Report of the
Defense Science Board Task Force
on
Future Strategic Strike Skills

March 2006

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

OFFICE OF THE SECRETARY OF DEFENSE
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DEFENSE SCIENCE
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY & LOGISTICS)

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on Future Strategic Strike Skills

I am pleased to forward the Final Report of the DSB Task Force on Future Strategic Strike Skills, chaired by Mr. Walter Morrow.

The Task Force was asked by the Assistant to the Secretary of Defense for Nuclear and Chemical and Biological Defense Programs (ATSD(NCB)) to examine the current adequacy and future needs of the specialized skills necessary to maintain, upgrade, and design replacement strategic nuclear and non-nuclear strike systems. The attached final report represents the complete work of the panel.

In preparing this report, the Task Force heard from a wide variety of experts from both the private and public sectors. The Task Force found several areas of concern regarding the future of the strike systems, namely: the direction of next-generations strike systems, inadequacy in the exploration of new strike concepts and technologies, and the Department of Defense's difficulty in attracting the best and brightest science and engineering.

I endorse all of the Task Force's recommendations and encourage you to review this report.

William Schneider, Jr.
DSB Chairman

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DEFENSE SCIENCE BOARD

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on Future Strategic Strike Skills

The DSB Task Force on Future Strategic Strike Skills has completed its work and a final report is attached. The Task Force was asked by the Deputy Assistant to the Secretary of Defense for Nuclear and Chemical and Biological Defense Programs (ATSD(NCB)) to examine the current adequacy and future needs of the specialized skills necessary to maintain, upgrade, and design replacement strategic nuclear and non-nuclear strike systems.

The Task Force found numerous areas of concern in regards to the future of strategic strike systems. The Task Force has compiled the following key assessments:

1. The DoD has not provided specific direction regarding next-generation strategic strike systems. Subsequently, the industry and government talent base is marginally thin in many of today's current systems, and may not be available for potential next-generation systems.

2. The exploration of new concepts and technologies for strategic strike of challenging targets in the far term is inadequate and will require access to a new talent base with different skills.

3. The strategic strike area most at risk today is ballistic missiles. Current skills may not be able to cope with unanticipated failures requiring analysis, testing, and redesign. Applications Programs are not sufficient to maintain skills.

4. DoD and industry have difficulty attracting and retaining the best and brightest students to the science and engineering disciplines relevant to maintaining current and future strategic strike capabilities.

5. Human capital management systems and strategies for identifying, tracking, and retaining critical skills are not being implemented effectively across all of the strategic strike constituent organizations.

The Task Force prepared eight major recommendations to improve the topics of concern. The Task Force's observations and recommendations have been consistent with previous DSB studies, and if implemented, will safeguard the future of strategic strike skills. The Task Force urges the senior leaders of the US Government to implement the recommendations at the earliest opportunity. To facilitate this, a draft action plan has been included with the hope that the Secretary of Defense will sign it out for immediate action.

Walter Morrow

Mr. Walter Morrow
Task Force Chairman

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Tasking

The Task Force was asked by the Deputy Assistant to the Secretary of Defense for Nuclear and Chemical and Biological Defense Programs (ATSD(NCB)) to examine the current and future capabilities of the specialized skills necessary to maintain, upgrade, and design replacement strategic nuclear and non-nuclear strike systems. Recently, there has been considerable concern that the majority of the personnel involved with critical engineering skills may soon be retiring, thus endangering future capabilities to maintain current systems and to design replacement systems. The availability of strategic skills among military personnel, civil service personnel and industrial personnel were to be examined. The Chiles Commission (prescribed by the National Defense Authorization Act of FY 1997) examined the capabilities for the design and testing of nuclear warheads, therefore the topic was not included in this study.

The Task Force was asked to provide remedial recommendations if their findings concluded that the availability of strategic strike system skills was in danger.

Membership

The Task Force included experienced individuals with backgrounds in strategic strike systems, listed in Appendix B.

Approach

Several approaches were used to gather pertinent information:

- Meetings were held with the past and current heads of STRATCOM, including a site visit to STRATCOM Headquarters.
- Briefings were heard from military, civil service, and industrial organizations involved with current operations and support of U.S. strategic strike systems.
- Data were requested of the current age distributions of critical strategic strike personnel in relevant organizations.

BACKGROUND

Policy Directions

With the end of the Cold War, further development of the nation's nuclear strike systems was terminated. Operational manning of those systems was continued along with maintenance and sustainment efforts. Plans were made to maintain these systems, but no specific actions were taken for replacing them with next-generation systems.

In 2002, Congress mandated a second Nuclear Posture Review (NPR) concerning the future of U.S. strategic strike forces. This review directed a continuation of reduced-size nuclear forces; development of strategic defense systems including ballistic missile defenses; and maintenance of a responsive defense infrastructure capable of responding to any new strategic system needs.
To-date, the Department of Defense (DoD) has not acted upon the NPR Implementer in its entirety. The Department's focus has instead been on improving upon conventional forces, and specifically on addressing insurgency warfare challenges. Additionally, the Department is currently conducting a Quadrennial Defense Review (QDR) with an assessment of the needs identified by specific scenarios that may, in some cases, utilize strategic strike.

Trends in Availability of Engineering Personnel to the DoD

In the early days of the Cold War, urgent national defense problems drew on the services of a significant percentage of U.S. professional engineers. Today most of the country's engineering talent is concerned with civilian developments, and only a small fraction is devoted to DoD problems. Currently, work related to strategic strike systems is not considered to be a desirable career path by engineering personnel, particularly when exciting and potentially lucrative careers are available in new technological areas such as computer/internet systems, quantum communications and computation, nanotechnology, etc.

The result has been that in many strategic strike critical skill areas, experienced personnel are nearing retirement with few replacements. This situation could lead to the potential loss of critical strategic strike systems knowledge.

STRATEGIC SKILLS SURVEY RESULTS

The Task Force heard briefings on strategic strike personnel management practices in the various military services, relevant industrial organizations, as well as in the Defense Threat Reduction Agency (DTRA). It also requested personnel age distributions from these organizations. Unfortunately, few of these organizations were able to provide such numerical data. A summary of the results obtained from the briefings and the limited survey data follows.

Navy

The Navy has a systematic Human Capital Management Plan focused on the retention of strategic strike skills over the long term. This was especially evident in the area of operations and sustainment of current systems, where the normal officer personnel system ensures a steady flow of new talent. Current Navy plans are to maintain current Submarine-Launched Ballistic Missile (SLBM) capability until approximately 2040. However, there is reason for concern in certain areas with respect to the ability of the industry to design replacement SLBM components and especially new SLBM systems, should they be needed to replace current systems. A strategic skills staff age distribution provided by one industry source, for example, showed that a serious loss of expertise would occur within 10 years, by which time almost half of the critical personnel will have left the company.

Army

Although the Army has no currently identified strategic strike mission, it must maintain a capability to understand nuclear effects, particularly on the battlefield. Toward that end, it has a well-managed officer career process to ensure that this capability is maintained by a continual flow of officers into this specialty.

Air Force

The Air Force has recently integrated its strategic ballistic missile personnel into its Space Corps. The Service has also instituted a supervisory organization to ensure a maintained presence of strategic nuclear strike personnel, including capable strategic operational and maintenance officers, as well as civilian engineering personnel. The age structure of the operational personnel and maintenance personnel appears to be well under control. It is too early to tell if this management system will be able to maintain the necessary engineering skills in the civil service and in industry. Specifically, there is some question as to whether the industrial capability to design replacement Intercontinental Ballistic Missile (ICBM) systems is being maintained, particularly when business opportunities for industry lie in different directions, such as conventional warfare and space systems. Data provided by the Air Force indicated that a serious decline in ICBM design capability would occur within 5 years and, with sustainment efforts, within 10 years.

On the other hand, prospects for long-term maintenance of bomber design capability appears assured, because of the sizeable design capabilities being employed for new tactical military aircraft and for civil air transport aircraft.

Application Programs

Due to concerns over the potential loss of strategic strike industrial expertise, the Office of the Secretary of Defense (OSD) has recommended for the past decade that the Air Force and Navy fund "Application" programs to retain certain industrial strategic skills. These programs involve the redesign of replacement components for current systems. The funding by the Services and Congress for these efforts has never equaled the original recommendation of the United States Strategic Command's Strategic Advisory Group (STRATCOM SAG). Moreover, this set of programs does not address retention of the skills necessary for the development of new replacement systems, should they be needed.

Defense Threat Reduction Agency (DTRA)

This DoD agency is charged with, among other things, understanding nuclear weapons effects. Government civil service personnel, military officers, and contractors are used to carry out this DTRA mission area. While military officers are involved with DTRA, a significant percentage of the civil service and contractor personnel is approaching retirement, according to an agency survey. As far as could be determined by the Task Force, DTRA does not have a Human Capital Management system directed to solve this problem.

C4ISR

Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) capabilities are provided by a variety of service organizations and government agencies. Because these capabilities are needed for modern precision conventional warfare, they should also be available for current and future strategic forces. Therefore, the skills needed for support of strategic forces could be available in the future with providing intelligence, Surveillance and Reconnaissance (ISR) capabilities for detecting low level nuclear programs.

New Strategic Strike Concepts

A Defense Science Board (DSB) Summer Study of 2003 addressed the future of U.S. strategic strike systems, including non-nuclear systems. It appears that relatively little additional action has taken place on this subject over the past 2 years, either with regard to next-generation (evolutionary) systems or in connection with new types of systems (revolutionary) for future objectives. The personnel required for the development of such systems should be highly innovative; attracting such individuals may be difficult due to the lack of financial incentives associated with civilian industry's efforts.

FINDINGS AND RECOMMENDATIONS

Based on the information received by the Task Force from a wide variety of briefings and surveys, it appears that a serious loss of certain critical strategic strike skills may occur within the next decade. More detailed findings and associated recommendations follow.

FINDING #1

- The DoD has not provided specific direction regarding next-generation strategic strike systems. Consequently, the industry and government talent base:
  - Are already marginally thin in many of today's current systems, and
  - May not be available for potential next-generation systems.

Recommendation

- The Secretary of Defense should, taking account of the NPR Implementer and the Task Force on Future Strategic Strike recommendations, give direction for next-generation strategic strike systems.

FINDING #2

- The exploration of new concepts and technologies for strategic strike of challenging targets in the long-term is inadequate and will require access to a new talent base with different skills.

Recommendation

- The Secretary of Defense should establish a DARPA office charged with defining and funding the exploratory development of future strategic strike concepts, to include the application of new technologies. Output would include:
  - Concepts for strategic attack that can be transitioned to the Services;
  - Conceiving and maturing technologies required by the concepts; and
  - Annual reports to the Secretary of Defense on progress in developing strategic strike technologies.

FINDING #3

- The strategic strike area most at risk today is ballistic missiles:
  - Current skills may not be able to cope with unanticipated failures requiring analysis, testing, and redesign;
  - A large number of skilled military, civil service, and contractor personnel are nearing retirement;
  - Design skills are rapidly disappearing, both for major redesigns of current systems and for the design of new strategic systems; and
  - Applications programs are necessary, but not sufficient to maintain skills; moreover, they have never been funded at the required levels.

Recommendation

- Ballistic missile program offices should devote resources to the transfer of critical knowledge and skills to early career personnel in industry.
- The Secretary of Defense should direct the Navy and the Air Force – absent near-term systems development – to fund advanced development (subsystem design, system prototype development, and testing) to support next-generation system development (which will also restore and maintain the skills base).
- The Secretary of Defense should ensure that the Navy and Air Force Applications Programs are fully funded at the STRATCOM SAG's originally-recommended levels to address critical areas not supported fully by advanced development.

FINDING #4

- DoD and industry have difficulty attracting and retaining the best and brightest students to the science and engineering disciplines relevant to maintaining current and future strategic strike capabilities.
- The National Defense Education Act (NDEA) program has the potential for attracting personnel to government; however, it currently does not have strategic strike element.

Recommendation

- Strategic strike program offices should encourage and fund supporting industries to develop combined undergraduate scholarship and co-op programs for U.S. citizens in relevant science and engineering disciplines that would:
  - Include the requirement to work for a period of time in DoD or the Defense industry; and
  - Encourage future graduate studies.
  - Take advantage of the NDEA program.

FINDING #5

- Human capital management systems and strategies for identifying, tracking, and retaining critical skills are not being implemented effectively across all of the strategic strike constituent organizations.

Recommendation

- The USD (AT&L) should ensure that strategic strike constituent organizations institute a skill and domain-knowledge management system, and include active duty, civil service, and industry personnel.

INTRODUCTION

In the past few years, concerns have arisen in the Office of the Secretary of Defense that skills necessary to maintain and modernize the country's strategic nuclear strike systems are endangered due to the imminent retirement of critical personnel.

The problem of retaining skills in the nuclear weapons area within the Department of Energy was earlier examined by the Chiles Commission Study.

Nuclear payloads represent only a portion of the current strategic strike weapon systems employing nuclear devices; i.e., C4ISR, delivery systems, operations, maintenance and a broad supporting infrastructure constitute the "weapon system." In addition, the reliance upon non-nuclear payloads in the future may change the way strategic strike systems are viewed. Thus, for current, near-term, and future strategic strike systems, all elements which comprise the weapon system need to be considered so that the skills necessary to develop, operate, and support all phases of the weapon system life cycle can be assessed.

As a result, the Acting Under Secretary of Defense (Acquisition, Technology and Logistics) requested the Defense Science Board to form a Task Force to study the adequacy and sustainability of skilled personnel needed to ensure the continued capability of United States strategic strike forces, both nuclear and non-nuclear.

If serious problems were discovered in the adequacy and sustainability of current or future strategic strike skills, the Task Force was asked to generate recommendations for maintaining such skills into the future.

TERMS OF REFERENCE/TASKING

The Under Secretary requested that the Task Force:

- Assess the current skills and their future viability to sustain U.S. nuclear and non-nuclear long-range strike forces.
- Identify new skill sets necessary to develop new long-range non-nuclear strategic strike concepts
- Recommend a strategy for successful evolution of current skills to those needed for future strategic strike forces.

A copy of the Terms of Reference is in Appendix A.

MEMBERSHIP

The Task Force membership was drawn primarily from individuals who had had an extensive career in the acquisition, operations, and maintenance of U.S. strategic systems. A number of members had also participated in the 2003 DSB Summer Study on Future U.S. Strategic Strike Systems. A complete list of participants is found in Appendix B.

METHODOLOGY/APPROACH

The Task Force held meetings over approximately a one-year period. The members heard a wide range of requested briefings on strategic strike personnel skills. In addition, the members discussed how best to assure sufficient future strategic skills given the current imbalance in the age distribution of those individuals. The classes of skills that were reviewed include:

- Military personnel charged with operating the weapons platforms or systems;
- Military and civilian personnel charged with strike planning;
- Individuals involved with the innovation of new classes of long-range strike capabilities, particularly non-nuclear;
- Military, civil service, and contractor personnel charged with maintenance of weapons platforms and weapons components, including guidance, rocket engines, fuzes, reentry bodies, etc.;
- Civil service and contractor personnel charged with the modernization of outmoded components such as guidance systems, flight control equipment, fuzes, etc.; and
- Government and industry personnel responsible for the planning and subsequent development of strategic strike systems for both the near-term and the future.

A complete list of all briefings received is found in Appendix E.

The Task Force also visited the U.S. Strategic Command in Omaha, NE, including a meeting with Admiral James Ellis, USN, STRATCOM Commander-in-Chief; and later met in the Pentagon with his successor, General James Cartwright, USMC.

DEFINITIONS

Strategic Strike. The DSB report on “Future Strategic Strike Forces,” dated February 2004, defined *strategic strike* as “a military operation to decisively alter an adversary’s basic course of action within a relatively compact period of time and can be either an isolated event or part of a military campaign.” The above definition applies as written. However, for the purposes of this Task Force, the definition of *military operations* is limited to nuclear and non-nuclear long-range strike systems, consistent with the Terms of Reference.

Strategic Skills. For the purposes of this Task Force, strategic skills are “the critical skills and domain knowledge needed to design, develop, produce, test, operate, and maintain nuclear and non-nuclear long-range strategic strike systems.” This includes the targeting skills and Intelligence, Surveillance, Reconnaissance (ISR) functions required to effectively use these systems.

TIMEFRAMES FOR FUTURE STRATEGIC STRIKE FORCES

The DSB report on “Future Strategic Strike Forces” described three time periods for consideration. The present Task Force has continued to use these timeframes as follows:

- Current systems sustainment (routine maintenance and remedying unanticipated problems)
- Next-generation (near-term) systems (deployed within the next 10-20 years) [evolutionary]
- Future systems (beyond 2025) [revolutionary]

ELEMENTS OF STRATEGIC STRIKE SYSTEMS

The Task Force divided the components of future strategic strike systems into the following elements:

C4ISR

- Intelligence to provide assessment and analysis of emerging threats
- Surveillance and Reconnaissance to monitor the threat and provide timely (persistent and responsive) information to the responsible command
- Battle Management to ensure that the responsible command has full and positive control of the weapon system in all phases of execution

Delivery Systems

- Bombers
- Cruise Missiles
- ICBMs
- SLBMs

Payloads

- Nuclear
- Non-nuclear

Platforms

- Bases for delivery systems

Future Alternatives

- Revolutionary concepts

The current programs that comprise the strategic force structure are shown in Table 1. In addition, the near-term activities that may lead to next-generation systems are also summarized. Some of these initiatives may lead to implementation of the recommendations for future systems that the 2003 DSB Summer Study provided in its February 2004 report.

Each of the elements relies upon a set of skills to assure efficient system development and effective operational performance. These skills are summarized in Table 2 for the evolution of current system capabilities to the next generation and, when applicable, for future systems. The latter, however, may be revolutionary in nature and require different skill sets (e.g., directed energy weapons, intrusive information operations, etc.) than those currently resident in the strategic strike force.

Elements of Strategic Strike Forces			
Elements	**Current Programs**	**Near-Term Activities**	**DSB Summer Study Recommendations**
C4ISR	Global Grid National Intelligence programs	DARPA robotics DARPA UAVs	Close-in, intrusive, persistent ISR; C4ISRTestbed
Aircraft	B-52, B-1, B-2	Global Strike Studies UCAV	Prompt Strike Analysis of Alternatives
CMs	ALCM, ACM, TLAM, TACTOM Hypersonic S&T	Global Strike Studies	Prompt Strike Analysis of Alternatives
ICBM	MM-3, MM-3 Life Extension Applications Programs	LBSD Analysis of Alternatives Applications Programs	Prompt Strike Analysis of Alternatives Conventional Peacekeeper
Payloads – **ICBM** **SLBM** **Aircraft**	 W62, W78, W87 W76, W88 B61, B83, W80-1	"Reliable Replacement Warhead"	Low-yield nuclear, earth penetrating, energetic materials, agent defeat
SLBM	D5, D5 Life Extension, Applications Programs	SLIRBM Concept studies Applications Programs	SLIRBM Prompt Strike Analysis of Alternatives Advanced payload integration
Platforms	SSBNs, SSGNs, SSN, ICBM basing, Aircraft		
Future Alternatives			Information Operations, Directed Energy Weapons, Space Basing

Table 1: Programs

Skill Areas for Future Strategic Strike Capability		
C4ISR	**Bombers**	**Cruise Missiles**
■ National Systems ■ Robotics ■ Tags ■ Multi-cultural linguists ■ Communications (Global Grid) ■ UAVs ■ Battle management modeling and simulation	■ Aerodynamics ■ Structures ■ Stealth ■ Manufacturing ■ Mission Systems ■ Propulsion ■ Flight Controls ■ Vehicle Systems ■ Hypersonics	■ Aerodynamics ■ Stealth ■ Manufacturing ■ Propulsion–small, inexpensive turbine engines; ram jets ■ Guidance–GPS, terminal homing ■ Hypersonics
ICBMs/SLBMs	**Payloads**	**Platforms**
■ Reentry Vehicles–homing, thermal protection, defense penetration, special purpose (EP, mobile targets) ■ Propulsion–large rocket motors, attitude control ■ Guidance–inertial, GPS ■ Rad-Hard Electronics–Dose rate	■ Low-yield nuclear ■ Earth penetrating ■ Agent defeat ■ Energetic Materials ■ Weapon effects	■ SSBN/SSGN • Security • Fire Control • Modifications for IRBMs/CMs • Next Generation ■ Aircraft • Forward location support (hangars) • UAVs/UCAVs ■ Conventional space-based (Future Concepts)

Table 2: Skill Areas for Future Strategic Strike Capability

BACKGROUND

Historically, the U.S. long-range strategic strike skill base benefited from the national priority and funding associated with supporting the Cold War mission. Moreover, for decades, concurrent Science and Technology (S&T), acquisition, and sustainment activity continuously exercised the critical skills necessary to support the full weapons systems life cycle. This resulted in a robust, motivated, and technically agile workforce that naturally maintained and transferred critical skills and domain knowledge through continuous application to real and important work.

However, since the division of the USSR in the early 1990s, significant changes have occurred in the numbers of engineering personnel in the U.S. Figure 1 shows that a 10% decrease has occurred since 2001. Moreover, Figure 2 depicts a decline in the number of Bachelor degrees awarded in the field of engineering since 1990. While graduations of engineering masters and doctorates have not declined since 1990, the percent of U.S. citizens graduating with advanced degrees has significantly declined since 1994, as shown in Figure 3.

U.S. Employed Engineers*
(in thousands)

1998	1999	2000	2001	2002	2003
2052	2081	2093	2122	2030	1830

*Technology Review 1999, 2002, 2003, 2004

Figure 1: U.S. Employed Engineers

U.S. Engineering Personnel

University Graduates* (in thousands)				
	1980	**1990**	**1995**	**2002**
B.S.	68.8	81.3	78.1	73.6
M.S.	16.2	24.8	29.7	26.9
Doctorate	2.5	4.98	6.1	5.2

* Statistical Abstract 2005

Figure 2: U.S. Engineering University Graduates

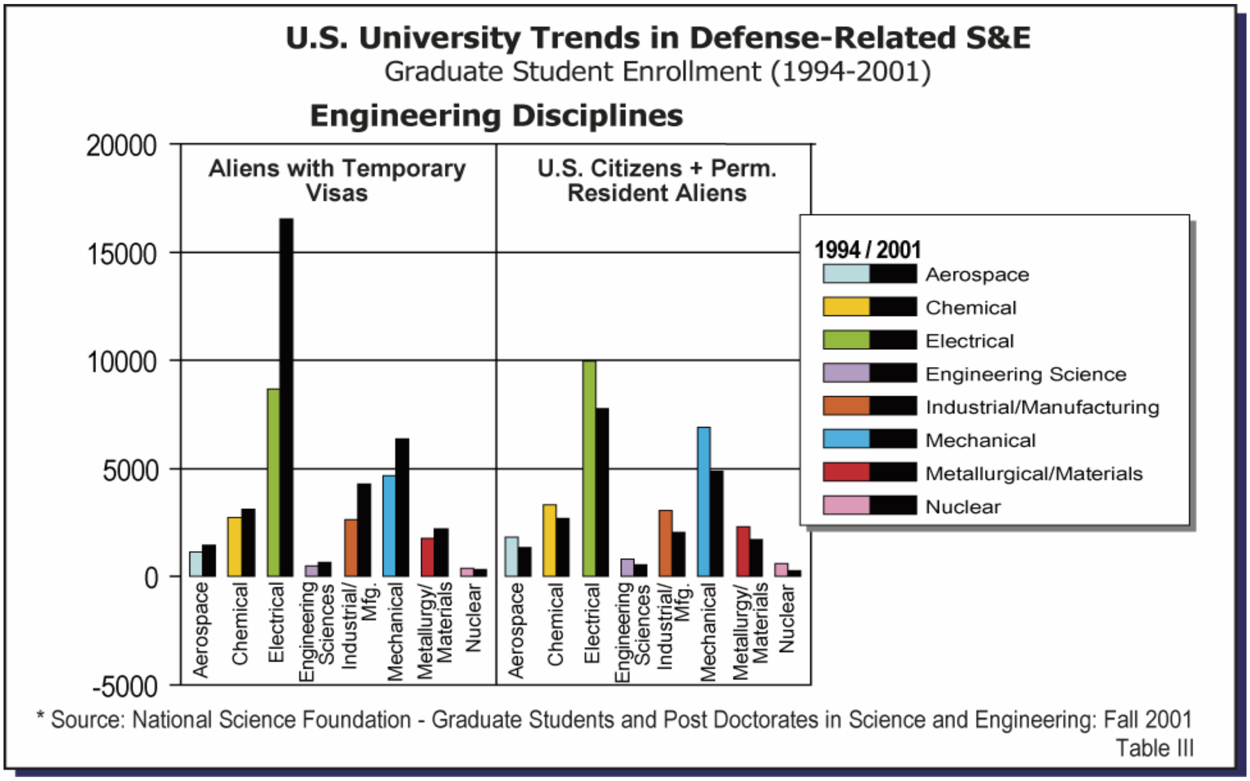

Figure 3: U.S. University Trends in Defense-Related S&E

A further impediment to hiring such talent for DoD programs is the prolonged waiting period associated with obtaining security clearances, as shown in Figure 4.

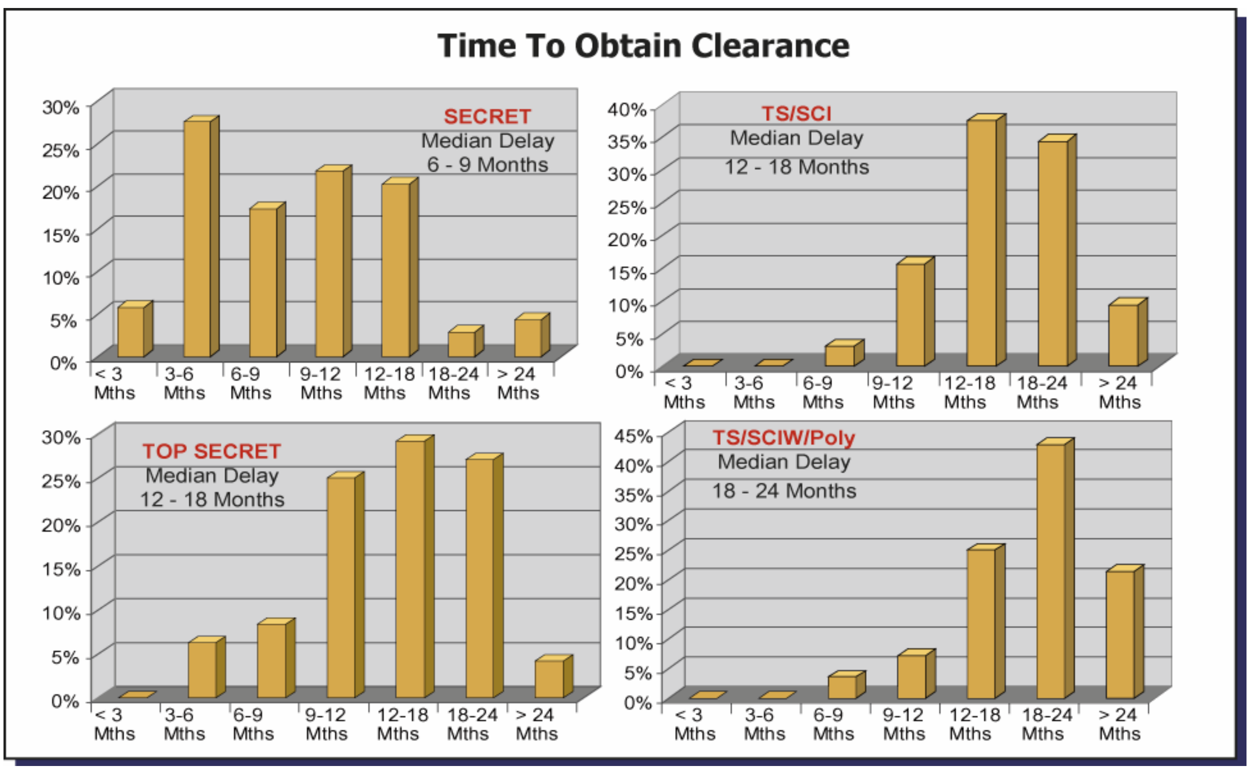

Figure 4: Time to Obtain Clearances

The reduction of funding for DoD military systems, together with reduction in the supply of engineering personnel, have resulted in a decline of more than a factor of two in the numbers of aerospace scientists and engineers employed in U.S. industries, as shown in Figure 5.

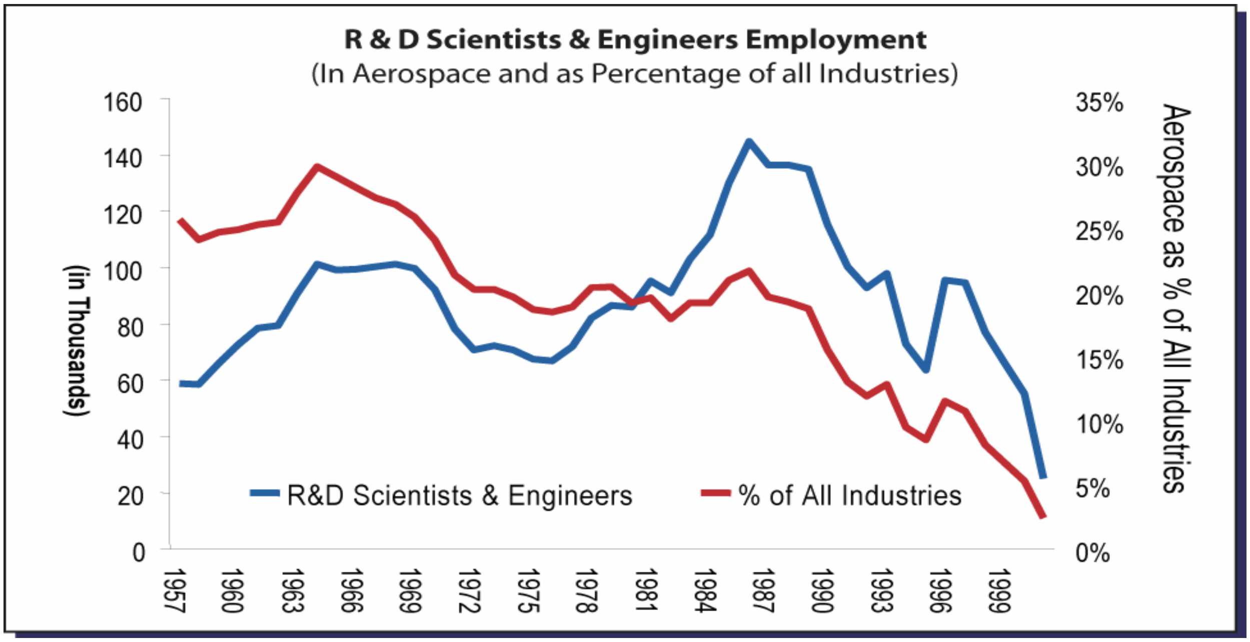

Figure 5: R&D Scientists & Engineers Employment

Finally, surveys of a group of 400 leading U.S. technology innovators show that only a very small percentage are interested in positions within defense industries and DoD (see Figure 6). Thus, the talent available for conceiving new classes of strategic strike systems is only a very small percentage of the critically important class of innovating technologists.

Leading Innovators*

Start-up	University	Non-Defense Industry	Defense Industry	Non-DoD Government	DoD Government
38%	41%	18%	1.4%	1.4%	0.5%

*Technology Review 1999, 2002, 2003, 2004

Figure 6: Leading Innovators

The end of the Cold War also profoundly affected the long-range strategic strike military-industrial complex. The continuous development cycle that started in the 1950s ended with deployment of the Peacekeeper and Trident II (D5) systems in the early 1990s. The rest of the 1990s saw a continuous erosion of national priority, clarity of mission, and funding levels. Science and Technology spending was also reduced as production programs ended or were reduced to minimum levels, leaving sustainment as the only area routinely exercising strategic strike skills. The current focus on the Global War on Terrorism has pushed the role(s) of future strategic strike systems further to "backburner" status.

As a direct result of these trends, the strategic strike skill base of the DoD is currently at risk due to an aging workforce and lack of apparent long-term career viability, as well as competition for scientific and technical personnel in the marketplace. Sustainment and maintenance activity will slow the loss of these skills, but cannot preserve them over time.

The critical skills and domain knowledge needed to design, develop, produce, and maintain nuclear and conventional long-range strategic forces cannot be hired from the mainstream workforce. The increased use of commercial-off-the-shelf (COTS)-based upgrades in current service life-extension programs have increased the commercial skills being leveraged in some areas. However, there are many areas, such as existing system and subsystem domain knowledge, nuclear safety and security disciplines, reentry systems, and radiation hardness, where skills providers have no commercial base from which to draw. These skills can be maintained only by the Department of the Defense. If lost, the general view of industry is that it would take five to seven years to reconstitute an adequately skilled workforce, and even then, expectations for error and cost overrun resulting from inexperience would likely be high.

The findings and recommendations from the "Commission on Maintaining United States Nuclear Weapons Expertise" (the Chiles Commission), dated March 1, 1999, and the DSB report on "Future Strategic Strike Forces," dated February 2004, are relevant to this study.

NUCLEAR POSTURE REVIEW

The 2001 Nuclear Posture Review (NPR) was mandated by Congress in the National Defense Authorization Act for Fiscal Year 2001. The NPR contains the results of a comprehensive Department of Defense review of the U.S. nuclear posture, as well as a long-range plan to sustain and modernize U.S. strategic nuclear and non-nuclear forces.

The NPR reinforces the four primary defense policy goals that were defined in the September 2001 Quadrennial Defense Review (QDR):

- **Assure** allies and friends of U.S. steadiness of purpose and our capability to fulfill our security requirements.
- **Dissuade** adversaries from undertaking programs or operations that could threaten U.S. interests or the interests of U.S. Allies and friends.
- **Deter** aggression and coercion by deploying forward the capacity to swiftly defeat attacks and impose severe penalties for aggression on an adversary's military capability and supporting infrastructure.
- **Defeat** any adversary if deterrence fails.

The NPR states that Cold War-style strategic planning, including a U.S.-Russia relationship based on Mutually Assured Destruction, is no longer appropriate. Instead, the NPR encourages building a new framework with Russia that is based on mutual cooperation, common responsibilities, and common interests, rather than distrust and hostility.

Following the direction outlined in the 2001 Quadrennial Defense Review, the NPR shifts planning for America's strategic forces from the threat-based approach of the Cold War to a capabilities-based approach. The capabilities-based approach provides a credible deterrent with the lowest level of nuclear weapons consistent with U.S. and Allied security.

The NPR directs a shift to a "New Triad" of strategic offensive and defensive capabilities that include: nuclear and non-nuclear strike capabilities; active and passive defenses; and a robust research, development, and industrial infrastructure.

The **first leg of the New Triad** incorporates conventional capabilities together with the traditional Nuclear Triad, which is composed of Intercontinental Ballistic Missiles (ICBMs), Submarine-Launched Ballistic Missiles (SLBMs), and long-range nuclear-armed bombers.

The **second leg of the New Triad** requires the development and deployment of active and passive defenses because, in the new security environment, offensive capabilities alone may not deter aggression. These defenses include the development of a missile defense system.

The **third leg of the New Triad** is a responsive defense infrastructure. Since the end of the Cold War, the U.S. defense infrastructure has been downsized, and the nuclear infrastructure, the U.S. industrial base, and the government labs previously focused on strategic systems have significantly deteriorated. New approaches to the development and procurement of new capabilities are being designed. In addition, the U.S. nuclear infrastructure needs to be repaired to increase confidence in deployed forces, eliminate unneeded weapons, and mitigate the risks of technological surprise. A critical element of the strategic strike infrastructure is the skills necessary to sustain existing capabilities and to be ready to create any new capability needed to counter changes in required capabilities.

At the center of the New Triad is the needed capability for rapid, responsive planning that requires agile command and control woven seamlessly together with persistent and intrusive intelligence, surveillance, and reconnaissance.

The NPR calls for U.S. nuclear forces to be reduced to between 1,700 and 2,200 operationally deployed strategic nuclear warheads by 2012. This is a level that will provide a credible deterrent with the lowest possible number of nuclear weapons consistent with national security requirements and Alliance obligations. The planned reductions will be completed in phases. While operationally deployed strategic nuclear forces are being reduced in number, the U.S. will continue to maintain a responsive force to remain prepared for any immediate or unexpected contingencies.

CURRENT STATUS

In addition to the shift of the Defense Department from strategic nuclear systems to conventional warfare, and more recently to insurgency warfare, there has been a shift in the interests of technology experts in the United States.

This has been driven in part by the consistently decreasing portion of the total U.S. technology development funding that is provided by the Defense Department. During the early days of the Cold War, a majority of total technology funding was devoted to defense problems, whereas today it is only a small percentage of the total.

Independently, this shift should still result in adequate numbers of defense technology staff, because the total development funding of the country is comparatively larger today. However, the most important factor pulling capable technology staff away from defense-related work as compared to 50 years ago is the possibility of substantial financial rewards by participation in high-technology start-ups.

Recent surveys by both Fortune[1] and Technology Review[2] show that over 90% of those judged to be the most innovative individuals in the U.S. are either associated with technology start-ups or hold positions with university offering research opportunities that could later lead to a start-up (See Figure 6, "Leading Innovators").

Most of the remaining 10% are associated with technology developments in large commercial organizations, with only three to four percent having positions within the Defense Department or with defense contractors. Presently most of the technical positions supporting current U.S. strategic forces are focused on maintenance or the re-engineering of systems developed in the past. Such positions do not require the most innovative of the U.S. technology personnel. With the proper incentives, however, it should be possible to recruit sufficient numbers of qualified personnel for maintaining U.S. strategic forces.

Conversely, in recent years interest has grown in the possibility of developing a non-nuclear strategic capability for the U.S. This will require the recruitment of creative individuals of the highest technical capability. To obtain the services of such individuals will require innovative recruitment incentives, both financial and professional.

Approximately 70,000 engineers and scientists graduate in the United States each year. China and India, on the other hand, graduate approximately 200,000. While many of the latter have pursued education in the U.S., these nations have established their own sets of educational programs, and have developed a trend of educating an increasing number of students in their native countries (See Figure 3, "U.S. University Trends in Defense-Related Science and Engineering").

Engineers and scientists over the years have been attracted to fields that they perceive to be "the next big thing." While no one knows what the future holds, many believe that nanoscale science, molecular biology (life sciences), and information science represent the technology "waves" (Toffler, 1980) of the future. Each in itself could be "the next big thing"; however, it is possible that there may be an intersection of all three fields that will provide a significant foundation and launching pad for the global future economically, and perhaps, even militarily. China is perceived to be in a position to take a lead in nanoscale technology, and India is now viewed to

[1] *Top 10 innovators*, Vol. 148 Issue 5, 2003, and *What drives America's great innovators?*, Vol. 150 Issue 8, 2004.
[2] October 1999, June 2002, October 2003 and October 2004.

be postured to be a leader in information sciences (not simply the low-cost provider of software coding on demand).

Strategic strike skills may well be in competition for the individuals pursuing the "next big thing(s)." In addition, future strategic strike initiatives may well depend upon nanoscale technology, information sciences, and perhaps even life sciences in ways not currently foreseen.

While the future evolves as noted above, the defense industry that brought us to where we are today continues to change in ways (e.g., mergers and acquisitions) that may well preclude drawing accurate conclusions from the past. For example, Douglas-Santa Monica was a leader in the development of maneuvering reentry vehicle (MARV) technology. That team was moved to Douglas-Huntington Beach, acquired by McDonnell-St. Louis, and then acquired by Boeing-Seattle followed by relocation to Boeing-Seal Beach. It is doubtful that anyone on the original MARV team remains. This is a common theme across the industry that emerged after WW II, and is now "transformed" again after the attacks of September 11, 2001. Are the necessary skills resident in the U.S. to provide operations and sustainment to the current systems and, perhaps more importantly, to assure that unforeseen problems can be addressed? And are the innovative design, test, and development skills represented in a way that permits the fielding of future strategic strike systems potentially required in the years to come?

STRATEGIC STRIKE CONSTITUENTS

For the U.S. to have the skill sets necessary in the 21st century to define, develop, operate, and maintain the strategic programs of the future, attention to those needs must be recognized and nurtured by the following constituents:

- Strategic Policy
- DoD Commands or Program Offices
- Supporting DoD Agencies
- National Nuclear Security Agency
- U.S. Industrial Base (Contractors)
- DoD Labs
- Federally Funded Research and Development Centers (FFRDCs)
- Others in support of the above; e.g., multi-tasked agencies such as National Security Agency (NSA), National Reconnaissance Office (NRO), Central Intelligence Agency (CIA), Defense Information Security Agency (DISA); second-tier contractors and their supply chains, etc.

Constituents also include organizations involved with: strategic policy; intelligence; weapons-effects assessments; kill-chain architectures for desired effects, targeting, etc.; the training and preparation for operations such as modeling and simulation; war games and responsive and adaptive planning for execution using "real time" communications, surveillance, and reconnaissance; offense/defense integration; and the "best available" staff support to cognizant Regional Combatant Commands (RCCs), independent of geography.

ICBMS/BASING

BACKGROUND

ICBM development in the U.S. has had a rich history, beginning with the logical evolution of the German V-2 liquid rocket system into longer-range versions that were capable of military operation. Thor was deployed in mid-1959, followed by the significantly larger Atlas a year later. Titan I and Titan II, both large liquid rockets capable of global reach with high-yield nuclear weapons, were deployed in the early 1960s. In the late 1950s the Air Force became interested in the notion of using smaller solid propulsion boosters for ICBMs to decrease handling operations and improve survivability through hardened silos. Minuteman I (MM I) was fielded in early 1962, MM II followed in 1965, and the multiple independently targeted reentry vehicle (MIRVed) MM III entered the force in 1970. Each had three propulsion stages and shared many components. The Peacekeeper, which followed in 1986, had the same “template” despite its increased size and improvements in accuracy.

Minuteman missiles were deployed in hardened silos located in missile bases throughout the Great Plains. The liquid Titan systems were based in Arkansas, Kansas and Arizona. Silo hardness technology was developed in the 1960s. The Peacekeeper was to have been deployed in a mode that relied upon Preservation of Location Uncertainty (PLU), so a considerable development effort took place in the 1970s to demonstrate the effectiveness of multiple protective shelters and deceptive basing concepts. Cancellation of the Missile X Multiple Protective Shelter (MX MPS) deployment in early 1981 turned attention to other basing systems: deep underground, rail mobile, air launched, and a number of camouflage/concealment/deception (CCD) systems, etc., which were developed to various degrees of maturity. Ultimately, the Peacekeeper (nee MX) program was significantly reduced in scope and a limited number of the missiles were deployed in existing Minuteman silos.

Finally, development of a three-stage Small ICBM was undertaken in the early 1980s to utilize its inherent mobility for CCD applications. A road-mobile (and off-road) version was initiated. However, the program was terminated early in its development. Thus, the last ICBM basing design team terminated development activity in the mid 1980s.

Beginning in 1963, the Air Force led the tri-Service ABRES (Advanced Ballistic Reentry Systems) technology development for the Army, Navy, and Air Force. This program successfully developed ballistic reentry vehicles which could be deployed as MIRVs, maneuver to evade interceptors or attack targets using on-board sensors, and control observables so that defenses could be negated. In addition, countermeasures were developed for the U.S. offensive forces and signature data was provided to the Army’s Ballistic Missile Defense (BMD) team. The ABRES program was strongly supported by OSD and historically received approximately $125-150 million per year (in then-year funding) for advanced development activities through Congressional appropriations to the Air Force. ABRES was terminated as a tri-Service program in 1984 and replaced by the Advanced Strategic Missile Systems (ASMS) program.

ABRES and then ASMS developed new missile designs (e.g., Small ICBM) and basing concepts (e.g., Deep Underground) as well as new guidance systems, fuzes, and advanced countermeasures for future strategic systems. ASMS was terminated by the Air Force in 1991, leaving a void in ballistic missile technology development.

As the Cold War began to wind down and as missile/basing development efforts in the U.S. were terminated, the Defense Science Board conducted a summer study in 1990, "Research & Development Strategy for the 1990s," to determine what course of action should be recommended to ensure these technologies (and skills) that might be needed for systems over the long-term could be preserved. The DSB recommended that "pre-prototype" or "prototype" development be conducted in 13 areas, four of which had ICBM implications: reentry systems, propulsion, guidance, and hardened electronics. The thought was that these efforts were unique to strategic applications, would not likely be addressed by tactical forces, and certainly would not be supported by the commercial sector. Candidates for prototype development were to be selected after considering the threat and the mission to be accomplished, with work proceeding on the selected candidate throughout the relevant (and selected) industrial base until the concept was ready for production and deployment. If the threat changed or the mission demanded another alternative, the prototype development was to change accordingly. Strategic Air Command recognized the need for the maintenance of technologies and for the skills that addressed future needs, and endorsed the program in the early 1990s. Both the Air Force and the Navy were requested to provide $25M/yr for each of reentry systems, guidance, and hardened electronics development, and $40M/yr for propulsion development (the larger amount was judged to be necessary because of the significant costs associated with large-scale rocket motor facilities). Collectively, these efforts became known as "Application Programs" and have continued to receive endorsement from U.S. Strategic Command (STRATCOM) and approval from OSD. However, these programs have not been fully funded over the years by the Services.

Several attempts were made in the 1990s to identify systematically the envisioned threats and future missions that could necessitate future strategic systems development. The thought was that a national study, (i.e., a "STRAT Y,"[3]) could bring focus to the process, including the Applications programs, so that pre-prototype and prototype development could be targeted at those areas of recognized importance for future systems. No OSD or DoD sponsor emerged to cause a STRAT Y to occur.

In the early 1990s, as a result of Base Closure and Realignment Committee (BRAC) activities, nearing the end of the Cold War, and Air Force interest in other missions, the ICBM Program Office was moved from Norton Air Force Base (AFB) to Hill AFB, where the ICBM logistics support had been headquartered. This move resulted in the decimation of what had been a strong and unique acquisition staff prepared to deliver significant milestones "on or ahead of schedule, within budget, which meet or exceed the users' requirements." Few, if any, Air Force personnel associated with today's ICBM program have participated in a system or subsystem design. Arms

[3] STRAT X was an intense, nine-month "national study" (staffed by key government officials and leaders from the industrial base assembled in the Washington area) in the late 1960s that was charged with identifying the set of strategic systems and subsystems necessary to meet the expanding Soviet threat. Trident submarines, for example, as well as aircraft launched cruise missiles (ALCMs), small/mobile ICBMs, and other concepts that were eventually deployed have a STRAT X legacy.

control and policy decisions since the mid-1990s have resulted in deactivating the MM II force and withdrawing Peacekeeper from the silo fields (an ongoing process nearing completion).

In the late 1990s, a series of "life extension" (LE) programs were initiated to prolong the life of Minuteman III. These programs, including guidance replacement, propulsion replacement (stages 1, 2, and 3), and post-boost vehicle propulsion, were charged with assuring that the operational availability and reliability of the deployed weapon systems were maintained at levels acceptable to STRATCOM. However, enhancing or improving the performance of the weapon system components was not permitted. In addition, the launch control system was modernized, replacing early 1970s control panels and electrical systems with current electronics and a modernized control panel approach. The goal is that the MM III in the field today and tomorrow will look and perform exactly as the 1970s version, but continue to do so with certainty over the years ahead.

CURRENT PROGRAMS

With modest funding, the ICBM Program Office and the supporting industrial base have done an outstanding job in maintaining the availability, reliability, accuracy, and survivability of the weapon systems to the satisfaction of STRATCOM. Northrop Grumman serves as the prime integrator for the Air Force, with first-tier contractor support from Boeing (guidance and ground systems), Lockheed Martin (reentry and ground systems), and ATK (propulsion). This team and their second-tier contractors (e.g., Aerojet, Allied Signal, Draper Labs, General Dynamics, Honeywell, Raytheon, Science Applications International Corporation (SAIC), and Textron) comprise the ICBM industrial base. The demographics of a typical industrial base contractor are shown in Figure 7.

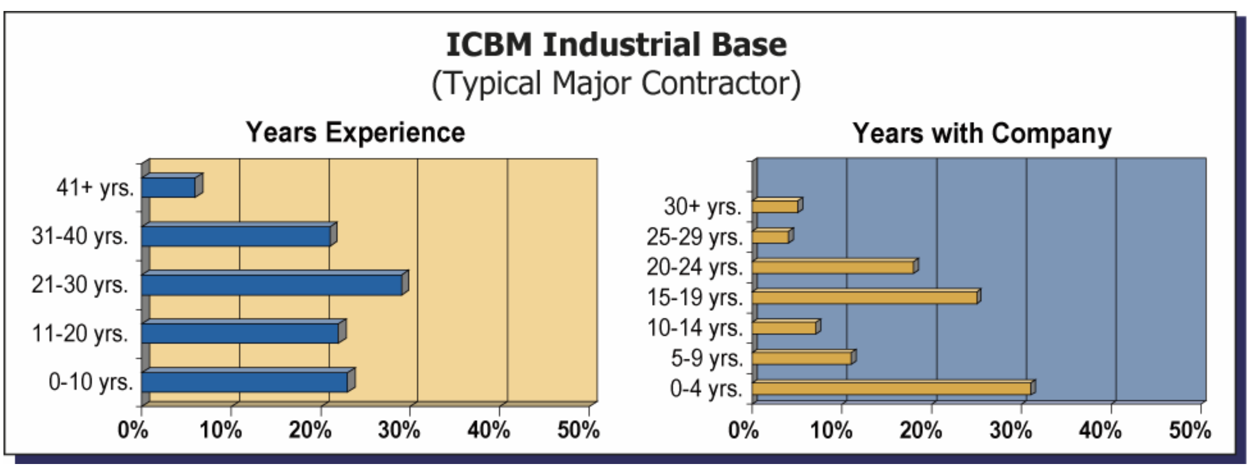

Figure 7: ICBM Industrial Base

Life-extension programs for Minuteman components have been a key element in maintaining systems-level performance of the deployed weapon systems. Importantly, lessons learned in deactivation of MM I and MM II, rigorous aging and surveillance, selection ("cherry picking") of stage components for Reentry Systems Launch Program (RSLP) missions conducted for the

Services, and an exemplary risk management approach have all served to provide a strategic deterrent that is available to STRATCOM for action whenever needed.

The skills base needed to assure the success of the current systems over the long term, however, is thin. The ICBM Program Office has conducted an assessment of the skills viewed to be critical for success in implementing the current program (see Figure 8) and concluded that guidance skills (see Figure 9), reentry systems critical skills (see Figure 10), and propulsion critical skills (see Figure 11) are, in the aggregate, "marginal" at present and moving toward an untenable "below critical mass" workforce within 5 years. Because the program management team has not participated in an ICBM design, and only a handful of those who comprise the current industrial base were involved in MM, Peacekeeper, or Small ICBM design and development, the situation could become even more dire than portrayed if an unexplained failure developed on one of the few remaining flight tests of the operational system. No one who designed the original MM III components in the late 1960s is actively engaged in the program, so root causes of design failure, should one occur, could be difficult to determine and correct.

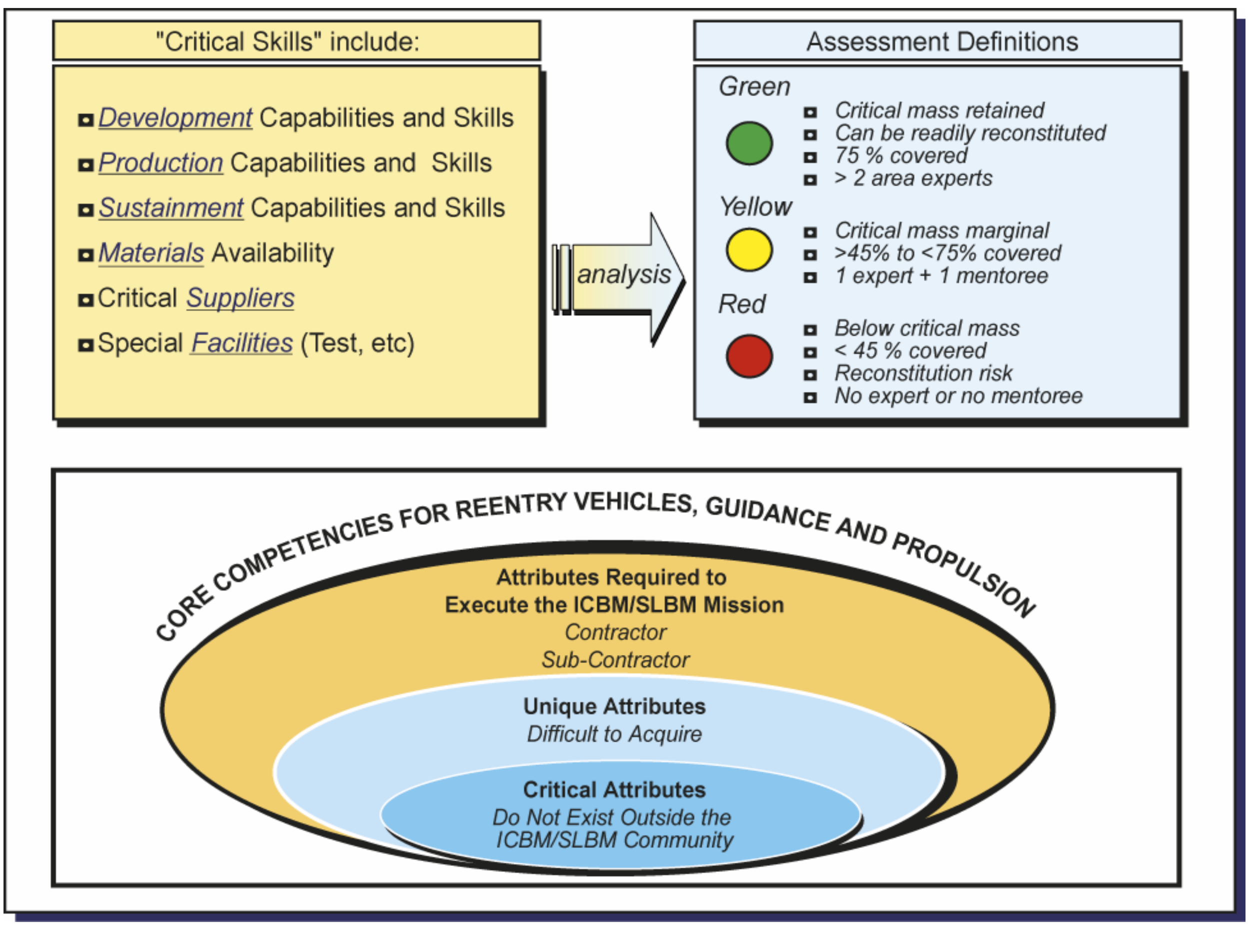

Figure 8: ICBM Infrastructure – Critical Skills

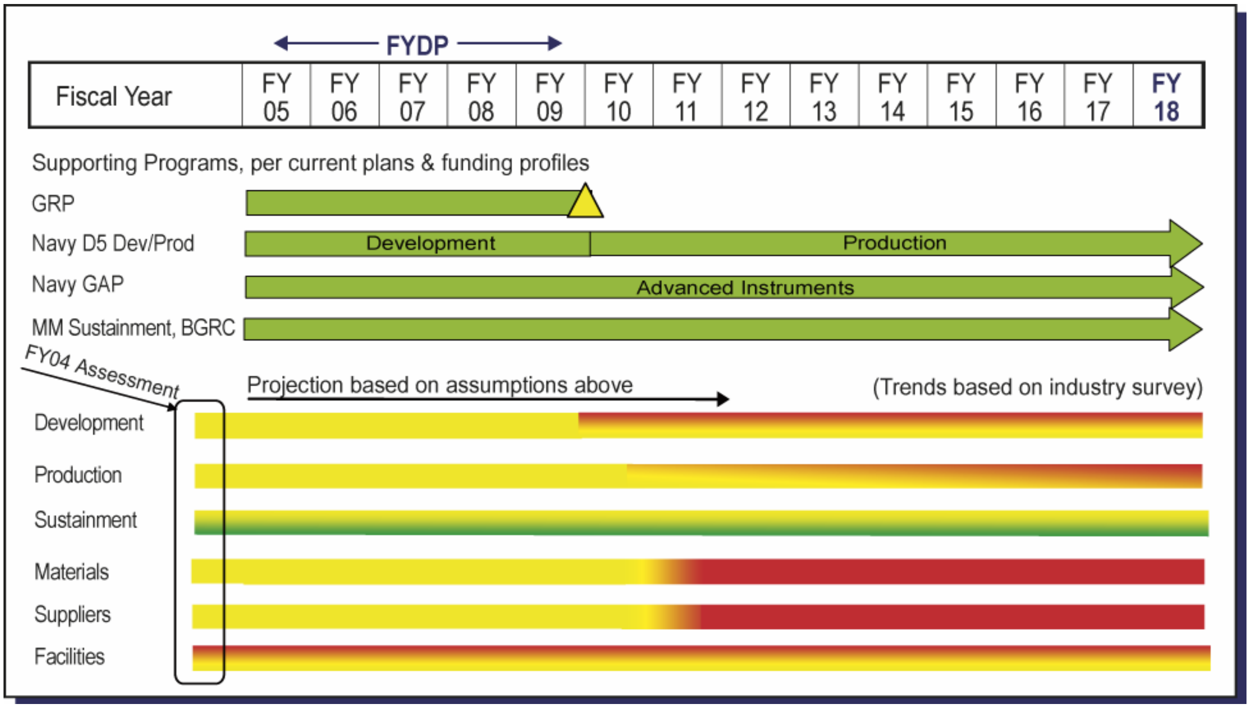

Figure 9: Guidance – Critical Skills

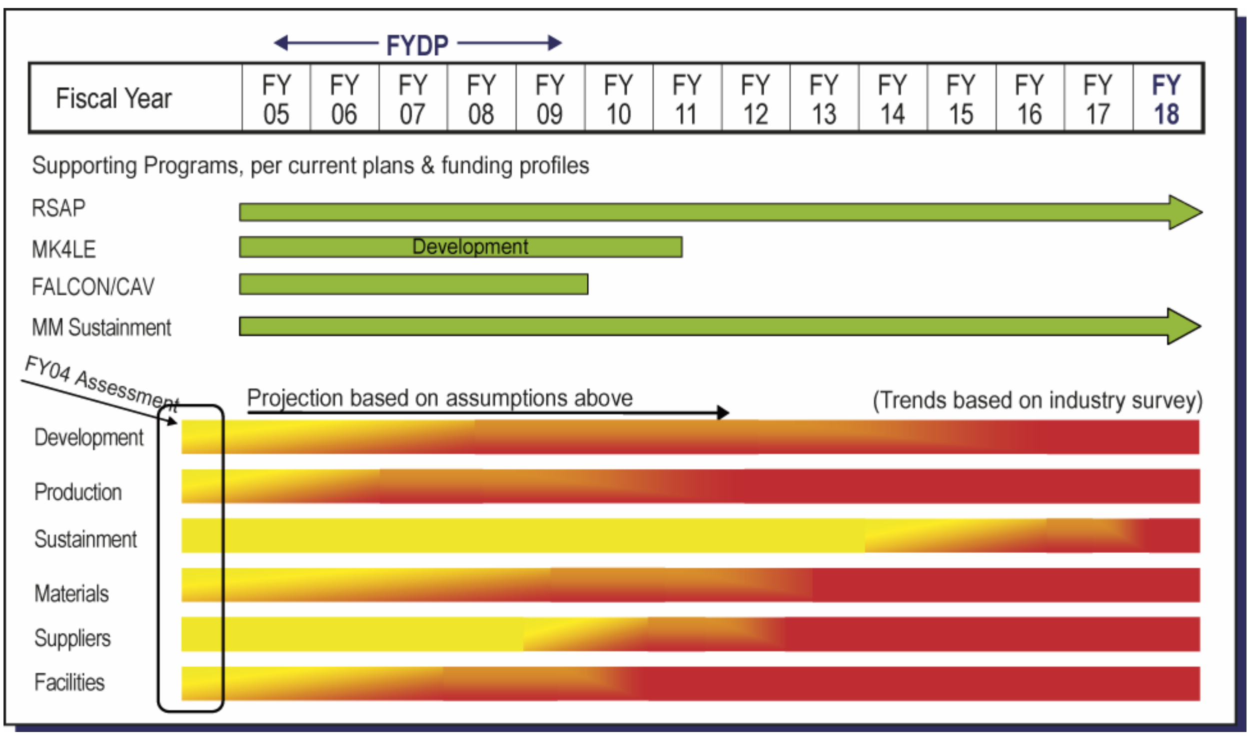

Figure 10: Re-entry Systems – Critical Skills

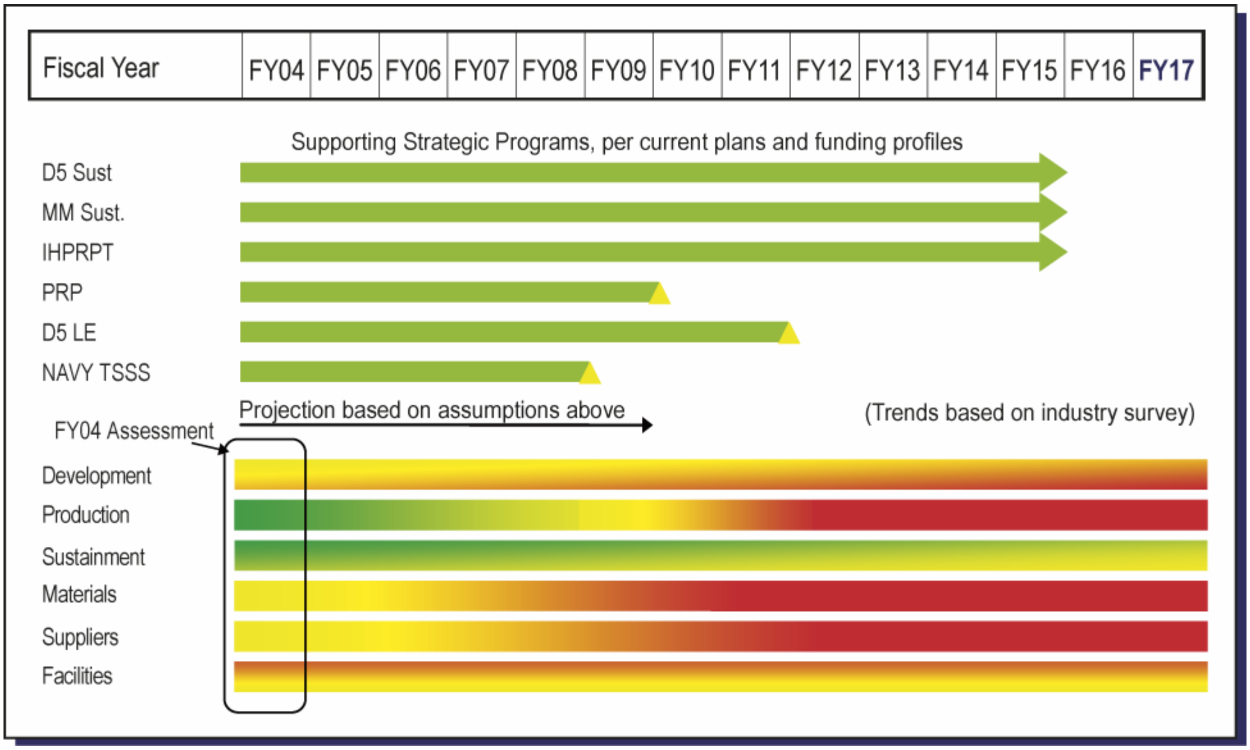

Figure 11: Propulsion – Critical Skills

The critical skills to support radiation-hardened parts are viewed by the ICBM Program Office to be available in the industrial base through funding by other Air Force programs. Because of this, the radiation- hardened electronics Application Program is managed elsewhere. Because of the differences in the threat level, however, the spectra of interest to ICBM technologists may not be addressed by satellite programs and other projects. The attention placed on weapons effects has decidedly been reduced since the early 1990s with the number of radiation-hardened electronics suppliers declining from 16 to only one or two in key areas. Few members of the current industrial team have participated in an underground nuclear test (the last one was conducted in September 1992) or modeled effects with above-ground X-ray or other test techniques. Few, if any, participants on the program have designed and developed hardened systems or subsystems, or developed survivable basing designs. Prior to the early 1990s, the ICBM Program Office conducted underground nuclear tests on components slated for operational use, routinely assessed the damage effectiveness of payload warheads against a broad spectrum of targets, recommended design and operational options to assure mitigation of fratricide environments, and actively engaged with the warhead developers in acquisition and implementation of a fully integrated weapon system.

NEAR-TERM SYSTEMS (2015 TO 2025)

Plans for ICBM systems in the near-term are focused on continuing and completing the life-extension programs and assessing means to extend the operational life of MM III through an enhanced aging and surveillance program.

The history of the ICBM Program Office suggests that developing another three-stage solid missile (e.g., a MM IV) should be easily addressable by the management team and the industrial base. It has, however, been 25 years since a new system was designed, and over 20 years since a missile system was developed and tested by an acquisition team. In these previous times, the ICBM Program Office was responsible for the technology development (propulsion, guidance, etc.), and did not rely upon laboratory support as the fast-paced schedule and the importance of immediate program integration drove the *modus operandi* to be one of a vertically integrated team. Similarly, the ICBM Program Office conducted its own weapons-effects testing and assessment and did not rely upon Defense Nuclear Agency (DNA) or other agencies for support. Consequently, the expertise that was assembled in the late 1950s through the early 1990s to implement the ICBM acquisition programs (development and deployment) no longer exists as an integrated enterprise.

Should another approach (an ICBM significantly different from MM III) be selected for a near-term development, the ICBM Program Office would need additional (and other) expertise in its management chain. In addition, the industrial base would need to draw on expertise now residing in other programs and projects (C4ISR, MDA, etc.). The expertise that created maneuvering vehicles, terminal-fix sensors, buried target kill capabilities, etc., is, for the most part, outside of the ICBM industrial base.

Peacekeeper is the most accurate U.S. long-range ballistic missile and has by far the largest throw weight. As such, it would seem to be a logical candidate to carry non-nuclear payloads on precision, surgical extraction missions, but the missile is being deactivated. As it is the most recent ICBM to be deployed, Peacekeeper represents the “latest” developments in ICBM technology. Some of the individuals who worked on the design in the late 1970s and who participated in its development during the 1980s are still available, should the need arise to retrofit Peacekeeper for conventional strike missions through off-board and/or on-board guidance updates.

FUTURE SYSTEMS (2025 AND BEYOND)

Because there has been no “STRAT Y” initiative and few of the recommendations relating to ICBMs of the 2003 DSB Summer Study on Future Strategic Strike Systems have been implemented, there has been little thinking about the future of ICBMs. C4ISR represents the future for (newly configured) payloads that could be delivered from land bases to global targets. The expertise and skills required to make this transformation currently exist in the community and could be assembled by the ICBM Program Office if the vision and mission were clear. Future emphasis, therefore, is likely to focus on the payloads, guidance systems, and responsive command and control (including off-board updates) rather than booster technology.

Basing skills (CCD, PLU, hardness, etc.) have been neglected for 20 years and are not exercised by the ICBM programs or projects. The sophisticated Air Force countermeasures programs have been abandoned and those skills are now supporting MDA initiatives. The ability to develop maneuvering vehicles, control observables, and negate defenses has been lost in the ICBM program and would require significant growing pains to reconstruct.

The future of ICBMs rests upon defining a vision of what is needed. This worked in the 1960s with STRAT X, when the appropriate expertise was assembled to do what needed to be done. That could happen again, but absent that clear direction, the ICBM skills base is, at best, prepared only to take on an evolutionary MM IV, and not to create truly new concepts.

SLBMs/SSBNs/SSGNs

Background

From the late 1950s to the deployment of the Trident II (D5) in 1990, concurrent science and technology, development, production, and sustainment activity exercised the critical skills necessary to support the full SLBM life cycle. This resulted in a robust, motivated, and technically agile workforce that naturally maintained and transferred critical skills and domain knowledge through continuous application to real and important work.

The critical skills and domain knowledge needed to design, develop, produce, and maintain SLBM systems cannot be hired from the mainstream workforce (Figure 12). The increased use of commercial off-the-shelf (COTS) products for obsolescence and Service life extension programs has increased the Navy's ability to leverage their skill base in some areas. However, there are many areas, e.g., existing system and subsystem domain knowledge, nuclear safety and surety disciplines, reentry systems, and radiation hardness, where there is little or no commercial base to draw upon. These skills can be maintained only by the Department of the Defense.

The following assessment will focus on the state of the SLBM military, civil service, and industrial skills base. Near-term and future strategic systems include the Virginia-class submarine and the SL-IRBM currently under study by SSP. The Trident I (C4) force is being retired and is therefore excluded. The need for SLBMs is planned beyond 2040. The discussion will address current, near-term (10 to 20 years), and future programs (beyond 2025).

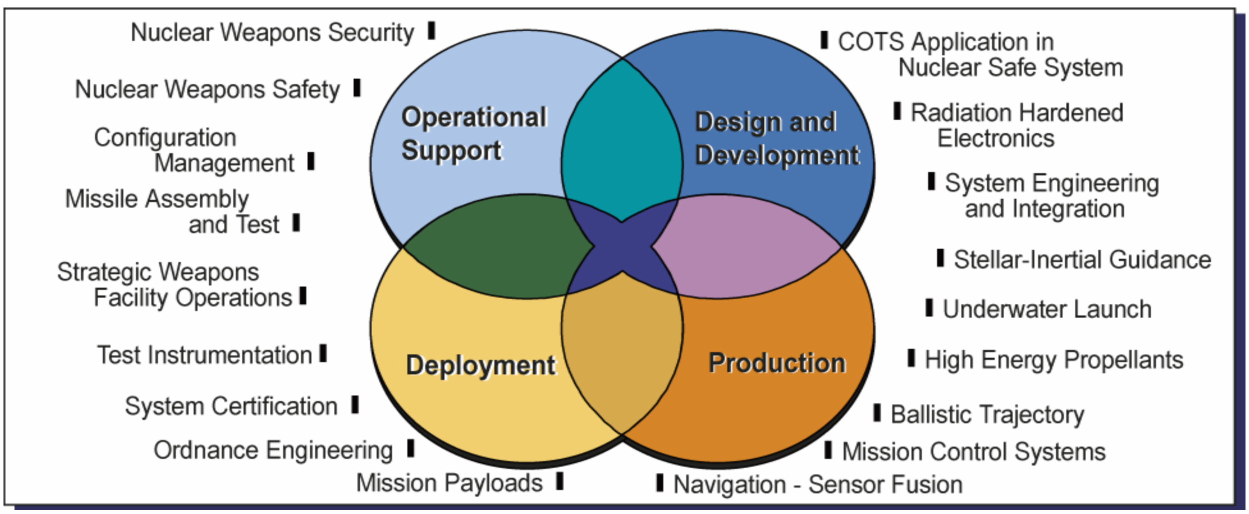

Figure 12: SLBM Critical Skills Mix

Current Programs

The SLBM force structure consists of 14 Ohio-class SSBNs deployed in two oceans and outfitted with Trident II (D5) missiles. The four oldest of the original 18 Ohio-class hulls are being converted to SSGNs and are scheduled to be completed by 2009. The SSBN and SSGN force is supported at and deployed from two Strategic Weapons Facilities (SWFs) – on the east coast at SWFLANT, Kingsbay, Georgia, and on the west coast at SWFPAC, Bangor, Washington. The industrial base consists of an eclectic group of ship construction, aerospace, guidance, rocket motor, ordnance, ballistic reentry, system assessment and test, and submarine navigation contractors. Prime and major subcontractors supporting the SLBM force are shown in Figure 13.

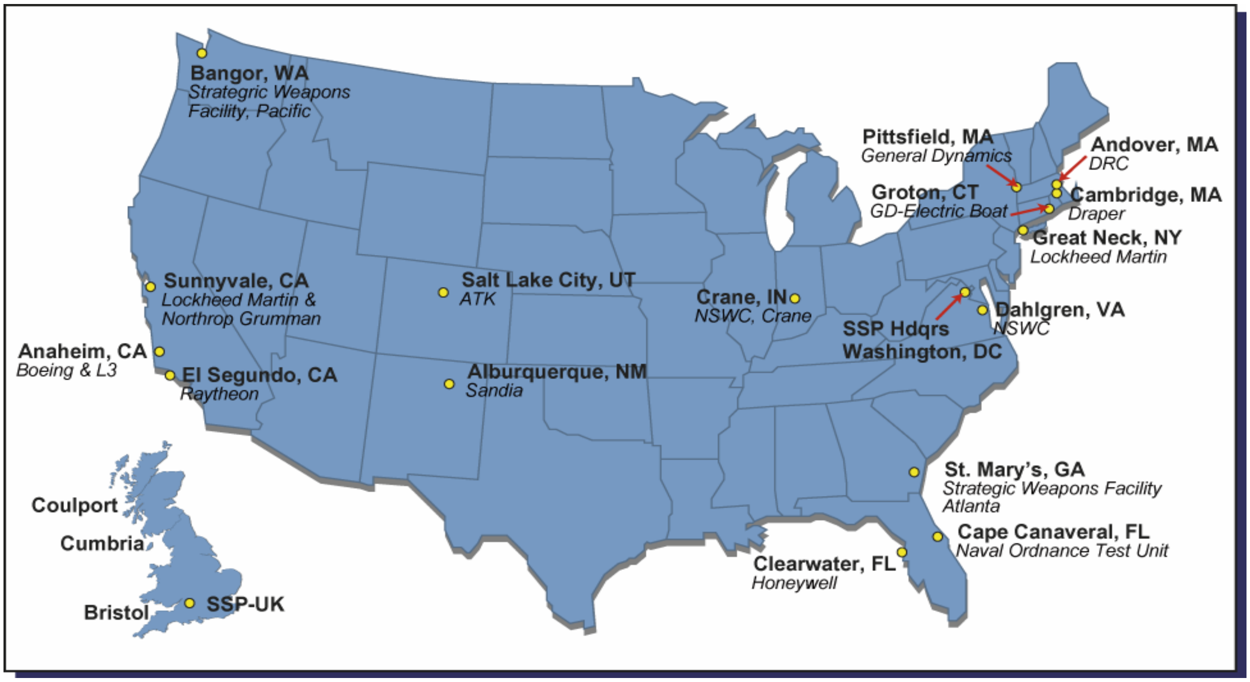

Figure 13: SLBM Facilities and Major Contractors

The SLBM program has benefited since its inception from the Navy's centralized management of the total life cycle by a single program office, Strategic Systems Programs (SSP). Centralized, total program planning and management of the military, civil service, and industrial workforce have been and continue to be exemplary. The SSP human capital management strategy is one of the basic tenets of their long-term mission assurance strategy.

Military

Warfare-qualified Engineering Duty Officers (EDOs) are brought into the program early in their careers and, after a training and qualification tour, are assigned positions of increasing responsibility that can ultimately lead to senior acquisition assignments and/or major command of strategic facilities at the 06 level. This is complemented by the Navy's rigorous management of the nuclear-trained officers and Petty Officers who man the SSBNs. Nuclear-trained submariner officers and Petty Officers serve as Weapons Officers on SSBNs and in fleet liaison, fleet certification, and other acquisition billets, to further close the loop between the system developer and the war-fighter. Continuation of this approach will sustain a qualified military skills base for current systems.

Civil Service

SSP has historically enjoyed low turnover in its civil service workforce. The workforce is dominated by baby boomers who have dedicated themselves to strategic careers based on the national priority associated with the Cold War. The civil service workforce is managed similarly to the military, with the majority of individuals spending their entire careers in SSP acquisition and management positions. However, the civil service workforce that developed the Trident I (C4) and Trident II (D5) systems has been retiring since Trident II (D5) was deployed in the early 1990s. SSP has an excellent mentoring program in place to transfer knowledge and develop future leaders. However, the entry-level and mid-career workforce are getting little or no substantive hands-on S&T, R&D, or major system development experience, because of limited opportunities to work on real programs.

The civil service workforce of today, therefore, is adequate for the current programs, but will be at increasing risk due to the lack of programs that support the maintenance of unique critical skills. Long-term career viability concerns, lack of a perceived national priority, marketplace dynamics, and future mission uncertainty add to the problem. Many young professionals are often looking for the "next big thing," which makes recruitment and retention in the current environment difficult. The current cadre of civil servants, supplemented with experienced staff from the retired military community and the SSP mentoring program, should maintain a qualified workforce for the rest of this decade.

Industrial Base

The SLBM industrial workforce is diverse, highly educated, and often isolated from the nation's mainstream military-industrial complex. The work is usually classified, is performed in dedicated facilities, and must be executed in compliance with unique safety and security disciplines. Technologies such as radiation hardness and ablative reentry heat shields, for example, have no commercial equivalents.

SLBM Industrial Base		
Subsystem	**Prime Contractor(s)**	**Major Subcontractor(s)**
System Integration & Assessment	Strategic Systems Programs (SSP)	BAE, JHU/APL
D5 Missile	Lockheed Martin Missiles & Space (LMMSC)	ATK
Missile Guidance	Charles Stark Draper Laboratory	Raytheon, DRC, Honeywell, GD
Reentry	LMMSC, Sandia	Textron
SSBN Navigation	Lockheed Martin	Boeing
Fire Control	General Dynamics (AIS)	
Missile Launcher	Northrop Grumman	
Ship Systems	General Dynamics (EB)	
Targeting & Assessment	JHU/APL, NSWC Dahlgren	

Table 3: SLBM Industrial Base

The Trident II (D5) system is currently undergoing a life-extension (LE) program to extend the service life of the weapon system until 2042, to match the hull life of the Ohio-class submarine. The life-extension strategy uses a mix of continuing production of the existing design, as well as redesign based on component criticality, expected life, and future supportability and affordability. The D5 Life Extension program will be sufficient for training and transferring domain knowledge to the next generation of inertial guidance and electronics engineers. COTs-based shipboard systems, such as fire control and submarine navigation, have periodic refresh cycles to exercise skills. However, propulsion activity is limited to production and sustainment; and reentry, except for a MK4 fuse upgrade for the W76, has only sustainment activity planned.

Based on the above considerations, industry inputs, and SSP assessments considered by the Task Force, the SLBM industrial skills base is adequate for the current system through the completion of the D5 production and Life Extension development programs planned for completion in the 2010-2013 timeframe.

Depots and Facilities

The Strategic Weapons Facilities (SWFs) at Kingsbay, GA, and Bangor, WA, are in continuous operation supporting the fleet. As such, the skills shown in Figure 14 are exercised with sufficient regularity that there is no significant concern. Both facilities and their major supporting contractors have workforce capital management plans that maintain the right mix of skills, experience, and knowledge transfer. Even in the absence of development and production, fleet returns for cause, service life assessment, and surveillance activity exercise core skills on a regular basis. As long as the SLBM force structure and current operational tempo remain at or near the current levels, there should not be a concern in this area.

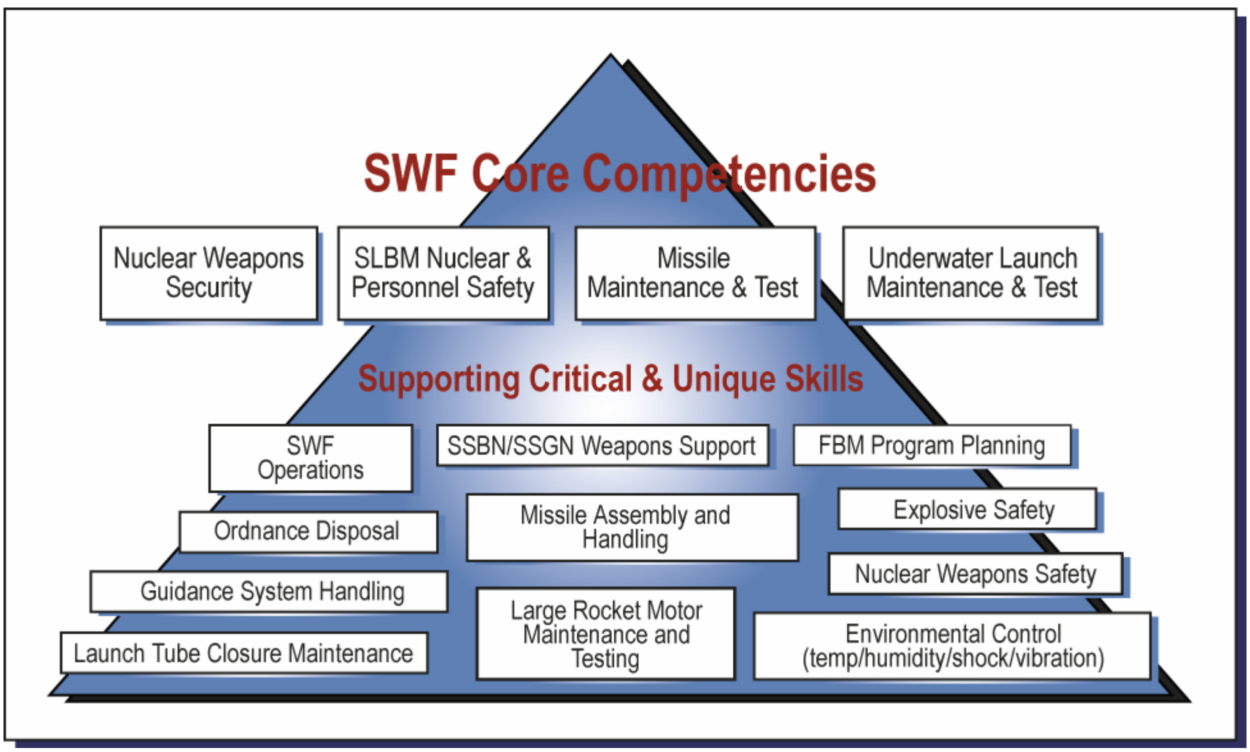

Figure 14: SWF Core Competencies

NEAR-TERM SYSTEMS (2015 TO 2025)

As discussed in the current systems assessment, the skills necessary to sustain currently deployed systems, i.e., configuration control, testing, assessing performance, identifying and developing solutions to technical problems, etc., have been in decline due to loss of budget and program scope for the last decade, but are generally adequate for sustaining today's force structure. However, there is no clear long-term strategy beyond the end of this decade. The combined impact of no clear national strategy, workforce demographics, and no planned development activity beyond circa 2015 will, in the absence of corrective action, put the workforce in serious jeopardy.

Modernization programs such as the LE and Application Programs have been effective in preserving DoD-unique technologies and capabilities as well as critical skills since the early 1990s. The currently planned, post-life-extension environment involves only the incorporation of life-extension alterations into the deployed fleet and sustainment activities. These activities are necessary but not sufficient for long-term maintenance of the S&T, prototype, design, and test skills needed for new development, complex failure investigations, and major technology insertions.

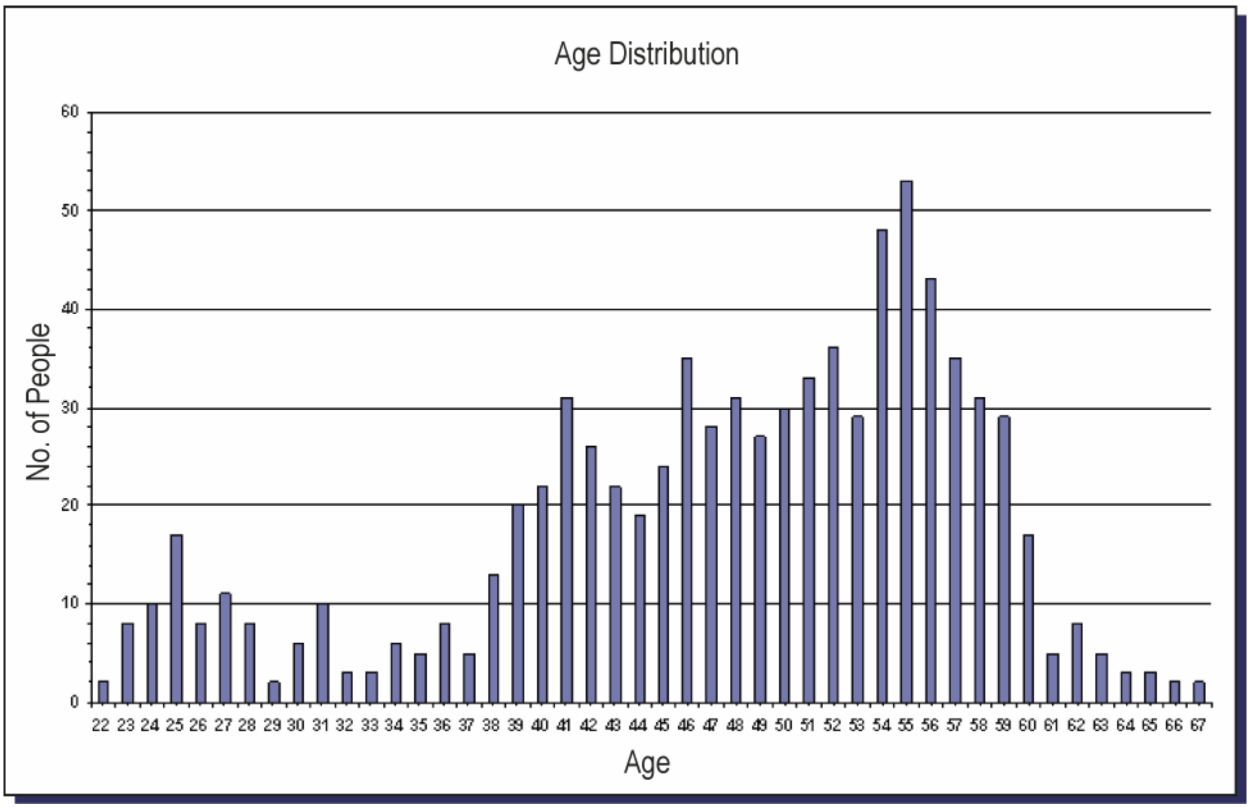

Figure 15: Typical Ballistic Missile Industrial Base Employee Age Distribution

In addition, current demographics do not favor long-term maintenance of skills, as shown in Figure 15. In the next 10 years, a serious loss from the workforce of personnel with SLBM domain knowledge and critical skills can be expected. S&T and development of non-nuclear strategic capability, such as that recommended by the 2003 DSB Summer Study, would attract innovative individuals with the strongest technical capabilities. Continuation of the SLBM Applications Programs will help with DoD-unique critical skills. If these areas are not supported, long-term sustainment of SLBM critical skills and support of future systems will be at serious risk.

FUTURE SYSTEMS (2025 AND BEYOND)

If the issues summarized under near-term systems are not addressed, then there will be a serious loss of the critical skills needed to support SLBM systems over the long term. Recruitment and retention of a workforce willing to make the long-term commitment necessary to become the leaders and skilled workers who can execute the development challenge for the next-generation SLBM will be difficult. Today, new-hire civil service and industry professionals have difficult career choices to make. Young people want to use the modern skills they have acquired in college, frequently at considerable cost to themselves and their families, in viable careers that provide long-term personal growth and financial opportunity.

This will become increasingly problematic as a significant portion of the current workforce will have to be replaced over the next 10 years. Subsequent to recruiting these replacement workers, their skills will need to be developed so they can be in position to execute the design and development of the next-generation SLBM system.

BOMBERS AND CRUISE MISSILES

BACKGROUND

Long-range bombers were the first long-range strike assets of the U.S. military forces. They played a major role in World War II, and the B-29 Super Fortress became the first nuclear delivery vehicle. Later generations of heavy bombers were fielded over the years, and they became increasingly capable in their ability to penetrate enemy air defenses.

The ever-increasing capabilities of air defenses prompted the U.S. to augment its bomber forces with long-range, air-launched cruise missiles, first with nuclear payloads and later with non-nuclear payloads. Cruise missiles could better penetrate air defenses, and they permitted the launching bombers to stand off from those defenses. At about the same time, the U.S. also developed and fielded long-range cruise missiles (nuclear and non-nuclear) to be carried on and launched from ships.

CURRENT SYSTEMS

The current U.S. strategic strike forces include three operational bomber aircraft: the B-52, the B-1, and the B-2. All of these are used to deliver conventional payloads. The B-52 and the B-2 are also part of the U.S. nuclear force structure. The B-1 has also served in a nuclear role, but is now used only for non-nuclear missions. All of these aircraft are undergoing modifications, including modernizing and improving avionics and integrating additional types of weapons.

The U.S. also has underway a Joint Unmanned Combat Air System (J-UCAS) program. This demonstration program is exploring technology and system concepts for the use of unmanned vehicles for various missions now conducted by manned tactical aircraft. Many aspects of these developments would also be applicable to unmanned, long-range strike aircraft.

The current U.S. strategic strike forces include both air-launched and sea-launched cruise missiles:

ALCM – Air-Launched Cruise Missile. Has nuclear and conventional variants.

ACM – Advanced Cruise Missile. Air-launched, nuclear only.

TLAM – Tomahawk Land-Attack Cruise Missile. Submarine- and surface-launched, nuclear (not currently deployed) and conventional.

TACTOM – Tactical Tomahawk. Submarine- and surface-launched, conventional. This is the only operational long-range cruise missile currently in production.

JASSM – Joint Air-to-Surface Standoff Missile. Air-launched, conventional. This is a shorter-range cruise missile, in early production. This and the preceding cruise missiles are subsonic.

> **SSST – Supersonic Sea-Skimming Target**. This ground-launched target vehicle is in development. Conceivably, air-launched and strike variants of it could be developed, most likely with conventional warheads.

ASSESSMENT

In general, strategic strike skills associated with air-breathing aircraft and missiles are healthy. To a large extent, this is because of the similarity in the skills needed for bombers and cruise missiles to those skills that are currently being exercised in the development and production of tactical military aircraft (both manned and unmanned), commercial aircraft, and tactical cruise missiles.

On the other hand, the absence of clear Department of Defense direction regarding future strategic strike systems makes it difficult, particularly for industry, to take the steps necessary to ensure an adequate skills base in the future. The Task Force heard this concern expressed by almost all of the industry representatives. They cited the need for a consistent government vision and roadmap, and investment in concept studies, technology demonstrations, and, finally, development and production programs. They are frustrated with what appears to them to be "constant" changes.

Many of the skill sets needed for bombers and cruise missiles are common: aerodynamics, structures, stealth, manufacturing, mission systems (avionics, including guidance, navigation, and control), propulsion, propulsion integration, vehicle systems, and overall vehicle configuration design. Some of these skills are unique to bombers, e.g., life-support for manned systems, crew-machine interfaces, large structures, large engines, complex sensor and weapon system integration. Some are unique to cruise missiles, e.g., small, inexpensive turbine engines and terminal homing.

Military

The military has the skills necessary to plan, develop, deploy, operate, maintain, and sustain current bombers and cruise missiles. They are doing so adequately at this time, and they have the necessary personnel processes in place to continue this into the future.

Government Civilian

The same is generally true for the government civilian force. However, these areas, like many others, are at some risk due to the aging of the civil service workforce and the shortage of younger personnel, caused by the combination of the 1980s strategic forces build-up and the relatively low rates of hiring over the past decade or so.

Industry

The Task Force heard a mixed story on the demographic situation in industry. In some areas, the situation appeared quite healthy. For example, one company indicated that about 30% of their engineers had been with their program for less than 10 years, only about 20% were within 10 years of retirement, and about 50% were in between. This is a good situation, and they appeared comfortable that they could handle this into the future. Comparatively, another company indicated that only about 10% had been with their program for 10 years and about 40% were within 10 years of retirement – a situation prompting considerably more concern. Yet another had about 15% in their first 10 years, 70% in the middle group, and only 15% within 10 years of retirement.

Not mentioned explicitly in the above list of skills are two areas which are of increasing importance and in which nearly all companies are experiencing shortages: systems engineering and software engineering. The increasing complexity of weapons systems, as well as the increased emphasis on "systems of systems," makes systems engineering ever-more critical. In fact, the term "systems of systems engineering" has become a familiar part of the vernacular. Similarly, such complexity, as well as the incorporation of computers into essentially all aspects of system and subsystem design, creates great demand for software engineers.

Industry, especially the larger companies, has considerable interactions with the academic community: they have intern, scholarship, and cooperative programs; they give research and development grants; they interact with the faculty to influence what is being taught and to involve the faculty in their programs; and they develop "strategic partnerships" with universities.

Industry representatives cited a number of challenges in addition to those caused by demographics and shortages of systems engineering and software engineers. There are fewer engineering graduates available. An increasing number are foreign and ineligible for security clearances. The mathematics and analytic skills of American-educated graduates are not as strong as those of India- or Far East-trained students. Much of the necessary training, in areas such as hypersonic propulsion (ramjets and particularly scramjets), have unique problems in thermal protection and management, engine-vehicle integration, fuels, and shapes, which must be provided on-the-job. However, the relatively small number of ongoing aircraft and missile programs provides few opportunities to train young engineers. Finally, the current graduates are, as a community, more mobile, which results in increased competition from non-defense firms.

NEAR-TERM SYSTEMS (2015 TO 2025)

The U.S. has a number of science and technology programs underway as part of the National Aerospace Initiative, including the development of hypersonic (> Mach 5) technologies for use on potential future missiles and aircraft. The Air Force is exploring options for Long-Range Strike which include as possibilities next-generation aircraft and cruise missiles. Candidate concepts include penetrating bombers (manned and unmanned, subsonic and supersonic), and stand-off aerial platforms that launch supersonic or hypersonic cruise missiles. Higher-speed concepts would be consistent with the U.S. strategy for more-survivable, more-responsive forces.

ASSESSMENT

Military and Government Civilian

The basic skills required for the military will change relatively little as Near-Term systems are developed and come into the force, although those overseeing the technical aspects of these programs may need education in new areas, such as hypersonics.

Industry

The points made above regarding the industry workforce apply for the ability to support Near-Term systems as well. The ability to support next-generation systems of the same general class as current systems will depend strongly on the health of the civilian aircraft and tactical military aircraft industries. The ability to support the development and production of aircraft and cruise missiles with hypersonic speeds will depend crucially on not only the continuation of science and technology programs in that area, but also programs that transition the relevant technologies into full-scale demonstrations, prototypes, and engineering demonstration models.

FUTURE SYSTEMS (2025 AND BEYOND)

In addition to the Near-Term systems described above, possibilities for the long-term include hypersonic bombers (manned or unmanned) as well as missiles.

ASSESSMENT

Military and Government Civilian

Again, the basic skills required for the military will change relatively little as future systems are developed and come into the force.

Industry

The points made above regarding the industry workforce apply for the ability to support future systems as well.

PAYLOADS

The strategic strike skills necessary to sustain the current strategic strike payloads, and to develop new ones, can be separated into those relevant to nuclear and non-nuclear munitions.

NUCLEAR

With regard to current nuclear strike systems, the status of the DoD skills relevant to the sustained operation of payload components that are the responsibility of DoD has been discussed extensively above. Briefly, skills are adequate for routine sustainment operations, and less certain in the face of unforeseen problems arising due to the increasing lack of development experience on the part of DoD personnel.

The National Nuclear Security Administration (NNSA) is responsible for the nuclear explosive package in missile payloads and for the entirety of nuclear bombs. The status of strategic strike skills within the NNSA was outside the purview of this Task Force.

NON-NUCLEAR

With regard to non-nuclear strategic strike payloads, currently only aircraft and cruise missiles fall into this category. The skills in this area are sound because they have been routinely exercised in the refurbishment of current capabilities as well as in the periodic development and deployment of new payloads.

The status of relevant strategic strike skills for future non-nuclear ballistic missile payloads is not good. Reentry and impact pose very different environments for non-nuclear munitions than those imposed on existing “conventional payloads.” There are no funded programs, or even exploratory development programs, that would enable the skills necessary to deal with the challenges posed by these environments to be developed.

C4ISR

BACKGROUND

C4ISR represents not only the foundation, but perhaps more importantly, the backbone for future strategic strike systems. Utilization of solid-state chip technology, application of rapidly evolving electronics, and expansion of an increasingly sophisticated global communications network grid have opened new avenues for weapon systems performance. Future strategic strike systems are not limited by historic mechanical (linear) or evolutionary development. Weapon systems of the future can achieve effective, reliable, and assured performance through emerging electronic, optical, computational, and software technologies that offer responsiveness, persistence, interactive command and control, and real-time mission success assessment.

The components of C4ISR for strategic strike systems, however, are diverse and individually rooted in development, deployment, and operational histories (or legacies) that do not necessarily share a common skills base or easily identifiable breadth and scope of expertise. For example, for over 40 years, developments in **intelligence** and the resultant assessments focused on exploiting those technologies that would permit the U.S. to peek over the Iron Curtain. The bulk of today's intelligence budget is still directed at systems and their supporting technologies that can provide optical and/or electronic glimpses from a distance at what may be happening at periodic intervals in "targeted" portions of the globe. The objective was and is to provide sufficient information so that political, military, and economic threats facing the U.S. in the near-term could be assessed.

Surveillance and reconnaissance (SR) development has been aimed at supporting those systems which can provide warning that a threat: has reached a state of military readiness and operation; is directed at the U.S. homeland, forces abroad, and/or friends and allies; and is "on the move." The SR supporting technologies have addressed quantification of the threat using visual, radar, optical, and/or electronic means. Thus, most of the SR development since the end of WWII has supported the notion of monitoring the status of the opposing bi-polar threat in areas of specific concern as they became accessible to our assets.

Command and control of strategic systems has been built upon the premise of establishing a regimen for tightly controlling the authorization to release nuclear weapons. Thus, the dependency upon quality ISR and assured secure communication channels has been central to strategic systems command and control architectures. Ballistic missiles have rigorous procedures for maintaining control over launch that require release authorization from the National Command Authority. Targets are pre-selected and unknown to the crews implementing the command direction. Bombers or aircraft carrying nuclear cruise missiles also have rigid, predetermined plans for targeting, but do have the flexibility for obtaining directed updates during the operation. This pre-planned responsive targeting operation has been the basis for strategic command and control since the early 1950s, and, as a consequence, technology has focused on "surety" of control, survivable and secure communication links, and strict adherence to pre-planned options with decision-makers responsible for selecting the option that meets the threat determined from necessarily time-urgent ISR assessments.

Communication links for strategic strike systems have necessarily relied upon multiple or parallel approaches to limit vulnerabilities to dedicated physical threats, jamming, or eavesdropping (tapping). Accordingly, there has historically been a desire to minimize the traffic and the content, thus leading to concise messages that can be used to implement the preplanned options, rather than dialog all of the perceived details of a situation. Consequently, sensors used for ISR have relied upon significant signal processing on-board, to reduce data to the bare essentials that need to be transmitted.

Computer technology has moved so fast since the late 1950s that it has now firmly become the fourth “C” in C4ISR and influences directly the breadth and scope of the mission that can be tackled by today’s weapon systems. Computers on-board weapons systems digest the SR data, provide navigation and guidance updates, offer the possibility of steering a payload to the target, and can assist in assessing the effects of the attack for commands located elsewhere.

CURRENT SYSTEMS

The skills to support today’s C4ISR systems have been nurtured over the years of the Cold War and remain committed to development and operational performance of assets that have been acquired by the intelligence community, related DoD agencies, and the Services. This National System has had the benefit of funding priorities and fast-track procurements leading to an environment that is regarded to be filled with technical challenge and one that offers professional satisfaction when success is achieved. Consequently, those with the appropriate skills are more easily attracted to the set of programs and projects that represent the National System and its supporting C4 and SR infrastructure. However, security clearances at the highest levels are requisite (see Figure 4 - Time to Obtain Clearances) and thus the trends of declining graduation rates (BS, MS, and PhD) of U.S. citizens who may qualify for employment should be a major concern for the C4ISR skills base in the years ahead (see Figure 3 – University Trends in Defense Related S&E). C4ISR and other skill sets must now draw upon a steadily decreasing pool size that can provide the needed talent (see Figure 1 – U.S. Employed Engineers; Figure 2 – U.S. Engineering University Graduates; and Figure 5 - R&D Scientists and Engineers Employment).

The companies comprising the U.S. industrial base that supports the National System, related surveillance and reconnaissance programs, command and control initiatives, and the supporting communications infrastructure are currently able to attract personnel needed to replace those that are reaching retirement. Approximately 30% of the workforce has been with the programs for less than 10 years, whereas approximately 18% appear to be within 10 years of retirement. However, increasing compensation competition from the commercial sector and a perceived lack of C4ISR vision (i.e., program stability) could well alter the positive demographics currently enjoyed by the industrial base, through movement of the recent hires to other programs or careers.

Despite the success in recruiting and the strong budget endorsements that the industrial base has enjoyed, there remain two causes for concern with the skills available for the current systems:

Access to Space

Today's C4ISR systems that support strategic strike rely upon assured, timely access to space. The discipline for successful launch was developed in the ICBM and SLBM programs in the late 1950s. The development of the liquid ICBM logically evolved into the "truck" necessary to carry space assets for C4ISR purposes into orbit (for example, the "1999 Air Force Assessment of the Titan IV Space Launch Failures") and carried over to the National Aeronautics and Space Administration (NASA) for space launches later in the 1960s. Both military and NASA space operations adopted policies, procedures, and supporting infrastructure skill sets to assure mission success. However, the numbers of ICBM and SLBM test firings have been dramatically reduced following the Cold War, and the NASA space launch program has encountered significant setbacks. Many commercial satellite providers now rely upon foreign boosters for access to space. The innumerable "-ilities" and strict pre-launch regimen, which represent the necessary checklists for a successful space launch, are perhaps viewed as "dull stuff" compared with the more exciting technical challenges of electro-optical eavesdropping and sophisticated signal processor development. The skills necessary for access to space are resident in those individuals reaching retirement and are not easily mentored or transferred in an environment with a shrinking launch schedule. Further, a steadily decreasing number of individuals have participated in a successful launch operation.

Weapons Effects

In addition to the problem of access to space, the skills associated with weapons effects are also necessary to ensure continued progress in C4ISR. Today, the number of individuals working on the various C4ISR programs who have worried about system or subsystem vulnerabilities to EMP—including black-out, red-out, or other nuclear weapon-induced effects—continues to decline, and the people with these skill sets are not being replaced. The view that the Cold War is over has caused many of the "requirements" for radiation hardening or survivability protection to be ignored or moved below the funding line. C4ISR for strategic strike may well have vulnerabilities that an adversary could seek to exploit, and the skill sets available today in the C4ISR community to address those concerns are not being replenished with the exception of some efforts at the NNSA laboratories. Both the EMP Commission and the DSB Task Force on Nuclear Weapons Effects Test, Evaluation, and Simulation have addressed this issue in greater detail. Unfortunately, their recommendations have yet to be seriously acted upon.

NEAR-TERM SYSTEMS (2015 TO 2025)

In the near-term, C4ISR for strategic strike systems will build upon the success that tactical and theater forces have enjoyed in developing sensors, rapidly deployable communication links, robust command and control (e.g., the Army's digitized battlefield), and the emerging stable of Unmanned Aerial Vehicles (UAVs). The realization of a global grid that is not bandwidth-limited will make possible the development of sensor systems that are capable of "ISRing" information without selective signal processing or restrictive communication links. This will allow the potential for transforming information into data that can be the basis for knowledge that drives subsequent action.

Skills to implement near-term C4ISR systems for strategic strike are available in the commercial marketplace (computers, communication, and networking) and throughout other DoD programs (sensors and platforms) used for tactical or theater operations. The challenge will be to define the evolutionary steps that C4ISR must take to move beyond the Cold War National Systems to a capability that is persistent, intrusive, and truly global with rapid deployment timelines. Once the systems are defined, the skill sets will follow to the industrial base and the government program offices. But that vision has not been provided.

Future Systems (2025 and beyond)

C4ISR to support future strategic strike systems will have to rely upon agents and analysts trained in the languages and cultures of potential global adversaries. These skills are not available to meet current embryonic demands and certainly not in the pipeline to support the intrusive, on-site intelligence operations envisioned for the future.

Development of robotics (or "critters") to serve as potentially expendable on-site collectors or sensors is in its infancy and requires a combination of mechanical and electro-optical skills not currently resident in the C4ISR community. These applications will likely depend upon Micro-Electro-Mechanical Systems (MEMS) and potentially even nanotechnology development skills.

The utilization of computer tags or embedded software that can be exploited by ISR analyses and assessments depends upon skill sets well-recognized by the commercial community (e.g., global financial networks) and the current defensive security structure. The transformation to information operations and exploitation of an adversary's assets will necessitate bringing in skill sets not present in significant numbers in the C4ISR industrial base or the government program offices.

Persistence and global reach of ISR are likely to become as dependent upon UAVs and the cooperative utilization of other assets (e.g., fighters, tankers, and commercial aircraft) as much of the current systems are on satellites. Thus, the skill sets available for the "primary mission" can be used to advantage or leveraged for global ISR capabilities. However, the magnitude of the challenge leading to a truly global deployment of UAVs with ISR capabilities suggests that those skills are currently not available in any significant number and will have to be developed to meet the demand.

Development of a truly net-centric command and control operation for strategic strike requires, at the outset, the skill of seeking change, which may not be a trivial obstacle. Given the will to have the capability to share information, appropriately protected, with all who have a need to access and participate, the skills will exist (commercial communications, entertainment modeling and simulation, etc.) to bring a collaborative command and control structure to strategic strike. This means that reach-back is real, responsive real-time retargeting is possible, offense-defense force elements can be integrated by the Combatant Commands, bomb damage assessments can be carried out as a timely part of the operation, and "battle management" is achievable.

In all likelihood, the greatest challenge facing the development of C4ISR skills to support future strategic strike systems is the definition of the strategic strike architectures and concepts of operation necessary to achieve long-term U.S. objectives. The movement from the Cold War systems will be slow and, indeed, some of them are needed for the long-term to support continuing deterrence objectives. However, the ability to dissuade, deter, or defeat others, whether they be emerging peers, ambitious nation-states seeking to establish a place at the table, or terrorist groups lurking for an opportunity, will depend upon many skill sets not currently resident in the C4ISR community that supports strategic strike. Fortunately, the U.S. has the educational system that can provide a pool of talent that will be needed, and it already is doing so in the commercial sector and in emerging technologies being developed to support Homeland Security, Special Operations Forces, the Missile Defense Agency, and others.

FUTURE ALTERNATIVES

An assumption of the Task Force's Terms of Reference is that many of the strategic strike skills required in the future will be different from those required for current strategic strike capabilities. Indeed, most of the future strategic strike options recommended by the 2003 DSB Summer Study have not been funded. However, efforts on directed-energy weapons, information operations, and space platforms for other applications provide a base upon which to build.

One of the exceptions, where a different skill set will be required, is in the area of hypersonic propulsion. While ramjet and scramjet propulsion concepts have been pursued from time to time over several decades, the activity has been in fits and starts, resulting in a lack of a critical mass of expertise anywhere in government or industry. The Task Force was informed that the recent Mach 10 flight of the ATK X-43A would not have been possible without the major contributions of recalled retirees who had been part of a decades-old program.

As defenses against air-breathing strategic strike systems continue to improve, hypersonic speed is a natural step for aircraft and/or stand-off missiles. The current absence of a funded, sustained program is delaying the day when the necessary skills will be developed that would ultimately allow hypersonic propulsion to play a part in strategic strike. The skills necessary to develop the advanced materials that will be required to handle the unique thermal and shock environments created during hypersonic flight are also not currently available, again due to a lack of coherent and sustained development activity.

Non-nuclear munitions, with the ability to survive intercontinental ballistic missile re-entry and then to operate effectively thereafter, is another area where current skills are inadequate. The expectations laid out in the Nuclear Posture Review for strategic strike are that non-nuclear capabilities will replace as many of the historic nuclear missions as possible. Today, there is inadequate development work on non-nuclear munitions for strategic strike re-entry systems to create the skilled cadre needed to reliably build and deploy such systems.

PERSONNEL MANAGEMENT

"Human capital management," is a term currently in vogue that simultaneously recognizes that personnel are as critical as capital facilities and equipment to the ability of an organization to perform its mission, and that an organization is unlikely to recruit and retain competent personnel without an active management plan to do so. The Office of the Secretary of Defense, and the Army, Navy, and Air Force have, to different degrees, acknowledged this challenge with regard to the personnel whose skills are critical to the successful accomplishment of their responsibilities contributing to the success of strategic strike missions.

The Task Force is convinced that the success of human capital management plans will ultimately depend upon adequate funding of challenging work and, most importantly, on real development programs that progress to production in selected cases. The routine sustainment of existing systems may be interesting enough for the retention of older personnel loyal to the programs they created and reluctant to change jobs at this point in their careers. Life-extension programs, with the introduction of some new capabilities, will be somewhat more attractive for new personnel and the retention of mid-career personnel.

However, neither of these activities will provide the challenges that new-design work offers for the recruitment and retention of the "best and the brightest." The best approach for knowledge transfer of the esoteric skills unique to strategic strike is for inexperienced personnel to work side by side with experienced mentors on new-design work, or on exploratory development programs when new systems are not programmed. The existing Applications Programs in the areas of guidance, re-entry, propulsion, and radiation-hardened electronics have provided some help in skill retention and knowledge transfer, but these programs are not sufficient by themselves and have been inadequately funded in the past. Recent funding decisions for these programs will make matters worse.

NAVY

The Navy's Strategic Systems Programs (SSP) is the only DoD strategic strike organization to specifically label their effort a "Human Capital Management Plan." It recognizes the aging of its current workforce and acknowledges that the lack of new development and production programs is a disincentive for the recruitment and retention of a skilled workforce.

SSP has developed a Strategic Plan to define management and performance requirements for their business lines and the human capital (military, civilians, and industrial partners) needed for the successful execution of each business element. Key to this success is the comprehensive human capital management plan currently being developed.

The SSP Human Capital Management Plan has defined the current status of their workforce (military and civilians) by education, technical and critical skills, program expertise, years of experience, and years to retirement. The Plan also provides a knowledge management and knowledge transfer process to ensure critical skills and program expertise will be captured and transferred from retiring/departing personnel. The plan will baseline the critical skills and program expertise needed for new business lines and the process for acquiring, training, and retaining the required personnel.

SSP has also mandated that their industrial partners (private industry and laboratories) provide an equivalent strategic plan for how they will support SSP in the near- and far-term (using SSP-projected budget resources) and manage their required human capital. Preliminary plans have been received from SSP industrial partners and, upon SSP concurrence, will be living documents for assessing changes in program requirements and budget resources.

The stated objective of SSP is: "Through these Strategic and Human Capital Management Plans, SSP will assure continued and future success of their programs." The Task Force is convinced that SSP is committed to their Human Capital Management Plan. We are equally convinced that such a plan is necessary. The data make clear that while military billets continue to be filled, and training programs are excellent, a large percentage the SSP civilian workforce is less than 10 years from retirement (for example, up to 50% at the Special Weapons Facility Pacific and 35% overall) .

Among its contractors, SSP initially directed implementation of a human capital management plan at the General Dynamics (GD) Pittsfield facility. The most impressive plan developed there has defined the critical skills required for SSP missions, assessed the relevant skills and risks of departure of GD personnel, developed Individual Knowledge Transfer Plans, including the use of mentors, and institutionalized the monitoring of knowledge management. SSP has recognized that mentoring does add additional cost, but has accepted these increased costs as necessary to retain the skills needed for current and future work within its contractor industrial base. Other contractors working with SSP are now designing similar plans for SSP approval.

ARMY

While having no strategic strike delivery mission, the Army has recognized that it may have to operate in weapons of mass destruction (WMD) environments created by hostile forces or even as a result of the use of U.S. strategic strike systems in support of Army missions. In recognition of this need to understand the consequences of nuclear and other WMD use, the Army has established a career path for officers who specialize in the understanding of WMD, including nuclear weapons effects. While not explicitly labeled "human capital management," the Army's program includes all the elements for the successful recruiting, training, and retention of personnel with the necessary WMD-related skills.

The Army's stated purpose for the Nuclear and Counterproliferation Functional Area (Functional Area (FA) 52) is that officers will: "… apply knowledge and expertise of weapons of mass destruction in developing national and theater strategy, plans and policy. In addition, these experienced officers conduct weapons effects research and analysis, formulate and verify international treaties, and plan the employment of nuclear weapons to support theater and strategic operations."

Officers enter the program as Captains between years 5 and 6, with career designation following promotion to Major with the possibility of continuing in this specialization through the rank of

Colonel. All FA52 officers are afforded an opportunity to obtain an advanced degree(s) in a relevant technical or strategic area, as well as specialized on-the-job training. The skills of this cadre are highly sought after, with officers serving tours with, among other assignments: OSD, OJCS, HQDA, STRATCOM, SHAPE, NORTHCOM, PACOM, EUCOM, USFK, JFCOM, DTRA, DIA, USANCA, USMA, DOE/NNSA.(see Appendix F for a full list of acronyms).

The Task Force was impressed with the professionalism and relevant WMD-related expertise of this cadre. The career path, as designed, has ensured strong interest in being a part of this program. The expertise developed is critical to the appreciation of nuclear effects within the Combatant Commands and offices throughout the Pentagon. We commend the Army on its recent decision to leave management of this program with the United States Army Nuclear and Chemical Agency rather than transferring it elsewhere.

AIR FORCE

The Air Force in 2003 articulated a Space Professional Strategy to, "Build a team skilled and knowledgeable in the development, employment, and integration of space systems, concepts, and doctrine to achieve national security objectives." The Commander, Air Force Space Command (AFSPC/CC) is the Space Professional Functional Authority (SPFA) responsible for the overall health and development of the community of Air Force Credentialed Space Professionals (CSPs). The CSP community is a subset of the larger category of "Space Professionals," who have a thorough understanding of the space medium and its effective application to joint warfighting. The CSP community uniquely falls under the Space Professional Certification Program and includes scientists, engineers, program managers, and operators (officers, enlisted and civilian) whose careers and experience are tracked by the Space Professional Management Office (SPMO) within AFSPC. The SPMO also manages the CSP community's Space Professionals education and certification. Over 7,000 active duty officers and enlisted personnel are included in the CSP Community, and their experience is tracked in nine key mission areas: Satellite Systems, Nuclear, Spacelift, ISR, Kinetic Effects, Space Warfare C2, Warning, Space Control, and Space Other. For example, more than 3,000 officers and enlisted personnel in the CSP Community are identified as having "Nuclear" experience, with about 900 of them having more than 5 years experience in the nuclear mission area. The civilian Guard and Reserve components have not been fully identified, but are expected to add another 2,500 members to the Air Force CSP Community.

In addition, in recognition of the gradual erosion of nuclear expertise within the Air Force, an Air Force Nuclear General Officer Steering Group (AFNGOSG) was created in 2002. This 21-member group, chaired by AF/XOS, is tasked to provide a single, cross-functional forum to identify, manage, and resolve issues of concern to ensure the USAF is organized, trained, and equipped to carry out its nuclear responsibilities. With respect to nuclear skills, the AFNGOSG established a program to develop and sustain a pool of officers and non-commissioned officers (NCOs) with appropriate expertise to support the Air Force nuclear mission by ensuring sufficient training, education, and experience. This program has identified over 22,000 personnel with nuclear experience. The Air Force identified 747 key nuclear billets that "…are so critical to the execution of the nuclear mission that if the person filling the position lacks the requisite experience, it will present an unacceptable risk to nuclear surety or mission execution."

The Task Force finds that the responsibilities of the Space Professional Functional Authority and the Air Force Nuclear General Office Steering Group should be very important to the maintenance of strategic strike skills within the Air Force. Both functions are relatively new, and it is therefore not surprising that the Task Force was provided no metrics by which to judge if the missions were being accomplished or whether there has been any positive impact on skills as a result of SPFA or AFNGOSG actions.

We recommend the Space Professional Management Office and the AFNGOSG work together to define requirements, metrics, and an implementation plan to ensure complementary actions in meeting U.S. needs for nuclear expertise as they relate to ICBMs. Equivalent agencies should also work with the AFNGOSG to define non-space-related nuclear requirements and metrics.

ICBM skills are at risk within the industrial base that supports the Air Force strategic strike missions. The ICBM SPO has taken the step of requiring the ICBM industrial base to identify the status and trends of strategic strike-relevant skills. The charts generated for skills critical to propulsion, guidance, and re-entry generally show green/yellow going rapidly to yellow/red (see Figures 9, 10, and 11).

Current ICBM-related industry personnel distributions show substantial fractions nearing retirement. Recruitment in most strategic-strike-unique areas is not taking place at a rate that will allow adequate training to replace the skills of retiring workers before they have left.

While industries are well aware of human capital management strategies, they must be guided by business realities, and they see no firm commitment to a next-generation system, or to an Air Force commitment to exploratory systems. In addition, unlike the Navy SSP, the ICBM SPO has not worked with its industrial base to identify and then fund incremental sub-system developments that would specifically retain critical skills.

The Applications Programs were created to fund strategic strike skills with no counterpart in commercial or other defense missions. They have contributed to sustaining these skills over the last decade. Applications Program funding by the Air Force and the Navy never reached the amounts recommended by advisory groups, amounts that would support the systems work that could demonstrate the necessary proficiency in strategic strike skills. Recent Navy and Air Force budget decisions have further cut funding for these programs.

These skills will disappear from the industrial base without meaningful defense work, as they have no counterpart in commercial industry. Industry uniformly asserts that it will take 5 to 7 years to reestablish critical personnel expertise if it is lost. The Task Force notes that redevelopment of expertise would be accompanied by technical and budgetary program failures, as new practitioners learned by their mistakes.

DEFENSE THREAT REDUCTION AGENCY (DTRA)

DTRA is the only Defense Agency with strategic strike responsibility examined by the Task Force. The assessment of strategic strike skills in DTRA is alarming. The only good news is that the billets occupied by military personnel show a healthy age distribution, and the relevant experience of these personnel seems commensurate with their responsibilities (see Army discussion above). Comparatively, civilian personnel, once the strength of the scientific excellence of DTRA and its predecessor agencies, show a very high average age, a dearth of less experienced PhDs, and severe shortages in 124 of 163 critical skill areas important to strategic strike. Within the Nuclear Technology Division (TDN) organization alone, 14 of its 29 members are over 60, including five (of a total of seven) with doctorates.

DTRA presented the Task Force with no plan for the management of human capital in the strategic strike area. Similar to industry, DTRA cited lack of a clear national plan for the future of strategic systems and the lack of Congressional support for exploratory strategic strike programs as hampering recruitment and diminishing the motivation of early- and mid-career personnel.

These same factors were cited by DTRA as affecting their unique industrial base personnel, which suffer from the same demographic trend (see Figure 16).

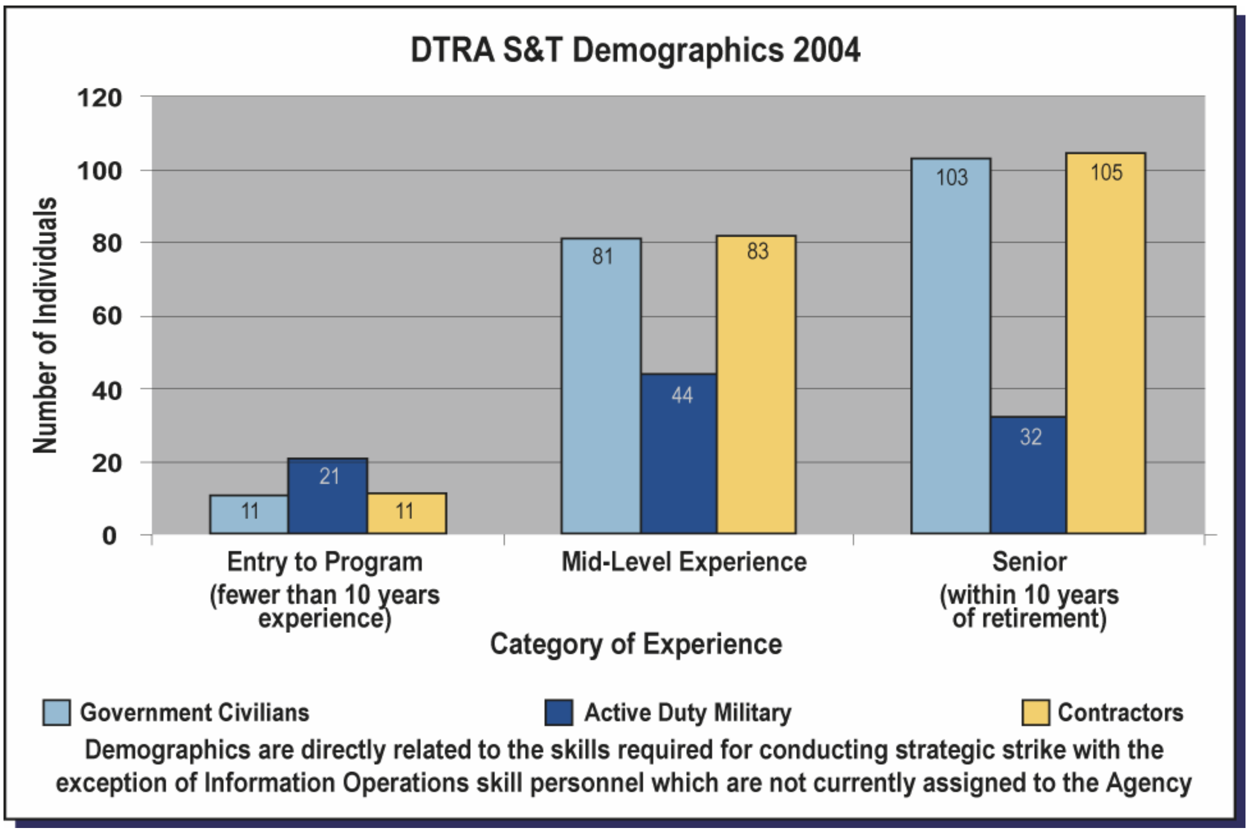

Figure 16: DTRA S&T Demographics 2004

U.S. STRATEGIC COMMAND

U.S. Strategic Command was the only combatant command visited by the Task Force. The STRATCOM briefings were helpful to understanding the spectrum of strategic strike responsibilities within that command. STRATCOM had no problems filling its military billets, with the exception of Information Operations (they are currently working on this issue), and they identified no problems with the strategic strike skills of the military personnel available to them.

Regarding the civilian staff, the Task Force found there to be no human capital management plan. The Command could not provide the information sought about civilian personnel experience levels and went so far as to suggest that the Defense Science Board could pay for any effort to obtain the information requested. The Command clearly does not manage its human capital, a situation that can only lead to poor performance in the long-term. Senior civilian billets have remained open for an extended period, and the Command faces the retirement of additional senior personnel in the near future.

FY06 National Defense Education Act (NDEA)

This Act has the potential for providing important support and resources for DoD long-range strategic strike skill retention. The Act focuses on future DoD critical science, engineering, and foreign language skills for people who are able to obtain clearance once their education is complete. The Act will include technical, undergraduate, graduate, doctoral, and post-doctoral levels.

The program scope under consideration might include up to 1,800 students through FY14. A possible mix would be 861 technical, 344 undergrads, 258 graduates, 129 doctoral candidates, and 207 post-doctoral positions. Two funding levels are being considered: $155 million over 6 years, equating to 1,800 students supported, and $950 million over 7 years, equating to 11,000 students. It is not clear if long-range strategic strike skills will be specifically addressed by this Act. DoD should engage with the Congress now to ensure this Act will acknowledge and support strategic skills.

REQUIREMENTS FOR STRATEGIC SKILL RETENTION

There are three fundamental questions with respect to obtaining and maintaining strategic strike skills within the United States into the future:

- What kind of workers do we need to perform our mission?
- How do we attract, develop, and retain them?
- How do we transfer critical knowledge to the next generation of workers?

The answers to these questions are best addressed by the use of a Skills and Domain Knowledge Management Process. Minimum elements are:

- Strategic and operating plans that include knowledge management;
- Definition of critical skills required;
- Assessments of Critical Skills, Risk of Departure, and Technical Agility development needs of personnel;
- Tools to manage/facilitate the process (HR database, etc.);
- Development of Individual Knowledge Transfer Plans, execution of plans, and monitoring of status; and
- Baseline Knowledge Management in company operation plans and processes on an ongoing basis to manage knowledge and critical skills.

The strategic strike workforce is diverse, highly educated, and often isolated from the nation's mainstream military-industrial complex. The work is usually classified, is performed in dedicated facilities, and must be executed in compliance with unique safety and surety disciplines. Technologies such as radiation hardness and ablative reentry heat shields, for example, have no commercial equivalents. However, the basic tenants of workforce stewardship apply:

Skills must be exercised. *Even the most experienced engineers and scientists cannot maintain their skills over time unless those skills are used*. Recruiting, training, mentoring, and domain knowledge transfer are not purely academic endeavors, and they can happen only in the presence of real and relevant work.

The strategic strike workforce must exercise the entire life cycle. *Day-to-day sustainment does not exercise all of the skills required to support S&T and new development*. Such activities must include: planning, concept definition, systems analyses, defining system requirements, and design for major modifications; responding to new threat-driven missions; determining how changes affect overall system performance; and making system cost/performance trade-offs through design and subsequent test and evaluation. These skills can be maintained over time only by engaging in real planning, S&T, and design activity.

People with strategic skills must be valued. A viable career path with reasonable promotion expectations is essential if DoD expects talented people to choose nuclear and conventional long-range strike as a career field in the twenty-first century. *A valued workforce is a managed workforce*. All skill providers must have an active skill and domain knowledge management system to ensure strategic skills professionals perceive their value and benefit from their "valued" status.

Strategic strike skills must be competitive with the "next big thing." Military, civil service, and industry professionals have difficult career choices to make. *Young people want to use the modern skills they learned in college at considerable cost to themselves and their families*. Challenging and relevant work should involve a mix of legacy and modern technology to ensure that assimilation of critical skills, knowledge transfer, and professional growth are realized.

Military careers require "management." The Military Services currently have some excellent processes and programs to identify, train, and manage the active duty community supporting nuclear and conventional long-range strike S&T, engineering, and operations. A continuation of this activity is vital if officers and enlisted personnel are to be recruited and retained. Careers in this area must be valued, and the opportunity for promotion must be predictable and real.

FINDINGS AND RECOMMENDATIONS

Nothing is possible without a national commitment and sense of mission. Clarity about the nation's policy and a firm, long-term commitment is the bedrock of any effective recruitment and retention strategy. People will respond to a well-communicated mission that is vital to the security of the nation. This was clearly validated by the Cold War experience. The Services' operational components and acquisition program offices, the defense agencies, and the supporting industrial base must have a supportive policy.

The DoD and STRATCOM should work with the Congress to develop a comprehensive policy on nuclear and conventional long-range strategic strike. There must be a sense that there *is* a future in this area or retention of the current workforce will be questionable and recruitment for the future of the best and brightest will be impossible…

DoD and STRATCOM should develop a 10-year strategic strike integrated transformation plan based on DoD policy, the Nuclear Posture Review, and the DSB Summer Study report on Future Strategic Strike Forces. The plan must be coordinated and integrated with DOE/NNSA planning. A path to the future would provide the vision and spectrum of capabilities from which the Services, agencies, program offices, and industrial base can plan and budget programs and make C4ISR, delivery system, and payload decisions. With a vision and supporting program baseline in place, the Services, agencies, and industrial base would then be able to assess the skills needs. This, in turn, would provide the basis for a sensible and credible strategy for recruiting, training, and retaining skilled personnel and allow for domain knowledge preservation and workforce career management.

In the absence of a clear national mandate, efforts to recruit military, civil service, and industry professionals into strategic strike programs will be a challenge. Today's graduates have difficult career choices to make; an effective win-win strategy could be to recruit talented professionals into an organization's leading-edge technology areas. This will be an attractive initial work assignment for those wishing to use their modern skills immediately. Over time, they can be exposed to the strategic strike area, which they will soon discover has real, relevant, and challenging technical work. A mix of legacy and modern technology benefits the organization, and ensures assimilation of legacy critical skills, knowledge transfer, and professional growth.

Specifically, the Task Force offers the following Findings and associated Recommendations:

FINDING #1

- The DoD has not provided specific direction regarding next-generation strategic strike systems. Consequently, the industry and civilian government talent base:
  - Is already marginally thin in many of today's current systems, and
  - May not be available for some potential next-generation systems.

Recommendation

- The Secretary of Defense should, taking account of the NPR Implementer and the DSB Future Strategic Strike recommendations, set direction and priorities for next-generation strategic strike systems.

FINDING #2

- The exploration of new concepts and technologies for strategic strike of challenging targets in the far-term is inadequate and will require access to a new talent base with different skills.

Recommendation

- The Secretary of Defense should establish a DARPA office charged with defining and funding the exploratory development of long-term strategic strike concepts, which should include the application of new technologies. Output would include:
  - Concepts for strategic attack that can be transitioned to the Services;
  - Conceiving and maturing technologies required by the concepts; and
  - Annual reports to the Secretary of Defense on the progress of strategic strike technology development.

FINDING #3

- The strategic strike area most at risk today is ballistic missiles:
  - Current skills may not be able to cope with unanticipated failures requiring analysis, testing, and redesign;
  - A large number of skilled military, civil service, and contractor personnel are nearing retirement;
  - Design skills are rapidly disappearing, both for major redesigns of current systems and for the design of new strategic systems; and
  - Applications Programs are necessary but not sufficient to maintain skills; they have never been funded at the required levels.

Recommendation

- Ballistic missile program offices should devote resources to the transfer of critical knowledge and skills to younger personnel in industry.
- The Secretary of Defense should direct the Navy and the Air Force—absent near-term systems development—to fund advanced development (subsystem design, system prototype development, and testing) to support next-generation system development (which will also restore and maintain the skills base).
- The Secretary of Defense should ensure that the Navy and the Air Force Applications Programs are funded at the STRATCOM SAG's originally-recommended levels to address critical areas not addressed by advanced development.

FINDING #4

- DoD and industry have difficulty attracting and retaining the best and brightest students to the science and engineering disciplines relevant to maintaining current and future strategic strike capabilities.
- The NDEA program has the potential for attracting personnel to government; however, it currently does not have a strategic strike focus.

Recommendation

- Strategic strike program offices should encourage and fund supporting industries to develop combined undergraduate scholarship and co-op programs for U.S. citizens in relevant science and engineering disciplines that would:
  - Include the requirement to work in DoD or the Defense industry; and
  - Encourage future graduate studies.
- Strategic strike program offices should also take advantage of the NDEA program.

FINDING #5

- Human capital management systems and strategies for identifying, tracking, and retaining critical skills are not being implemented effectively across all of the strategic strike constituent organizations.

Recommendation

- The USD(AT&L) should ensure that strategic strike constituent organizations institute a skill and domain-knowledge management system; and
- Include active duty, civil service, and industry personnel.

SUMMARY OF FINDINGS

Finding # 1

- The DoD has not provided specific direction regarding next-generation strategic strike systems. As a consequence, the industry and government talent base:
  - Is already marginally thin in many of today's current systems, and
  - May not be available for some potential next-generation systems.

Finding # 2

- The exploration of new concepts and technologies for strategic strike of challenging targets in the long-term is inadequate and will require access to a new talent base with different skills.

Finding # 3

- The strategic strike area most at risk today is ballistic missiles:
  - Current skills may not be able to cope with unanticipated failures requiring analysis, testing, and redesign;
  - A large number of skilled military, civil service, and contractor personnel are nearing retirement;
  - Design skills are rapidly disappearing, both for major redesigns of current systems and for the design of new strategic systems; and
  - Applications Programs are necessary but not sufficient to maintain skills; they have never been funded at the required levels.

Finding # 4

- DoD and industry have difficulty attracting and retaining the best and brightest students to the science and engineering disciplines relevant to maintaining current and future strategic strike capabilities.
- The NDEA program has the potential for attracting personnel to government; however, it currently does not have a strategic strike focus.

Finding # 5

- Human capital management systems and strategies for identifying, tracking, and retaining critical skills are not being implemented effectively across all of the strategic strike constituent organizations.

Figure 17: Summary of Findings

Table 4 provides the Task Force's best estimate of the adequacy of current and future strategic skills necessary to support the nation's strategic systems.

Skills Assessment			
	Current	**Near-term**	**Future**
C4ISR	Green/Yellow	Yellow	Yellow
Delivery Systems:			
■ Bombers	Green	Yellow	Yellow
■ Cruise Missiles			
●Nuclear	Yellow	Yellow	Yellow
●Non Nuclear	Green	Green/Yellow	Yellow
■ ICBMs	Green/Yellow	Red	Red
■ SLBMs	Green	Yellow	Yellow/Red
Ballistic Missile Payloads:			
■ Nuclear (not evaluated)			
■ Non-nuclear	Yellow/Red	Red	Red
Bomber/Cruise Missile Payloads:			
■ Nuclear (not evaluated)			
■ Non-nuclear	Green	Green	Yellow
Platforms/"Bases":			
■ Ships/Subs	Green	Green	Yellow
■ Space	Red	Red	Red
Future Alternatives	Red	Red	Red
Critical Mass Retained: Green, Green/Yellow	Critical Mass Marginal: Yellow, Yellow/Red	Below Critical Mass: Red	

Table 4: Skills Assessment

SUMMARY OF RECOMMENDATIONS

- The Secretary of Defense should, taking account of the NPR Implementer and the DSB Future Strategic Strike recommendations, give direction for next-generation strategic strike systems.
- The Secretary of Defense should establish a DARPA office charged with defining and funding the exploratory development of long-term strategic strike concepts, which should include the application of new technologies. Output would include:
    - Concepts for strategic attack that can be transitioned to the Services;
    - Conceiving and maturing technologies required by the concepts; and
    - Annual reports to the Secretary of Defense on the progress of strategic strike technology development.
- Ballistic missile program offices should devote resources to the transfer of critical knowledge and skills to younger personnel in industry.
- The Secretary of Defense should direct the Navy and the Air Force—absent near-term systems development—to fund advanced development (subsystem design, system prototype development, and testing) to support next-generation system development (which will also restore and maintain the skills base).
- The Secretary of Defense should ensure that the Navy and the Air Force Applications Programs are funded at the STRATCOM SAG's originally-recommended levels to address critical areas not addressed by advanced development.
- Strategic strike program offices should encourage and fund supporting industries to develop combined undergraduate scholarship and co-op programs for U.S. citizens in relevant science and engineering disciplines that would:
    - Include the requirement to work in DoD or the Defense industry; and
    - Encourage future graduate studies.
- Strategic strike program offices should also take advantage of the NDEA program.
- The USD(AT&L) should ensure that strategic strike constituent organizations institute a skill and domain-knowledge management system; and
- Include active duty, civil service, and industry personnel.

Figure 18: Summary of Recommendations

Appendices

Defense Science Board

DSB

Department of Defense

A. Terms of Reference

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION, TECHNOLOGY AND LOGISTICS

FEB 24 2004

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference -- Defense Science Board Task Force on Future Strategic Strike Skills

You are requested to form a Defense Science Board (DSB) Task Force to assess the future strategic strike force skills needs of the Department of Defense (DoD).

The strategic environment facing the United States is substantially changed from the times when we deployed our current nuclear strike forces and implemented the concepts that guide their use. The Nuclear Posture Review, the President's direction for the Unified Command Plan and the recent budget initiatives restructure our strategic posture. Last summer the DSB assessed DoD needs for future strategic strike forces. Assessed was the application of technology for non-nuclear weapons systems, communications, planning systems, and intelligence as well as the integration of strategic strike with active defenses as part of the new triad. This "skills" study will complement the previous strategic forces study by focusing on the people and the skills necessary to develop, maintain, plan, and successfully execute future strategic strike forces.

You are requested to:

1. Assess current skills available, both nuclear and non-nuclear of current long-range strike forces.

2. Identify, assess and recommend new/modified/enhanced skill sets necessary for successful future strike force development, planning, and operations.

3 Recommend a strategy for the successful evolution of the current skills to those required by future strike forces.

The Study will be co-sponsored by me as the Acting Under Secretary of Defense (Acquisition, Technology, and Logistics) and the Assistant to the Secretary of Defense (Nuclear, Chemical and Biological Defense Programs). Mr. Walter Morrow, Jr., will serve as chairman of the Task Force. Colonel Danny Wilmoth, USAF, OATSD(NCB), will serve as Executive Secretary and Commander David Waugh, USN, will serve as the Defense Science Board Secretariat representative.

The Task Force will operate in accordance with the provisions of Public Law 92-463, the "Federal Advisory Committee Act," and DOD Directive 5105.4, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Michael W. Wynne
Acting

B. TASK FORCE MEMBERSHIP

Members

Mr. Walter Morrow, Chairman
Dr. Robert Barker
Dr. George Schneiter
Mr. John Stillwell
Dr. Robert Strickler

Executive Secretary

Col Danny Wilmoth, USAF

DSB Representative

CDR Dave Waugh,USN

Government Advisors

Mr. Stan Gooch, USSTRATCOM
Mr. Richard Gullickson, DTRA
Col James Hyatt, USAF XOS/NO
Mr. Robert Krum, Navy SSP
Mr. Elliott Lehman, DIA
Dr. Don Linger, DTRA
Mr. Sean Nolan, OUSD(I)
Mr. Thomas Scheber, OUSD(P)
Mr. James Thompson, OUSD(AT&L)

Support

Mr. Robert Genkinger, SAIC
Ms. Anne Marvin, SAIC

C. DRAFT ACTION PLAN

FOR THE SECRETARY OF DEFENSE

The strategic strike mission remains a critical component of United States national security capability. It is now evident that our ability to execute the full spectrum of strategic strike will be in danger as a result of the imminent loss of many of the skills necessary to effectively carry out strategic strike, from research, through development, testing, production, and sustainment. Our skilled strategic strike work force—in industry and government—is retiring at a rate faster than new personnel are being hired and trained. I have become convinced that recruitment into relevant industries and government agencies has been hampered as a result of absence of a clear roadmap for the future of strategic strike systems and, as a consequence, lack of relevant programs. To remedy this serious problem faced by the nation, I am directing the implementation of a series of actions designed to make the future of strategic strike systems clear, to initiate exploratory development programs for strategic strike, to ensure that strategic strike skills are actively tracked, and to make careers in the skills important to strategic strike attractive to the brightest and the best.

To that end I direct the following actions:

1. USSTRATCOM shall define the capabilities need for future strategic strike (15 years and beyond) in accordance with the policies developed by OSD (Policy) as a result of the QDR and the NPR Implementer. These evolutionary capabilities shall include definition of the C4ISR architecture essential to support future strategic strike, missile defense, and offense/defense integration. In addition, USSTRATCOM shall identify the payloads necessary to support future mission objectives and determine the launch systems required to provide delivery of those payloads to meet strategic mission needs. USSTRATCOM shall also identify the elements of transformation for future strategic forces; e.g., information operations, directed energy weapons, unconventional basing, etc., that may be required to meet evolving mission needs. The USSTRATCOM assessment of capabilities needed to support my direction should be completed within one year of this action plan.

2. The Director of DARPA shall establish a Strategic Strike Systems Technology office charged with defining and funding the exploratory development of far-term (revolutionary) strategic strike concepts, which shall include the application of new technologies including directed energy weapons, information operations, persistent and intrusive ISR, revolutionary payload, delivery system and basing concepts as well as hypersonic propulsion concepts needed for strategic attack. These concepts can be transitioned to the Services for development and maturation of technologies required for eventual deployment. The Director, DARPA, shall provide the first annual report describing the activities and accomplishments of this new office to me within one year of the date of this action plan.

3. The Services shall devote resources to the transfer of knowledge and skills critical to the sustainment of the future strategic strike mission to younger personnel in industry. The Services shall direct and fund industry contractors to continue or establish mentor and training programs to transfer critical knowledge and skills and require the demonstration of such programs as a condition of contract award. The first review and update of these practices and activities shall be provided to me within 180 days of the date of this action plan.

4. The Secretary of the Navy and the Air Force with guidance from STRATCOM shall develop a strategic plan for the appropriate funding of advanced development programs (subsystem design, system prototype development, and testing) to support next-generation system development. These plans shall be provided to me within 180 days of the date of this action plan.

5. The Secretaries of the Navy and the Air Force after planning, programming, and implementing the advanced development programs shall fully fund the Navy and the Air Force Applications Programs at the levels originally recommended by the USSTRATCOM SAG ($20 million a year for each program, except the Propulsion Application Program, which should be funded at $40 million a year) so that skills in areas critical to the current or planned force, but not addressed by the advanced development initiatives are maintained. Both the advanced development programs and the application programs shall be planned and programmed within 180 days of the date of this action plan.

6. The Services, defense agencies and combatant commands that support the strategic strike mission shall encourage and fund supporting industries to develop combined undergraduate scholarship and co-op programs for U.S. citizens in relevant science and engineering disciplines (including physics, chemistry, engineering, computer science, etc.) that would include the requirement to work in DoD or the Defense industry (specifically areas related to strategic strike) and encourage future graduate studies. The first review and update shall be provided to me within one year of the date of this action plan.

7. The Services shall participate fully in the NDEA program by providing input to the DDR&E on required disciplines and requesting that NDEA service agreements and government payback be served in strategic strike-related offices and organizations. This action shall be initiated within 180 days of the date of this action plan and the status reported on an annual basis to me.

8. The Secretaries of the Navy and the Air Force, in coordination with the Chairman of the Joint Chiefs of Staff, shall encourage the existence or direct the establishment, within all strategic strike constituents, of a skill and domain-knowledge management system that includes active duty, civil service, and industry personnel. The first review and update from each Service shall be provided to me within one year of the date of this action plan.

9. The USD (AT&L) shall track the completion of this action plan and shall be included as an informational addressee on all correspondence, reports and documents related to completion of this plan and future strategic strike skills.

D. TASK FORCE REQUEST FOR DATA

JFCOM DATA REQUEST

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

16 August 2004

Admiral E. P. Giambastiani, USN
Commander
U.S. Joint Forces Command
1562 Mitscher Avenue
Norfolk, VA 23551

Dear Admiral Giambastiani,

I am writing to ask your help in support of a new Defense Science Board Task Force on **Future Strategic Strike Skills**. A copy of the Terms of Reference (TOR) is attached. The scope of this study includes examining the skills necessary for the full spectrum of strategic strike options from non-kinetic to nuclear.

The Task Force has begun its analysis of those skills necessary to perform future strategic strike operations. While the study is weighted towards examining the nuclear end of the strategic strike spectrum, it is not limited to nuclear skills. There are a number of enabling skills that traverse the entire spectrum (i.e. C4ISR, staff planning, acquisition, policy, etc.). At this point in its research, the Task Force needs direct input from the Joint Staff, each Service, and Combatant Command that play a role in future strategic strike missions. Specifically, the Task Force requests your written response to the following questions:

GENERAL
What do you see as your current strategic strike roles/missions and capabilities?
What do you see as your future roles/missions?
What skills do you need to meet your future roles/missions?
What challenges do you foresee in acquiring, sustaining and retaining those skills?
Are there any programs initiatives in place to ensure you have the needed skills for future roles/missions?
Can you recommend any strategies for the evolution of the current skills to those required to meet your future roles/missions?

COMBATANT COMMANDS
What reliance is placed upon DoD agencies, DoD labs, Federally Funded Research and Development Centers, and other government entities and the contractor base to support Combatant Commanders?

SERVICES
How do the services support the Combatant Commanders in strategic skills development?

What success are you having in acquiring young personnel to replace the experienced personnel which are now retiring from Service?

Your response should not be limited to military personnel and/or federal employees. The past few years has shown an increasing dependency on contractor support to supplement staffs. Additionally, the industrial base provides much needed expertise. Therefore, please include contractor and industrial base support in your discussions as well. Your response should be unclassified, but may include classified annexes. Once your responses have been reviewed, the Task Force may request a briefing by your respective organizations to clarify or expand on any issues of interest.

The Task Force hopes to present a final report to the USD(AT&L) during the Spring of 2005, and therefore requests your response before September 30, 2004. Any questions and your responses should be directed to the Task Force's Executive Secretary, Col Dan Wilmoth, 703-697-9409, danny.wilmoth@osd.mil, danny.wilmoth@osd.smil.mil.

William Schneider, Jr.

Dr William Schneider, Jr.
Chairman

Attachment:
As stated

STRATCOM DATA REQUEST

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

15 November 2004

General James E. Cartwright, USMC
Commander, U.S. Strategic Command
901 SAC Boulevard, Suite 2A
Offutt AFB, NE 68113-6000

Dear General Cartwright,

I am writing to ask your help in support of the Defense Science Board Task Force on **Future Strategic Strike Skills.** A copy of the Terms of Reference (TOR) is attached. The scope of this study includes examining the skills necessary for the full spectrum of strategic strike options from non-kinetic to nuclear.

The task force continues its analysis of those skills necessary to perform future strategic strike operations. At this point in its research, the task force needs direct input from the United States Air Force, United State Navy, United States Strategic Command (STRATCOM) and the Defense Threat Reduction Agency (DTRA)

The task force is looking for demographic data for the organizations (currently) responsible for strategic strike systems which include:

1. Department of Defense (DoD) Commands or Program Offices
2. Supporting DoD Agencies (e.g., DTRA)
3. DoD Labs
4. Federally Funded Research and Development Centers (FFRDCs)
5. Other Government Entities
6. US Industrial Base

A detailed list of questions and an example of the matrix the Task Force intends to fill out with the data you provide is attached.

The task force hopes to present a final report to the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) during the Spring/Summer of 2005, and therefore requests your response before January 5, 2005. Any questions and your responses should be directed to the Task Force's Executive Secretary, Col Dan Wilmoth, 703-697-9409, danny.wilmoth@osd.mil, danny.wilmoth@osd.smil.mil. Please have your POC contact Col Wilmoth as soon as practical to receive additional information on this task.

Dr William Schneider, Jr.
Chairman

Attachments:
As stated

E. LIST OF BRIEFINGS

April 14, 2004
Mr. Steve Henry, *DATSD*
Mr. Mike Novak, *OUSD (AT&L)*

May 14, 2004
Lt Col Barry Leiher, *USAF*
Mr. Robert Beimler, *US Army*
CAPT Patrick Hopfinger, *USN*
CDR John Wolfe, *USN*

June 24, 2004
ADM James Ellis, *USAF*
Mr. Tom Scheber, *OSD*
LTC Anne Winkler, *USSTRATCOM*
COL David Ifflander, *OP30*
CAPT Rick Holdcroft, *ST11*
Col David Solomon, *IO12*
Lt Col Furgini, *USSTRATCOM*

September 15, 2004
Maj Mark Clark, *USAF*
Lt Col Christopher Poock, *AF/ILM*
Col Cal Hutto, *AFSPC/DPA*
Col Allan Netzer, *OO-ALC*

September 16, 2004
COL Edward Schmidt, *NNSA*
Ms. Kathleen McInnis, *CSIS*
Dr. Don Linger, *DTRA*
Maj John Zabel, *US Army*
Mr. Jim Howard, *SSP*

October 6, 2004
Mr. Jim Howard, *SSP*
Mr. Mike Eagan, *GDAIS*
Ms. Lisa Finneran, *GDAIS*
Ms. Erin Moore, *LMMSC*
Mr. Bert Cole, *Strategic Weapons Facility, Pacific*

October 7, 2004
Mr. Frank Moore, *Northrop Grumman*
Mr. Kevin Cummings, *ATK*
Ms. Kathy Robinson, *AeroJet*
Mr. Lou Spina, *Boeing*
Mr. Daniel Swallom, *Textron*

November 16, 2004
Mr. Mark Locher, *USD (I)*
Mr. Jim Detjen, *DIA*
Mr. Mark Director, *AeroJet*

November 17, 2004
Mr. Mark Jefferson, *Lockheed Martin Corp.*
Dr. Don Linger, *DTRA*
Mr. Ted Harshberger, *RAND*

December 14, 2004
Dr. Ron Sega, *DDR&E*
Mr. Don Diggs, *ASD(NII)*
Gen Cartwright, *USSTRATCOM*

December 15, 2004
Mr. Robert Bakos, *ATK Thiokol Incorporated*
Dr. Charles Henkin, *Lockheed Martin Corp.*
Mr. Mark Jefferson, *Lockheed Martin Corp.*
Mr. Stuart Wildman, *Lockheed Martin Corp.*
Mr. Rex Agler, *Lockheed Martin Corp.*
Mr. Ned Newman, *Boeing*

December 16, 2004
Capt Tom Boyce, *USNR*

January 12, 2005
Mr. Jim Howard, *USN*
Mr. Bob Shaw, *DDR&E*
Mr. Neil Kacena, *Lockheed Martin Corp.*

February 16, 2005
Mr. Jim Howard, *USN*

F. ACRONYM LIST

ABRES	Advanced Ballistic Reentry Systems
ACM	Advanced Cruise Missile
AFNGOSG	Air Force Nuclear General Officer Steering Group
ALCC	Airborne launch Control Center
ALCM	Air-Launched Cruise Missile
AMCC	Air Mobility Command Center
AoA	Analysis of Alternatives
ASMS	Advanced Strategic Missile Systems
BRAC	Base Closure and Realignment Commission
CCD	camouflage/concealment/deception
CIA	Central Intelligence Agency
COTS	Commercial off the Shelf
DARPA	Defense Advanced Research Projects Agency
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
DOE	Department of Energy
DSB	Defense Science Board
DSP	Defense Support Program
DTRA	Defense Threat Reduction Agency
DoD	Department of Defense
EDO	Engineering Duty Officers
EMD	Electro-mechanical Device
EMI	Electro-magnetic Interference
EMP	Electromagnetic Pulse
EUCOM	European Command
FFRDC	Federally Funded Research and Development Center
GD	General Dynamics
GPS	Global Positioning System
HR	Human Resources
ICBM	Intercontinental Ballistic Missile

ISR	Intelligence, Surveillance and Reconnaissance
IO	Information Operations
JASSM	Joint Air-to-Surface Standoff Missile
JFCOM	Joint Forces Command
J-UCAS	Joint Unmanned Combat Air System
LE	Life Extension
LEP	Life Extension Program
LMMSC	Lockheed Martin Missiles & Space
MEMS	Micro-Electro-Mechanical Systems
NDEA	National Defense Education Act
NNSA	National Nuclear Security Administration
NORTHCOM	Northern Command
NPR	Nuclear Posture Review
NRO	National Reconnaissance Office
NSA	National Security Agency
OJCS	Office of the Joint Chiefs of Staff
OSD	Office of the Secretary of Defense
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology and Logistics
OUSD(I)	Office of the Under Secretary of Defense for Intelligence
OUSD(P)	Office of the Under Secretary of Defense for Policy
PACOM	Pacific Command
PLU	Preservation of Location Uncertainty
QDR	Quadrennial Defense Review
RCC	Regional Combatant Command
RSLP	Reentry Systems Launch Program
SATCOM	Satellite Command
SecDef	Secretary of Defense
SHAPE	Supreme Headquarters Allied Powers, Europe
SLBM	Submarine-Launched Ballistic Missile
SLIRBM	Submarine-Launched Intermediate Range Ballistic Missile
SPO	Systems Program Office
SR	Surveillance and Reconnaissance

SSBN	Nuclear Powered Ballistic Missile Submarine
SSGN	Nuclear Powered Guided Missile Submarine
SSN	Nuclear Powered Attack Submarine
SSP	Strategic Systems Programs
SSST	Supersonic Sea-Skimming Target
S&T	Science and Technology
STRATCOM	Strategic Command
STRATCOM SAG	Strategic Command's Strategic Advisory Group
SWF	Strategic Weapons Facility
SWFLANT	Strategic Weapons Facility Atlantic
TACAMO	C^2 Communications Relay Squadron
TACTOM	Tactical Tomahawk
TLAM	Tomahawk Land-Attack Cruise Missile
UAV	Unmanned Air Vehicle
UCAV	Unmanned Combat Air Vehicle
UGT	Underground Nuclear Test
USAF	U.S. Air Force
USANCA	U.S. Army Nuclear and Chemical Agency
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
USFK	U.S. Forces Korea
WMD	Weapons of Mass Destruction