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15. SUBJECT TERMS
This report is a product of the United States Air Force Scientific Advisory Board Committee on Science & Technology and the Air Force Vision: A Critical Partnership and Strategy for the Future. Statements, opinions, recommendations, and conclusions contained in this report are those of the committee and do not necessarily represent the official position of the U.S. Air Force or the Department of Defense.
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Science & Technology and the Air Force Vision Achieving a More Effective S&T Program

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There are considerable on-going efforts within the Air Force Research Laboratory (AFRL) to improve the science and technology (S&T) program. Each year the Air Force Scientific Advisory Board (SAB) conducts independent quality reviews within the labs. The reviews assess the quality and long-term relevance of the Air Force S&T program. Quality here is broadly defined to include science, people, strategy, resources, focus, facilities, and results. These reviews clearly indicate that the quality of the S&T program is improving and most of the projects are well focused on future Air Force capabilities.

However, based on extensive benchmarking, it is also apparent that a more effective S&T program can be achieved. This study offers recommendations that apply both internally and externally to AFRL. The members of this study team strongly urge that these recommendations be adopted.
Concerns Leadership Raised Surrounding S&T Program

- Air Force topline budget pressure
- Lack of an effective methodology for valuing and prioritizing S&T investments in warfighter terms
- Lack of visibility into the program
- Extent to which external S&T sources (defense, industry, academia) offset the need for Air Force S&T investment
- Efficiency of S&T program execution

Enormous Air Force topline budget pressures adversely impact modernization and infrastructure as well as emerging mission area resource requirements. The S&T program has taken substantial budget cuts as a consequence.

There is a lack of an effective methodology for valuing and prioritizing S&T investments in warfighter terms. Hence, the benefits of an increased (or decreased) S&T investment versus other needs are unclear. It is also unclear what the core science investment contributes to the longer-term needs of the Air Force. To some, the basic and longer-term research efforts appear to be a jobs program.

There is a lack of senior leadership visibility into the program. There are many projects spanning a wide variety of needs addressing the short, intermediate, and long term. The inherent complexity makes characterization of the S&T portfolio a significant communication challenge. Consequently, there has not been a shared sense of direction and buy-in at the executive level.

It is not clear to what extent non-Air Force S&T investments—for example, from the Defense Advanced Research Projects Agency (DARPA)—reduce the need for Air Force S&T investment.

Finally, the efficiency of execution is questioned. Leadership would like to see more bang for the buck. Many perceive that not enough gets out of the laboratories and into the hands of the warfighter, and that the transition process takes too long.
The S&T Vision Study was charted by the Secretary of the Air Force (SecAF) and the Chief of Staff of the Air Force (CSAF) as one of four studies for 2000. The Terms of Reference provided the following charter, and are based on the concerns previously mentioned:

1. Develop a technology investment strategy guided by the Air Force Long Range Plans, Air Force Vision, and U.S. National and Military Strategies. In addition, provide technology possibilities and/or opportunities.

2. Review industry investments to determine level of effort in Air Force S&T being mindful of the potential divestiture by industry in any given area.

3. Review the tools that industry uses to determine where to invest, form strategic partnerships, and recommend tools that can by used by AFRL.

4. Develop and recommend strategies for S&T investment at all levels to include industry partnerships, workforce implications, risk assessment, and hedges.

5. From the above, recommend a level for the Air Force S&T topline budget.
The study panel consisted of five retired generals (12 stars), three prior S&T laboratory commanders (two Air Force and one Army), three Air Force Chief Scientists (one current and two former), and numerous members from industry, academia, and Federally Funded Research and Development Centers with substantial S&T experience.

Panel members were divided into five teams. **Team 1** was led by Lt Gen (R) George Muellner. Members included MGen (R) Bob Rankine and Dr. Gerold Yonas. The team addressed the role of the Chief Executive Officer (CEO) in terms of guidance and participation in the S&T program. **Team 2** was chaired by Lt Gen (R) Mal O’Neill. Members included Dr. Art Chester, Dr. Matt Ganz, Dr. Keith Richey, and Dr. Bill Rouse. This team focused on the linkages with other organizations and the problems associated with the transition of technology from the AFRL. **Team 3** was overseen by Dr. Tony Pensa. Members included Col (R) Bill Byrne, Dr. Janet Fender, and Mr. Jim Mattice. The team evaluated topline funding guidelines and improved ways of leveraging external sources. **Team 4** was headed by Dr. Valerie Gawron. Members were Col Don Erbschloe, Lt Col Walt Hammond, and Ms. Teresa Lunt. This team documented the current Air Force S&T planning process, benchmarked the processes of comparable government agencies and companies, and reviewed studies on improving planning processes. **Team 5** was led by Dr. Dan Hastings. Members were Dr. Bart Barthelemy, Dr. Jim Hendler, MGen (R) Don Lamberson, and Dr. Elsa Reichmanis. The team examined people, facility, and organizational issues.

The roles of the remaining panel members are indicated on the chart.
The study team considered itself compliant with the Terms of Reference with the exception of recommending a level of investment for the Air Force S&T topline budget, which is explained on the following two charts.
Previous studies have established a comprehensive compilation of industrial S&T investment
- DSB 1998: Mr. Walter E. Morrow Jr./MIT Lincoln Laboratory
  - Basic research (0.05% to 3.5%)
  - Development focused research (0.05% to 15%)
- No unassailable way to establish topline from these data

Arbitrarily setting the topline, by whatever means, has a number of drawbacks. It restricts top leadership’s ability to manage the total budget in times of extreme constraints. It does not account for programmatic changes that naturally occur from year to year, such as the cancellation of a large program or the addition of a major new activity. Perhaps most detrimental, it can lead to an entitlement mentality within the organization.

In 1998, a Defense Science Board (DSB) study Chaired by Walter Morrow, former Director of the Massachusetts Institute of Technology (MIT) Lincoln Laboratory, conducted a comprehensive look at S&T spending in the commercial sector. The levels referred to are not easily associated with the Air Force S&T levels. In all cases, the study found that the amount of investment is driven by the core business technology needs and is determined through a bottom-up methodology. The commercial sector uses the technology investment “level” as a guideline. It provides a sanity check or test for reasonableness.
Industrial R&D investment determined by technology needs to support core businesses

- Budget adjustment consequences defined in terms of business impact
- Level of investment guidelines used after the fact to ensure “ballpark” posture relative to competition and historical levels

This study proposes an analogous process

- Provides Air Force leadership with insight into the content and value of the S&T program
- Defines budget adjustment consequences in warfighter terms
- Resulting topline should be tested (sanity-checked) against historical levels (1.8–2.2%) and special needs

Industrial research and development (R&D) investment is determined by the technology needed to support the business. Although the process varies considerably from business to business, it generally contains many common elements. Leadership provides a few guidelines that are consistent with the strategic plan and take into consideration extraordinary investment needs, such as a new product line, a major customer need, or a perceived competitive threat. The organization then recommends individual R&D projects consistent with these guidelines and normal business needs. Top leadership reviews the recommendations, taking into consideration affordability and using rule-of-thumb historical investment levels as a sanity check. Several iterations are often required to arrive at a final budget and a list of approved projects.

This study will propose a process for annually establishing the S&T topline budget based on warfighter needs (both present and future) and affordability. This allows the S&T portfolio to be characterized in terms of warfighting capabilities and the S&T core competencies required to enable those capabilities. The S&T investment can be valued against other compelling Air Force budget needs. At the end of this process, the S&T investment, as a percent of Air Force total budget, should be compared with historical levels, which typically are in the range 1.8 percent to 2.2 percent. This is analogous to the industry sanity check, and if the S&T investment is out of this range, the rationale should be explainable based on special circumstances or needs.
Create technology options in time to meet emergent warfighting needs
Shape the future (game changers—for example, stealth, GPS) and avoid technological surprises
Position U.S. industry to deliver and sustain technologically superior systems
Maintain in-house expertise to make good technology acquisition decisions—be a smart buyer
React rapidly to solve the Air Force’s technical problems (911 service)

The yin and yang of a successful S&T program are requirements pull and technology push—both are essential. The portion of the program pulled by requirements creates technology options in time to meet emergent warfighter needs, such as the engines and avionics of the F-22. But innovation arising from technology breakthroughs often creates new, previously unimagined, system concepts that can reshape future Air Force operations. Past examples of these “game changers” include stealth, the Global Positioning System (GPS), night vision, and Joint Surveillance Target Attack Radar System, all of which contributed markedly to the successful outcome in the Persian Gulf War. Initially these new concepts were reluctantly embraced by the operational community, but they have subsequently become essential elements of Air Force concept of operations (CONOPS).

Most of the Air Force S&T program is executed under contracts with industry in order to infuse new technology into companies that will eventually deliver and sustain the new weapon systems. However, some portion of the S&T budget must be directed toward AFRL in-house research to connect AFRL scientists and engineers to the global research community so they can select the right technologies to pursue on contract, be aware of the state of the technology developments of others, and rapidly react to solve immediate Air Force technical problems.

It is important to recognize that industry invests in S&T in an area unique to Air Force needs in response to Air Force investments in that area. Industry uses such Air Force investment as an indicator that the Air Force is serious about the development of that technology and its use in potential future systems.
Industry S&T is driven by the need to meet near-term financial objectives in the marketplace, and industry investment is driven by the business case. Air Force S&T is driven by the need to meet warfighter needs in the battlespace. As a result, industry prioritizes its S&T investments to capture near-term, high-return, and high-dollar-value programs. The Air Force, on the other hand, must prioritize its S&T investments to ensure that it has technically superior weapons and support systems that will enable continuing mastery of the aerospace domain. It is only when these industry and Air Force priorities coincide that the Air Force can depend upon industry S&T investments to address Air Force needs. Generally, industry invests when:

- A major system procurement is anticipated
- A broader market can be pursued
- The Air Force invests in S&T, leading to a future system acquisition

Anticipation of a major system procurement will drive industry to develop proprietary technology as a discriminator, but generally for near-term applications only. Long-term, Air Force—unique S&T is usually only accomplished by Air Force funding—either contracted or via an in-house effort.
Panel members visited, consulted with, or were briefed by numerous companies and organizations in industry, the Air Force, and other government agencies.

The panel focused on two primary technological areas in its sampling from industry—aerospace and information technology. In particular, common attributes and best practices were sought. Eight companies were selected on the basis of excellence in their respective markets as well as in-depth familiarity by the study panel members. In addition, the panel reviewed three companies (3M, DuPont, and Nokia) that were part of a recent global benchmarking study conducted by Professor Ed Roberts of the MIT Sloan School.

The Air Force organizations represent the key players and stakeholders in the Air Force S&T enterprise, including the planners (Air Staff), executors (AFRL), and customers (product centers and major commands [MAJCOMs]).

Finally, the Air Force S&T process was compared to and contrasted against those from other Services, Department of Defense (DoD) organizations, and government agencies, including the Defence Evaluation and Research Agency (DERA) of the U.K.
This simplified diagram depicts an S&T process extracted from companies with the best practices. The top leadership drives the process by articulating a clear vision accompanied by a few specific goals that are both an impetus to action and collectively drive the enterprise to a desired future state.

The strategic plan, customer needs (warfighter), and technology opportunities, in turn, drive S&T planning, which culminates in an S&T plan. Customer needs represent the user pull, and technology opportunities represent the technology push. It is critical that there is a reasonable balance between these two. The S&T plan consists of the individual projects and performance objectives clearly linked to major goals and critical future capabilities (CFCs). In addition, the plan addresses cost and schedule. The plan and the budget realities need to be rationalized through an iterative process that is depicted by the feedback arrow between “S&T Budget” and “S&T Planning.” The plan drives the execution phase. If cost, schedule, and technical performance baselines are established for S&T deliverables (primarily in the 6.3 portion of the portfolio), then those responsible for execution can more easily be held accountable.

Relative to this process, the SAB study identified three major areas (leadership, planning, and execution) where improvements would enhance the effectiveness of the overall S&T program. Leadership issues involve goal setting, advocacy, and accountability. Planning concerns relate to linking user requirements to individual technology projects, the transition from 6.3 to 6.4, and the inability to value the S&T portfolio. Finally, execution concerns center around leveraging external resources and maintaining a viable science and engineering (S&E) workforce.
Successful corporations are driven by a clear understanding of their vision. In *Built to Last: Successful Habits of Visionary Companies*, James C. Collins and Jerry I. Porras describes the habits of visionary companies, “they preserve a cherished core ideology while simultaneously stimulating progress and change in everything that is not part of their core ideology… the vision builds on the interplay between what we stand for and why we exist that does not change and sets forth what we aspire to become, to achieve, to create that will require significant change and progress.”

The vision is championed by the CEO and is widely shared throughout all levels of the organization. The vision provides the long-term strategic direction and includes a few critical goals without which the vision could not be achieved. Clear, compelling, measurable goals unite and drive the organization to achieve critical milestones on schedule and within budget. A goal should be challenging, exciting, highly motivating, easily communicated, and substantially achievable within a given timeframe.
The goals are a key input into the S&T planning process, although many other needs that must be addressed as well. The plan provides clear linkages between customer needs and the S&T projects. Even though the specific plans can cover extended periods of time, the goals and the progress toward those goals are reevaluated and reaffirmed or modified every year to adjust for changes in markets, competitive forces, suppliers, and relevant technology. Tools or methodologies are used to value and prioritize investment opportunities. Competitive pressures force the organization to avoid reinventing the wheel. As a result, the culture encourages “buy before make.”

The CEO holds the chief technology officer (CTO) accountable for achieving definitive milestones associated with the goals, including cost, schedule, and performance. In the absence of a few goals, it is more difficult to hold the CTO accountable due to the sheer quantity of disparate projects in a typical large S&T program.

Any S&T organization rises and falls with the quality of its people. While excellent facilities are important, it is people, either in teams or as individuals, who accomplish the mission. The people are supported by and supportive of a culture of excellence. This means that poor-quality work is not considered acceptable and is quickly expunged. It means that respect flows from the
quality of ideas, depth of analysis, innovation, and leadership shown by individuals in the laboratory. This culture of excellence is one that is never satisfied with the status quo, but is always interested in doing better, every year, by all metrics of importance in the organization. This culture of excellence is always pushing the people and organization to be “world class” in their work or to leave areas where they cannot achieve this stature.
Slide 14: Leadership

Outline

Leadership Vision & Guidance

Accountability

⇒ Leadership
- Goals
- Advocacy
- Accountability

Planning
- Development Planning
- Technology Transitions
- Portfolio Characterization

Execution
- Leveraging Partnerships
- Leveraging Commercial Technology
- Workforce Issues

Customer Needs (Pull)

Strategy

Technology Opportunities (Push)

S&T Planning

S&T Budget

Execution
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Fourteen Critical Future Capabilities (CFCs) appear in Volume 3 of the Air Force Strategic Plan:
- Comprehensively express needed Air Force responses to the “compelling demands of the future security environment”
- However, not specific enough to define a system concept leading to a technology plan

Critical Future Goals (CFGs) are needed that:
- Are derived from the CFCs
- Are explicit enough to be measured
- Are problems that evoke system concept solutions
- Move the Air Force toward its vision

Top leadership defines the few CFGs

The 14 CFCs in Volume 3 of the Air Force Strategic Plan provide a comprehensive framework for expressing needed Air Force responses to the “compelling demands of the future security environment.” However, they are not sufficiently specific to define a system concept leading to a technology plan. In fact, each could harbor a variety of system concepts.

Critical Future Goals (CFGs) are needed that represent the top leadership’s highest priorities. They should be expressed in a way that describes a needed capability and evokes system concept solutions. They should be derived from the CFCs and be explicit enough to be measured. There may be more than one CFG per CFC, but there also may be CFCs without CFGs. The important point is that the group of CFGs is championed by the leadership. The CFGs collectively describe the desired future state of the Air Force, and they define a timetable for achieving that future state. They make the vision real, understandable, and actionable. For example, finding targets under trees might be classed as a CFG. It responds in part to the CFC referred to as Precision Engagement—“Create precise effects rapidly, with the ability to retarget quickly, against large target sets anywhere, anytime, for as long as required.” Of course, a great deal more specificity would be required to make this example actionable.
The existing linkage between vision and enabling technologies is missing several important steps. CFCs are well stated and by intent cover a very broad spectrum. However, it is very difficult for the AFRL leadership to construct a prioritized S&T plan from these broad descriptions. Stated differently, almost any conceived S&T project can be linked to a CFC. Clearly stated CFGs would enable top leadership to express areas of particular importance and bring more focus to the process. CONOPS and associated system concepts would be developed by operators and development planners (to be discussed later). These concepts, in turn, would drive S&T execution plans to achieve the system concepts in a timely fashion. Hence, enabling technologies could be readily identified.

It is important to note that not all enabling technologies would be generated in this manner, only those that can be directly linked to CFGs. Other customer needs and technology push would evolve the balance.

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1 Air Force CONOPS 2020 provides the vision by articulating, in six mission areas, how aerospace power is executed. The 14 CFCs have been mapped to these six mission areas.
This example describes a 3-year S&T plan to create and demonstrate the capability to find, identify, and kill TUT. It demands focused investments in specific technical areas involving sensors, information technology, and advanced weapons. This achievement will make demands on many Air Force S&T and operational organizations and lead to a fundamental change in warfighting tactics and strategy. This goal, as part of an overall plan to deal with time-urgent relocatable targets, will motivate and stimulate a substantial portion of the Air Force S&T community and demand the integration of air, space, and information operations. This example is challenging, exciting, highly motivating, easily communicated, and represents a significant goal achievable within a given timeframe.
Leadership: Goal Setting

Recommendations

- Establish or reaffirm CFGs annually (SecAF, CSAF, and MAJCOM/CCs)
- Establish concept to achieve each CFG (Development Planning activity, addressed later)
- Create an S&T execution plan for each CFG (AFRL/CC)
  - Assign a program manager with budget authority for each CFG
  - Present execution plans for approval by SecAF, CSAF, and MAJCOM/CCs at annual review of entire S&T portfolio

The CFGs are established or reaffirmed by the top leadership (SecAF, CSAF, and MAJCOM/CCs) who spend quality time pondering, debating, and prioritizing critical future needs and capabilities within the Air Force. This is not envisioned as a staff job, although some staff preparation may be necessary.

A Development Planning organization, to be addressed later, establishes concepts to achieve each CFG by working closely with warfighters, product centers, and AFRL. AFRL/CC assigns a program manager with budget authority for each CFG. The program manager develops a detailed execution plan, including a roadmap that defines the end state as well as intermediate milestones and deliverables along the way. Enabling technologies are clearly linked to the milestones so that the S&T community not only understands the performance objectives, but also the time-critical nature of each S&T project. These plans are presented for approval at an annual review of the entire S&T portfolio by SecAF, CSAF, and MAJCOM/CCs.
Lack of MAJCOM sponsorship reduces the competitiveness of the S&T portfolio in the budget process

In these times of constrained budgets, S&T funding reductions are difficult to avoid. The S&T program element has taken its share of cuts; some would argue excessively so. The issue here is not so much the cuts, but the lack of representation during the budget-cutting process. S&T needs a voice like other budget elements. Top leadership should fully understand the implications of S&T budget cuts before making the final decision. When a group of senior leaders meets to balance the budget, it is always easier to cut someone else’s budget and even easier to cut the budget of someone who is not represented.

The 4-star sponsorship can bring the perspective and vision that is needed to close the gap between those in the S&T community who can envision future capabilities based on evolving technology and the warfighters who understand operations but lack the technical background to realistically project future opportunities based on new technologies.
Advocate and defend S&T budget to include both portfolio content and infrastructure roles (AFMC/CC)

The Assistant Secretary of the Air Force, Acquisition (SAF/AQ) advocates and defends the S&T budget in the Pentagon. In addition, uniformed 4-star advocacy for the S&T program and budget is essential. Air Force Materiel Command, Commander (AFMC/CC) should provide this advocacy.
There is no apparent agreed-upon baseline in the plan for cost, schedule, and technical performance for most S&T program deliverables.

Hence, it is difficult to hold the AFRL/CC accountable.

There are thousands of S&T projects each with cost, schedule, and technical performance requirements. Many of these project plans change during the course of a year for a variety of reasons. There is no apparent agreed-upon baseline at the beginning of the fiscal year, and certainly the baseline changes during the year.

At present, there is no two-way accountability involving both the deliverables on cost and schedule by the AFMC/CC and the provisions of adequate resources by the leadership. The annual review provides the opportunity to reaffirm the vision, strategy, and goals and to share information on discoveries and assess the progress toward the goals. It is vital that adequate resources are provided with sufficient predictability to deliver results without inefficient and demotivating reprogramming, rescheduling, and rebudgeting.

Although the AFRL/CC can be held accountable by individual customers, it is difficult to hold him accountable for the total S&T program. Establishing specific goals would bring more focus, alignment, and a sense of priority to the S&T program, making it easier to hold AFRL/CC accountable for delivering what is most important as defined by the Air Force leadership. In addition, more visibility into the S&T program would enhance accountability and buy-in by the leadership.
The AFRL/CC has the responsibility not only to lead the execution process, but also to represent the status of the programs to the Air Force leadership. He must also maintain a commitment to excellence by creating and sustaining a culture of innovation that is vital to future Air Force success in anticipating and dealing with emerging asymmetric threats. As stated in *Joint Vision 2020*, “An experimentation process with a low tolerance for error makes it unlikely that the force will identify and nurture the most relevant and productive aspects of new concepts, capabilities, and technology.” The annual review should seek to stimulate not only commitment and accountability but also the flexibility to make wise decisions in the face of uncertainty that permeates fields with rapidly changing technology.
Outline

Leadership Vision & Guidance → Accountability

- Customer Needs (Pull)
- Strategy
- Technology Opportunities (Push)
- S&T Planning
- S&T Budget
- Execution

⇒ Planning
- Leadership
  - Goals
  - Advocacy
  - Accountability
- Execution
  - Leveraging Partnerships
  - Leveraging Commercial Technology
  - Workforce Issues

Integrity - Service - Excellence

10/13/00
The Air Force lacks a systematic process for development planning. Specifically, there are no apparent means to evaluate cross-organization concepts and CONOPS, link operational requirements and concepts with technology, perform system trade studies, and prioritize S&T investments. For example, finding targets under trees could conceivably be accomplished by either an airborne platform or a satellite system. Rigorous trade studies need to be conducted, free from organizational bias, to arrive at an optimum solution.

The development planning activities formerly at the product centers have atrophied due to reorganization and lack of funding. The current Technology Planning Integrated Product Team process has not been directed toward focusing S&T investments through evaluation of future system alternatives. The Air Force needs to take lessons learned from these earlier and ongoing activities and establish an updated development planning function in which operators, developers, and technologists working together can rigorously work the trade space. The results of this process then provide a framework for setting priorities in the S&T program.
The study panel recommends that the SecAF and CSAF direct the creation of an institutionalized capability for development planning and establish a program element to fund it. AFMC/CC should provide the lead for the Air Force and ensure a system-of-systems focus across product lines. In addition, AFMC/CC (through its product centers) should ensure a bridge between user requirements and technology evolution. The mixing bowl process can be employed to provide a voice for all stakeholders.

The panel believes that the Army Materiel Systems Analysis Activity (AMSAA), a Field Operating Agency that has been used successfully for Army development planning, provides a candidate organizational model for Air Force development planning. However, the proposed Air Force activity should have a narrower focus than AMSAA and require strong coupling to product centers for product-specific systems engineering expertise. The panel envisions a small organization of highly competent people that draws on the resources of the product centers, MAJCOMS, and AFRL, and has senior leadership visibility. For this activity to have leverage and impact, it must not become a bureaucratic, staff-level exercise!

The development planning function should deliver options for consideration and enable the AFRL/CC to prioritize S&T investments to effectively support Air Force CFCs as detailed in
Volume 3 of the Air Force Strategic Plan. Functions performed by development planning should include:

- Assisting the warfighter in quantifying and refining operational capabilities
- Synthesizing and analyzing alternative concepts to satisfy needs
- Helping AFRL identify enabling S&T initiatives, impacts, and value
- Dealing with complexities at the system-of-systems-level
- Quantifying the value and total ownership cost of options
This chart shows a conceptual Air Force implementation of an AMSAA-like activity for development planning. The Development Planning Activity reports to AFMC and provides the Commander with an effective way to compare alternate concepts to meet a warfighter need or expanded CONOPS. For example, the requirement for finding and targeting tanks under trees might be addressed with space surveillance, helicopters, unmanned aerial vehicles (UAVs), or other means. The activity would act as an objective evaluator to advise the Commander on the benefits and risks of these competing systems’ concepts.

The Development Planning Activity should be organized in direct congruence with CFCs in order to focus on crosscutting technologies and CONOPS and systems-of-systems solutions rather than product-specific alternatives. The Development Planning Activity should participate with the Battelabs and Air Force systems analysis activities to expand the applicability of concept studies and drive future CONOPS.

The need for detailed engineering insights into product concepts requires a strong coupling within AFMC among AFRL, product centers, and the Development Planning Activity. The product centers must provide the necessary systems engineering insight while AFRL provides the technological possibilities. It is especially important that AFRL have a keen awareness of relevant commercial technology opportunities as well.
The Panel examined the transition of technology into operational systems. The Panel found organizational and budgetary barriers that impede transition from 6.3 to 6.4. The operator, developer, and technologist are organizationally separated, adversely impacting the planning and execution. Funding pathways are similarly isolated.

Also, concern has been expressed that the transition to 6.4 signals initiation of a major new system start, entry into the Defense Acquisition Board process, etc., which is not the case. In fact, the transition process begins long before this (while concepts are being evaluated), and acts to stimulate S&T evolution rather than commit the Air Force to a specific system.

The Panel was favorably impressed with the relatively new Applied Technology Council (ATC) process, which has been used at least once by every Product Center to review maturing technology. The ATC brings together warfighter, developer, and the AFRL and provides a decision forum where all parties can assess and commit to the 6.4 transition or terminate lower-priority 6.3 programs in favor of ones more likely to transition.
The Panel recommends unifying and expanding the role of the ATCs, which should provide a forum for selection and prioritization of concepts for system development that result from the development planning process described earlier. When competing concepts involve multiple Product Centers, AFMC/CC should chair the Council. In addition, the ATC should ensure effective linkage between concepts for system development and the S&T program. The operational MAJCOMs provide warfighter insights as well as Program Objective Memorandum advocacy. The ATC will include SAF/AQ representation, typically through Program Executive Officers or Program Managers.

The Development Planning Activity should provide staff support to the ATC. Since the development planning process begins early in the system life cycle, the ATC is able to expeditiously identify potential resource or other issues for transition. The development planner provides the baseline transition plan for the ATC and updates it as required due to changes in requirements or technology evolution.
The Air Force S&T program includes a portfolio of projects organized by six Integrating Technology Thrusts (ITTs): Space Superiority, Precision Strike, Information Dominance, Aircraft Sustainment, Aircraft Protection, Agile Combat Support. Although an attempt was made to relate the thrusts to the Air Force core competencies and, by inference, the CFCs (although they are not mentioned explicitly), the direct support of the Air Force core competencies is not clear. Some ITTs have similar titles to the core competencies, but others do not. The panel does not feel that this structure provides the necessary understanding or visibility into the S&T program.

An alternate S&T portfolio characterization, directly aligned with Air Force core competencies and the CFCs associated with each core competency described in Volume 3 of the Air Force Strategic Plan, would enable the contribution of S&T to the Air Force vision to be established, quantified, and managed. This would provide information needed to make informed decisions on how to trade off programs within the S&T budget, data to judge the contribution of external partners’ resources to Air Force needs, and insight that can be used by Air Force leadership to trade off S&T investment with other investments.
The characterization of the S&T portfolio must clearly show how the S&T investment enables the CFCs and CFGs (an example portfolio characterization tool is described in detail in Appendix A). The quantified contribution of each project supporting a CFC or CFG must be determined. The technical contributions might come partly from Air Force S&T and partly from other sources, such as other government agencies, industry, international cooperation, or use of commercial technology. The characterization would display the contribution from all partners. It would also provide an assessment of the health and relevance of technical competencies within the laboratories needed to support the CFCs and CFGs.

The characterization tool described in Appendix A represents the current status (budget, technical progress, cost, and schedule) of all the S&T projects. The characterization tool, supported by analysis, will help define the impact on CFCs and CFGs and the changes in budget, performance, cost, or schedule.

Viewed as a total across all CFCs, the integrated S&T portfolio will show the impact of S&T investment on the overall Air Force vision and will provide data for informed decisions regarding allocation of resources in the S&T program, as well as reallocation (plus-ups or cuts) between the S&T accounts and other accounts in the Planning, Programming, and Budgeting System process.
The SAB recommends that the AFRL/CC implement a characterization tool to provide executive-level visibility into the entire S&T program and the value of its elements to support the Air Force CFCs and associated CFGs.
Outline

Leadership Vision & Guidance → Accountability

Leadership
- Goals
- Advocacy
- Accountability

Planning
- Development Planning
- Technology Transitions
- Portfolio Characterization

⇒ Execution
- Leveraging Partnerships
- Leveraging Commercial Technology
- Workforce Issues
AFRL has always been incentivized to partner and is doing it well
- Many leveraged partnerships have been established
- Considerable savings have been realized
- Reduced S&T funding has reduced the opportunity

Partner must be able to project reasonable return on investment (satisfy the business case)

There are risks
- Government partners can reprioritize their funding support
- Industry partners can change their IR&D plans

With exceptions, financial benefits are not visible

The Integrated High Performance Turbine Engine Technology (IHPTET) program is a good example of a leveraged partnership. “Partnership” in this context means two or more organizational entities that pool their resources to achieve a common objective. The IHPTET program involves multiple organizational entities (the Army, Navy, Air Force, National Aeronautics and Space Administration [NASA], General Electric, Pratt & Whitney, and others). The principal objectives are to double the thrust-to-weight ratio, increase fuel efficiency, and reduce cost turbofan jet engines. Industry is contributing about 50 percent to the total effort.

In general, AFRL has done a good job of partnering and there are many examples, IHPTET being just one. Although they can always do better, partnering only works when all partners can justify the investment. Industry must be able to project a reasonable financial return. This generally means there are broader applications for the technology than DoD. In the case of IHPTET, the industrial partners are clearly looking at the opportunities in the commercial airline marketplace. The Air Force must justify the need on the basis of warfighter needs. Only when the needs of the warfighter sufficiently overlap the needs of industry (financial performance) are the conditions ripe for a partnership.

It appears that AFRL is not getting much credit for its partnership efforts to date, due to lack of visibility. The portfolio characterization tool will provide more insight.
The portfolio characterization tool provides visibility into funding contributions by funding sources such as industry or a government agency. Funding source detail is down to the levels of aggregated projects and technology competency and is linked to CFGs and CFCs. Data can be aggregated to provide an executive summary. Trends can be tracked to determine whether partnership leveraging is improving or deteriorating.
AFRL appears to be coordinating its S&T investments with other government agencies.

However, it is not doing as well in tracking and evaluating commercial technologies in some areas.

Best-practice companies devote S&T resources to continuously tracking and evaluating relevant commercial technologies.

AFRL goes to considerable lengths to coordinate S&T investments with other government agencies. An example is the Space Technology Alliance. The alliance is chaired by the AFRL Space Vehicle Director, and membership consists of almost every governmental entity that is investing in space.

AFRL is not taking sufficient advantage of commercial technologies and products, as evidenced by a major finding in the last S&T Quality Review. Companies with best practices have redefined the role of their R&D organizations. Some portion of their organizations and resources is dedicated to continuously tracking, evaluating, and adapting relevant commercial technologies and products, emphasizing fast-paced technologies such as computers, software, electronics, and communications. Industry has learned that evaluating commercial off-the-shelf products is as important as keeping track of what is happening. Hands-on testing reveals far more than do brochures and data sheets. Those companies that learn to leverage and take advantage of these commercial technologies and products can achieve both improved performance and reduced cost. This improvement can mean a decided competitive advantage in the marketplace.
Leveraging Commercial Technology

Recommendations

- Increase emphasis on tracking and acquiring commercial technology (AFRL/CC)
- Incentivize buy before make behavior (AFRL/CC)
- Provide independent assessment via SAB Quality Review (SAF/AQ)

Industry has learned that “make or buy” decisions are best made when a justification or recommendation is made to a higher level that has final decision authority and does not benefit by a “make” decision. In other words, get the bias out of the decision process. Often, organizations will rationalize a “make” decision when “buy” is more appropriate. This was evident in the recent SAB S&T Quality Review finding. In the context of AFRL, “make” means develop in-house or fund a subcontractor to develop. The idea is to avoid development if at all possible. The lowest overall cost to the Government is the objective.

The SAB S&T Quality Review generally looks at whether the laboratory is duplicating or can benefit from external R&D. The independent assessment recommendation would require the SAB be more deliberate in this regard.
The 1999 Science and Technology Workforce for the 21st Century study (STW-21), chaired by Air Force Chief Scientist, Dr. Daniel Hastings, was charged by SecAF Peters with characterizing the existing Air Force S&T workforce and determining strategies to stretch toward an ideal workforce. In many ways, this S&T study is a logical follow-on to STW-21.

It has been one year since STW-21 was briefed to the Air Force senior leadership. There have been a few successes in the implementation of the recommendations. For example, the artificial ceiling for promotion to high grades in the laboratory has been lifted. Under Secretary of the Air Force DeBattiste has been very involved in pushing some personnel initiatives through the Office of Personnel Management and the Office of the Secretary of Defense (OSD). However, large, important recommendations remain with only partial progress. Personnel initiatives are needed to enhance flexibility in recruiting, retaining, and rewarding high performers and removing substandard performers. Conversion to the GOCA model, through an increase in number and flow-through of the “agile section” of the S&E workforce with term and temporary hires, Intergovernmental Personnel Act exchanges, and postdoctoral fellowships, would augment the Government S&E workforce with additional collaborators of national repute.
Aggressive implementation of STW-21

- Provide S&E leaders the tools to recruit, retain, develop, and manage their workforce in an agile and timely manner (SAF/US)
- Look for innovative ways to bring additional world-class talent into the lab (AFRL/CC)
- Champion and provide external oversight of STW-21 implementation (AFMC/CC)

The primary recommendation is to turn up the heat on implementation of STW-21. This is particularly critical and important with a change of administration in AFRL. All three key positions—the commander, executive director, and chief scientist—either have or will change shortly. The new commander of AFRL, primarily, must lead the adoption of STW-21 initiatives.

Effective implementation of STW-21 recommendations will be enhanced through external oversight. The AFMC/CC should assume the role of working with AFRL leadership, helping it to overcome bureaucratic and political obstacles and overseeing the progress of this effort.
Graveyard Spiral:
- Uniformed technical expertise is a core competency that is necessary in the transformation to an aerospace continuum
- The overall military S&E capability of the Air Force is eroding
  - Problems in accession, retention, and development
- The past 4 years have created a looming crisis due to accessions insufficient for sustainment
- Retention of military S&Es at 11 years (39%) is below even that of pilots (41%) in the same year group

The past 4 years have created a looming crisis due to accessions insufficient for sustainment. The graph shows the current (as of 1999) inventory of military engineers versus the sustainment necessary to preserve the force. After the first 4 years, it can be seen that the inventory roughly matches the sustainment or authorized curves. However, from the first 4 years’ data it can be seen that a crisis in military engineers will soon occur, if it has not occurred already. The Air Force has been accessing during those 4 years at slightly over half the rate necessary to sustain the force. When one projects that 4-year period into the later periods (say, 8- to 12-year middle
management period), with normal retention there may be fewer than 50 military engineers in any 1-year group.

It is interesting to note that, at the same point in time (11 years of commissioned service), the retention of military S&Es (39 percent) is even worse than that of pilots (41 percent). The combination of lower accession rates with lower retention results is the graveyard spiral that is occurring and needs to be stopped.
Fills of advanced academic degree (AAD) training slots are far short of quotas

Total quotas seem adequate; however, distribution may be out of line with critical Air Force needs

The Air Force cannot continue as a high-tech force without S&E officers

<table>
<thead>
<tr>
<th>AFIT S&amp;E Quotas</th>
<th>MS Quota</th>
<th>MS Fills</th>
<th>PhD Quota</th>
<th>PhD Fills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aero/Astro/Mech</td>
<td>32</td>
<td>10</td>
<td>10</td>
<td>0</td>
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<tr>
<td>Acq Mgmt</td>
<td>21</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Comp Sci/Engr</td>
<td>22</td>
<td>9</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Elect Engr</td>
<td>43</td>
<td>21</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Electro Optics</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Engr Phys/Nuclear</td>
<td>17</td>
<td>6</td>
<td>8</td>
<td>3</td>
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<tr>
<td>Environmental</td>
<td>12</td>
<td>12</td>
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<td>0</td>
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<tr>
<td>Logistics Mgmt</td>
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<td>0</td>
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<td>12</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Ops Anal/Rsch</td>
<td>20</td>
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<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Sys Eng/Space Ops</td>
<td>11</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>TOTAL</td>
<td>230</td>
<td>128</td>
<td>35</td>
<td>5</td>
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</table>

A further serious deficit occurs with respect to the advanced academic degree education of S&E officers. The SAB recommends that at least half of the S&E officers have technical master’s degrees and that 15 percent have technical Ph.D.s. This level of education is necessary to provide the technical leadership needed for high-technology acquisitions occurring within the Air Force.

The table shows the quota versus fills for several Air Force Institute of Technology (AFIT) engineering degree programs in FY00. The first observation is that the total fills do not come close to filling the quotas—128 of 230 at the master’s level and 5 of 35 at the Ph.D. level.

Equally important, there are serious distribution deficiencies of the programs with respect to Air Force needs. For example, electro-optics is critical in directed-energy applications and intelligence, surveillance, and reconnaissance such as Space-Based Infrared System, the Airborne Laser, and the Space-Based Laser. Yet there are no Ph.D. fills and only two master fills. Similarly, in computer science and computer engineering, which are key to command and control and information operation applications, there are no Ph.D. fills and less than half the masters needed.
The process for generating AAD requirements could be improved. Not only are officers not necessarily being educated in the right fields, but AFIT cannot be expected to operate efficiently with such low and unstable input.

The Air Force will be in serious trouble technically if this situation is allowed to continue. The SAB believes that the Air Force cannot continue as a high-technology force without S&E officers who have appropriate advanced academic technical competence.
A reasonable first step is to initiate a policy to up the gain in S&Es from the three officer accession sources (U.S. Air Force Academy, Reserve Officer Training Corps, and Officer Training School), with strategic vectoring of graduates into critical fields.

The quotas for advanced technical degrees should be increased, but even more important, the quotas need to be filled. The SAB is concerned about the apparent lack of incentive for an officer to attain an advanced technical degree. The hurdles (for example, releasing eligible officers for school because of increased ops tempo) should be identified and removed so that officers have an incentive to pursue an advanced degree and see it as career-enhancing.

A new revised career management plan should be instituted to enhance the career opportunities and progression for S&E officers. This will require senior-level attention from SAF/AQ. Furthermore, the S&E officer should feel that their careers are the concern of at least one very senior Air Force officer, as is the case for rated personnel.

The SAB feels that these recommendations are the minimum corrections to stop the graveyard spiral. We feel that they must be applied soon and persistently to be effective.
Conclusion

- Summary Recommendations
- Terms of Reference Compliance
Summary Recommendations for SecAF and CSAF

- Set specific CFGs that provide a basis for key system and operational concepts and S&T planning
  - Linked to CFCs in Vol 3, Air Force Strategic Plan
  - Updated annually
- Hold AFRL/CC accountable for formulating and executing an S&T plan that achieves CFGs and other warfighter requirements
  - Preside over the annual review of S&T plan and execution of previous year’s plan
  - S&T portfolio presentation should link entire S&T investment to CFCs and emphasize major technology demos and attainment of CFGs and other key warfighter requirements
Summary Recommendations (Cont’d) for SecAF and CSAF

- Create program element to reenergize development planning
  - Hold AFMC/CC accountable to ensure system-of-systems focus across product lines
  - Formulate systems and operational concepts that address CFGs and other warfighter requirements
  - Provide basis for prioritization of S&T plan based on rigorous system trade studies
- Direct increased emphasis on accession, retention, and development of S&E officers
  - Note: S&E summit scheduled in Dec 2000 to define path forward
Summary Recommendation
for Air Force SAE

Hold AFRL/CC accountable for executing S&T plans to provide needed technical performance on agreed schedule for agreed cost
Summary Recommendations for AFMC/CC

- Lead implementation of revitalized development planning, integrating it across product centers, and use it to establish priorities for the S&T plan
- Advocate the S&T program and budget as represented in the S&T plan into new Air Force Resource Allocation Process
- Chair ATC when competing concepts involve multiple product centers
- Play increased role in S&E officer development and retention
Summary Recommendations for AFRL/CC

- Use trade studies from development planning to focus and prioritize S&T investments to achieve CFGs and meet other warfighter requirements.
- Characterize the value of the entire S&T program in warfighter terms and present the characterization to Air Force leadership annually.
- Hold program managers accountable for cost, schedule, and performance for each CFG and other key projects.
- Increase emphasis on tracking and acquiring commercial technology—incorporate buy before make behavior.
This chart correlates the various findings and recommendations of the study to the Terms of Reference.

In the first item, the study recommends a process through which leadership goals will ultimately be reflected in the S&T plan. In the second item, specific recommendations are made in the areas of partnerships and leveraging of external technology. Item three was addressed by defining a tool for executive-level characterization of the S&T portfolio. This tool, once created, will provide decision makers with information appropriate for valuing and prioritizing the S&T portfolio.

Specific recommendations concerning both the civilian and military workforces are made in compliance with item four. The portfolio characterization tool described in item three also addresses this item.

The final item was not addressed directly. Rather, a process is described that will allow setting the topline budget.
Appendix A: Conceptual Model for S&T Characterization

Slide 49: Example S&T Portfolio Characterization Tool

Headquarters U.S. Air Force

Integrity - Service - Excellence

Appendix: Example S&T Portfolio Characterization Tool
A conceptual S&T portfolio characterization model is depicted in this chart. At the aggregate level, the entire S&T program is linked to the CFCs. As can be seen, the CFGs are linked to the appropriate CFCs, but not all CFCs have CFGs. Also, several CFGs may be associated with one CFC.

There are essentially four elements to this model. First, there are specific projects (primarily 6.3, but with some complement of 6.2 funding) that focus on achieving specific CFGs. There are also projects associated with Technology Competencies, primarily 6.2-funded technology areas needed to support a broader range of Air Force missions, but that support the achievement of one or more CFGs. The third group of projects are those linked to achievement of the broader CFC, but not a specific CFG. These will likely be both 6.2- and 6.3-funded projects. Finally, there is the basic research program (6.1), which provides the foundation for future technology development, enabling the next set of CFGs and, thus, supports all CFC statements.

The SAB envisions that aggregated projects will be hyperlinked to this summary document in a manner that allows more detailed information to be viewed if necessary to understand the top-level information displayed.

The important point is that, once developed, this tool will provide the Air Force with a means of easily portraying connectivity between the S&T program and the future Air Force.
This tool has additional benefits. There are a number of metrics, such as the two depicted here, that can be captured and displayed. In the first example, the bars represent individual aggregations of projects and the agency (or industry) providing the funds. The individual bars are color-coded in proportion to the funding provided. For example, DARPA is providing approximately 60 percent of the funds needed to execute the first project under CFG1. This provides a ready mechanism to visually depict the degree of leveraging within AFRL and track it over time. It also can be used as an indicator of the funding risk tied to achieving the CFGs and CFCs.

The second example shows a method of depicting the health of projects. Earlier in this report, the SAB recommended that CFGs have specific cost, schedule, and performance objectives much like an acquisition program, and that the AFRL/CC be held accountable for achieving those objectives. Health can also be depicted for Technical Competencies with appropriate metrics. This depiction, when aggregated for all CFCs, provides an executive-level means to do exactly that. It also provides cues to problem areas that can be explored because each cell is hyperlinked to more detailed information.

This chart only displays two metrics, but others can be easily added as needed. The SAB believes that this tool provides a mechanism to track and display (at an executive level, with hyperlinked backup information) any metric needed to assess the execution and health of the S&T program.
This characterization tool can also be used to understand the impact of budgetary adjustments. In the above example, moving technology development funds from one CFC statement to another is being considered. This tool allows for executive-level depiction of the impact of that proposal and allows senior Air Force leadership to better assess the impact. Because each cell is hyperlinked to more detailed information, specific areas can be investigated if necessary to make more informed decisions.
To further understand how the characterization tool might be used, consider the notional example of finding targets under trees. In this example, top Air Force leadership has established a CFG to find, identify, and kill targets under trees globally within 3 hours of tasking. Noting that the health of one of the projects, very high frequency (VHF) change detection (CD), has been rated “yellow”; more details about the execution of the CFG projects are requested. Clicking on the appropriate CFG displays the detailed bar chart shown on the next slide.
This chart provides a brief summary of the overarching objective of the TUT CFG. It also provides insight into metrics for the three projects developing technology for TUT.

To successfully achieve the objectives of this CFG, it is necessary to detect, identify, and engage hostile targets. Through analysis of existing equipment and projects in development, it was determined that the best method to detect targets within the necessary time lines was through a combination of ultra high frequency (UHF) and VHF synthetic aperture radars (SARs) on a Global Hawk UAV. DARPA was already developing the UHF SAR system, so AFRL undertook the development of the VHF SAR receiver. To identify targets, it was necessary to fuse this data with data from other intelligence sources. Finally, a new fuze required development in order to engage and destroy hard targets, such as tanks, using only one bomb. Thus, the VHF CD project, the Sensor Fusion project, and the Height of Burst (HOB) Fuze form the core projects for TUT.

From the first metric, it can be seen that more than half of the funding for VHF CD and Sensor Fusion is provided by DARPA, while the Air Force is funding the entire HOB Fuze project. Thus, the Air Force is heavily leveraging the investment of DARPA to satisfy this CFG.
The second metric shows that, between VHF CD and Sensor Fusion, if successful, about 80 percent of the desired capability is achieved. Thus, this provides a measure of the importance of each project to achieving the CFG.

Finally, from the “Health” metric, which summarizes the cost, schedule, and performance of each project, we can see that there is a problem with the VHF CD project. The hyperlink to this project reveals more details.
Hyperlinking from the VHF CD project title displays a summary of this project. From this chart, we see that the performance of the VHF CD project is being impacted by higher-than-predicted false alarms in DARPA’s Foliage Penetration (FOPEN) Radar program. The workaround solution for this technical difficulty, is to rely more on the VHF sensor and modify the CD algorithms to account for this shift.

This example illustrates the power inherent in the proposed characterization tool. Air Force leadership can rapidly receive information about the S&T program at the portfolio level, CFC level, CFG level, or project level, if necessary. Multiple metrics can be tracked concurrently.

This suggested tool provides a valuable method to assess the connectivity of the S&T program to the future Air Force, while simultaneously assessing its value and health.
Appendix B  
Terms of Reference  

USAF Scientific Advisory Board 2000 Study  
Science & Technology and the Air Force Vision: A Critical Partnership and 
Strategy for the Future  

BACKGROUND: In 1995 as part of New World Vistas, the SAB reviewed, through personal 
interviews with leaders of aerospace industry, R&D investments with emphasis on long-term. 
Their findings are most dramatically captured in one prominent CEO’s statement: I am 
embarrassed to say that we no longer do long-term R&D.  

Industry is driven by earnings to share holders, which forces their investments to be largely near-
term and R&D becomes R&D—little research and mostly development. Whether industry does 
true, long-term R&D or not, it does invest in research. Companies have developed sophisticated 
tools for guiding these investments and developing strategic partnerships with universities and 
industry.  

The AFRL was created in 1997 with one of its goals that of better tying of S&T investments to 
Air Force needs and its future. Portfolios were developed for each of the Directorates mindful of 
investments in related areas in other Services, DARPA, OSD, and defense agencies. Investments 
by industry were also considered, but unevenly across the Directorates. Since its creation, AFRL 
has divested either largely or completely in some areas based on the above analysis and budget 
pressures. The recent S&T topline reductions have weakened what was a well-balanced 
portfolio development 5 years ago in several critical areas.  

Study Products: Briefing to SecAF and CSAF in October 2000. Publish report in December 
2000.  

Charter: This study, guided by the Air Force Long Range Plans, Air Force Vision, and U.S. 
National and Military Strategies, will develop an Air Force strategy for dealing with these 
realities by:  

1. Developing a technology investment strategy informed by those documents and the best technical 
minds regarding Air Force needs and technology possibilities/opportunities.  
2. Reviewing industry investments to determine level of effort in Air Force S&T being mindful of the 
potential divestiture by industry in any given area (how long can the Air Force depend on an industry 
source—affects work force and minimum level of effort on a topic, for example, heavy DARPA 
funding in information technology).  
3. Reviewing the tools industry uses to determine where to invest and form strategic partnerships and 
recommend tools that can be used by AFRL.  
4. Developing and recommending strategies for S&T investment at all levels to include industry 
partnerships, work force implications, risk assessment and hedges.  
5. From the above, recommending a level for the Air Force S&T topline.  

The study will review all recent reports related to this subject (for example, Defense Science 
Board) to avoid duplication. This study will answer a Fall ’99 CORONA tasker deriving from 
the S&T Funding Strategy presentation there. It grows from a continuing SAB concern about 
and partnership with AFRL regarding the best use of Air Force S&T resources and leveraging 
opportunities.
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Appendix C
Study Team

Study Chairman
Dr. William F. Ballhaus, Jr.

SAB Military Director
Lt Gen Stephen B. Plummer

General Officer Participants
Brig Gen Paul Nielsen
Maj Gen Richard Paul, USAF (Ret)

SAB Executive Director
Col Gregory H. Bishop

SAB Study Executive Officer
Ms. Melody Darby, AFRL/XPPR
Lt Col Paul A. Schubert, AF/SB

SAB Study Technical Writer
Maj Larry Merkle, USAFA

Team Leaders
CEO Guidance and Participation Team: Lt Gen George K. Muellner, USAF, (Ret)
Linkages and Transitions Team: Lt Gen Malcolm R. O'Neill, USA, (Ret)
Funding Guidelines and Leveraging External Sources: Dr. Antonio F. Pensa
Effective Planning Process Team: Dr. Valerie J. Gawron
Other Factors: Dr. Daniel E. Hastings
Study Members

Dr. William F. Ballhaus, Jr., Chair  
Corporate Vice President, Engineering and Technology  
Lockheed Martin Corporation

Mr. Jeffrey E. Grant, Deputy Chair  
Private Consultant

Dr. Robert R. Barthelemy  
Director of Education and Training  
Universal Technology Corporation

Col William A. Byrne, USAF (Ret)  
Director, Albuquerque Operations  
Universal Technology Corporation

Mr. Art Chester  
President  
HRL Laboratories

Mrs. Natalie W. Crawford  
Vice President and Director, Project AIR FORCE  
RAND

Col Donald R. Erbschloe  
HQ USAF/ST

Dr. Janet Fender  
Chief Scientist, Space Vehicles Directorate  
Air Force Research Laboratory

Dr. Matthew W. Ganz  
Vice President for Programs  
The Charles Stark Draper Laboratory, Inc.

Dr. Valerie J. Gawron  
Principal Human Factors Engineer  
Veridian Engineering

Dr. Daniel E. Hastings  
Professor  
Massachusetts Institute of Technology
Dr. Robert W. Selden  
Private Consultant

Dr. James C. Williams  
Honda Professor  
The Ohio State University

Dr. Gerold Yonas  
Vice President and Principal Scientist  
Sandia National Laboratories
# Appendix D
## Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AAC</td>
<td>Air Armament Center</td>
</tr>
<tr>
<td>AAD</td>
<td>Advanced Academic Degree</td>
</tr>
<tr>
<td>AETC</td>
<td>Air Education and Training Command</td>
</tr>
<tr>
<td>AF/DP</td>
<td>Air Force Deputy Chief of Staff, Personnel</td>
</tr>
<tr>
<td>AFIT</td>
<td>Air Force Institute of Technology</td>
</tr>
<tr>
<td>AFMC</td>
<td>Air Force Materiel Command</td>
</tr>
<tr>
<td>AFPC</td>
<td>Air Force Personnel Center</td>
</tr>
<tr>
<td>AFRL</td>
<td>Air Force Research Laboratory</td>
</tr>
<tr>
<td>AMSAA</td>
<td>Army Materiel Systems Analysis Activity</td>
</tr>
<tr>
<td>ARL</td>
<td>Army Research Laboratory</td>
</tr>
<tr>
<td>ASC</td>
<td>Aeronautics Systems Center</td>
</tr>
<tr>
<td>ATC</td>
<td>Applied Technology Council</td>
</tr>
<tr>
<td>BMDO</td>
<td>Ballistic Missile Defense Organization</td>
</tr>
<tr>
<td>CC</td>
<td>Commander</td>
</tr>
<tr>
<td>CD</td>
<td>Change Detection</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CFC</td>
<td>Critical Future Capability</td>
</tr>
<tr>
<td>CFG</td>
<td>Critical Future Goal</td>
</tr>
<tr>
<td>CONOPS</td>
<td>Concept of Operations</td>
</tr>
<tr>
<td>CSAF</td>
<td>Chief of Staff of the Air Force</td>
</tr>
<tr>
<td>CTO</td>
<td>Chief Technical Officer</td>
</tr>
<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency</td>
</tr>
<tr>
<td>DERAD</td>
<td>Defense Evaluation and Research Agency</td>
</tr>
<tr>
<td>DoD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>DSB</td>
<td>Defense Science Board</td>
</tr>
<tr>
<td>ESC</td>
<td>Electronic Systems Center</td>
</tr>
<tr>
<td>FOPEN</td>
<td>Foliage Penetration</td>
</tr>
<tr>
<td>GOCA</td>
<td>Government-Owner, Collaborator-Assisted</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>HOB</td>
<td>Height of Burst</td>
</tr>
<tr>
<td>IHPETET</td>
<td>Integrated High Performance Turbine Engine Technology</td>
</tr>
<tr>
<td>IR&amp;D</td>
<td>Independent Research and Development</td>
</tr>
<tr>
<td>ITT</td>
<td>Integrating Technology Thrust</td>
</tr>
<tr>
<td>MAJCOM</td>
<td>Major Command</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>OCR</td>
<td>Office of Coordinating Responsibility</td>
</tr>
<tr>
<td>OPR</td>
<td>Office of Primary Responsibility</td>
</tr>
<tr>
<td>OSD</td>
<td>Office of the Secretary of Defense</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RDEC</td>
<td>Research, Development, and Engineering Center</td>
</tr>
<tr>
<td>S&amp;E</td>
<td>Science and Engineering</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Name</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>S&amp;T</td>
<td>Science and Technology</td>
</tr>
<tr>
<td>SAB</td>
<td>Air Force Scientific Advisory Board</td>
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<tr>
<td>SAE</td>
<td>Service Acquisition Executive</td>
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<tr>
<td>SAF/AQ</td>
<td>Assistant Secretary of the Air Force, Acquisition</td>
</tr>
<tr>
<td>SAF/US</td>
<td>Under Secretary of the Air Force</td>
</tr>
<tr>
<td>SAR</td>
<td>Synthetic Aperture Radar</td>
</tr>
<tr>
<td>SecAF</td>
<td>Secretary of the Air Force</td>
</tr>
<tr>
<td>SMC</td>
<td>Space and Missile Systems Center</td>
</tr>
<tr>
<td>SPO</td>
<td>System Program Office</td>
</tr>
<tr>
<td>STW-21</td>
<td>Science and Technology Workforce for the 21st Century Study</td>
</tr>
<tr>
<td>TARDEC</td>
<td>Tank Automotive Research, Development, and Engineering Center</td>
</tr>
<tr>
<td>TUT</td>
<td>Targets Under Trees</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
</tr>
<tr>
<td>UHF</td>
<td>Ultra High Frequency</td>
</tr>
<tr>
<td>USAFA</td>
<td>U.S. Air Force Academy</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
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Appendix E
Organizations Consulted

Air Force
ABL SPO
ACC/CC
AF/CV
AF/ST
AF/XP
AFMC/DRX
AFOSRAFRL/CA
AFRL/CC
AFRL/MN
AFSPC/CS
AIA/CAASC/CC
ASC/CD
ASD/311HSW
AWACS SPO
ESC/CCSAF/AQ
SAF/AQR
SBIRS SPO
SMC/CC

Industry
3M
Boeing
DuPont
General Electric
Hughes
IBM
Lockheed Martin
Lucent
Microsoft
Nokia
Sun
Other Government Agencies
AMSAA
ARDEC
ARL-CERDEC
DARPA
DAS (STE)
DASA (RT)
DERA
DUSD (S&T)
ERDEC
MCCDC
MCSC
MCWL
MICOM RDEC
NATO/RT
NIST
NRDEC
NRL
ONR
SOCOMTARDEC
Initial Distribution

Headquarters Air Force

SAF/OS  Secretary of the Air Force
AF/CC  Chief of Staff
AF/CV  Vice Chief of Staff
AF/CVA  Assistant Vice Chief of Staff
AF/HO  Historian
AF/ST  Chief Scientist
AF/SC  Communications and Information
AF/SG  Surgeon General
AF/SF  Security Forces
AF/TE  Test and Evaluation

Assistant Secretary of the Air Force

SAF/AQ  Assistant Secretary for Acquisition
SAF/AQ  Military Director, USAF Scientific Advisory Board
SAF/AQI  Information Dominance
SAF/AQL  Special Programs
SAF/AQP  Global Power
SAF/AQQ  Global Reach
SAF/AQR  Science, Technology and Engineering
SAF/AQS  Space and Nuclear Deterrence
SAF/AQX  Management Policy and Program Integration
SAF/MI  Assistant Secretary (Manpower, Reserve Affairs, Installations & Environment)
SAF/SN  Assistant Secretary (Space)
SAF/SX  Deputy Assistant Secretary (Space Plans and Policy)

Deputy Chief of Staff, Air and Space Operations

AF/XO  DCS, Air and Space Operations
AF/XOC  Command and Control
AF/XOI  Intelligence, Surveillance, and Reconnaissance
AF/XOJ  Joint Matters
AF/XOO  Operations and Training
AF/XOR  Operational Requirements

Deputy Chief of Staff, Installations and Logistics

AF/IL  DCS, Installations and Logistics
AF/ILX  Plans and Integration

Deputy Chief of Staff, Plans and Programs

AF/XP  DCS, Plans and Programs
AF/XPI  Information and Systems
AF/XPM  Manpower, Organization and Quality
AF/XPP  Programs
AF/XPX  Strategic Planning
AF/XPY  Analysis
### Initial Distribution (continued)

#### Deputy Chief of Staff, Personnel

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#### Office of the Secretary of Defense

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<td>Under Secretary for Acquisition and Technology</td>
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<td>USD (A&amp;T)/DSB</td>
<td>Defense Science Board</td>
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<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency</td>
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<tr>
<td>DIA</td>
<td>Defense Intelligence Agency</td>
</tr>
<tr>
<td>DISA</td>
<td>Defense Information Systems Agency</td>
</tr>
<tr>
<td>BMDO</td>
<td>Ballistic Missile Defense Organization</td>
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#### Other Air Force Organizations

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<tr>
<td>AC2ISRC</td>
<td>Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center</td>
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<tr>
<td>ACC</td>
<td>Air Combat Command</td>
</tr>
<tr>
<td>- CC</td>
<td>Commander, Air Combat Command</td>
</tr>
<tr>
<td>- 366th Wing</td>
<td>366th Wing at Mountain Home Air Force Base</td>
</tr>
<tr>
<td>AETC</td>
<td>Air Education and Training Command</td>
</tr>
<tr>
<td>- AU</td>
<td>Air University</td>
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<tr>
<td>AFMC</td>
<td>Air Force Materiel Command</td>
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<tr>
<td>- CC</td>
<td>Commander, Air Force Materiel Command</td>
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<tr>
<td>- EN</td>
<td>Directorate of Engineering and Technical Management</td>
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<tr>
<td>- AFRL</td>
<td>Air Force Research Laboratory</td>
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<tr>
<td>- SMC</td>
<td>Space and Missile Systems Center</td>
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<td>- ESC</td>
<td>Electronic Systems Center</td>
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<td>- ASC</td>
<td>Aeronautics Systems Center</td>
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<td>- HSC</td>
<td>Human Systems Center</td>
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<tr>
<td>- AFOSR</td>
<td>Air Force Office of Scientific Research</td>
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<td>AFOTEC</td>
<td>Air Force Operational Test and Evaluation Center</td>
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<td>AFSAA</td>
<td>Air Force Studies and Analyses Agency</td>
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<td>Air Force Space Command</td>
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<td>Air Intelligence Agency</td>
</tr>
<tr>
<td>AMC</td>
<td>Air Mobility Command</td>
</tr>
<tr>
<td>NAIC</td>
<td>National Air Intelligence Center</td>
</tr>
<tr>
<td>NGB/CF</td>
<td>National Guard Bureau</td>
</tr>
<tr>
<td>PACAF</td>
<td>Pacific Air Forces</td>
</tr>
<tr>
<td>USAFA</td>
<td>U.S. Air Force Academy</td>
</tr>
<tr>
<td>USAFE</td>
<td>U.S. Air Forces in Europe</td>
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#### U.S. Army

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<tr>
<td>ASB</td>
<td>Army Science Board</td>
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#### U.S. Navy

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<td>NRAC</td>
<td>Naval Research Advisory Committee</td>
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<tr>
<td>Naval Studies Board</td>
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Initial Distribution (continued)

U.S. Marine Corps
DC/S (A) Deputy Chief of Staff for Aviation

Joint Staff
JCS Office of the Vice Chairman
J2 Intelligence
J3 Operations
J4 Logistics
J5 Strategic Plans and Policies
J6 Command, Control, Communications, and Computer Systems
J7 Operational Plans and Interoperability
J8 Force Structure, Resources and Assessment

Other
Aerospace Corporation
ANSER
MITRE
RAND
Study Participants
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Science & Technology and the Air Force Vision: Achieving a More Effective S&T Program

Dr. William F. Ballhaus, Jr., Lt Gen George K. Muellner, USAF, (Ret),
Lt Gen Malcolm R. O'Neill, USA, (Ret), Dr. Antonio F. Pensa, Dr. Valerie J. Gawron,
Dr. Daniel E. Hastings

AF/SB
Pentagon
Washington, DC  20330-1180

SAF/OS
AF/CC
Pentagon
Washington, DC  20330-1670

There are considerable on-going efforts within the Air Force Research Laboratory (AFRL) to improve the science and technology (S&T) program. Each year the Air Force Scientific Advisory Board (SAB) conducts independent quality reviews within the labs. The reviews assess the quality and long-term relevance of the Air Force S&T program. Quality here is broadly defined to include science, people, strategy, resources, focus, facilities, and results. These reviews clearly indicate that the quality of the S&T program is improving and most of the projects are well focused on future Air Force capabilities.

However, based on extensive benchmarking, it is also apparent that a more effective S&T program can be achieved. This Study offers recommendations that apply both internally and externally to AFRL. The members of this Study team strongly urge that these recommendations be adopted.


Abstract (Maximum 200 Words)

Unclassified

Unclassified

Unclassified

None