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Scientific Advisory Board

Report on

Science & Technology and the Air Force Vision: Achieving a More Effective S&T Program

SAB-TR-00-02

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14. ABSTRACT

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.

15. SUBJECT TERMS
Science and Engineering Planning, Science and Technology, Leveraging Partnerships, Commercial Technology, Development Planning, Portfolio Characterization, Goal Setting, Advocacy, Accountability

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Science & Technology and the Air Force Vision:
A Critical Partnership and Strategy for the Future

Slide 1: Introduction

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.

Slide 2: Concerns Leadership Raised Surrounding S&T Program

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.

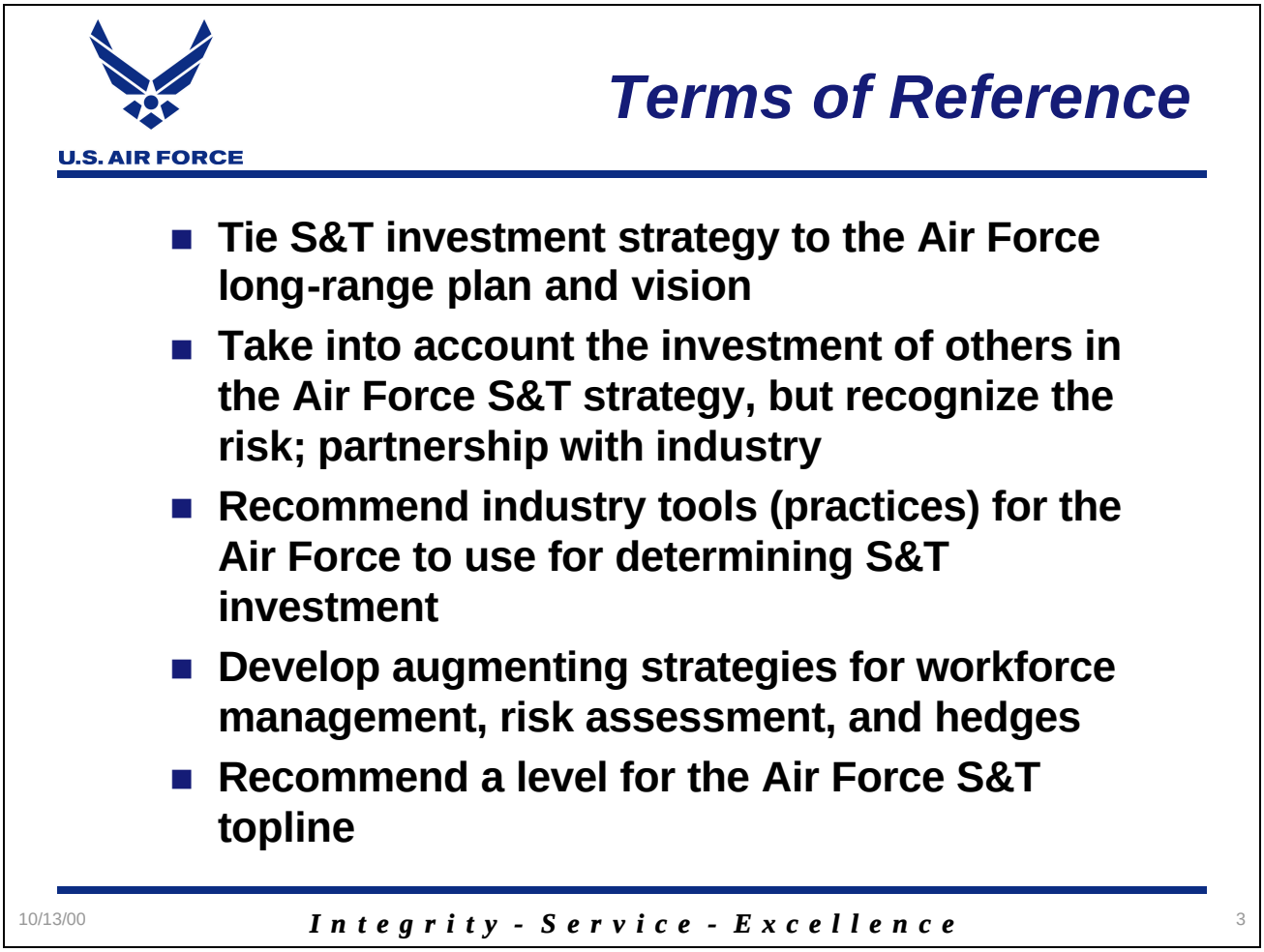
There is a lack of an effective methodology for valuing and prioritizing S&T investments in warfighter terms. Hence, the benefits of an increased (or decreased) S&T investment versus other needs are unclear. It is also unclear what the core science investment contributes to the longer-term needs of the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

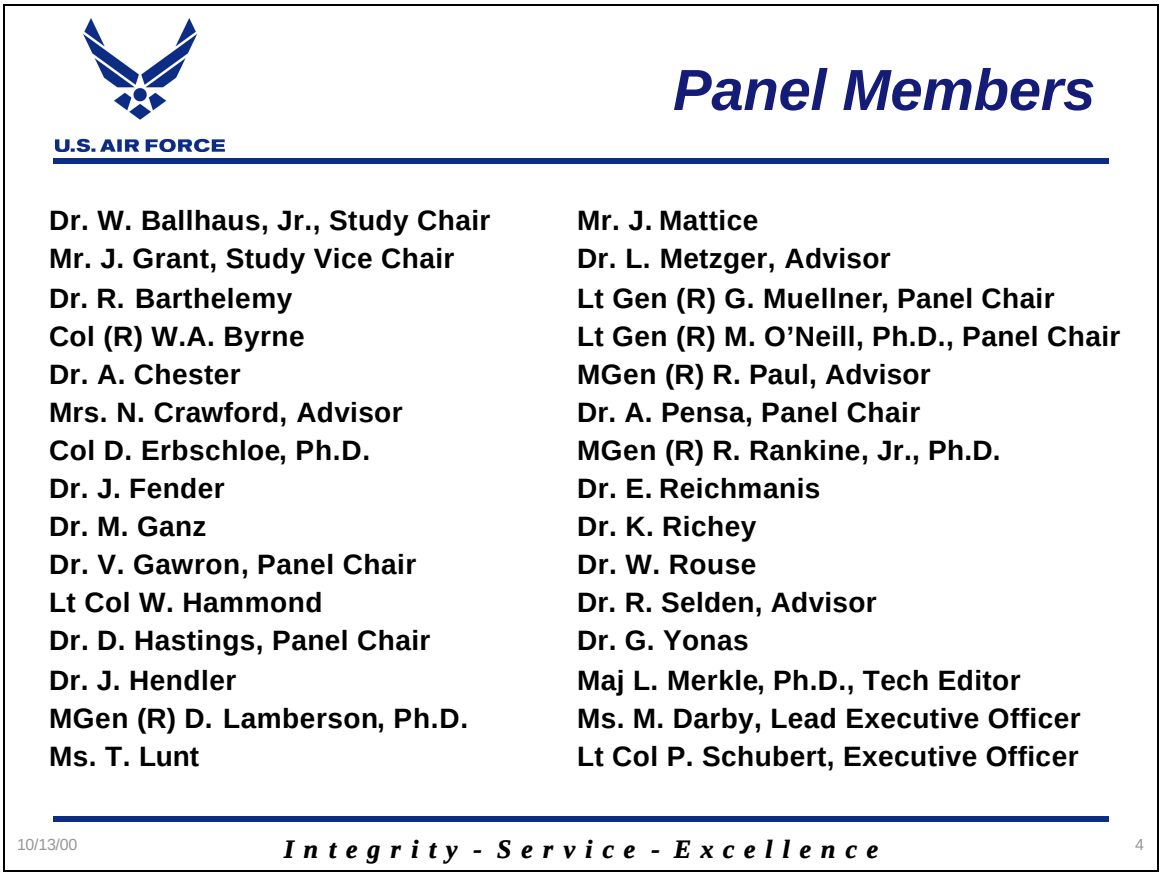
Slide 3: Terms of Reference



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.

Slide 4: Panel Members



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.

Slide 5: Terms of Reference

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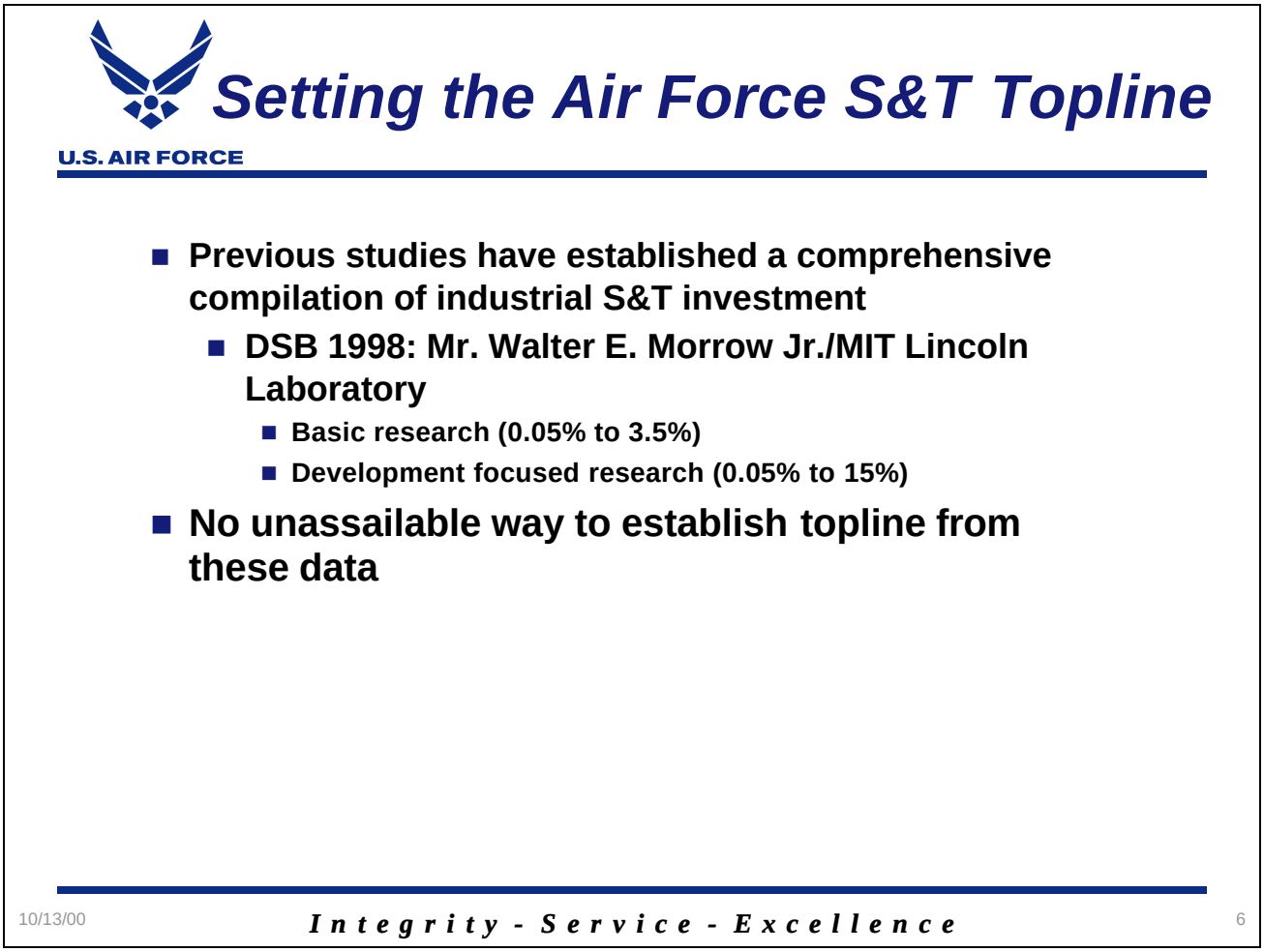
Terms of Reference

Tie S&T investment strategy to the Air Force long range plan & vision	✓
Take into account the investment of others in the Air Force S&T strategy, but recognize the risk; partnership with industry	✓
Recommend industry tools (practices) for Air Force to use for determining S&T investment	✓
Develop augmenting strategies for workforce management, risk assessment, and hedges	✓
Recommend a level for the Air Force S&T topline	Alternative: process for valuing

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.

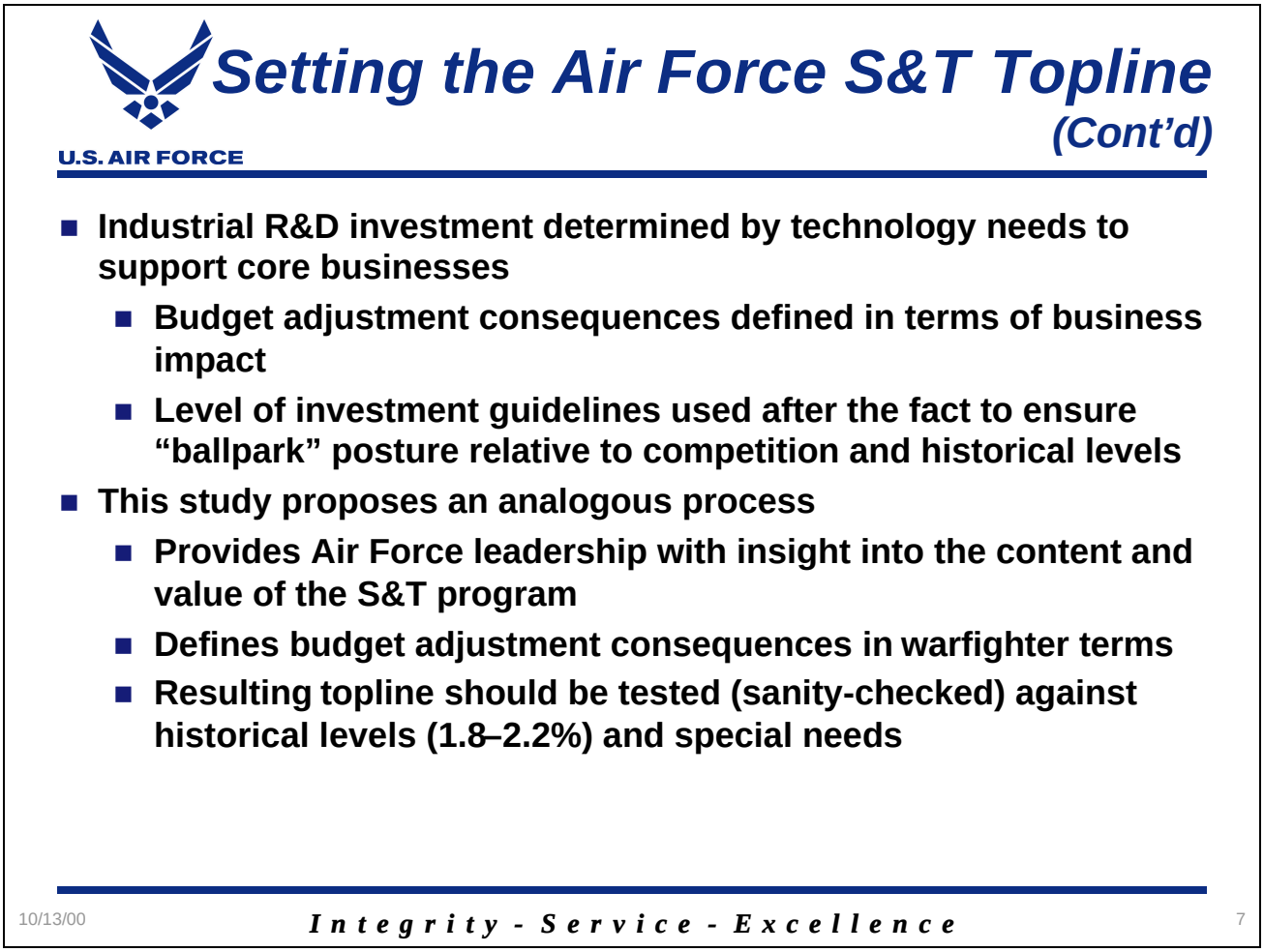
Slide 6: Setting the Air Force S&T Topline



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.

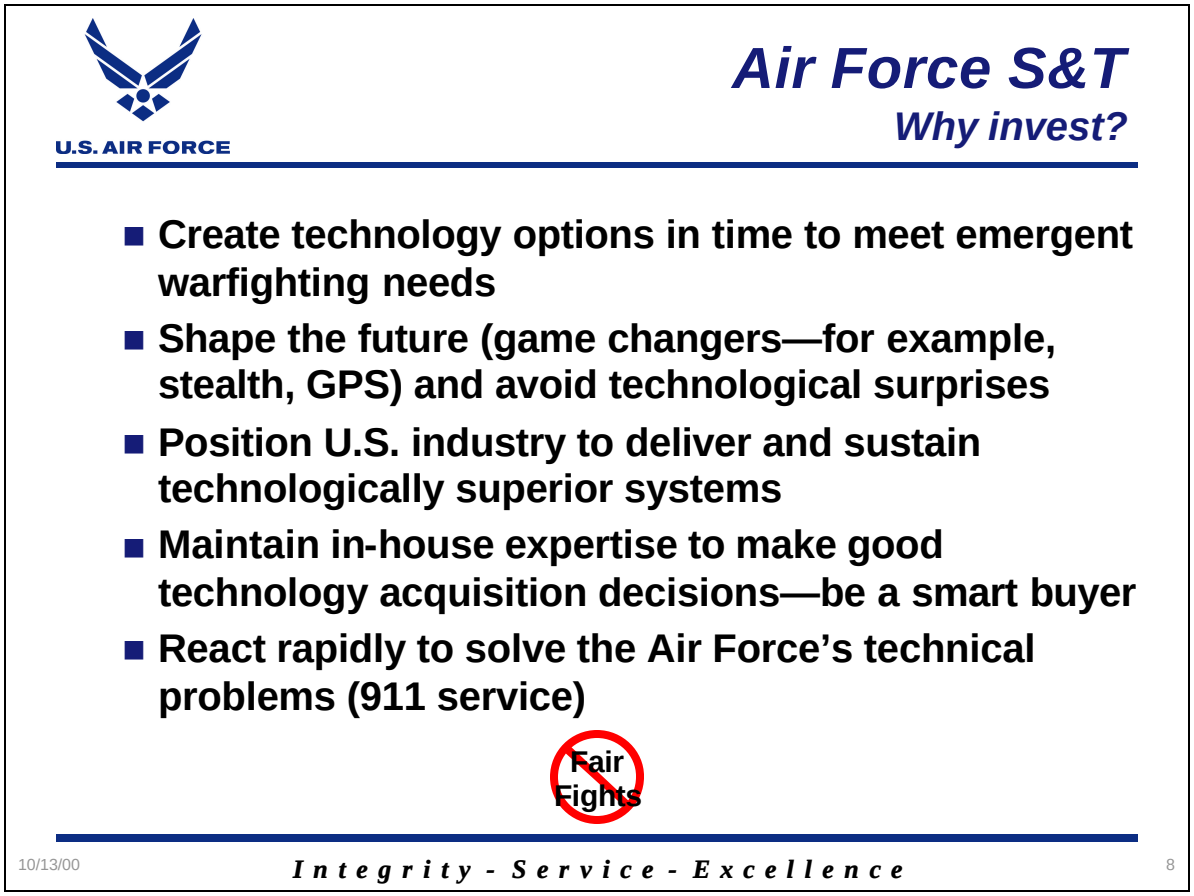
Slide 7: Setting the Air Force S&T Topline (continued)



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.

Slide 8: Air Force S&T—Why Invest?



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.

Slide 9: Air Force and Industry S&T—Key Contrasts

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Air Force and Industry S&T

Key contrasts

What drives industry S&T investment?

- Financial objectives
- Marketplace
- RESULT: Industry prioritizes S&T investments toward near-term, high-return, and high-dollar programs—business case

What drives Air Force S&T investment?

- Warfighter needs
- Battlespace
- RESULT: Air Force prioritizes S&T investments to ensure continuing operational superiority—no fair fights

Air Force can rely on industry only when "RESULTS" align

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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.

Slide 10: Organizations Reviewed

U.S. AIR FORCE

Organizations Reviewed

Industry	Air Force		Other Gov't	
3M	AF/CV	AFMC/DRX	DUSD (S&T)	MCCDC
Boeing	AF/ST	AIA/CA	DASA (RT)	MCWL
DuPont	AF/XP	ASC/CC	DAS (STE)	MCSC
General Electric	SAF/AQ	ASC/CD	SOCOM	ARL
Hughes	SAF/AQR	ASD/311HSW	ARDEC	ONR
IBM	ACC/CC	ESC/CC	CERDEC	NRL
Lockheed Martin	AFSPC/CS	SMC/CC	ERDEC	DARPA
Lucent	AFRL/CC	ABL SPO	MICOM RDEC	NIST
Microsoft	AFRL/CA	AWACS SPO	NRDEC	NATO/RT
Nokia	AFRL/MN	SBIRS SPO	TARDEC	DERA
Sun	AFOSR		AMSAA	

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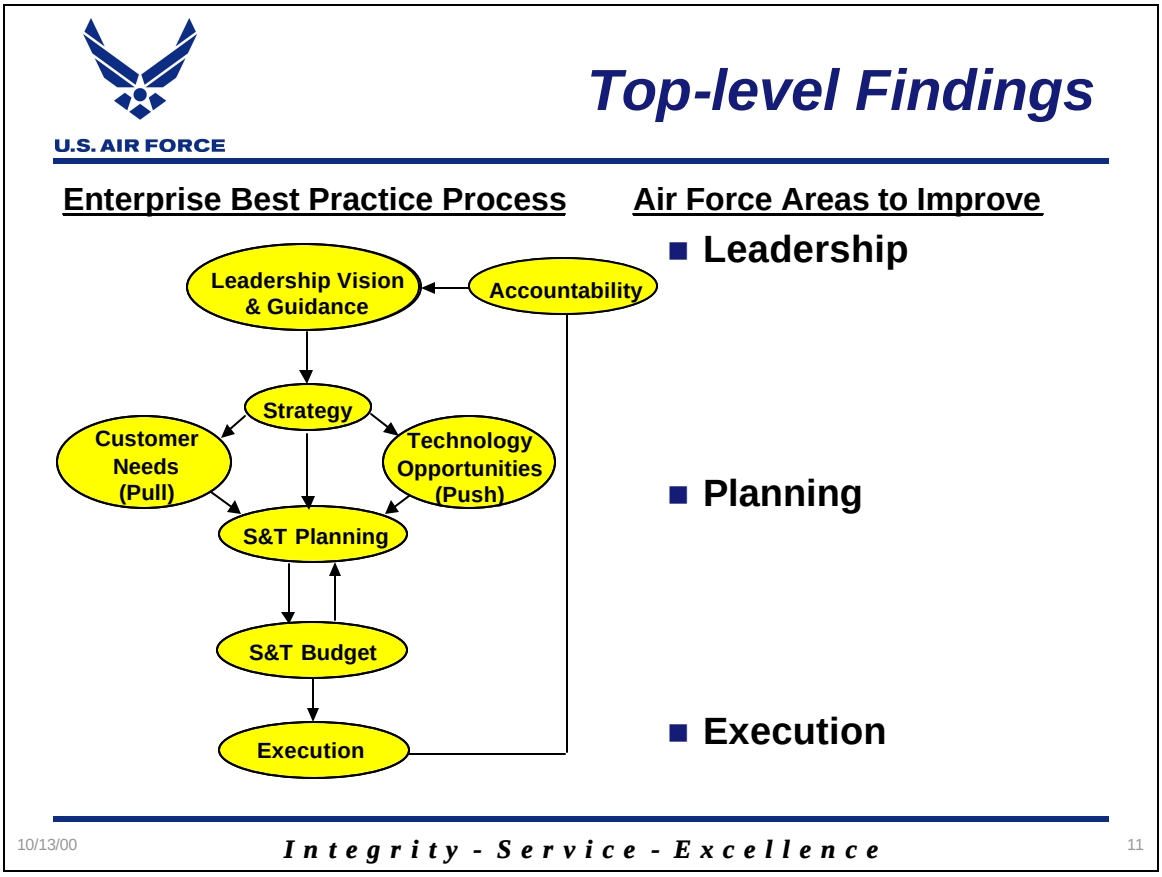
Panel members visited, consulted with, or were briefed by numerous companies and organizations in industry, the Air Force, and other government agencies.

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.

Slide 11: Top-Level Findings



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.

Slide 12: Attributes of Successful Enterprises—Benchmarking Results

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Attributes of Successful Enterprises

Benchmarking Results

- **Leadership involvement: The CEO champions the vision and top-level strategy and goals and recognizes S&T as important to both present and future business**
- **Vision: A widely shared and clear idea of purpose that is the basis for action throughout the corporation**
- **Strategy: A shared sense of direction—how to achieve the vision**
- **Goals: A few, clear, compelling, measurable objectives, derived from the vision, supporting the strategy, that stimulate S&T planning and progress**

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.

Slide 13: Attributes of Successful Enterprises—Benchmarking Results (continued)

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Attributes of Successful Enterprises

Benchmarking Results (cont'd)

- **Plan: The goals allow the creation of an S&T plan that provides coherent schedules and investments for attaining the goals**
  - **Provides clear linkages between customer needs and S&T projects**
  - **Employs tools for valuing and prioritizing investment opportunities**
  - **Emphasizes buy before make—high awareness of relevant marketplace**
- **Accountability: The CEO holds the CTO accountable for executing the S&T plans to achieve the goals**
- **Motivated workforce: Quality people driven by culture of excellence**

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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

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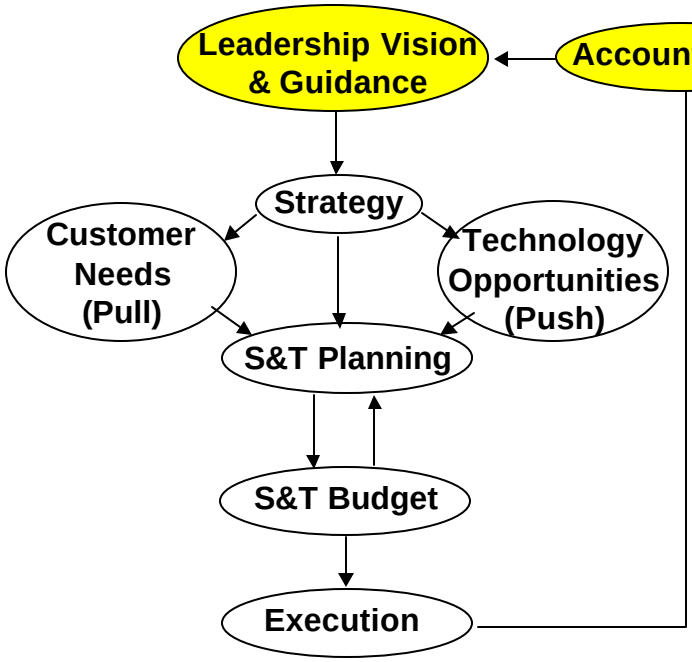
Outline



⇒ **Leadership**
- **Goals**
- **Advocacy**
- **Accountability**

Planning
- Development Planning
- Technology Transitions
- Portfolio Characterization

Execution
- Leveraging Partnerships
- Leveraging Commercial Technology
- Workforce Issues

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Goal Setting

Slide 15: Findings

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Leadership: Goal Setting

Findings

- **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

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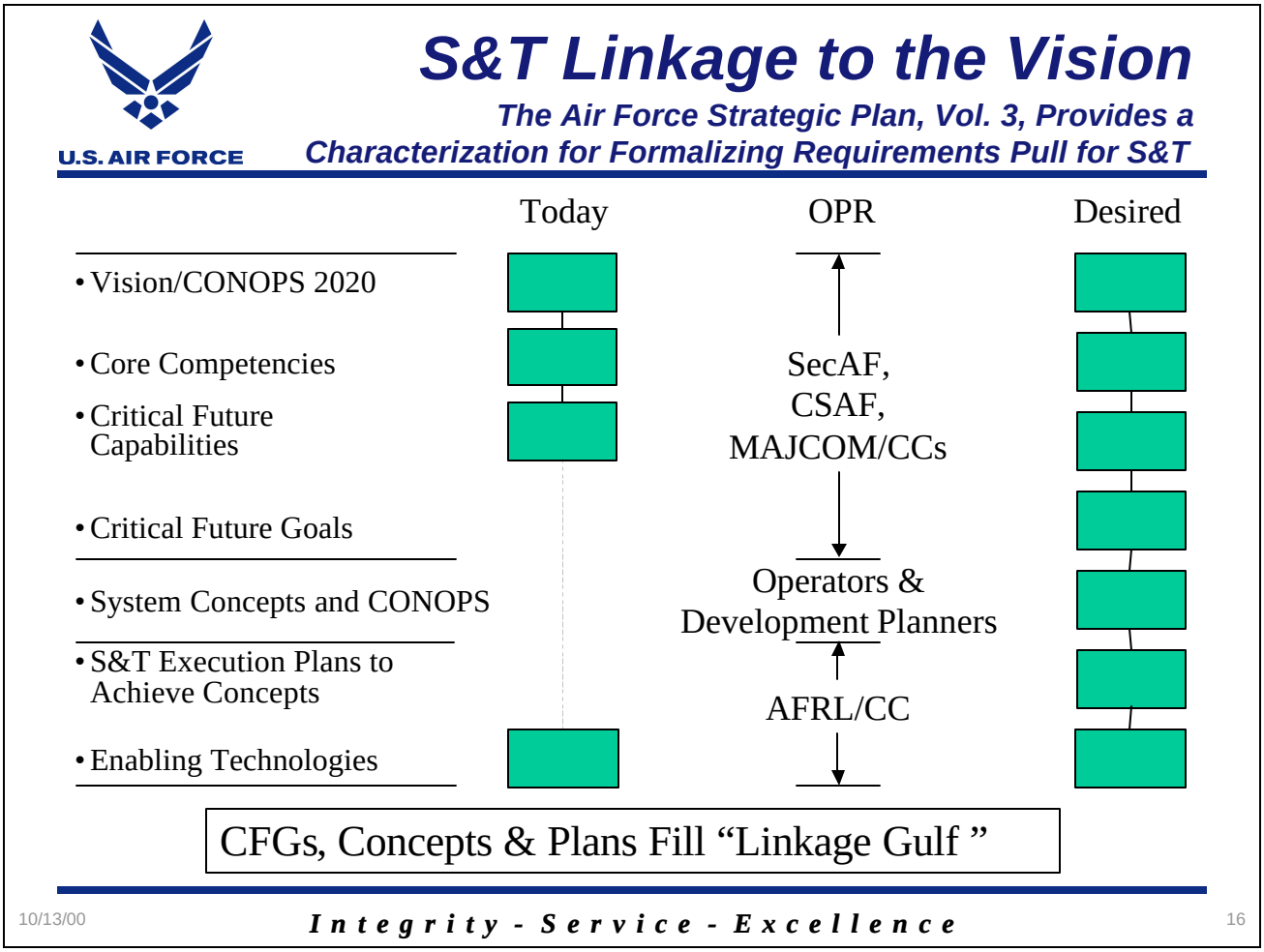
The 14 CFCs in Volume 3 of the Air Force Strategic Plan provide a comprehensive framework for expressing needed Air Force responses to the "compelling demands of the future security environment." However, they are not sufficiently specific to define a system concept leading to a technology plan. In fact,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

Slide 16: S&T Linkage to the Vision



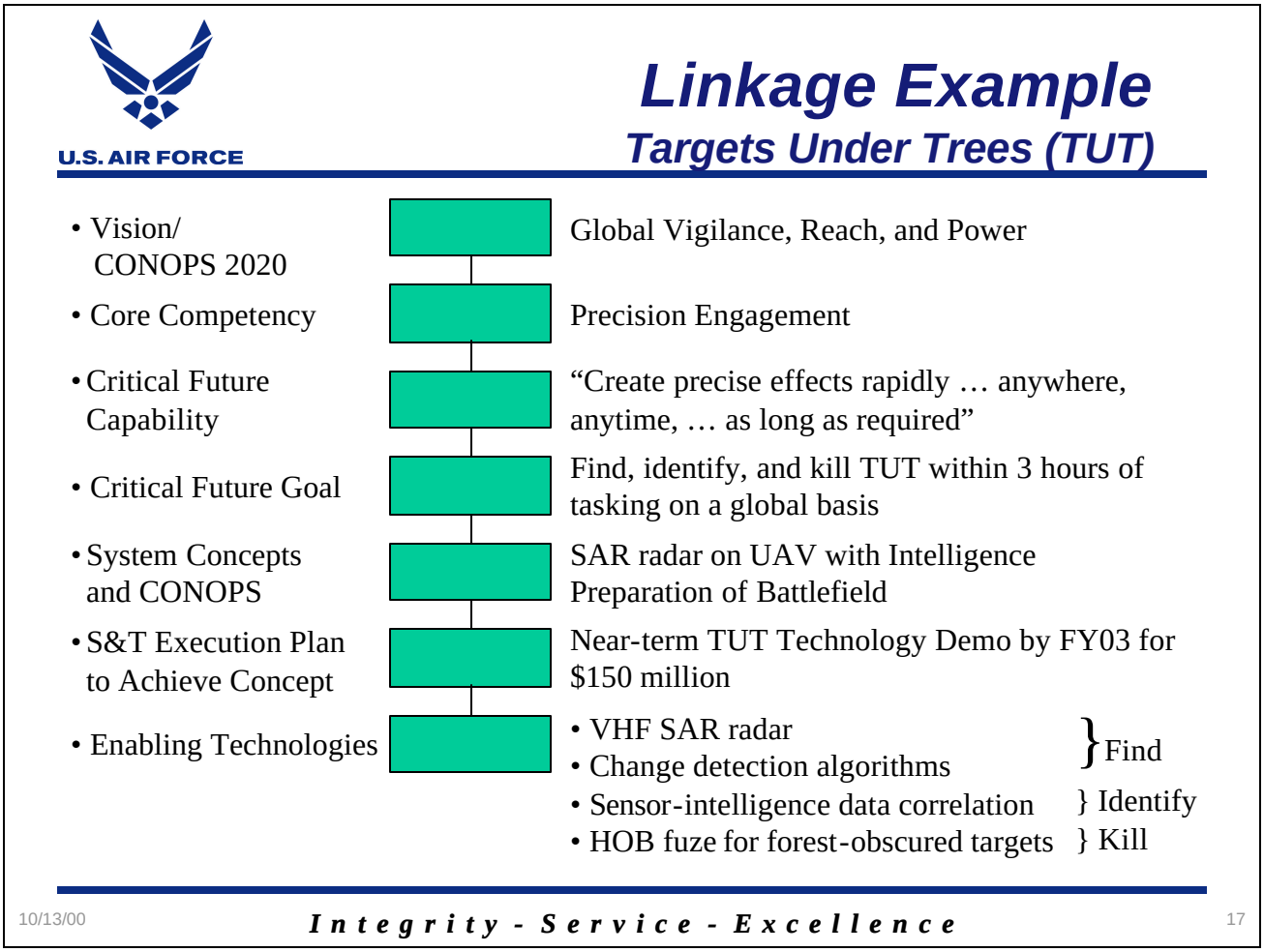
The existing linkage between vision and enabling technologies is missing several important steps. CFCs are well stated and by intent cover a very broad spectrum.[1] However, it is very difficult for the AFRL leadership to construct a prioritized S&T plan from these broad descriptions. Stated differently, 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.

[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.

Slide 17: Linkage Example—Targets Under Trees



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.

Slide 18: Recommendations

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Leadership: Goal Setting
Recommendations

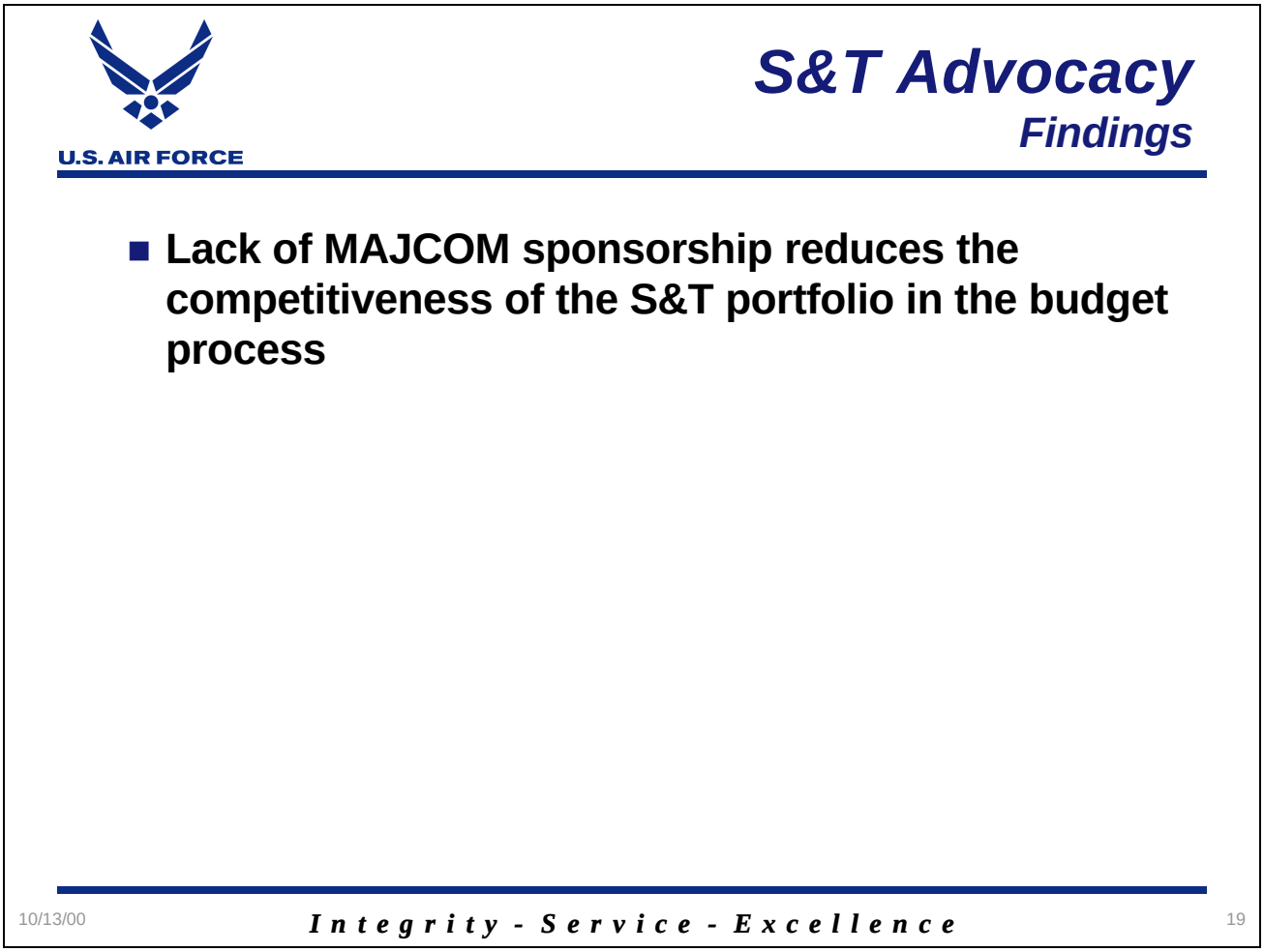
- **Establish or reaffirm CFGs annually (SecAF, CSAF, and MAJCOM/CCs)**
- **Establish concept to achieve each CFG (Development Planning activity, addressed later)**
- **Create an S&T execution plan for each CFG (AFRL/CC)**
  - **Assign a program manager with budget authority for each CFG**
  - **Present 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.

S&T Advocacy

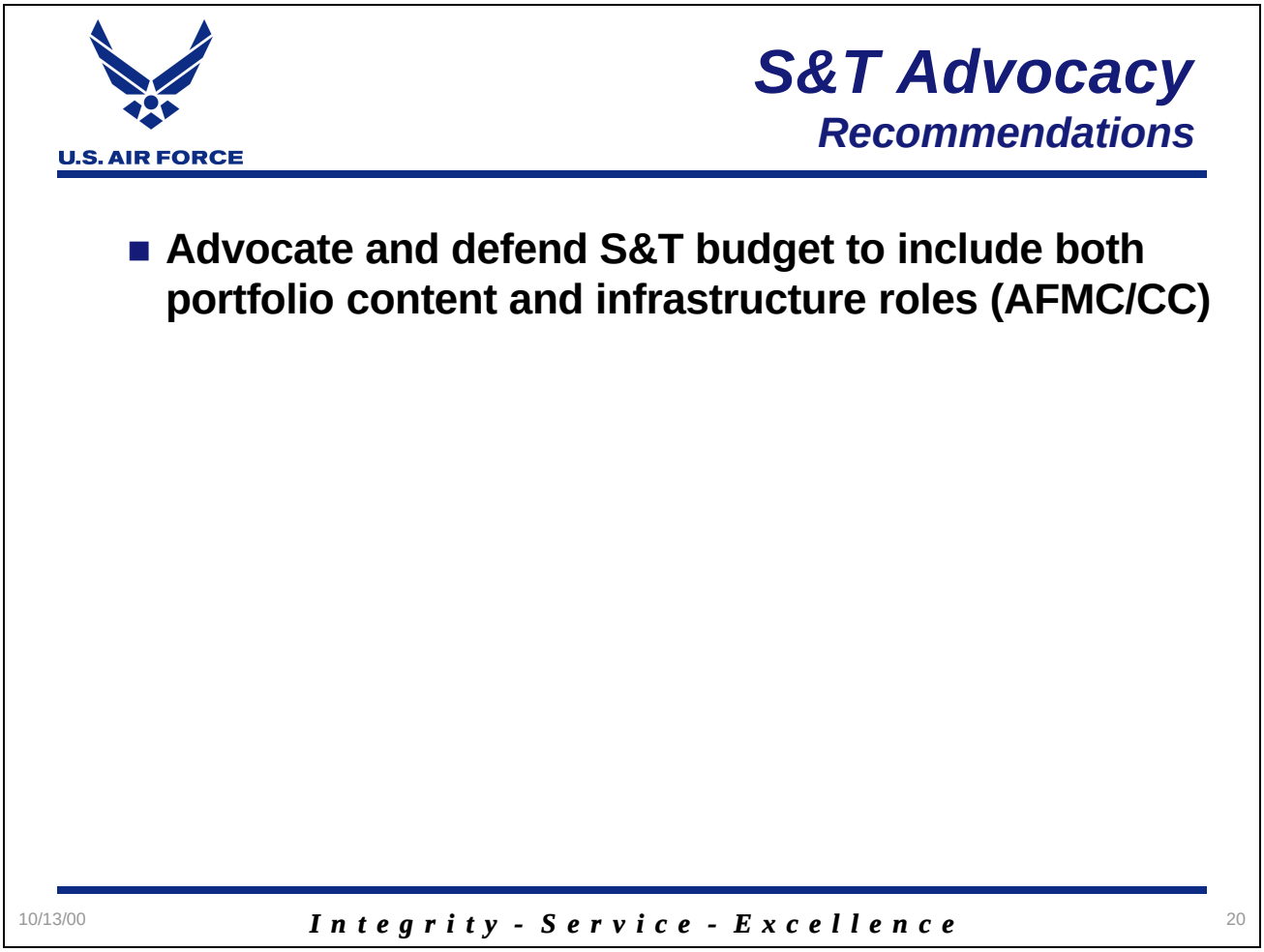
Slide 19: Findings



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.

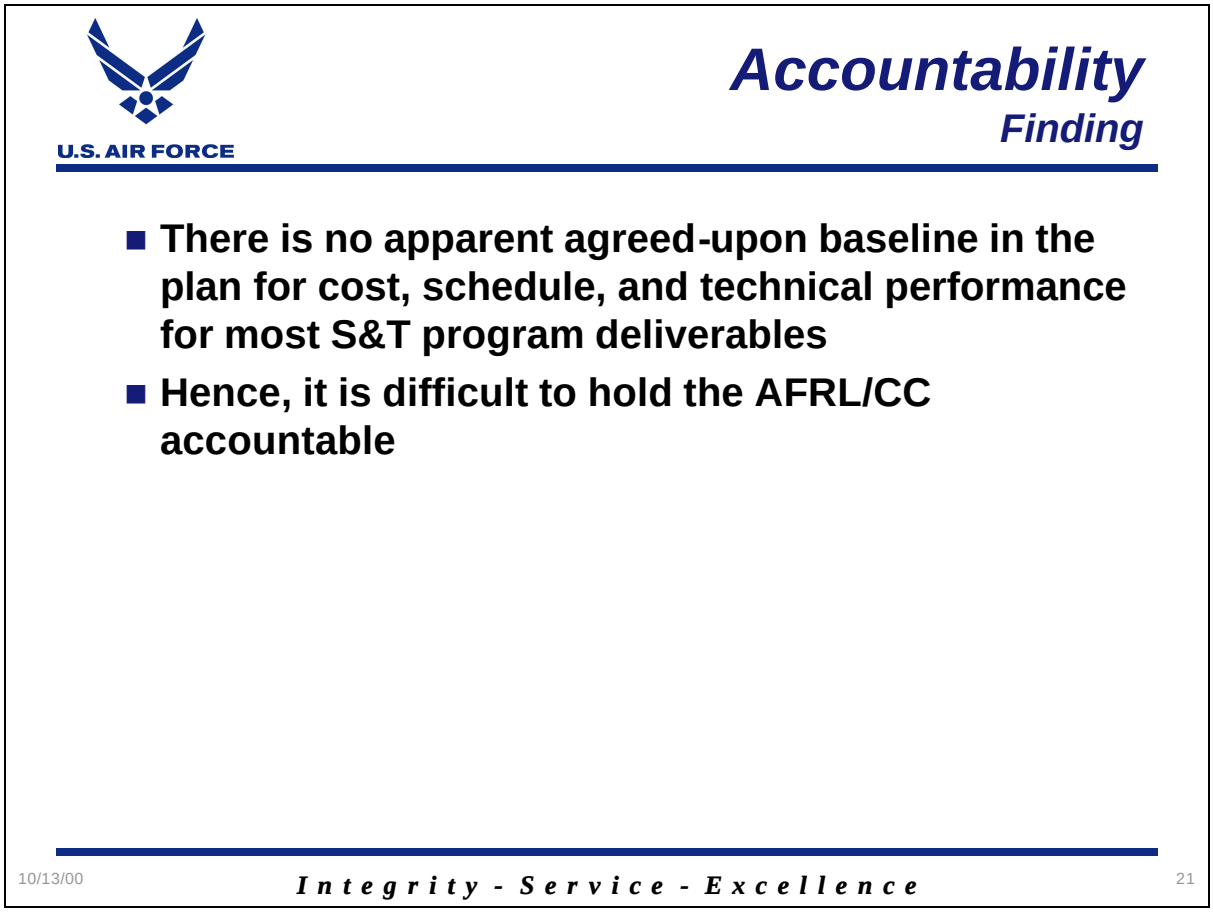
Slide 20: Recommendations



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.

Accountability

Slide 21: Finding

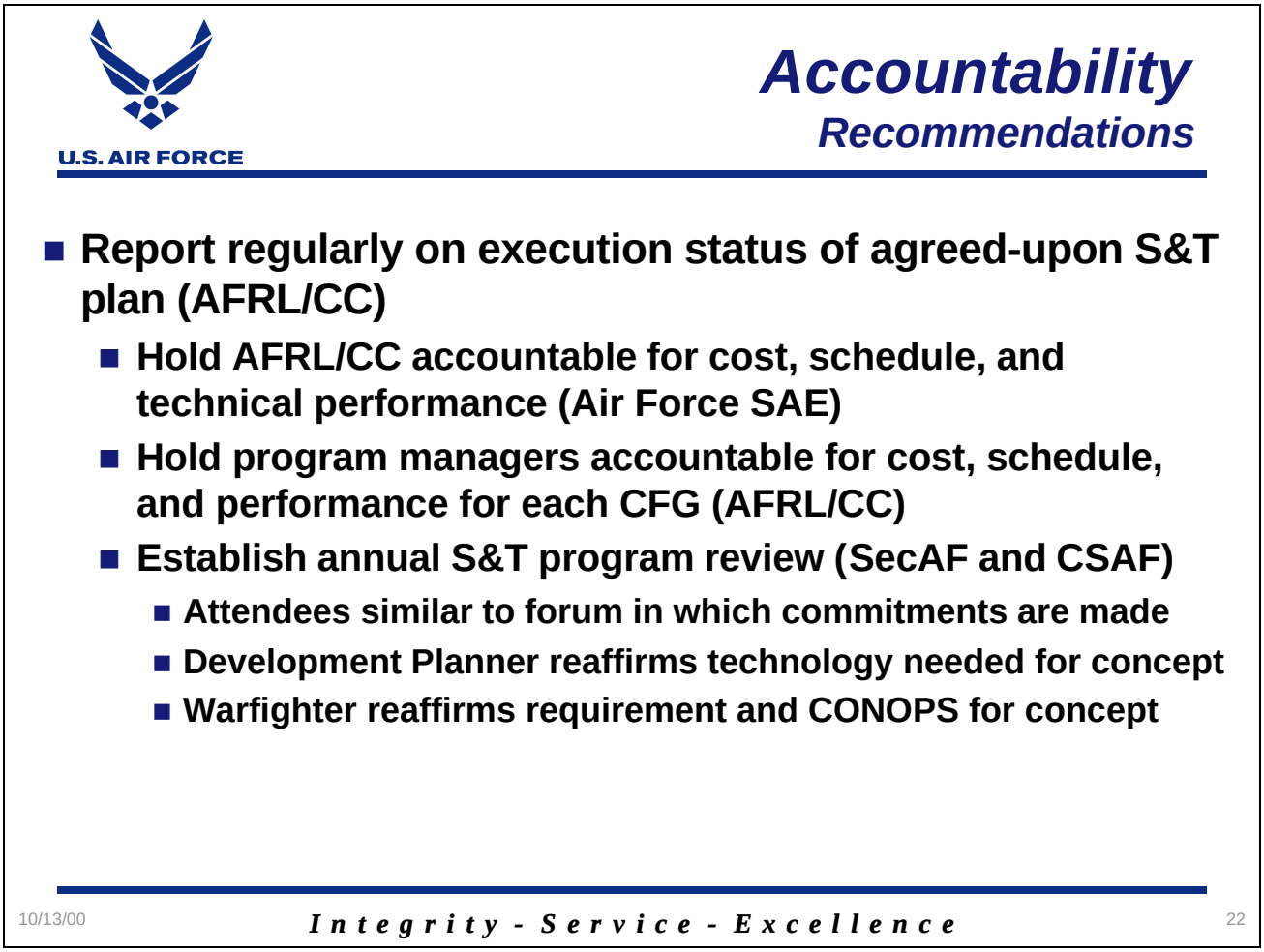


There are thousands of S&T projects each with cost, schedule, and technical performance requirements. Many of these project plans change during the course of a year for a variety of reasons. There is no apparent agreed-upon baseline at the beginning of the fiscal year, and certainly the baseline changes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

Slide 22: Recommendations

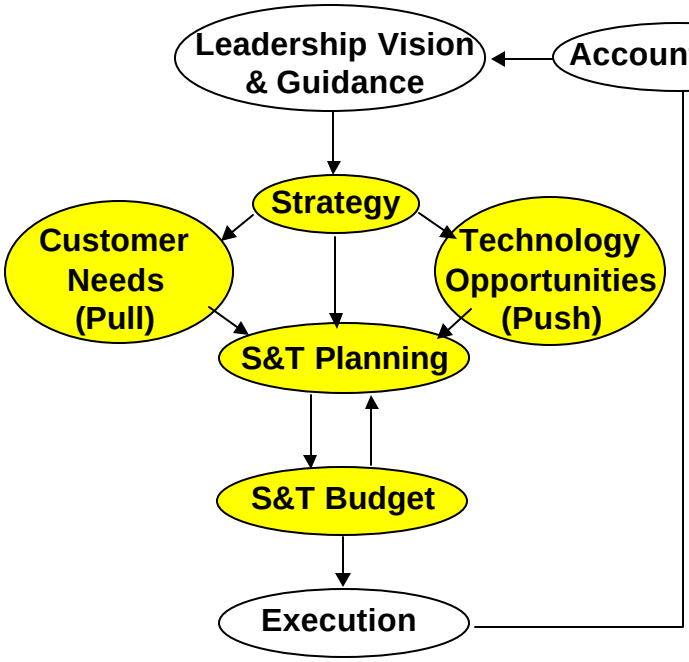


The AFRL/CC has the responsibility not only to lead the execution process, but also to represent the status of the programs to the Air Force leadership. He must also maintain a commitment to excellence by creating and sustaining a culture of innovation that is vital to future Air Force success in anticipating 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.

Slide 23: Planning

U.S. AIR FORCE

Outline



- Leadership
  - Goals
  - Advocacy
  - Accountability
- ⇒ **Planning**
  - **Development Planning**
  - **Technology Transitions**
  - **Portfolio Characterization**
- Execution
  - Leveraging Partnerships
  - Leveraging Commercial Technology
  - Workforce Issues

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Development Planning

Slide 24: Findings

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.

Slide 25: Recommendations

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.

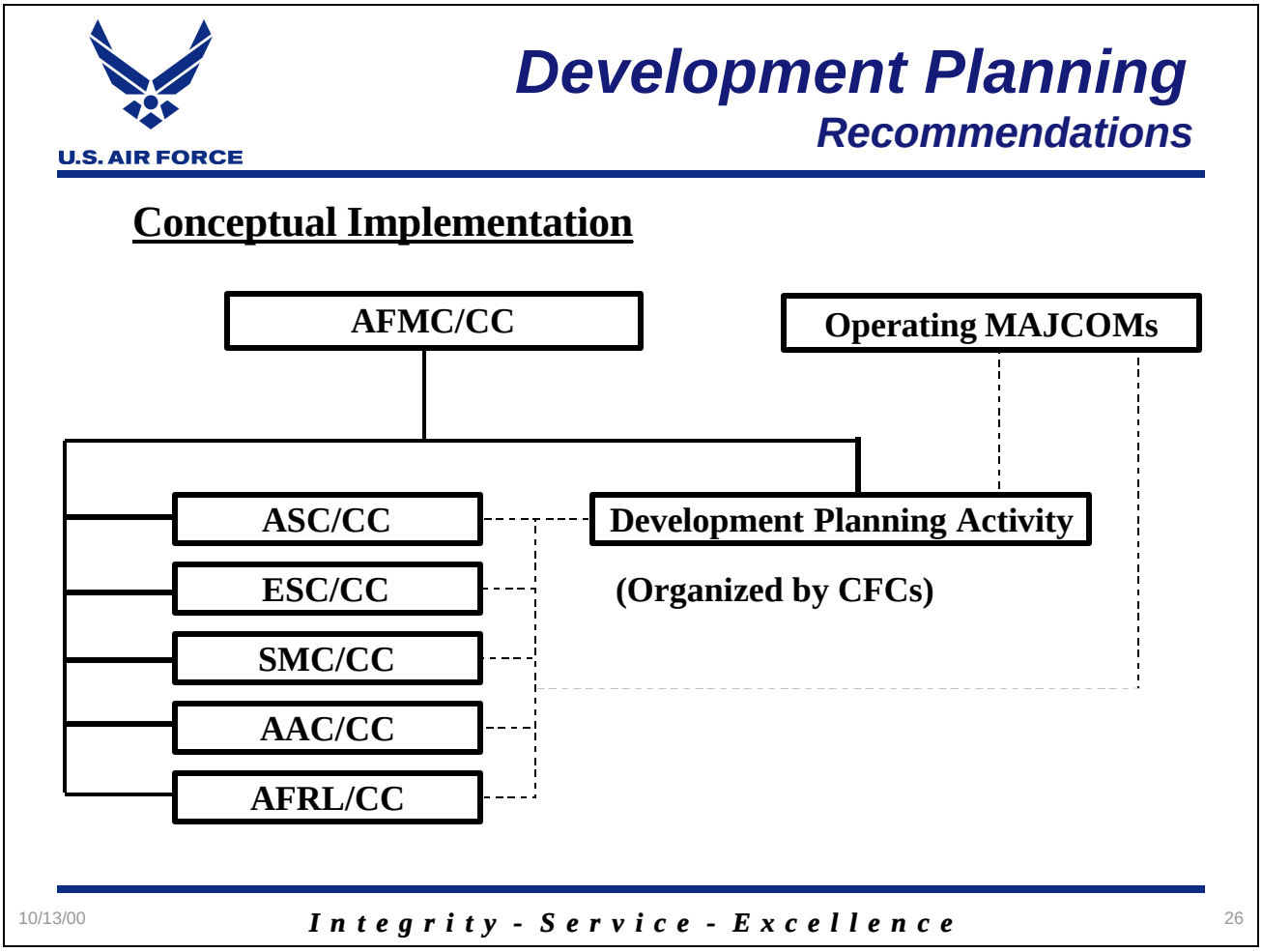
The panel believes that the Army Materiel Systems Analysis Activity (AMSAA), a Field Operating Agency that has been used successfully for Army development planning, provides a candidate organizational model for Air Force development planning. However, the proposed Air Force activity should have a narrower 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

Slide 26: Recommendations (continued)



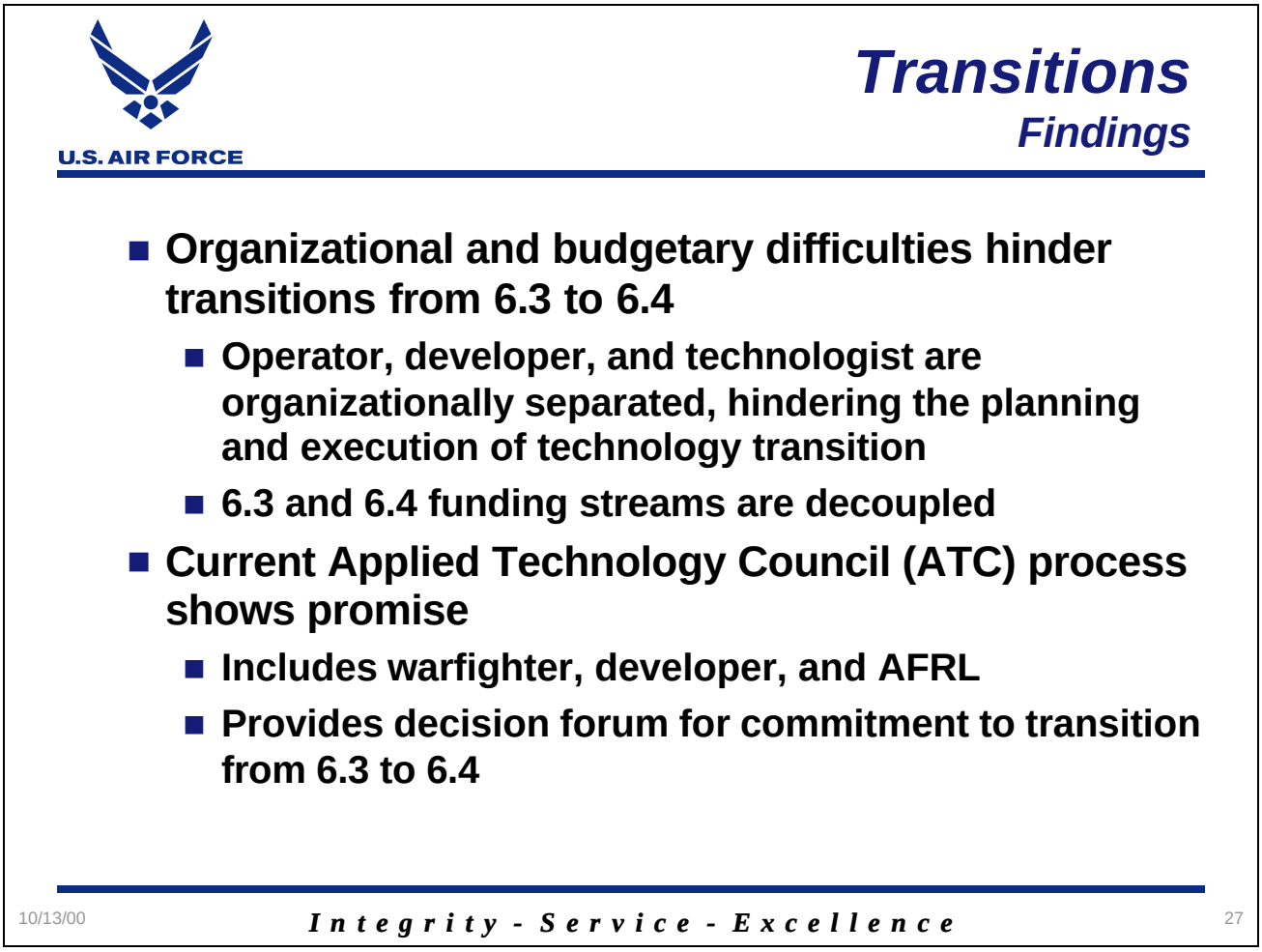
This chart shows a conceptual Air Force implementation of an AMSAA-like activity for development planning. The Development Planning Activity reports to AFMC and provides the Commander with an effective way to compare alternate concepts to meet a warfighter need or expanded CONOPS. For example, the requirement 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 Battlelabs 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.

Transitions

Slide 27: Findings

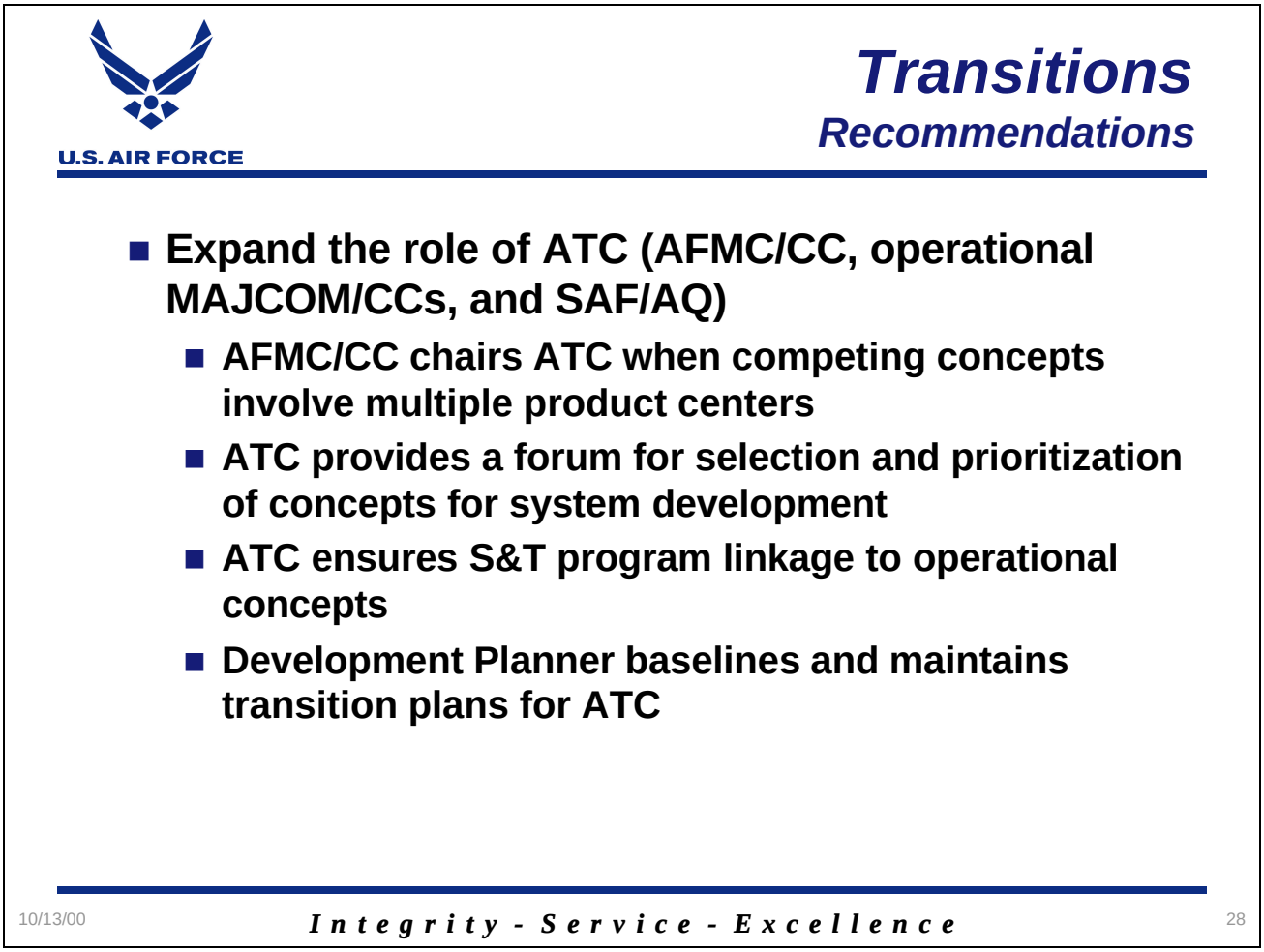


The Panel examined the transition of technology into operational systems. The Panel found organizational and budgetary barriers that impede transition from 6.3 to 6.4. The operator, developer, and technologist are organizationally separated, adversely impacting the planning and execution. Funding pathways 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.

Slide 28: Recommendations

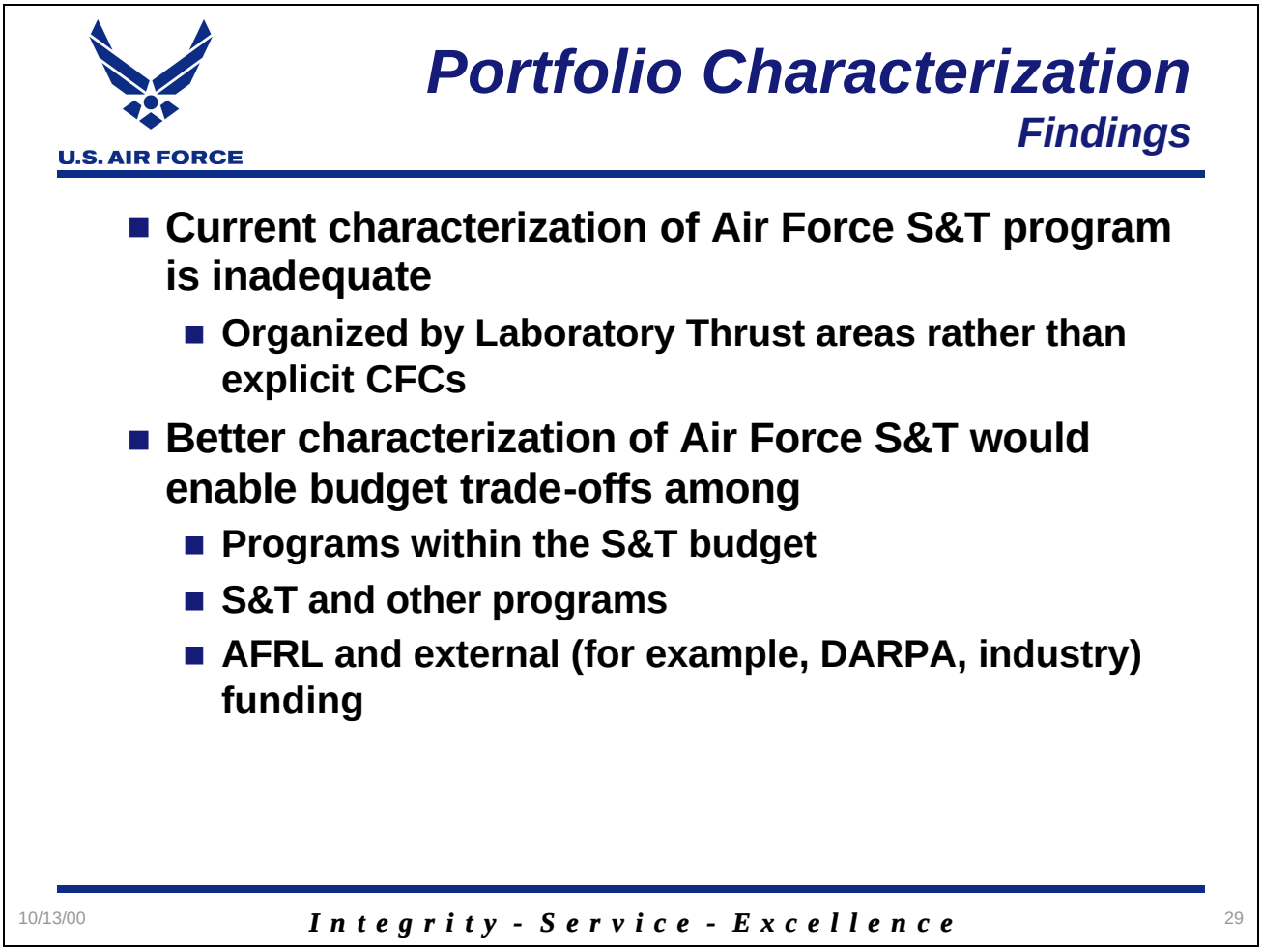


The Panel recommends unifying and expanding the role of the ATCs, which should provide a forum for selection and prioritization of concepts for system development that result from the development planning process described earlier. When competing concepts involve multiple Product Centers, AFMC/CC should 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.

Portfolio Characterization

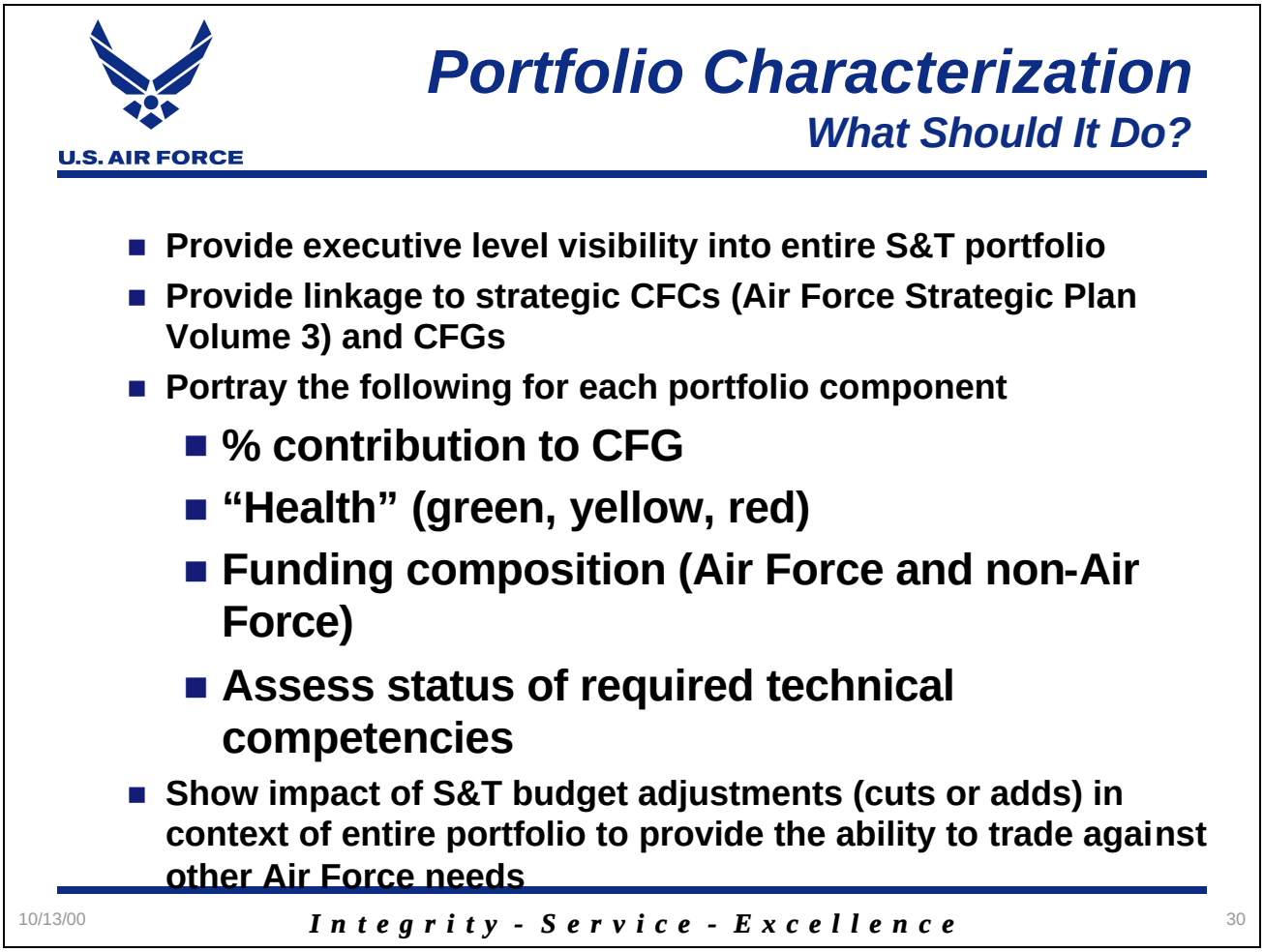
Slide 29: Findings



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.

Slide 30: What Should It Do?

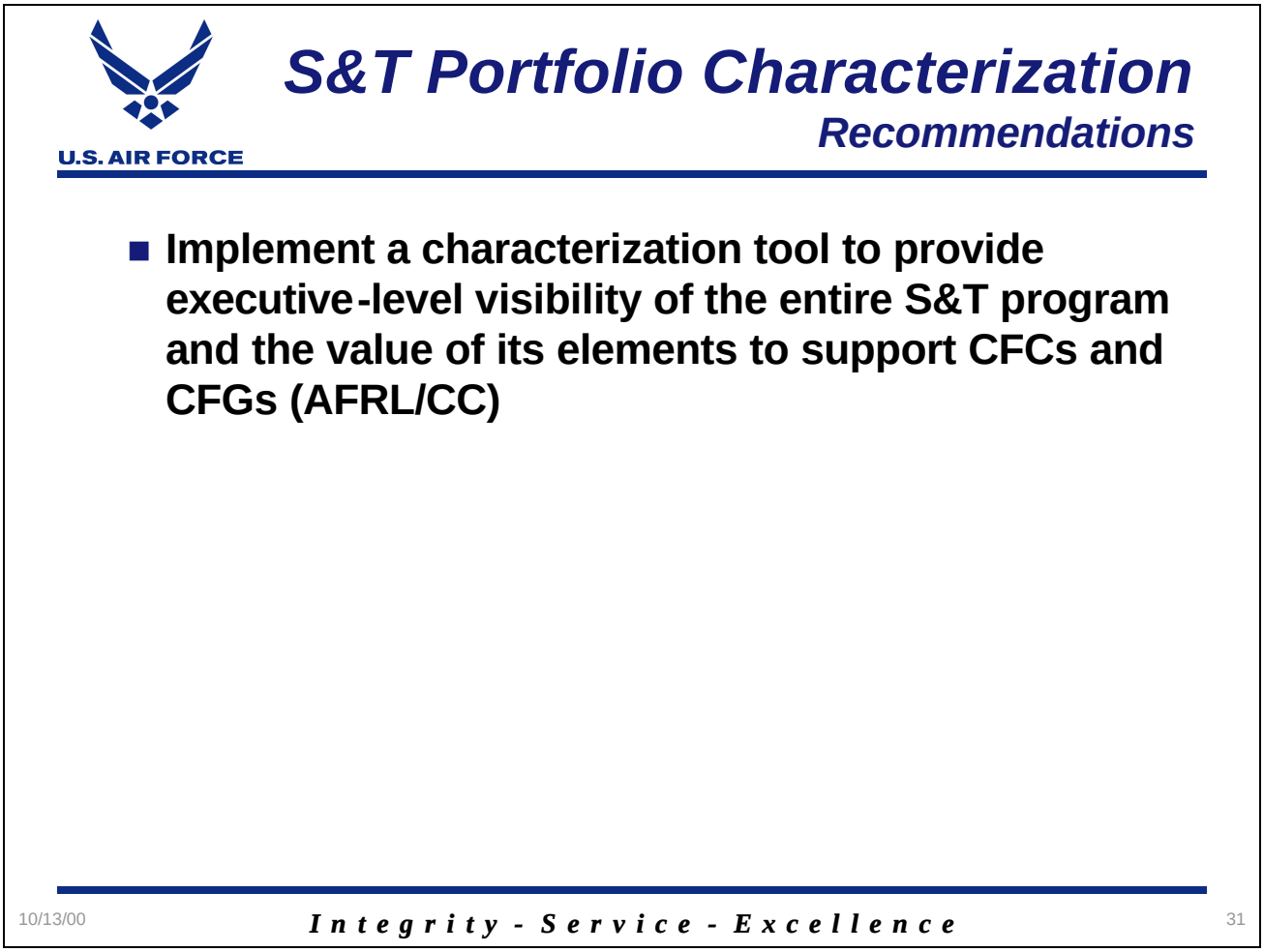


The characterization of the S&T portfolio must clearly show how the S&T investment enables the CFCs and CFGs (an example portfolio characterization tool is described in detail in Appendix A). The quantified contribution of each project supporting a CFC or CFG must be determined. The technical contributions 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.

Slide 31: Recommendations



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.

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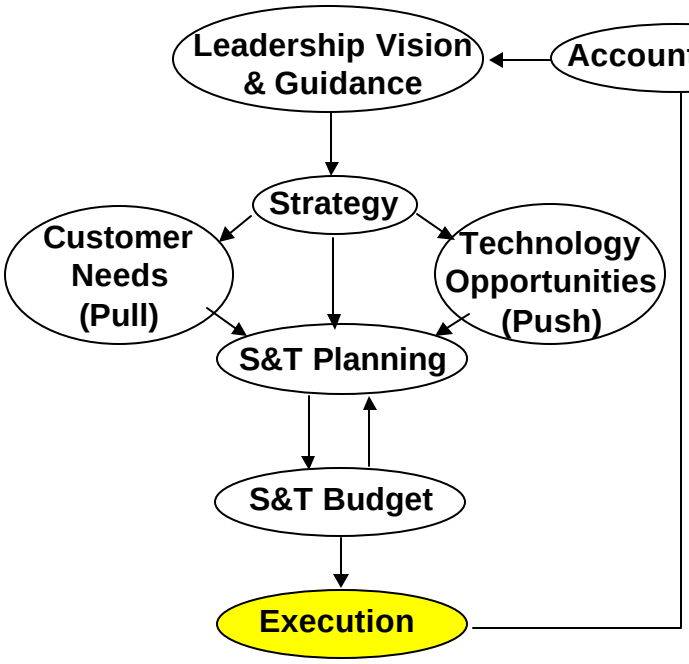
Slide 32: Execution

U.S. AIR FORCE

Outline



- Leadership
  - Goals
  - Advocacy
  - Accountability
- Planning
  - Development Planning
  - Technology Transitions
  - Portfolio Characterization
- ⇒ **Execution**
  - **Leveraging Partnerships**
  - **Leveraging Commercial Technology**
  - **Workforce Issues**

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Leveraging Partnerships

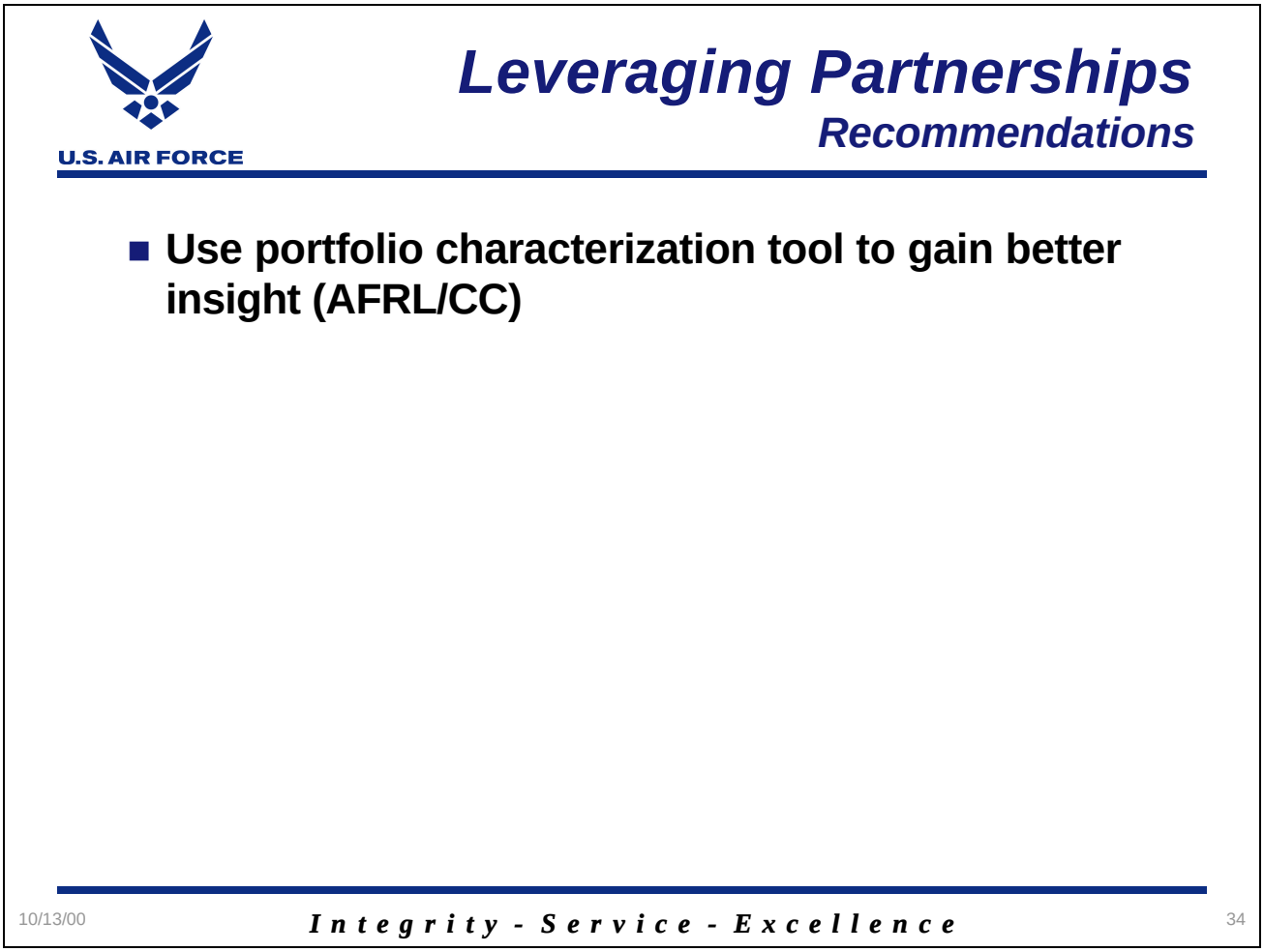
Slide 33: Findings

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.

Slide 34: Recommendations



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.

Leveraging Commercial Technology

Slide 35: Findings

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.

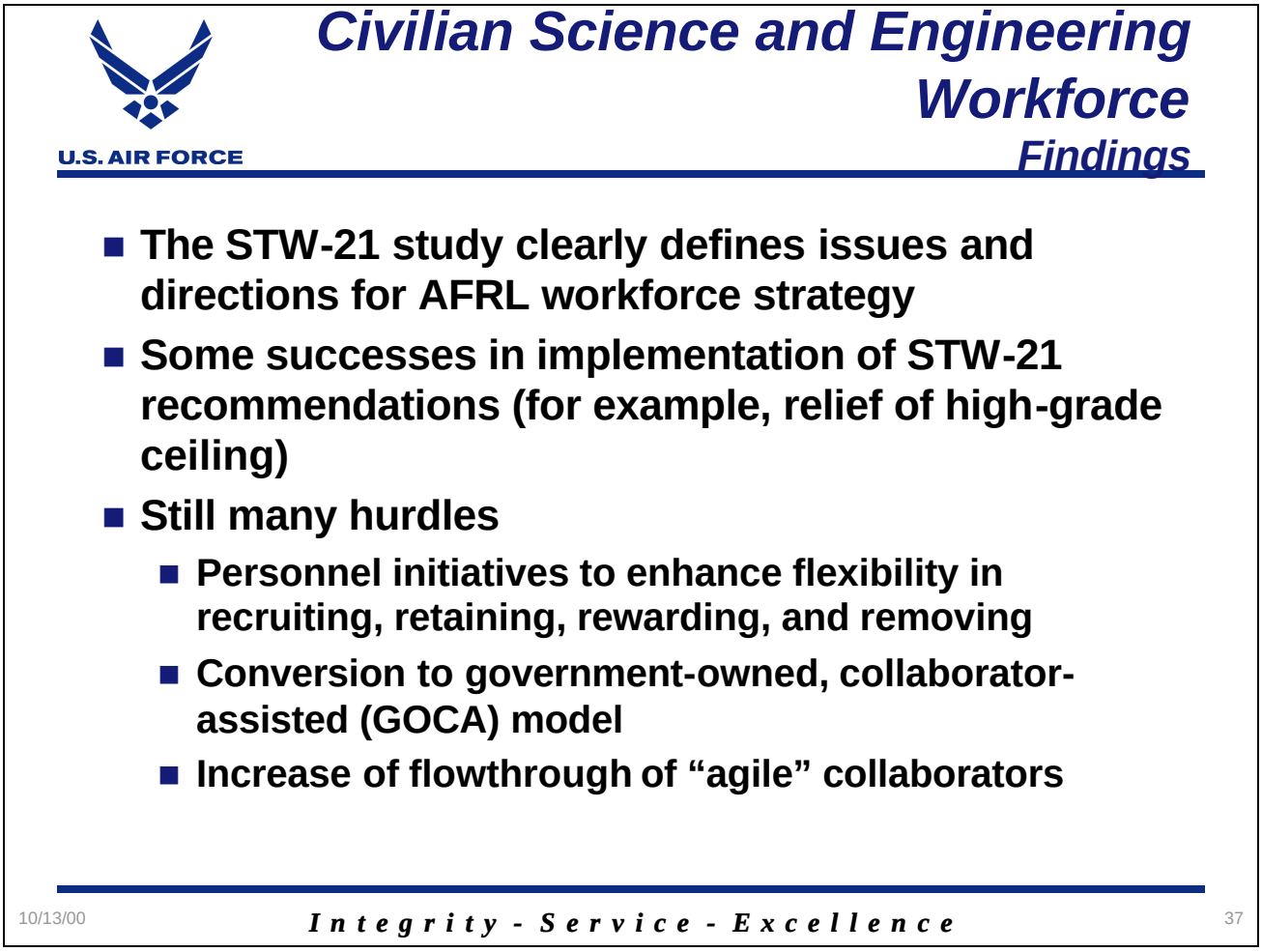
Slide 36: Recommendations

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.

Civilian Science and Engineering Workforce

Slide 37: Findings



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.

Slide 38: Recommendations

U.S. AIR FORCE

Civilian S&E Workforce

Recommendations

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.

Military S&E

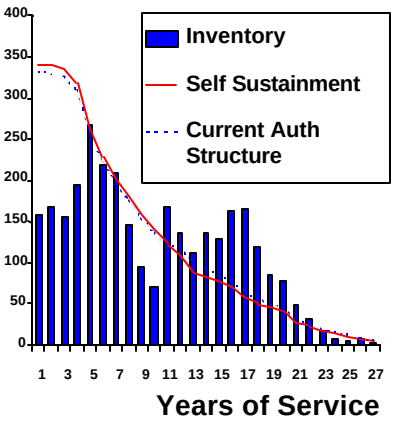
Slide 39: Findings

U.S. AIR FORCE

Military S&E
Findings

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



Source: AFPC

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Just as Dr. Theodore von Karman advocated for the Air Force of that day, the transformation of the modern Air Force into the aerospace continuum will require uniformed technical expertise. The SAB believes that this military technical expertise is a core competency and should be cared for and managed accordingly.

There is considerable evidence that the overall military S&E capability of the Air Force is eroding and can be likened to the aerodynamically familiar "graveyard spiral" from which a robust recovery must be applied if the pilot is to survive. The SAB has found worsening trends in accession and retention as well as in development and management of the S&E force. 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.

Slide 40: Findings

U.S. AIR FORCE

Military S&E
Findings

- **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**

AFIT S&E Quotas	MS Quota	MS Fills	PhD Quota	PhD Fills
Aero/Astro/Mech	32	10	10	0
Acq Mgmt	21	20	0	0
Comp Sci/Engr	22	9	3	0
Elect Engr	43	21	8	2
Electro Optics	9	2	1	0
Engr Phys/Nuclear	17	6	8	3
Environmental	12	12	0	0
Logistics Mgmt	21	7	0	0
Meteorology	22	12	2	0
Ops Anal/Rsch	20	13	3	0
Sys Eng/Space Ops	11	2	0	0
TOTAL	230	128	35	5

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

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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.

Slide 41: Recommendations

U.S. AIR FORCE

Military S&E
Recommendations

- **Increase S&E accessions (AETC/CC and USAFA/CC)**
- **Align technical degree quotas with needs, then fill them (AF/DP)**
- **Institute an improved career management plan for S&E officers to emphasize their value and visibility to the Air Force (S&E Functional Manager)**
- **Manage the S&E officer corps (SAF/AQ-OPR, AFMC/CC-OCR)**
  - **Note: S&E summit scheduled in Dec 2000 to define the path forward**

Stop the military S&E graveyard spiral!

10/13/00 *Integrity - Service - Excellence* 41

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.

Slide 42: Conclusion

U.S. AIR FORCE

Conclusion

- Summary Recommendations
- Terms of Reference Compliance

Slide 43: Summary Recommendations for SecAF and CSAF

U.S. AIR FORCE

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

Slide 44: Summary Recommendations for SecAF and CSAF (continued)

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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

Slide 45: Summary Recommendation for Air Force Service Acquisition Executive (SAE)

U.S. AIR FORCE

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**

Slide 46: Summary Recommendations for AFMC/CC

U.S. AIR FORCE

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

Slide 47: Summary Recommendations for AFRL/CC

U.S. AIR FORCE

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—incentivize buy before make behavior

Slide 48: Terms of Reference Compliance

U.S. AIR FORCE

Terms of Reference Compliance

Terms of Reference Item	Compliance Action
Tie S&T investment strategy to Air Force long- range plan and vision	■ Leadership sets CFGs to drive concepts to drive S&T plan
Take into account the investment of others in Air Force S&T strategy, but recognize risk; partnership with industry	■ Partnerships ■ Leveraging external technology
Recommend industry tools (practices) for Air Force to use in determining S&T investment	■ Defined tool for characterizing S&T portfolio at executive level (valuing and prioritizing S&T)
Develop augmenting strategies for work force management, risk assessment, and hedges	■ Recommended actions to deal with Air Force S&E officer and civilian workforce issues ■ S&T portfolio characterization tool defines dependencies on non-Air Force funding sources
Recommend a level for Air Force S&T topline	■ Process for setting CFGs and S&T portfolio characterization tool provide basis for setting S&T topline in light of other Air Force needs ■ Sanity checks provided by previous studies

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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

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Appendix: Example S&T Portfolio Characterization Tool

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Slide 50: Conceptual Model

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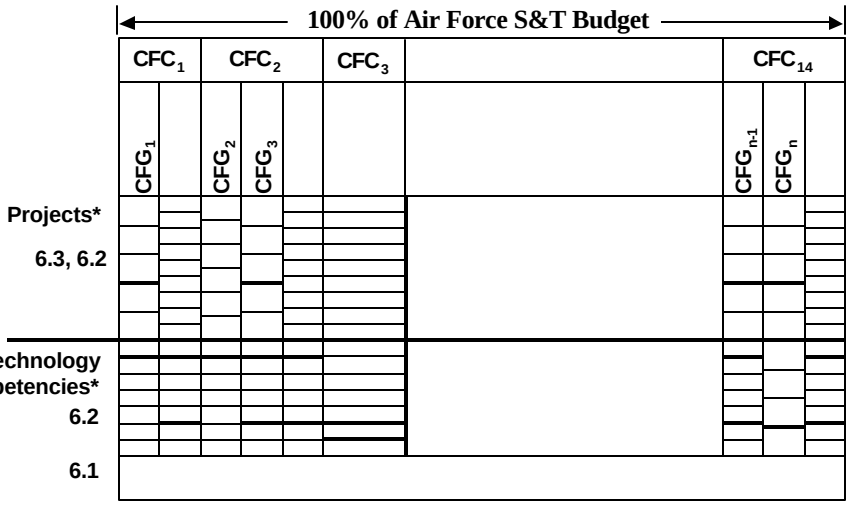
Characterization
Conceptual Model

CFCs and CFGs



* Aggregated to provide strategic perspective

Technology roadmaps hyperlinked to each element

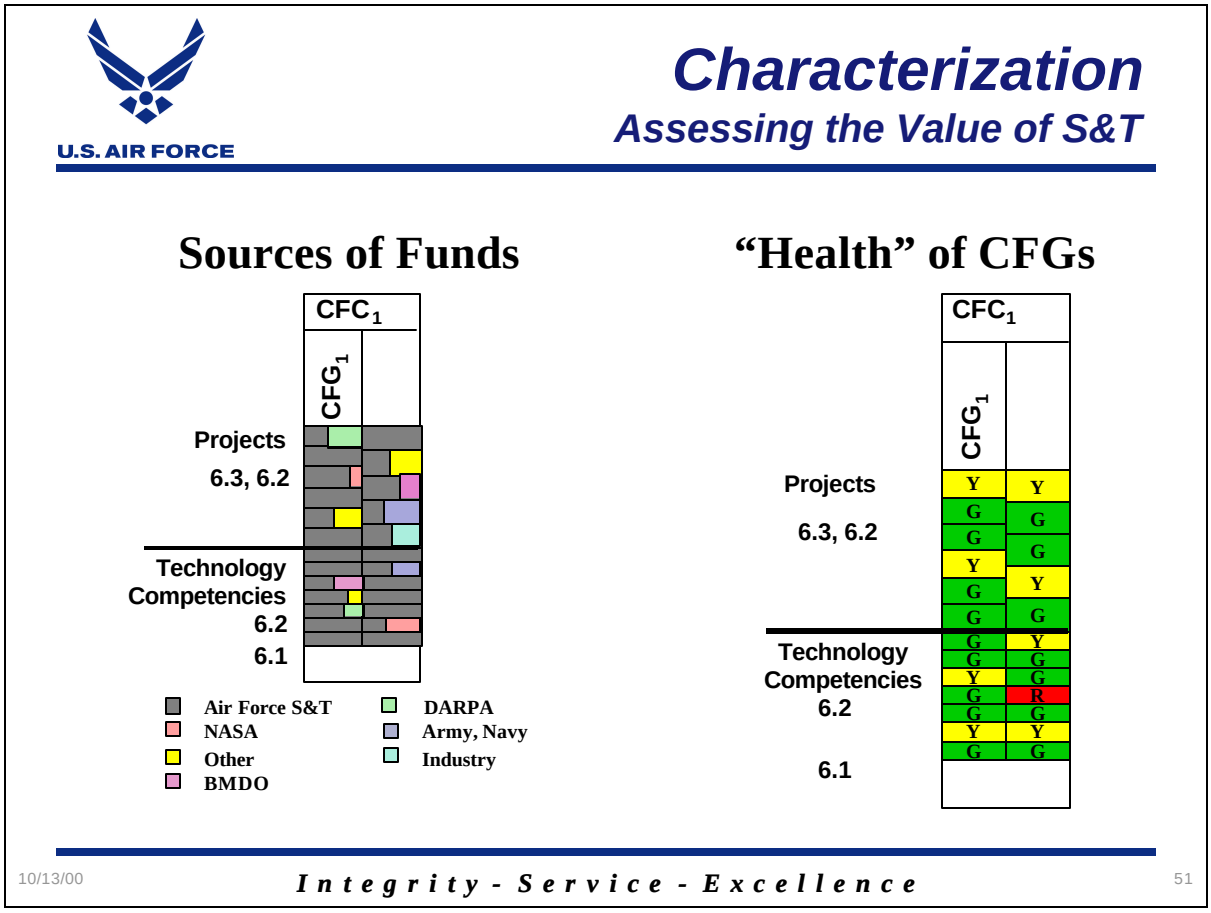
A conceptual S&T portfolio characterization model is depicted in this chart. At the aggregate level, the entire S&T program is linked to the CFCs. As can be seen, the CFGs are linked to the appropriate CFCs, but not all CFCs have CFGs. Also, several CFGs may be associated with one CFC.

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.

Slide 51: Assessing the Value of S&T

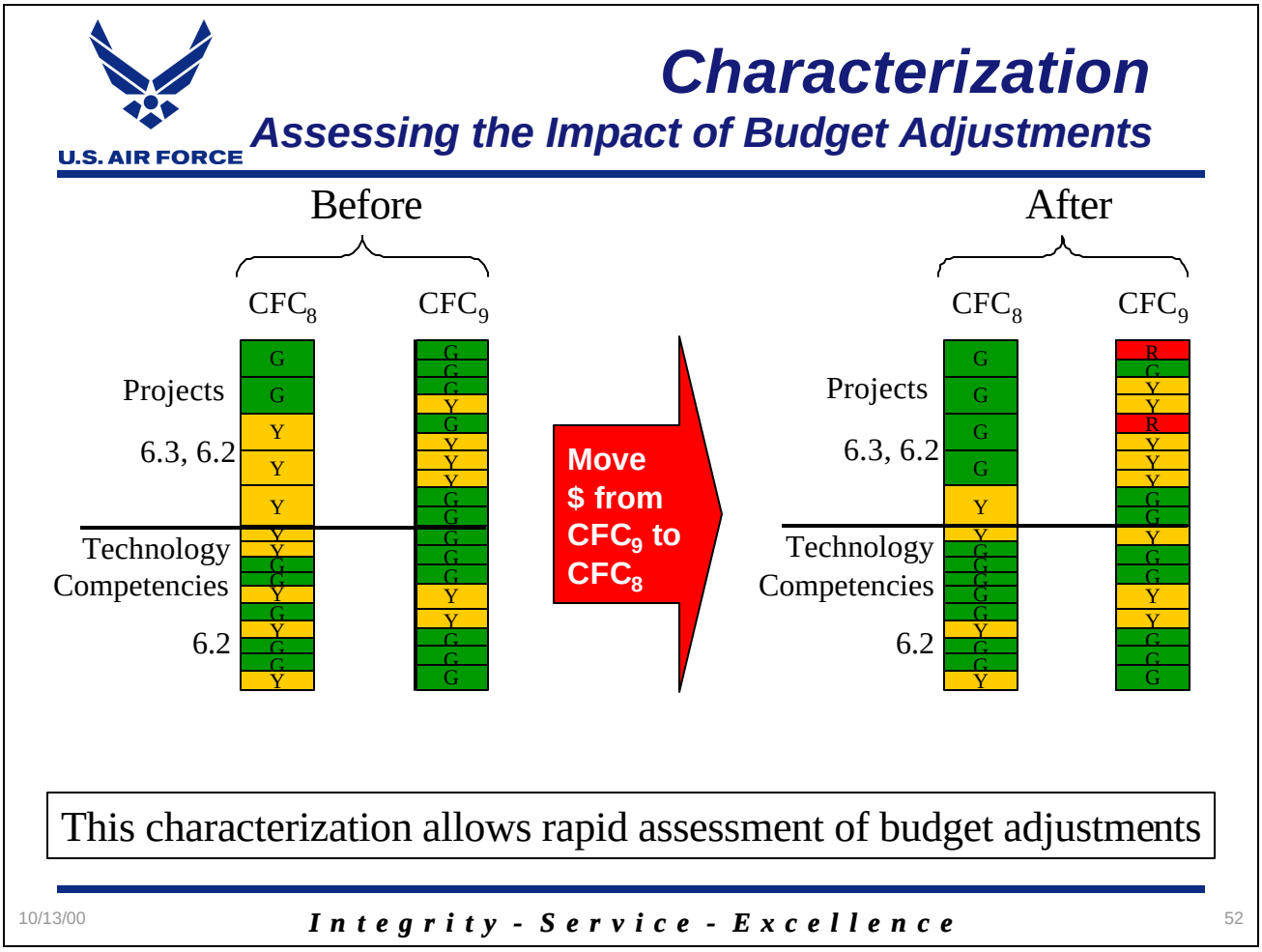


This tool has additional benefits. There are a number of metrics, such as the two depicted here, that can be captured and displayed. In the first example, the bars represent individual aggregations of projects and the agency (or industry) providing the funds. The individual bars are color-coded in proportion to the funding provided. For example, DARPA is providing approximately 60 percent of the funds needed to execute the first project under CFG_1. 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.

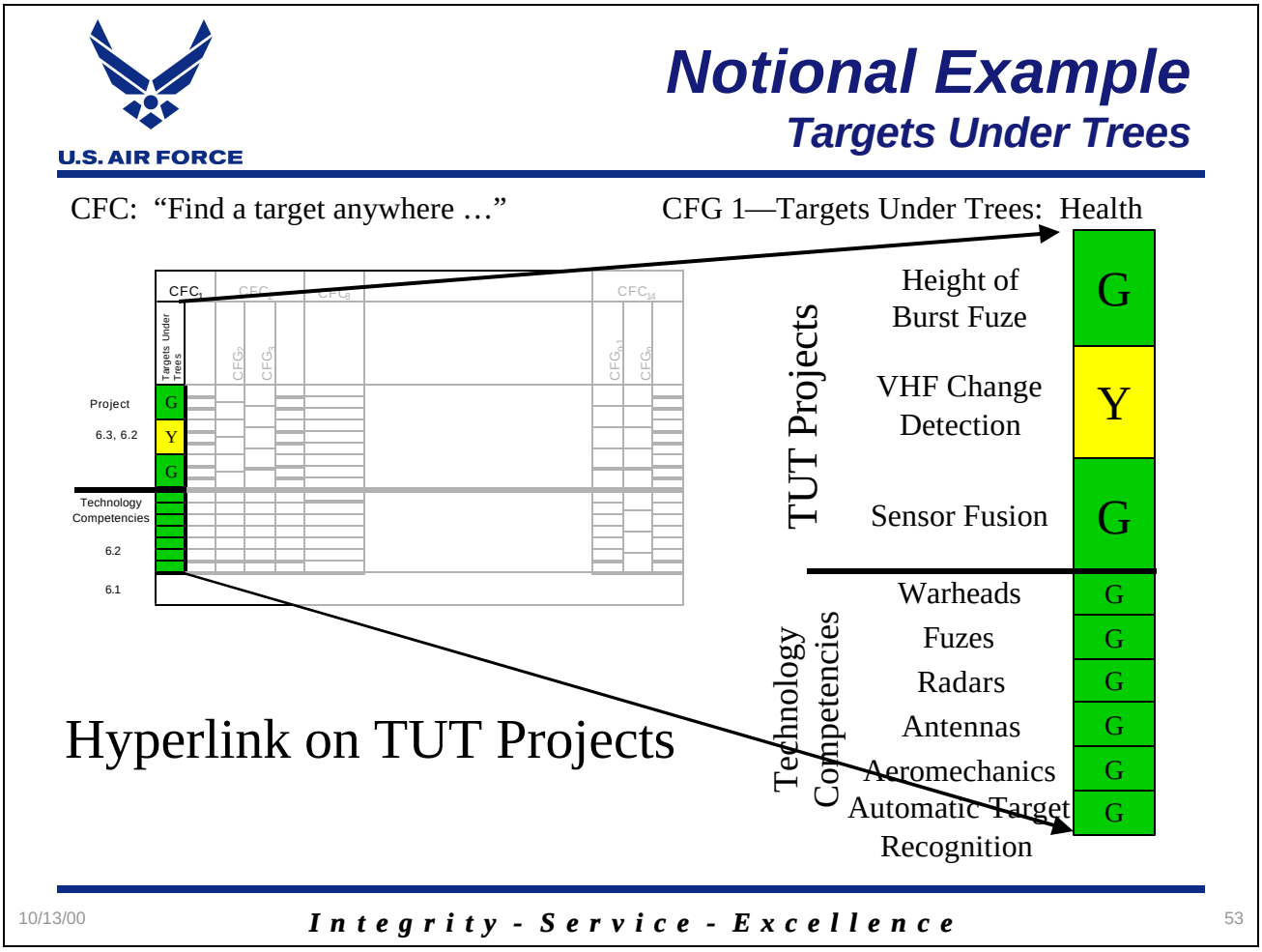
This chart only displays two metrics, but others can be easily added as needed. The SAB believes that this tool provides a mechanism to track and display (at an executive level, with hyperlinked backup information) any metric needed to assess the execution and health of the S&T program.

Slide 52: Assessing the Impact of Budget Adjustments



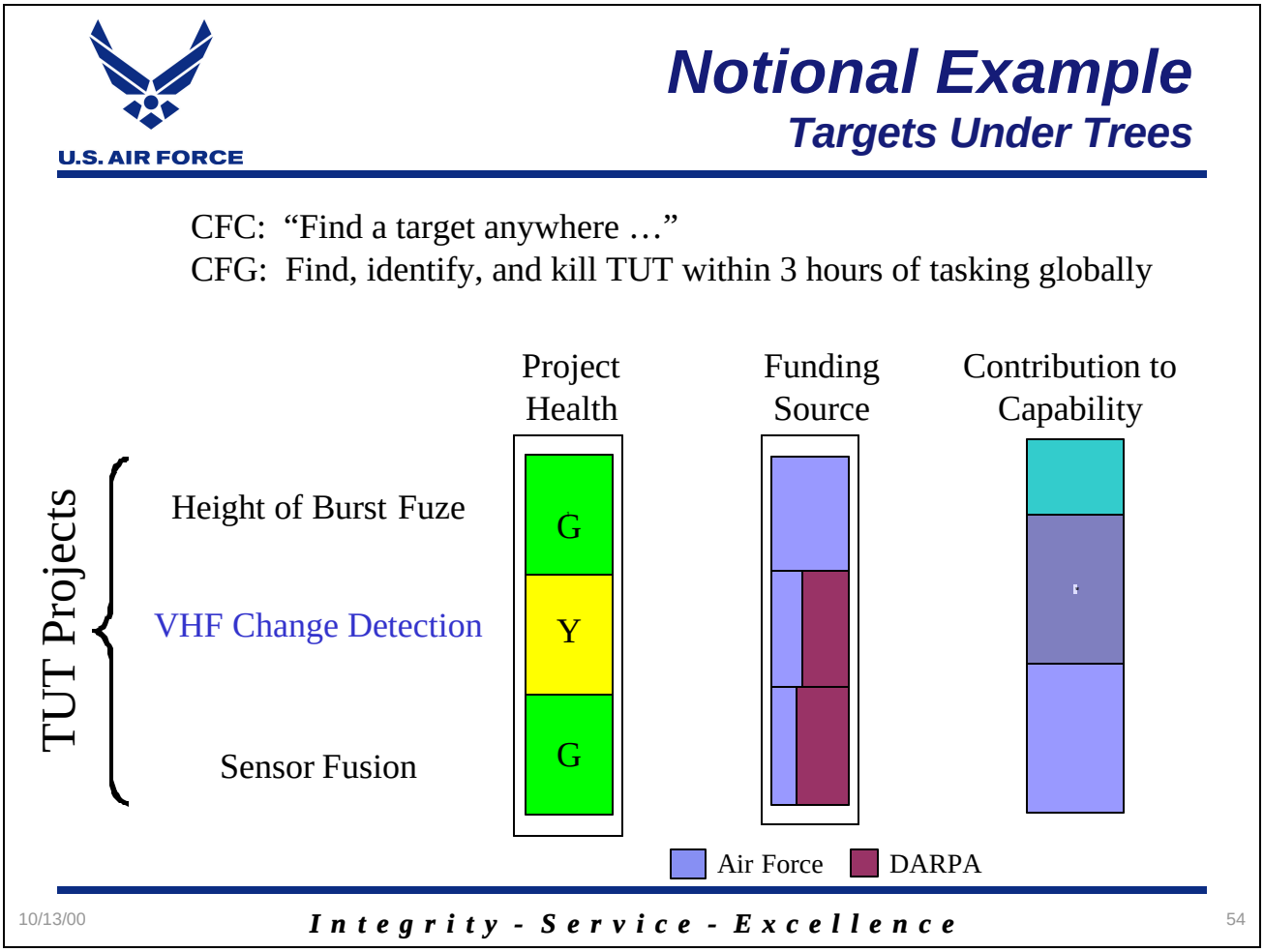
This characterization tool can also be used to understand the impact of budgetary adjustments. In the above example, moving technology development funds from one CFC statement to another is being considered. This tool allows for executive-level depiction of the impact of that proposal and allows senior 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.

Slide 53: Notional Example—Targets Under Trees



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.

Slide 54: Notional Example—Targets Under Trees (continued)



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.

Slide 55: Notional Example—Targets Under Trees—VHF Change Detection

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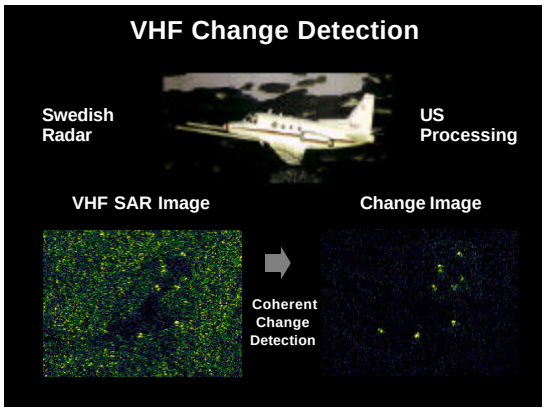
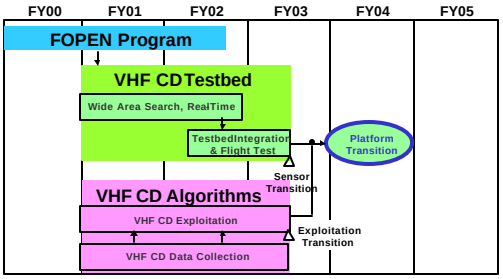
Notional Example

Targets Under Trees—VHF Change Detection



VHF CD ROADMAP



AF Baseline	2000	14200	12000	3300	0	0
DARPA	25000	25000	12000	0	0	0
TOTAL	27000	39200	24000	3300	0	0

G	Cost	Technical issue: results of FOPEN tests indicate higher-than-expected false alarms
G	Schedule	
Y	Performance	Solution: modify VHF CD algorithms and test in testbed

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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
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Appendix D
Acronyms and Abbreviations

AAC	Air Armament Center
AAD	Advanced Academic Degree
AETC	Air Education and Training Command
AF/DP	Air Force Deputy Chief of Staff, Personnel
AFIT	Air Force Institute of Technology
AFMC	Air Force Materiel Command
AFPC	Air Force Personnel Center
AFRL	Air Force Research Laboratory
AMSAA	Army Materiel Systems Analysis Activity
ARL	Army Research Laboratory
ASC	Aeronautics Systems Center
ATC	Applied Technology Council
BMDO	Ballistic Missile Defense Organization
CC	Commander
CD	Change Detection
CEO	Chief Executive Officer
CFC	Critical Future Capability
CFG	Critical Future Goal
CONOPS	Concept of Operations
CSAF	Chief of Staff of the Air Force
CTO	Chief Technical Officer
DARPA	Defense Advanced Research Projects Agency
DERA	Defense Evaluation and Research Agency
DoD	Department of Defense
DSB	Defense Science Board
ESC	Electronic Systems Center
FOPEN	Foliage Penetration
GOCA	Government-Owner, Collaborator-Assisted
GPS	Global Positioning System
HOB	Height of Burst
IHPTET	Integrated High Performance Turbine Engine Technology
IR&D	Independent Research and Development
ITT	Integrating Technology Thrust
MAJCOM	Major Command
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
OCR	Office of Coordinating Responsibility
OPR	Office of Primary Responsibility
OSD	Office of the Secretary of Defense
R&D	Research and Development
RDEC	Research, Development, and Engineering Center
S&E	Science and Engineering

S&T	Science and Technology
SAB	Air Force Scientific Advisory Board
SAE	Service Acquisition Executive
SAF/AQ	Assistant Secretary of the Air Force, Acquisition
SAF/US	Under Secretary of the Air Force
SAR	Synthetic Aperture Radar
SecAF	Secretary of the Air Force
SMC	Space and Missile Systems Center
SPO	System Program Office
STW-21	Science and Technology Workforce for the 21st Century Study
TARDEC	Tank Automotive Research, Development, and Engineering Center
TUT	Targets Under Trees
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
USAFA	U.S. Air Force Academy
VHF	Very High Frequency

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 SPOSMC/CC

Industry

3M
Boeing
DuPont
General Electric
Hughes
IBM
Lockheed Martin
Lucent
Microsoft
Nokia
Sun

Other Government Agencies

AMSAA
ARDEC
ARLCERDEC
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

AF/DP	DCS, Personnel

Office of the Secretary of Defense

USD (A&T)	Under Secretary for Acquisition and Technology
USD (A&T)/DSB	Defense Science Board
DARPA	Defense Advanced Research Projects Agency
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
BMDO	Ballistic Missile Defense Organization

Other Air Force Organizations

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

U.S. Army

ASB	Army Science Board

U.S. Navy

NRAC	Naval Research Advisory Committee
Naval Studies Board	

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
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ABSTRACT (Maximum 200 Words)

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.

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