data flow. It requires a common view of the battlefield by both the commander and his staff to aid in agile decision-making and rapid execution of orders and to minimize misunderstanding. Therefore, near real-time information must be accessible to all who need it, when they need it, at any place on the battlefield and in a usable form.[3]

Understanding the Transition Phase

As the global society enters the information age, military operations are inevitably impacted and transformed. Satellite communications, video teleconferencing battlefield facsimile machines, digital communications systems, personal computers, the Global Positioning System and dozens of other transforming tools are already commonplace and present options and capabilities that were unheard of just a few decades ago.[4] Because the forces depend on situational awareness and synchronization to achieve success, care must be taken to keep information age support systems connected and operating properly. Functionally, networking systems focuses energy on ensuring commanders receive and disseminate decisionable information without interruption. Army tactical command and control (C2) systems form the digital information channels of the Army Battle Command System (ABCS). Working in concert, these systems provide commanders direct communications with their units; opportunities for

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[2]Alvin and Heidi Toffler, *War and Anti-War: Survival at the Dawn of the 21st Century* (Boston, MA: Little, Brown and Company, 1993), 3-5.

[3] Charles M. Burke, "The 'Bondage' of Tradition," *Military Review* (July-August 1995): 10.

[4] David S. Alberts, *Information Age Transformation: Getting to a 21st Century Military* (Washington, D.C.: DOD Command and Control Research Program, 2002), 43.

timely, accurate, concurrent planning at all levels; and an enhanced ability to react more skillfully than the enemy.[5]

In network centric warfare, the value of a platform is based upon its ability to operate as part of a network, not by its ability to operate independently.[6] The technical capability to do this exists today. The power of computers drastically increases while size decreases. Software is becoming more versatile, interactive and user friendly. The penetration and proliferation of sensors are becoming more complete. Soon it may become possible to respond to a command's request and sense, fuse and deliver the needed information quickly, anywhere on the battlefield. Fusing data will complete the process of examining and combining all sources of information in order to develop a complete, accurate assessment.[7] The information age brings great potential for the rapid fusion of disparate bits of information that is then quickly disseminated from the corps commander to the individual tank crew[8]. Information age warfare in all its variety will retain many of the attributes of past wars – it will not be remote, bloodless, sterile or risk free despite advanced technology. There is no purely technological solution to war, because war, in the final analysis can never be divorced from its human dimension. Although the conduct of information age war may change substantially, the nature of war remains relatively constant. Success comes to those who can exploit the full potential of computer technology within new organizations and develop new attitudes toward personnel and work processes, new ways of operating and new management concepts – concurrent with development. Success will come to those who 'unlearn' industrial age rules and adapt the new practices of the information age quickly. Ultimately, the

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[5] Stephen F. Garrett, "Evolving Information-Age Battle Staffs," *Military Review* (March-April 1998): 32.

[6] Alberts, 21.

[7] Department of Defense. Joint Publication 1-02, *Dictionary of Military and Associated Terms*, 12 April 2001, 172.

[8] Burke, 10-11.

information age will dominate, but vestiges of the industrial and the agrarian ages will remain. While some parts of the world will become information based, others will remain industrial, agrarian or some variation in between. Even within nations, all three 'ages' may coexist. Variety, increased complexity and uncertainty will characterize the global community. Our requirement is to adapt.[9]

With the advent of the information age, the conduct of war changed fundamentally. Previously, industrial and agrarian age armies relied upon written and verbal reports that could be hours or even days old in order to maintain situational awareness and understanding of the battlespace. Information age armies develop a shared situational awareness based on common, up-to-date, near complete friendly and enemy information digitally distributed among elements of a force. First, operational and tactical forces know where their enemies are and are not. While this 'knowledge' is neither absolute nor 'perfect', it will be at least significantly better than achieved before. Second, information age armies know where their own forces are much more accurately than ever before. The same technology permits those armies to deny information to the enemy. Last, the enemy and friendly information is distributed among the forces to create a common perception of the battlefield among commanders and staffs. This shared situation awareness, coupled with the ability to conduct continuous operations day and night, allows information age armies to observe, decide and act faster, more precisely and more decisively than their unsophisticated enemies do. In information age armies, digitally linked vehicles, fire support, sustainment systems and command and control platforms are organized as part of a joint network that includes the platforms and systems for sea, air and space forces.

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[9] Gordon R. Sullivan and James M. Dubik, *Envisioning Future Warfare* (Fort Leavenworth, KS: U.S. Army Command and General Staff College Press, 1995), 50-51.

GEOSPATIAL INFORMATION

Topographic support changed little in the decades following World War II. The mass production of analog paper products such as maps and imagery was laborious and expensive. Further, it provided coverage of a small, limited percentage of the Earth's surface. In the mid-1980s, the Department of the Army granted approval for the development of digital topographic capabilities, which spurred a military topographic revolution. In the early 1990s, the Army began the integration of information technology into tactical units spurring another Revolution in Military Affairs (RMA). The digital RMA is based upon the premise that improvements in computers and electronics will continue to improve communications, information processing and information networks. In 1996, the Joint Staff published Joint Vision 2010. Joint Vision 2010 sought to guide the technological and doctrinal development of the military services into the 21st century.

Geospatial engineering is an extension of traditional topographic engineering and is necessary to support Force XXI digitization and Army Transformation. Prior to these initiatives, terrain analysis was completed at the division level and above. Semi-autonomous operations by maneuver brigades demand a clear understanding of terrain and weather effects. To meet this challenge, Force XXI introduced dedicated terrain analysis and geospatial engineering support to maneuver brigades. Later geospatial analysis was expanded to all maneuver brigades during the Division Advanced Warfighting Experiment. Brigade level geospatial engineering support is now a standard element in all working concepts and the SBCT. Therefore, geospatial engineering is organizationally linked to information dominance and the success of the digital force.[10]

[10] Earl Hopper, Brian Murphy and Chris Morken, "Geospatial Engineering: A Rapidly Expanding Engineer Mission," *Engineer* (May 2001): 14-15.

Geospatial engineering includes the information field that encompasses geodetic, geomagnetic, imagery, gravimetric, aeronautical, topographic, hydrographic, littoral, cultural and toponymic data when that data is accurately referenced to a precise location on the surface of the earth. At its basic level, geospatial information provides a 'map' that can be used to indicate location. Multiple sources are used to produce geospatial information. Geospatial information may be published in a variety of forms: printed maps, charts, and publications; digital simulation and modeling databases; photographs; or digitized maps and charts or attributed centerline data.[11]

The objective of geospatial information is to provide the commander with timely, complete, and accurate information about the battlespace. Geospatial information provides the basic framework for battlespace visualization, which is used for military planning, training, and operations including navigation, mission planning, mission rehearsal, precise targeting and battle tracking. Geospatial services include tools that enable users to access and manipulate data, and include instruction, training, laboratory support, and guidance for the use of geospatial data.[12]

The fundamental parameters of geospatial information in the national, commercial and defense communities are geography and time. Geography and time provide a natural reference framework for information superiority. The defense community uses the geospatial framework to integrate other information. As such, the common operating picture begins with a three dimensional topographic grid. Other information such as imagery, survey data, manmade features, geology, weather, environmental effects, demographics, and political boundaries are then indexed to the topographic grid. In fact, any type of information from a multitude of sources

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[11] Department of Defense, Joint Publication 2-03, *Joint Tactics, Techniques, and Procedures for Geospatial Information and Services Support to Joint Operations*, 31 March 1999, GL-3.

[12] Ibid.

that can be correlated to a specific location can be integrated into the geospatial framework.[13] Specific applications of geospatial information include providing comprehensive regional, continental, hydrographic and oceanographic databases to assist the commander in visualizing the battlespace and making decisions. Geospatial information provides terrain, infrastructure and environmental information for use in evaluating and selecting sites for communication equipment, radar and electronic warfare systems; operational intelligence relating to movement (information on road surfaces, bridge construction and capacity, and cross-country trafficability) and weapons placement.

Assembling geospatial data and communicating it faster than the enemy ensures the commander has a superior understanding of the battlespace. A superior understanding of the battlespace allows the commander to defeat an enemy force rapidly and efficiently. The use of precise attrition and maneuver allows the commander to dominate his battlespace. Therefore, to dominate the battlespace the commander must have information dominance. Digitization provides an efficient means to link the soldiers, weapons, sensors and commanders into a synchronized fighting force.[14]

The digitization of the battlespace provides a tremendous opportunity for enhancing the United States' warfighting capabilities and addressing the challenges of military operations through robust situational awareness and visualization. These capabilities are augmented through computer simulation and the tremendous growth in geospatial information technology. Geographic information data management options have expanded rapidly over the past several years. Software and hardware advances have provided better network access to spatial data, have

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[13] Debra L. Kabiner, *Geospatial Information Requirements of the Objective Force* (Carlisle Barracks, PA: United States Army War College, 2001), 9-10.

[14] Jeffrey L. LaFace, *Digitization and the Commander: Planning and Executing Military Operations* (Fort Leavenworth, KS: U.S. Army Command and General Staff College School of Advanced Military Studies, 2001), 36.

allowed development of more complex geospatial data models and have made the integration of geographic information systems (GIS) and database systems a reality. The use and proliferation of GIS and digital mapping further serve to enhance military situational awareness and visualization.

Sun Tzu stated, "Those who do not know the conditions of mountains and forests, hazardous defiles, marshes, and swamps cannot conduct the march of an army.[15] The United States anticipates using fewer forward deployed troops in military contingencies. Therefore, the required forces will deploy from bases within the United States. Units will operate in little known geographic regions. To do so effectively, the deploying units will rely upon digital geospatial information to understand the terrain and its effects.

IMPACT OF NIMA ON MILITARY OPERATIONS

For decades, the United States has enjoyed information superiority – a clearer view of unfolding events – over its adversaries. Largely, that advantage was because the United States collected more and better geospatial data, particularly from satellite sensors, than its adversaries. In the future, adversaries will gain ready access to such geospatial data through commercial sources. This dramatic change threatens the United States' information superiority. In 1996, Congress consolidated the Defense Mapping Agency, the Central Imagery Office and imagery functions from within the Defense Intelligence Agency, Central Intelligence Agency and National Reconnaissance Office to establish NIMA. The consolidation created a single combat support structure chartered to merge imagery and mapping data from separate defense and intelligence entities. NIMA is the primary source for providing imagery, imagery intelligence and geospatial information in support of national security objectives. NIMA has broad authority over the United

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[15] Sun Tzu, *The Art of War*, trans. Thomas Cleary (Boston, MA: Shambala Publications, Inc., 1988), 144.

States Imagery and Geospatial Information System (USIGS), the extensive network of systems involved in the acquisition, production and use of imagery, imagery intelligence and geospatial information. The USIGS has a common information management framework that enables sharing data, services and resources among its members and customers.

NIMA's primary impact on military operations was the synergy obtained through merging imagery and geospatial databases: providing richer information that is timely, relevant and accurate.[16] As part of the charter, Congress empowered NIMA to serve as the intermediary between tactical units and the high-end of the imagery spectrum and to prescribe the technical architecture and standards for imagery processing and dissemination.

In 2000, the Defense Science Board conducted a review of NIMA, addressing how the organization can aid in maintaining information superiority in a world of proliferating sensors. NIMA has the mission of ensuring that American forces and policy makers can operate in an environment of superior imagery and geospatial information. The Defense Science Board believed that the United States could maintain information superiority, based on four elements: superior (often user-customized) exploitation of information; timely, high velocity delivery of only the needed information; fusion/integration of all relevant intelligence information into a geospatial framework; and United States' unique collection. However, to meet those expectations the Board identified seven major recommendations:

- Strengthen NIMA's role as functional manager of United States Imagery and Geospatial Information

- Create the Tasking, Processing, Exploitation and Dissemination (TPED) System

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[16] John Strebeck, "Organizing National Level Imagery and Mapping," *Joint Force Quarterly* (Spring 1998): 32.

- Elevate Modernization within NIMA organization
- Nurture United States commercial imagery and geospatial industry
- Sufficiently fund all elements critical to imagery and geospatial information
- Protect and extend United States geospatial information superiority
- Evolve NIMA to a smaller, elite, mission-driven organization[17]

Achieving overall information superiority depends strongly on NIMA products and systems because the geospatial framework (grounded in three dimensions and time) is the single, natural framework that can serve as a basis for fusion of all information. Accurate geospatial registration provides the framework for merging intelligence products of all kinds to yield the common operating picture. Additionally, the Defense Science Board determined NIMA should participate in setting modeling and simulation standards for imagery and geospatial information interoperability and require its use. NIMA assumed the role of authenticator for imagery and geospatial products. The agency must also develop standards for the metadata tags that all products need to carry to describe the product's pedigree, as well as the standards and the tools to authenticate products.[18] In October 2002, NIMA announced the establishment of the National Center for Geospatial Intelligence Standards (NCGIS) to address standards related to the technologies, data architecture and software used by the defense, intelligence and homeland security communities. The center is to help ensure a standards-based approach necessary for interoperability on multiple levels and will provide the flexibility and fiscal oversight necessary

[17] Anita Jones and Peter Marino, *Report of the Defense Science Board Task Force on National Imagery and Mapping Agency* (Washington, D.C.: Defense Science Board, April 2000), cover letter.

[18] Ibid, 25-26.

to meet customer geospatial information needs without a duplication of efforts from government and commercial entities.[19]

Many of NIMA's analog map products have been on a six-, nine- or 12-year update schedule. The increasing importance of terrain and, thus, maps to operations has made the use of erroneous or out-of-date maps potentially disastrous.[20] Increasingly, operations require current information immediately at the onset of activity. Digitizing this information allows rapid updating and dissemination of the appropriate product. The space shuttle radar-mapping mission in 2000 compiled digital terrain and elevation data at 30 meter spacing over 80 percent of the earth. This covers virtually all territory with 20-meter horizontal and 16-meter vertical absolute accuracy. General King, recent director of NIMA, stated, "Technology is not our speed bump. Obtaining the right resources is the challenge that we face". Part of this challenge is modernizing and then incorporating the agency's 170 legacy systems into its future architecture. The agency already outsources over 25 percent of its geospatial information production to private industry.[21] All of these actions are in accordance with the Defense Science Board's seven recommendations.

Knowledge of the battlespace is a prerequisite to any successful military operation. For more than 80 years, the Army has been using the 1:50,000 scale map, technically known as the Topographic Line Map (TLM) to see terrain. Though it has served well in the past, it has limitations that severely diminish its utility in the information age. NIMA is undergoing a revolutionary change in how it provides terrain information to the Department of Defense. Spurred by recommendations from the Defense and Army Science Boards, NIMA published the

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[19] Dan Caterinicchia, "Geospatial center to oversee standards," available from http://www.fcw.com, Internet, accessed 4 November 2002.

[20] Patrick O'Sullivan, *Terrain and Tactics* (Westport, CT: Greenwood Press, 1991), 120.

[21] Robert K. Ackerman, "Balkans Serve as Proving Ground for Operational Imagery Support," *Signal* (October 1999): 19.

Geospatial Information Infrastructure Master Plan in 1997. Known as the Foundation Data concept, the plan describes the changes that NIMA and the mapping products customers must make to achieve the information superiority tenets of Joint Vision. The Foundation Data concept is a revolutionary data-production scheme that is designed to provide warfighters exactly what they want when they need it. NIMA based its old production strategy upon a standard suite of products, which presents several issues. First, the map was a predefined product that may or may not have features or data important to the commander. A commander received the standard complete map or no map – nothing in between. Second, these very expensive maps were developed 'just in case' based on service-defined requirements. After production, the maps were stored in a Defense Logistics Agency warehouse. After several years, the information became outdated. Updates are expensive, time consuming and unresponsive to the commander's needs. Third, the current TLM holdings covered less than 25 percent of the earth's surface. Operations have often begun without complete mapping coverage, including for example operations in Grenada, Somalia, and Desert Storm.[22]

Foundation Data Concept Components

The Foundation Data Concept consists of a near worldwide medium resolution set of imagery, elevation, features, and safety of navigation information. Specifically the foundation contains four elements. The first element is imagery, which includes both 1-meter stereo and 5-meter monoscopic imagery. These data sets are relatively easy to generate and can serve as a map background with the addition of grid lines. Imagery provides the warfighter a view of the battlespace that is unavailable with a traditional map. The second element is elevation data. Based on a successful space-shuttle radar mapping mission in February 2000, NIMA has the data it needs to cover all land between 84 degrees south latitude and 84 degrees north latitude with an

[22] William Pierce, "Going, Going, Gone… Bidding Farewell to the 1:50, 000-Scale Topographic Line Map," *Engineer* (May 2001): 10.

elevation reading every 30 meters, providing a contour interval approximately equal to a 1:50,000 TLM. This data allows location of intervisibility lines in the area of operations and construction of more accurate three-dimensional views and fly-throughs. Foundation Feature Data (FFD) comprises the third element. This component generates traditional map views. The data contains not only features, such as roads, vegetation, rivers, and lakes, but also feature attributes or descriptors, such as road widths, road/runway surface types and tree types. These attributes are not restricted to the legend but are an integral part of the database that can be recalled by clicking on the digital map. The final element of the Foundation Data Concept is the Mission-Specific Data Set (MSDS). While the foundation components provide enough information to conduct general planning, the Geospatial Information Integrated Master Plan recognizes that more information must be generated to satisfy the information needs of specific commanders. The revolutionary aspect of the MSDS is simply providing the terrain data defined by the commander that answers the commander's terrain-information needs. Another characteristic is that all data sets are custom-made for warfighters.[23]

Concept and implementation methodology depends on a robust satellite-communications system to handle dissemination of the MSDS from a division (or higher) command post to multiple receivers. The joint system being developed is the Global Broadcasting Service (GBS). The GBS provides the bandwidth and data throughput to satisfy the broadcast dissemination of required MSDSs to warfighters. Warfighters, the end users of the digital data, will be able to push and pull data through the GBS. The majority of the ABCSs will use the digital data to visualize, analyze and evaluate the terrain.[24]

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[23] Ibid, 10-11.

[24] Ralph M. Erwin, "Disseminating Digital Terrain Data to Warfighters," *Engineer* (May 2001): 17.

Benefits to the Army

The Foundation Data concept supports geospatial information requirements in several ways. First, all foundation data references the same datum or earth reference system. The Department of Defense has defined the World Geodetic System 1984 (WGS84) as the standard for military mapping. However, in excess of 100 datums are currently in use worldwide. Thus under the Foundation Data concept, all data will be tied to the same earth reference, providing a common view of the battlespace. Second, information learned about terrain for one operation will be preserved for future use as it is incorporated into the NIMA database. Third, embedded attributes in the database will support automated analysis and generation of tactical decision aids to include cross-country mobility analysis, automated route selection, slope analysis, 3D fly-throughs, and line-of-sight analysis to support realistic mission planning and rehearsal. Fourth, commanders specify the content of high-resolution terrain information data they need to make decisions. Lastly, updating procedures will allow integrating field-derived information into local and national databases. Attributes that can be determined on the ground (such as stream velocity, bank height and bridge classification) can be captured and integrated into the database – potentially making every soldier a viable collector of terrain information.[25]

Although this concept of treating MSDS packages like products seems to be a reasonable approach, it will be difficult for the services to move rapidly into the future for three significant reasons. The first is that NIMA currently meets most of its terrain information needs with legacy products. Secondly, several aspects of the Foundation Data concept require new training strategies. Modifying current topographic training is not sufficient. This new training will include changes in technical topographic training and the military decision-making process in which ordering an MSDS is an explicit step to basic map reading. Lastly, NIMA's current

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[25]Pierce, 11-12.

holdings of this new data are relatively sparse, because the concept is still in the initial stages of development.[26]

JOINT VISION 2010 AND JOINT VISION 2020

The introduction of the Joint Vision documents facilitates change in the conduct of war and lays a conceptual foundation for future forces. This conceptual change also affects the general understanding of America's role in the global community, national sovereignty, threats to the nation's security, the nature of economic competition, and the requirements to succeed in that competitive environment. This transition between the industrial and information ages produces uncertainty and unprecedented change.

Joint Vision 2010 (JV2010) provided the joint conceptual framework to guide the continuing transformation efforts in building the most effective force for the United States.[27] The framework identified four operational concepts intended to focus development of the service-specific core competencies towards future joint capabilities. Those future capabilities depend upon realizing the potential of information age technologies. In Joint Vision 2010 depicted information superiority as the sole enabler connecting the four concepts: dominant maneuver, precision engagement, full-dimensional protection and focused logistics. The synergy obtained among these four concepts will enable the military forces to dominate the full range of military operations from humanitarian assistance to full-scale conventional war as illustrated in Figure 1 below.

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[26] Ibid, 13.

[27] Department of Defense, *Joint Vision 2020.* Washington, D.C., June 2000, 1-2.

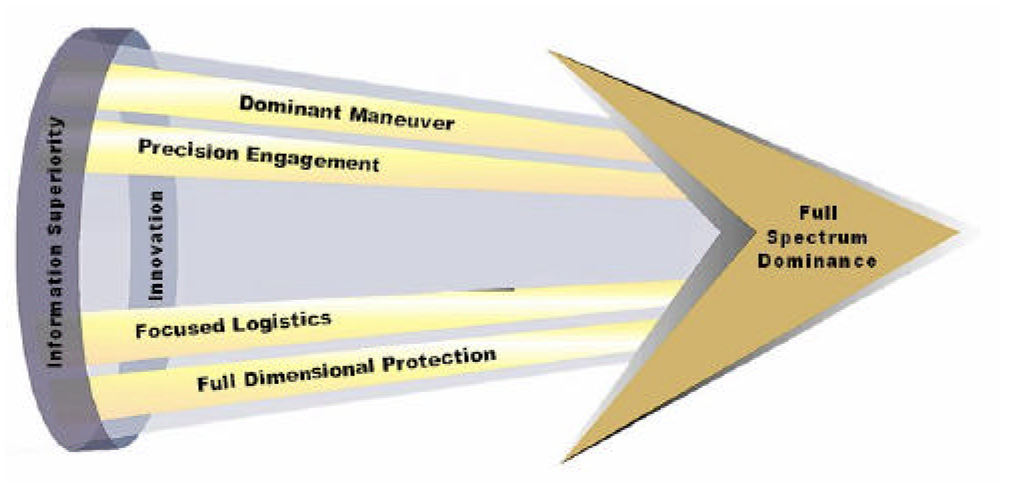

Figure 1. Tenets of Joint Vision 2010/2020.[28]

Information superiority is defined as "that degree of dominance in the information domain which permits the conduct of operations without effective opposition."[29] Essentially achieving information superiority provides the operational commander the ability to see and hear virtually anything of importance to his operation. This secures and provides the commander with the operational advantage to accomplish the mission while exploiting or denying the enemy's capability to do so.[30]

The subsequent Joint Vision 2020 (JV2020), issued in 2000, built upon the themes introduced in Joint Vision 2010, but changed the attention paid to information superiority from technological innovation toward a concept labeled 'decision superiority'. Concisely defined, decision superiority is the ability in combat to arrive at and implement better decisions faster than

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[28]Department of Defense. Joint Vision 2020 Briefing, available from http://www.dtic.mil/jointvision/jvpub2.htm, Internet, accessed 18 December 2002, adapted from slide 11.

[29] Department of Defense, Joint Publication 1-02, *Dictionary of Military and Associated Terms*, 203.

[30] Department of the Army, Field Manual 3-0, *Operations*, 11-2.

the enemy can react. In noncombat situations, decision superiority is the tempo that allows the friendly force to shape the situation or react to changes and accomplish its mission[31]

A military unit possesses decision superiority when the competitive advantage provided through information superiority has been effectively converted into superior decisions and timely actions. Geospatial information references locations on the surface of the earth incorporating the domains of land, sea, air and space and, as such, becomes the foundation upon which all other battlespace information is integrated. Geospatial information provides the basic framework for battlespace visualization, planning, decisions and actions. Without geospatial information, information superiority and subsequently decision superiority cannot succeed.

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[31] Department of Defense, *Joint Vision 2020*, 7.

Operational concept	Elements	Geospatial contributions
Dominant Maneuver	Decisive speed	Know where to go and the fastest way to get there
	Positioning and Repositioning	Know locations of combat elements
	Massed effects	Know locations of enemy forces and civilian enclaves
Precision Engagement	Right target	Know enemy and friendly locations
	Right weapon	Know the terrain and environmental effects enables correct weapon choice
	Desired effect	Knowing building materials enables knowledge about effects
Full-Dimensional Protection	Theater assets	Know locations of all assets
	Protection	Know weather effects on personnel and equipment
Focused Logistics	Right place	Know precise locations
	Right time	Know length of time required to arrive at location

Figure 2. Geospatial Contributions to JV 2020 Operational Concepts

As illustrated in Figure 2 above, geospatial information fully supports and complements the elements of each tenet of JV2020. Each of the four operational concepts possesses definitive elements. Geospatial information provides specific data in support of each element, contributing precision in each element and enabling a more coherent understanding of the battlespace.

ARMY TRANSFORMATION

Like Joint Vision, an underlying concept for Army transformation is information superiority and the exploitation of information. Geospatial information will provide the framework to maintain the information superiority crucial to future operations. The future security environment demands that the United States be prepared to face a wide range of threats, which will require operations based on rapid force projection, rather than forward presence. The United States Army has embarked upon its own path of transformation. In the *Army Transformation Roadmap*, Chief of Staff of the Army General Eric Shinseki and Secretary of the Army Thomas White stated,

> The Army is taking a phased approach to developing its capabilities over time. In the near term, we are focusing on fielding the Stryker Brigade Combat Teams, "digitizing" the Legacy Force by creating a common operating picture and enabling the heavy force to harness the power of information, while designing the Objective Force. In the mid-term, we will complete the fielding of Stryker Brigade Combat Teams and the digitization of the Legacy Force, and begin fielding the Objective Force. In the far term, we will continue fielding the Objective Force, even while seeking the next "leap ahead" in our capabilities. The Army views Transformation as a continuous process; we will never cease in our efforts to set and dominate the terms of military competition.[32]

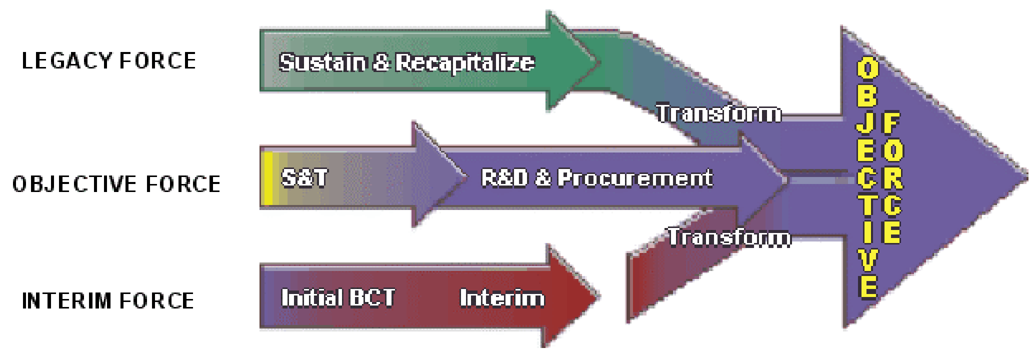

Figure 3. Army Transformation.[33]

The Army will transform and maintain land power dominance. During the transformation, the Army will possess components of three force designs: the legacy force with

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[32] Department of the Army, *Transformation Roadmap*, available from http://www.army.mil/vision/Transformation_Roadmap.pdf, Internet, accessed 16 February 2003, viii.

[33] Department of the Army, Transformation Briefing, January 2002, available from http://www.army.mil/vision/Transformation/index.html, Internet, accessed 16 February 2003, adapted from slide 2.

selective modernization, interim force and finally, the objective force (see Figure 3 above). The Army's goal (in view of the Objective Force) is to have a force that is more responsive, deployable, agile, versatile, lethal, survivable and sustainable than the current force. For soldiers, cultural change is something not yet fully understood or appreciated. Notwithstanding the inherent challenges, the Army is implementing changes that will provide future warfighters with effective and efficient organizations.[34] Full integration of geospatial information systems across the force is demonstrated in the placement of terrain teams at lower echelons.

The Legacy Force will guarantee near-term warfighting readiness, while maintaining existing capabilities. Designated formations will selectively recapitalize and modernize. Modernization includes the insertion of digital technologies to provide greater situational awareness. Under the Force XXI modernization program digital terrain teams are located within the maneuver brigade.[35] Digitization is a term widely used to describe various technological efforts to improve battlefield operating systems. Digitizing the battlefield is the application of technologies to acquire, exchange, and employ timely digital information throughout the battlespace, tailored to the needs of each commander. Digitization allows each soldier to maintain a clear and accurate vision of the battlespace. Digitization provides the warfighters a horizontally and vertically integrated digital information network that supports warfighting systems and assures command and control (C2) decision cycle superiority. The intent is to create a simultaneous common operating picture of the battlefield from soldier to commander at each echelon.

The Interim Force fills the near-term capabilities gap between the Army's heavy and light forces and will leverage today's state-of-the-art technologies to bridge the capabilities gap

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[34] Garrett, "Evolving Battle Staffs", 36.

[35] Transformation Briefing.

between today's Legacy Force and the arrival of the Objective Force.[36] The Stryker Brigade Combat Teams (SBCT) will validate organizational and operational models for the Interim Force. Most of the SBCT's development effort has been on fighting capabilities and configuration. However, because the SBCT's effectiveness is dependent on information superiority, the SBCT structure reflects the incorporation of information technologies. Recognizing the need to exploit geospatial information resulted in the assignment of an organic terrain detachment within the Maneuver Support cell, a special supporting staff element.[37]

The critical transformation path, and the main effort for transformation, leads to an Objective Force that is strategically responsive and deployable, versatile and agile, and sustainable for extended regional engagement and sustained land combat. Because the Objective Force is projected to have combat capable "boots on the ground" capabilities within 96 hours[38], the Army's rapid deployment schedule does not provide enough time for the force to conduct extensive mission rehearsal. Therefore, the survival of and success of the deployed force require superior situational awareness and accurate, relevant geospatial knowledge.

DIGITAL PRODUCT TRANSFORMATION

In the digital topographic world, there are three types of products. Standard products are hardcopy or softcopy products mass-produced for the Department of Defense and are available through the supply system using a national stock number (NSN). Nonstandard products also include hardcopy and softcopy items but are not mass-produced. Local terrain teams create these products using the Digital Topographic Support System (DTSS) and tailor these products to

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[36] Ibid.

[37] Department of the Army, Field Manual 3-21.31, *The Stryker Brigade Combat Team*, (Washington, D.C., 13 March 2003), 1-37.

[38] Transformation Briefing.

support specific operations. A third category, such as TerraBase products, is created at the unit/user level.[39]

The Army may have been reluctant to exploit digital information products in the past, but the tide is quickly turning and the organization as a whole has no choice but to move forward with the technological advances. With the proliferation, sophistication, and availability of digital technology in the late 1980s came the natural impulse to apply digital solutions to battlefield functions. The Engineer School developed the DTSS to provide engineer terrain teams with automated assistance performing terrain analysis and creating topographic products. The DTSS were originally fielded at the division level and above. Other Battlefield Operating Systems (BOS) were simultaneously developing automated tools to assist in collecting, analyzing, and disseminating information relevant to their unique requirements. These evolved with the addition of other systems into the ABCS (Army Battle Command System), which today consists of 11 separate systems.[40] Data entered into a network is not linear in nature - observations made and entered into the network are immediately available on the network. Because networks are not hierarchical, the receiving, storing, displaying and the disseminating information by the system occurs at a more rapid pace than was possible in a non-digitized unit.

The DTSS provides quick and accurate tactical terrain analyses and digital topographical products in support of mission planning, decision making and combat operations that greatly enhances the effectiveness of the Army in meeting its combat mission. The DTSS software, largely successful at the technical level, permits enhancements through software upgrades and DTLOMS adjustments. Since it is able to leverage commercial software, the DTSS is a fully

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[39] Christopher E. Kramer, "*Terrain Analysis Considerations*," available from http://call.army.mil/products/newsltrs/01-19/01-19ch3.htm, Internet, accessed 12 September 2002, 9.

[40] Eugene Snyman and Kenneth Bergman, "Engineer Digital Command and Control," *Engineer* (April 2002): 16.

integrated member of the ABCS and is a stable, reliable system in the field. Unique government applications provide added functionality to process digital terrain data. The Joint Mapping Toolkit (JMTK) was designed to serve as a common system for terrain-data displays and some embedded-data analysis throughout ABCS. Problems with the JMTK release led to the variety of display software as each system sought its own display tool. As such, there are currently seven different terrain-data display software packages within ABCS, which prevents commonality in terrain-data representation and functionality.[41]

The current ABCS have system problems because data connectivity and transfer between lower (below brigade) and upper (brigade and above) levels of the tactical Internet are not seamless. For example, obstacle overlays generated at task force, brigade or division level do not digitally transfer from the Maneuver Control System (MCS) to Force XXI Battle Command Brigade and Below (FBCB2) platforms. Secondly, FBCB2 cannot generate the data tags for many different overlay symbols, such as obstacles tracking using the doctrinal obstacle numbering. The Maneuver Support Center at Fort Leonard Wood, Missouri (MANSCEN) is developing campaign plans to ensure future updates and system developments address and rectify these problems. This includes a FBCB2 screen that automatically updates a relational database, allowing each status update to override existing data. This database in turn would automatically update an overlay that is auto-posted to other MCS screens – therefore, data entered on FBCB2 screens would essentially create an automatic, real-time, dirty battlefield overlay.[42]

The Force XXI structure created a brigade-level terrain analysis team fully supported by the DTSS, allowing brigade tactical operation centers (TOCs) to receive and display digital information including movement rates, vegetation, soil and slope analysis, line-of-sight (LOS)

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[41] Ibid, 18.

[42] Eugene Snyman and Jeffrey A. Bedey, "Assessing Engineer Priorities in the Division Capstone Exercise," *Engineer* (February 2002): 14.

analysis and time-distance factors. During a recent capstone exercise, a division terrain team successfully received a digital terrain data update of several gigabytes via satellite from NIMA, validating one aspect of the reach-back capability proposed in transformation discussions. Many examples exist that illustrate the general movement toward consistent interest, understanding, and utilization of terrain visualization among maneuver commanders. Improvements to this capability fall into three categories. First, the Engineer School must address several training issues. Terrain teams need tactics, techniques and procedures (TTP) to increase the proficiency of the complex and perishable skills required by a terrain analyst. Additionally, engineer staffs and ABCS users need training to know what products to request, when in the planning and execution cycles to request them, and how to use these geospatial products. Second, there are technical issues with the way geospatial products are stored, managed, and used in TOCs. No proponency has been established for the map server on which all maps are stored and which is integrated into the ABCS architecture. The ABCS also lacks an effective common tool kit to view and manipulate map data across all ABCS systems. Both of these issues are being resolved for future updates to DTSS and ABCS. The third issue involves dissemination of data from national sources to maneuver commanders. Although the NIMA-to-TOC transfer of map data worked, it was not without challenges. The Global Broadcast Service (GBS) that facilitates the data transfer was heavily dependent on contract support. The Engineer School is currently working to educate other maneuver community members on this critical data transfer capability.[43]

Additionally, several publicly documented instances have demonstrated that units can exploit GIS data without having the luxury of a dedicated terrain team or high-end GIS capabilities. For example, in 1999 the Minnesota National Guard at Camp Ripley, Minnesota developed a sophisticated database, integrating more than 75 data layers to develop and test tactical use of administrative GIS data layers. Their experiment was based on selecting the best

[43] Snyman and Bedey, 15.

sites for conducting a river crossing operation. While their experiment was a success in proving GIS capabilities are available to units without high-end systems like the DTSS, it also showed that the appropriate hardware and software, a GIS-competent operator and resident database were essential to that success.[44] Additionally, an engineer battalion deployed to the National Training Center in 2001 provided relatively sophisticated terrain products using programs downloaded from the Internet and data supplied by their post training area management office.[45] While these are both 'good news' stories, several issues remain. The data was for routine, established areas. The operators may have understood only a single software program, which also poses further interoperability issues. With the current geostrategic operating environment, routine data and access to a singular program is unlikely to provide or support the geospatial requirements of the commander.

However, taking advantage of current and future technologies, the Objective Force commander will have at his disposal tactical decision-making aids, collaborative and interactive planning tools, real-time access to reach-back expertise and resources, and the ability to conduct mission rehearsals on the move. These capabilities will be facilitated by enhanced systems that will enable the information superiority to see first, understand first, act first, and finish decisively.[46]

ABCS AND BATTLESPACE VISUALIZATION

Topographic engineers, the mapmakers of the past, are becoming the terrain visualization experts of the future. Tailored prints and digital maps will be there for the soldiers in the field

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[44] Tim Rensema, Craig Erickson and Steve Herda, "GIS – The Bridge into the 21st Century," *Engineer* (April 2000): 34-36.

[45] Charles Driscoll, "Masters of Terrain," *Engineer* (February 2002): 36-38.

[46] Snyman and Bergman, 20.

who need them. Geospatial products will be locally produced and provide critical mission specific information. However, to produce information dominance the Army must provide the maneuver force commander with instant comprehension of the terrain and its effects. Terrain analysis attempts to describe completely the area of operations in militarily significant terms.[47] History is replete with examples of tactical successes achieved by commanders with the ability to use terrain visualization to their advantage and the enemy's disadvantage. For example, in 1815 at the Battle of Waterloo, Lord Wellington placed his troops on the reverse slope of the ridge, effectively mitigating the effects of Napoleon's artillery and providing cover for his own formation. The most successful commanders possess the ability to "see the terrain" and its effects on combat operations. To see the terrain is to understand how the terrain affects both enemy and friendly mobility and the commander's ability to mass, disperse, observe, deploy and kill the enemy with direct and indirect fires. Terrain products give the commander and staff the ability to visualize the battlespace and insights into how to fight on that particular terrain.[48]

To improve agility, all commanders need a way to obtain and use timely battle space information so they can consistently make informed decisions faster than the enemy. Making and communicating battlefield decisions faster than the enemy permits the unit to operate at a tempo that keeps the enemy off balance and stifles his ability to react effectively. This speed is especially important for smaller contingency forces that need every available advantage to defeat an enemy. Digitization provides warfighters with horizontally and vertically integrated information networks that assure C2 decision cycle superiority.[49]

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[47] Dennis R. Powell, *Computer Based Terrain Analysis for Operational Planning* (Los Alamos, NM: Los Alamos National Laboratory, 1987), 2.

[48] Leon J. LaPorte and David F. Melcher, "Terrain Visualization," Military *Review* (September-October 1997): 76-78.

[49] Mark D. Calvo, "Digitizing the Force XXI Battlefield," *Military Review* (May-June 1996): 68.

Because information is the currency of command,[50] the common operating picture (COP) provides a single display of the relevant information available on friendly, enemy and environmental elements within a commander's area of interest and displays that information on a common map. This capability helps commanders make timely decisions about force requirements and direct resources and forces to where they are needed in theater, enhancing the commander's battlespace awareness.[51] Through battlespace awareness, the commander knows where everything is of military significance in his area of operation.[52] The COP is a combination of visual products by which a commander and staff can digitally build, display and maintain a clear, accurate and common view of the battlespace. The COP allows collaborative interaction and real-time information sharing without providing too much or too little information necessary for decision-making and battlespace visualization. The Army continues to invest in technologies and to develop procedures that increase commanders' ability to understand the battlespace. These modernizing efforts will increase the capability to share a full-dimensional, highly accurate COP and disseminate guidance, orders and plans. Technological applications, such as the ABCS, that help visualize, illustrate, brief and rehearse options contribute to a common understanding of the commander's intent and concept of operations.[53]

In the information age's increasingly automated environment, battlefield synchronization is undeniably paramount. Information age battlefield synchronization relies upon efficient and effective control and use of information. The Army endeavors to create battlefield visualization or total situational awareness by combining command and control systems from each of the

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[50] Sullivan and Dubik, 44.

[51] Department of the Army, Headquarters, Field Manual 3-0, *Operations* (Washington, D.C., 14 June 2001), 3-6.

[52] LaFace, 35.

[53] Department of the Army, Field Manual 3-0, *Operations*, 11-14 -11-15.

combat functions into one integrated system. Terrain visualization is an important part of that process, for it is the process through which a commander sees how terrain influences battlespace in both his and the enemy's operations.[54]

Battlespace dominance depends on the ability to leverage the technologies that generate precision forces and weapons and to enhance these assets with efficient and effective command and control. Information is important in the evolving concept of knowledge – a concept dependent on synchronization. Information must be accessible and shared through system interoperability and used in coordinated battlefield operations. Even so, the mission, commander's intent and operational concept continue to serve as the road map to success and the frame of reference used to filter the constant information flow to get the right information at the right time and place to achieve overwhelming information superiority and battlefield success.[55]

Eventually, terrain visualization will be less dependent on hard copy maps and products. Current and future technologies are digital, information-based capabilities that are directly linked into battle command systems. Engineers continue to refine their capabilities to visualize the terrain and translate that into meaningful information that the maneuver commander can use to fight and win on the battlefield. Terrain visualization brings the battlefield alive for the maneuver commander. It enables the commander to see how he and the enemy will fight, allowing him the opportunity to use terrain as a weapon. The truth is we do not know where we will fight tomorrow, which is why the ability to visualize the terrain and battlespace is critically important today.

With any operation, the fastest and most efficient method of imparting complex data to another person is through use of visual aids. With computer and digital transmission, our ground

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[54] LaPorte and Melcher, 75.

[55] Garrett, "Evolving Battle Staffs", 19-20.

forces have acquired the potential to use this second sense (sight) to supplant the traditional method of remote information understanding (hearing).[56]

To see the battlespace holistically and precisely, future commanders at all levels will rely on maintaining a common appreciation and visualization of all the collective, synergistic aspects and dimensions of the dynamic, ever-changing battlespace. Without a common appreciation of ongoing battlespace conditions, what is actually happening throughout the area of operations remains for the interpretation of each commander, or any individual with access to the shared information flow. Sharing one common map and set of conditions with all commanders through a network ensures examination of the right data for decisions, a shared basis for understanding the battlefield throughout the command and maintenance of a single frame of reference for examining solutions.[57]

Digitizing the force allows a relevant common operating picture of the battlespace to be created and shared electronically by all commanders, staffs and soldiers. Hence, pace will rapidly increase, resulting in a higher operations tempo (OPTEMPO) and greater battlespace dispersion. These shared information-age advantages will reduce battlespace uncertainties and shorten the length of the decision cycle.[58] Last-minute changes in plans could then be much more profound without the traditionally associated confusion. All of this stems from the ability to disseminate information and orders quickly down across several levels with minimal degradation in the understanding.[59]

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[56] Robert L. Bateman, "Avoiding Information Overload," *Military Review* (July-August 1998): 7.

[57] Garrett, "Evolving Battle Staffs", 28-29.

[58] Ibid, 26.

[59] Bateman, 58.

DIGITAL VULNERABILITIES

At the same time that the DOD has infused these technological advances into operations at an ever-increasing rate, the DOD has gone from being the driving force in information technology to being a specialty user. The DOD, by policy and by necessity, finds itself in a new situation, relying upon commercial-off-the-shelf (COTS) technology in order to acquire and field cost-effective systems. The widespread proliferation of information age technology, as well as DOD's increased reliance on COTS products, has contributed to a significant increase in vulnerability.[60]

The DOD's increasing reliance on COTS hardware and software increases vulnerabilities by making military systems familiar to sophisticated adversaries and by exposing them to software developers and technicians who may not be subject to security regulations. Hence, design and acquisition procedures need to consider security and minimize exposure; some systems may be too sensitive to rely upon COTS designs or procurement. This reliance upon COTS products also has a deleterious impact upon the United States government's in-house capability to maintain the expertise to adapt COTS systems and to create capabilities not necessarily needed by the commercial sector. In many cases, these systems will need revision to maintain interoperability with new systems, a process that necessitates the linkage of COTS systems with military requirements. This means not only building linkages between systems, but also having the capacity to reengineer the systems and processes that the systems support. COTS reliance in military systems is very different from relying upon commercial systems. Plans for the DOD to rely upon commercial satellite communications systems must recognize that other clients can make demands on these systems and may limit the DOD's access to them in times of crisis. Moreover, the design of commercial systems does not always allow for graceful

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[60] Ibid, 44.

degradation or full back up in the event of system failure. Therefore, basic availability may be an issue when relying upon commercial systems, particularly in times of crisis. Contractual arrangements and contingency plans for crises must address the availability issue.[61]

The use of COTS hardware and software also deeply affects field units. While the DTSS possesses an adaptable system, COTS products add significant capabilities not currently a part of the DTSS suite. Frequently the Army does not field these COTS products across the entire Army. Rather, the individual units purchase the COTS products with their own funds, which presents issues for individual soldier training and data. When field units purchase COTS products, they must be compatible with the DTSS architecture and capable of exploiting common formats for interchangeable terrain visualization data if they are to enable terrain teams to build, modify, and annotate data in the field. Constant review of COTS products should provide capabilities for potential incorporation into future DTSS enhancements. In addition, many of these COTS products are proprietary in nature, where the local user can manipulate the information but cannot update the data. Invariably, to update the database with user-specific information, that information must return to the product developer for incorporation into the database, adding many hours and expense to the maintenance of the geospatial information. However, the recent establishment of NIMA's National Center for Geospatial Intelligence Standards intends to ameliorate these issues by establishing the standards that all services and support agencies must use.

Instead of the DTSS, the Engineer School currently uses TerraBase in engineer officer training, to support the expectation of maneuver commanders that the engineer remain the terrain expert. The program functions include line of sight, slope and elevation analyses; terrain categorization; and oblique and perspective views. However, the program is limited in that it

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[61] Ibid, 69-70.

does not consider the effects of vegetation, hydrology or weather. Another limitation is that data for many locations may not be readily available in a compatible format. The program, also available through Internet download, is provided on CD-ROM to engineer basic, advanced, and pre-command courses and once annually to Command and General Staff School (CGSC) Army engineer students. However, there is no formal training for officers in other branches.[62]

As the sophistication of military information systems support structure grows over time, the inherent vulnerabilities become more important. First, all military equipment is in danger of capture. Hence, steps must be taken to prevent equipment loss, to ensure that losses are known, and to frustrate enemy exploitation of captured systems. Important defensive systems include but are not limited to unique keys to identify and authorize users on particular systems, devices that report the location of key hardware and equipment items via satellite, authentication procedures and security codes.[63]

As forces become increasingly networked, the risk of penetration increases. Additionally, the mere task of noticing a penetration or attempt becomes more difficult. Often system problems cannot be readily diagnosed as natural or as the product of information warfare attacks. A single penetration can be exceptionally damaging, particularly in a richly connected information system. The knowledge that the system/databases have been penetrated and may be corrupted can greatly inhibit decisive and effective decision-making. New security defenses are necessary to detect, assess, and counter such attacks.[64]

Similarly, text and data mining, or ‘electronic dumpster-diving’, creates another vulnerability. Data mining, available to anyone, has become the most productive means to sift for

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[62] Kramer, 8.

[63] Alberts, 66.

[64] Ibid, 67.

information from the deluge of data that resides in or flows through cyberspace. Data mining provides ready access for discovery, theft or competitive advantage. In addition, data mining approaches classified sources in quality and information that a military organization (or even a private citizen) may not realize it possesses.[65] Additionally, these actions may go completely unnoticed.

Misinformation, even the smallest amount, can negate the benefits of increased quantity and quality of information. Previously, it could be reasonably assumed that the information received through the chain of command was reliable. With the free flow of information derived from the chain of command and the subsequent introduction of many new and perhaps unproven sources of information, the information environment can no longer be treated as fully reliable. However, network centric warfare principles contribute to the abilities to spot, question and deal with misinformation – bringing more intelligence on a problem increases the likelihood that misinformation and its sources are harmlessly removed.[66]

It may be a decade or more before the military sufficiently understands the implications of the doctrine introduced by JV2010 and JV2020, which raises several problems in addition to training and education. The current generation of satellites is reaching obsolescence. Given the lead times for design and development, decisions about the next generation of satellites must be made now. The rapid development of commercial space and the increasing likelihood that the ability to use space freely will become threatened compound the issue. Additionally, the awareness that accompanies access to space will bring with it inevitable incentives to deny the use of space to others in time of conflict or crisis. In the worst case, interdiction could include attacks on satellite systems or the ground infrastructure that supports them. Following a major

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[65] Alan D. Campen, "Intelligence is the Long Pole in the Information Operations Tent," available from http://www.us.net/signal/Archive/Mar00/intelligence-mar.html, Internet, accessed 17 February 2003.

[66] Alberts, 68.

service war game in 1997, then Secretary of Defense Cohen was briefed that "future adversaries will seek to reduce our information dominance… It is to their advantage to render any of our space systems useless, thereby giving them parity in space which ultimately gives them asymmetric advantage." Continued technological innovation and adaptation will be vital to maintain the information dominance currently enjoyed and upon which JV2020 rests.[67]

Commanders must keep in mind that the information they will use to make tomorrow's decisions on the battlefield relies upon the capabilities of the satellites built and launched today.[68] Observation satellites are the immediate concern, although commercial communications and navigation satellites also pose military concern. Two considerations bring observation satellites to the fore: the great value both psychologically and militarily of the visual data they supply and the greater vulnerability of observation satellites to a wide variety of countermeasures compared with other types of satellite. Because of these considerations, observation satellites seem likely to be the first targets of intentional malicious interference.[69] The biggest military value of commercial satellite imagery is pre-hostilities – perhaps to map precise of target locations. However, once hostilities begin, the commercial systems may need to shut down to protect them from attack: a shut down or be shot down situation.[70]

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[67] Thomas Behling and Kenneth McGruther, "Planning Satellite Reconnaissance to Support Military Operations," available from http://www.cia.gov/csi/studies/winter98-99/art10.html, Internet, accessed 3 November 2002.

[68] Amy Wallace, "Enemy Geospatial Engineers: We Are Not Alone," *Engineer* (February 2002): 34.

[69] James Oberg, "Spying for Dummies - The National Security Implications of Commercial Space Imaging, " *Spectrum Magazine* (November 1999): 1.

[70] Ibid, 7.

CONCLUSIONS and RECOMMENDATIONS

Geospatial information provides the foundation and basic framework for information superiority, the common thread in Joint Vision and Army transformation but not without limitations in training, materiel, and existing support agencies. Within the current military environment, the Army can expect continued rapid advancements in technology and geospatial information systems and increased reliance upon information management and other agency support services. Digitization and increased technology provide the commander and staff with an exponential increase in information. It is critical that the commander identify what information he needs to make decisions or to change his vision of the battlefield.

An information age transformation of the DOD requires a military and civilian support workforce that has been properly educated and trained. People will need the right sets of skills and experiences. Although many military professionals are trained to use only specific BOS information systems, the emphasis needs to shift away from a focus on individual systems. All military professionals need to understand the entire ABCS network and the need to provide geospatial information consistent across the networked system. Although there has been progress in professional military education, the educational process needs to be revised and improvement accelerated to include significant changes in the curriculum. These changes would ensure that all students (not just ones that are in technical specialties) develop a sound technological understanding of information technologies (including their advantages, vulnerabilities, limits and applications) and their impact on military operations and affairs.[71] In addition, support agencies, such as NIMA, must ensure their personnel understand military requirements and are able to respond to those needs. NIMA must also begin processing and providing relevant data sets developed for user-specific needs as outlined in the Foundation Data concept.

[71] Alberts, 123-124.

For the Army, the concept of transformation leads to the Objective Force. Observations and lessons learned from Force XXI digitization initiatives and the SBCT structure will influence the doctrine that affects the design, training and employment of the Objective Force. The Legacy and Interim forces have already realized and profited from the inclusion of terrain teams at the maneuver brigade level; this enhancement bodes well for the Objective Force structure. To provide the geospatial information that commanders will require, the Army must also streamline and accelerate the acquisition process for incorporating COTS products and capabilities across the force so that units do not buy systems that may be incompatible with either the DTSS or the ABCS. The disparate individual training requirements stemming from multiple incompatible systems would be eliminated, because all terrain teams would possess the same hardware and software capabilities, which is not the case today. With 'pure-fleeting' the geospatial information systems, all terrain analysts would receive the same training on the same equipment.

Given that potential adversaries have access to virtually the same information and information technologies, the success in effecting DOD's information age transformation will determine the margin for victory. The ability to integrate a wide variety of systems into a true system of systems depends not only upon available technical skills, but also upon how well the processes, doctrine, organizations and culture adapt to take advantage of the opportunities that technology affords. Success depends not upon technical prowess, but upon the ability to adapt and leverage the capabilities provided by technology.[72] The ABCS holds much promise once the individual BOS components have been integrated by a common geospatial information baseline providing the framework for developing the common operating picture.

To avoid the potentially crippling scenario of system degradation based on information push-pull, the appropriate policy, doctrine and procedures regarding the use of information-

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[72] Ibid, 10.

networked systems must be developed and instituted. Education, training and practice are required to raise awareness of the issue and to develop the skills needed to operate in a degraded information environment. Network tools must provide warnings when the limits of the distribution system are approached and to help bring the situation under control. Additionally, the distribution infrastructure must maximize robustness and flexibility. The only certainty is that systems will not be used exactly as intended or under precisely the conditions assumed in their design, development and testing.[73]

Perhaps an important lesson learned is the reckless slighting of geospatial information during the preparation of any military plan, the conduct of any military operation, or the expenditure of scarce resources and funds on any military program. President Dwight D. Eisenhower, in an address at West Point in April 1959, stated it best: “The Principles of War are not, in the final analysis, limited to any one type of warfare, or even limited exclusively to war itself… but principles as such can rarely be studied in a vacuum; military operations are drastically affected by many considerations, the most important of which is the geography of the region.”[74]

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[73] Alberts, 62.

[74] John M. Collins, *Military Geography for Professionals and the Public*, available from http://www.ndu.edu/inss/books/milgeo/milgeocontents.html, Internet, accessed 14 September 2002.

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