Science, Technology, and U.S. National Security Strategy

Preparing Military Leadership for the Future

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Foreword

While I have spent most of my intellectual life in the social sciences—studying international relations and earning a PhD in international law—it is quite clear to me that science and technology are an enormous part of our ability to protect the United States. We need the teaching of Thucydides, Clausewitz, and Mahan—but also the lessons of Edison, Einstein, and Faraday.

The key is finding the right balance between the study of strategy, policy, tactics, history, and other traditional military disciplines and the hard sciences, especially in emerging fields like artificial intelligence, computational science, biosynthetics, genomics, robotics, nanotechnology, and advanced materials.

To create security in this turbulent twenty-first century, we will require officers skilled in science and technology who are initially tracked into these fields, continue to learn throughout their careers, and are given ample opportunity to interact with the private sector, where so many of the most important advances occur.

In this superb and concise study of how best to create that cadre of officers, the authors lay out a practical, systemic, and logical path. We should follow it carefully, and invest intelligently with the very best of our human capital.

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The authors would also like to thank the participants of the two roundtables held at CSIS (see Appendices C and D). Finally, the authors would like to thank the many former and current government officials and academic experts who provided input to the report (see Appendix E).
Executive Summary

The United States has long sought qualitative military superiority to deter the next war, and if necessary, to fight and win that contest. Developing, acquiring, and then sustaining technological advantages over our adversaries has been part of that strategy since World War II, along with our heavy reliance on the quantitative muscle that the arsenal of democracy provided.

Today’s imperative is to identify, adapt, and field advanced technologies with military applications. This initiative is often referred to as the “Third Offset.” Unlike the first two offset strategies that provided enduring, albeit now less competitive edges, this Third Offset will be driven by much faster-paced technological changes. In Gen. Joe Dunford’s words, “There is no substitute for leadership that recognizes the implications of new ideas, new technologies and new approaches and actually anticipates the effects of those adaptations.”1 It also demands a culture of experimentation that embraces failure where it is thoughtful and considered since the path ahead is not known. In our judgment, it also must include complementary professional military education (PME) and human resources/talent management (HR) systems and processes to promote creative and critical strategic thinkers.

A dominant theme of the twenty-first century is the democratization of science and technology (S&T). It is a driving force throughout global society and pervasive throughout all aspects of human endeavor, to include national security. High-technology weapons are no longer the exclusive domain of only a few nations. Smaller states are expanding their arsenals and infusing advanced technologies into their warfighting tactics, operations, and strategy. The democratization of technology has also given some nonstate actors (from small groups to individuals) access to capabilities that in the past have only been reserved for nation states. Indeed, the technologies of destruction and the attendant increased capabilities of communication and surveillance, create a threat landscape unlike any we have faced.

In this challenging, technologically informed environment, the U.S. military must continue to ensure a competitive advantage. One of the ways to do so is to develop a cadre of technologically competent officers with the requisite leadership and operational skills to excel in this fast-paced and ever-evolving environment. It involves a complementary set of selection, assignment, promotion, and military and civilian education opportunities that infuse our next generation of leaders with strategic, creative, and critical thinking attributes to interact effectively between and among the policy, technology, and operational communities.

In short, what is needed is a system that allows a group of these select officers to move between operational and S&T tracks throughout their careers. The end goal is the creation of a cohort that has demonstrated excellence in both fields, and that is able to reach the highest levels of the military and national security communities. It also strongly suggests that the entire

force be more sensitized to the S&T world, so that as a minimum, they will recognize the tactical, operational, and strategic applications of emerging sciences and technologies, and understand the value they offer against legacy systems, operational concepts, and doctrines. This goal needs to be accomplished without building additional career tracks and yet not subsuming S&T under the acquisition career field where it is likely to lose some sharpness of focus and connectedness to national security strategy and be restricted to those branch-selected officers.

Preparing our leadership for the challenges and opportunities of S&T carries with it a central role for education—who gets what, how much, and when.

Specifically, joint professional military education (JPME) is faced with internal challenges to its own relevancy in its task of delivering the right material, with appropriate methodologies, at the right times, to the right people. While bedrock seminal content such as Thucydides, Clausewitz, Mahan, or Boyd will endure as critical elements of the curricula over generations, other academic content is more transient as the security environment evolves. Equally important, academic methodologies must adopt techniques that best leverage the learning styles of the upcoming leadership generation (and by implication apply cognitive science to JPME).

In our judgment, one of the Chairman of the Joint Chiefs of Staff’s Desired Leader Attributes (DLA)\(^2\) should be the ability to “understand the scientific method and apply it to the challenges of innovation and emerging technologies.”

A Way Forward

Among the steps to be considered:

1. Design early opportunities with identifiable secondary career tracks and promotional opportunities for individuals to self or be system-selected to specialize in S&T; these career tracks must have reasonable promotion potential.
2. Craft academic programs that build on each other throughout one’s career, culminating with strategic level perspectives and abilities to integrate S&T knowledge across disciplines and with policy.
3. Create improved opportunities for officers to interact and cross-pollinate with the industrial sector and the extensive government laboratory system—both their ideas and their people.
4. Utilize tier-one private and public universities for specific advanced degree S&T offerings and programs in lieu of, or in partnership with, existing PME schools. This should also include leveraging Service ROTC programs to introduce specific S&T topics into curricula and providing more content direction for those pursuing graduate education.
5. Allow selected officers greater freedom of movement between operational and S&T assignments and educational opportunities to build a cadre of officers able to perform at the highest military levels and have private-sector networks and relationships.

Science and Technology: The pace of scientific and technological (S&T) innovation over the past 100 years has been astounding. Rapid advances in medical, biological, computing, cognition, physics, chemistry, materiel science, aerospace, energy, and many other fields have benefited the world—and also benefited the Joint Force and U.S. Army. As our Army seeks to preserve or extend its dominance into the twenty-first century, how should we think about the role of science and technology? Will the rate of S&T innovation continue to accelerate into the future and provide us opportunities to exploit—or is the rate of S&T innovation slowing down? Are new or different S&T fields more promising than others from a military standpoint?³

Mark A. Milley
General, U.S. Army Chief of Staff

Science, Technology, and U.S. National Security Strategy

Preparing Military Leadership for the Future

Introduction

The United States has long sought qualitative military superiority to deter the next war, and if necessary, to fight and win that contest. Simply put, the United States does not want a fair fight among equal forces, but rather it seeks to end wars quickly and decisively. Obtaining and then sustaining technological advantages over our adversaries has been part of that strategy since World War II, along with our heavy reliance on the quantitative muscle that the arsenal of democracy provided.

The First Offset and Second Offset are two distinct periods in our post–World War II national security posture that exemplify our evolving qualitative superiority strategy:

- The First Offset relied on the threatened use of battlefield nuclear weapons to counter the quantitative advantages of the Soviet Union’s and Warsaw Pact’s conventional forces;
- The subsequent Second Offset relied on the application of global positioning systems (GPS) to precision-guided munitions and stealthy delivery platforms to again address quantitative shortfalls against potential adversaries.

Today’s emphasis is to find that next, Third Offset. Emanating from Secretary of Defense Chuck Hagel’s 2014 defense innovation initiative, Secretary of Defense Ash Carter and Deputy Secretary of Defense Bob Work describe the Third Offset as part innovation, part investment in science and technology (S&T), and part entrepreneurial spirit to find those disruptive, game-changing and force-multiplying capabilities, and then to craft their associated operating concepts. Unlike the first two offset strategies that provided enduring but diminishing competitive edges, this Third Offset will be driven by much faster-paced technological change. In Secretary Carter’s words, “The race now depends on who can out-innovate faster than anyone else.” It also demands a culture of experimentation that embraces failure where it was thoughtful and considered since the path ahead is not known (Elon Musk to Secretary Carter, June 2016). In our judgment, it also must include complementary professional military education (PME) and human resources (HR) systems and processes to promote creative and critical strategic thinkers.

Background and Study Genesis

CSIS originally proposed a study that looked at addressing both an understanding of emerging S&T possibilities and a grasp of S&T investment strategies and S&T expertise within the U.S.
defense enterprise. After completing the first study, it was decided a follow-up study that offered a more detailed set of options to incorporate science and technology more deeply into the national security strategy thinking of our nation’s future military and civilian leaders would be beneficial.

**The Importance of Science and Technology**

America’s global strategic leadership rests on a strong foundation of science and technology, which has contributed to our political, economic, and military dominance throughout much of the twentieth and into the twenty-first centuries. Perfecting industrial age capacities, including techniques for mass production, contributed to both our economic development and our victory in World War II. In addition, our ability to develop and relatively quickly field state-of-the-art military capabilities—culminating with the development of the atomic bomb—contributed immeasurably to the Allied victory. After 1945 our ability to project power across the globe was unmatched. The United States was the leader in global affairs as well as in science and technology.

In this World War II era, research and development was connected to operational requirements. In the postwar years, deliberate decisions were made to have dedicated locations for basic research to flourish. The National Science Foundation was an outgrowth of this thinking. The precursors to the Department of Energy labs were critical to the Manhattan Project, and the Department of Defense Service labs were seen as an important investment in more focused research and development, aligned to the missions of their parent organizations. Yet a constant tension ensued between these labs that sought to conduct science for the sake of discovery and the desire to have operational outcomes as by-products of these significant investments. The Defense Advanced Research Projects Agency (DARPA) formed in 1958—in the aftermath of the Soviet’s Sputnik rocket launch—was an attempt to get back to a connected model where science and technology was tied to operational requirements.

Today the United States confronts a different world in which science and technology is globalized. The barriers for conducting research and development have been reduced. The competitive advantage the United States enjoyed in the post–World War II era has been eroded as more nations are investing in research and development. U.S. government and overall U.S. share of R&D is shrinking as a percent of global R&D. Neither large multinational corporations nor small start-ups can claim to be the exclusive leaders in research and development. However, each has an important role to play in the development and fielding of technological advances.

Equally important, the industrial age that defined the period of the Cold War has been replaced by an information age where flows of information and ideas occur in milliseconds. Assured communications allow for instantaneous direction of the elements of national power. Advanced technology allows for owning the night through use of advanced optics and night vision devices, fielding ubiquitous networks that fuse vast amounts of data for warfighting commanders across the globe, and employing precision effects for achieving U.S. goals and objectives. However, the United States is no longer the only nation with these capabilities and in some cases is no longer the dominant nation in some fields.
The changes occurring around the globe mandate a different way of thinking about technology and maintaining our competitive advantage. The Department of Defense can no longer think of conducting its research and development internally in all areas of interest. Rather in select areas, the DoD must rely on industry for R&D. Examples include biotechnology, cyber and information technology, and even the space industry. In other areas led by the DoD, investments will be required to provide the necessary capabilities. The trick will be to differentiate between these different types of technology areas.

Efforts such as Joint Vision 2010 mandated by Chairman of the Joint Chiefs of Staff, General John Shalikashvili, that led to the development of the Joint Requirements Oversight Council (JROC), the Department of Defense various transformation efforts undertaken at the Service levels in 1999–2002 and more recently the Defense Digital Service (DDS) and the Defense Innovation Unit Experimental (DIUx) are efforts to align research, development, and acquisition with operational or warfighting requirements.

A related topic receiving important emphasis by senior DoD leaders and within the operational force is innovation. Innovation is inextricably linked to science and technology, and in many instances the terms are used interchangeably. Yet there are also nuanced differences that are worthy of highlighting.

The reason for the confusion largely relates to the perceived similarities between technology and innovation. Technology is the application of scientific knowledge for practical purposes, while innovation is the process of translating ideas or inventions into something of value. Both seek to provide practical solutions to problems. So the distinction between technology development and innovation comes down to whether the application stems from scientific knowledge (as in the case of technology development) or from an idea or invention (as in the case of innovation). However, both are engineering disciplines that use applied principles in search of solutions to operational problems.

Both S&T and innovation are nonlinear processes. That is, discovery and creativity do not proceed in a linear manner, but rather have a recursive nature. As discoveries are made or innovations adopted, invariably they lead to other innovations.

An important distinction between S&T and innovation surrounds how these efforts proceed within organizations. S&T derives from a formal process, where important areas of interest receive support for investigation and discovery. Links to operational problems are important, but not always a driving force, such as in the case of basic research that seeks to gain an understanding of a phenomenon without regard to a specific application or outcome.

In contrast, innovation directly relates to satisfying operational needs. It depends on having a deep understanding of operations and looking for better ways to accomplish a task or new approaches to improving operational effectiveness and efficiency. Innovation is also about the free flow of ideas and the culture of the organization. For organizations to embrace innovation means that trial and error must be allowed, even embraced. “Failures” provide opportunities for reevaluation, reflection, and perhaps even return to first principles. This is not to say that innovation lacks discipline, but rather that by nature it is freer flowing than S&T. Secretary Carter’s establishment of the Strategic Capabilities Office (SCO) will drive this innovation culture.
This effort focuses directly on S&T and by inference on innovation. It makes the case that the ability to understand the scientific method and apply it to operational challenges is a critical skill for the joint officer, now and in the future. It also makes the case that additional skills will be required for applying the S&T lens to analyzing operational concepts with longer-range policies, strategies, and resource decisions. And most importantly, it highlights the necessity of developing a culture of experimentation, risk taking, and failure (fail early and often).

So the ultimate question is: In such a world where science and technology features so prominently, how can the military develop the capacity for recruiting, training and educating, developing, nurturing, and ultimately retaining leaders with the intellectual depth and curiosity and operational acumen to lead today and into the future.

The Case for Change

A dominant theme of the twenty-first century is the democratization of science and technology. It is a driving force throughout global society and pervasive throughout all aspects of human endeavor, to include national security. High-technology weapons are no longer the exclusive domain of only a few nations. Smaller countries are expanding their arsenals and infusing advanced technologies into their warfighting tactics, operations, and strategy. The democratization of technology has also given some nonstate actors (from small groups to individuals) access to capabilities that in the past have only been reserved for nation-states.

In this challenging, technologically informed environment, the U.S. military must continue to ensure a competitive advantage. One of the ways to do so is to develop a cadre of technologically competent officers with the requisite leadership and operational skills to excel in this fast-paced and ever-evolving environment.

In sum, what is needed is a personnel system that allows a group of these select officers to move between the operational and S&T tracks throughout their careers. The end goal is the creation of a cohort that has demonstrated excellence in both fields, and is able to reach the highest levels of the military. It also strongly suggests that the entire force be more sensitized to the S&T world, so that as a minimum, they will recognize the tactical, operational, and strategic applications of emerging sciences and technologies, and understand the value they offer against legacy systems, operational concepts, and doctrines. This needs to be accomplished without building additional career tracks and yet not subsuming S&T under the acquisition career fields where it is likely to lose some sharpness of focus and connectedness to national security strategy and be restricted to those branch-selected officers.

Curricula for Science and Technology in Military Education Programs

Given the emerging importance of S&T to national security decisions, both policy and acquisition, inclusion in the JPME curricula becomes a natural extension. In thinking about what level of engagement in the subject is necessary and desirable from an organizational and personnel perspective, one can conclude that a single approach would be highly limiting. While
all students would benefit from a working knowledge of the importance of S&T, others would likely desire to have a greater exposure to and understanding of the topic.

Therefore, in developing a program, several principles should apply. First, all students should have an introduction into the topics of S&T in national security affairs. Second, students might desire to self-select into a deeper examination of the topic. Still others might have a desire to participate in a concentration in the S&T field. Third, regardless of which track a student might decide to pursue, emphasis can be made by infusing S&T discussions into current topics with minimal overhead; an example would be to have an S&T-related learning objective in current courses being offered. Finally, the teaching methodology should be in keeping with the focus on seminars, augmented with lectures as required. The curricula will entail a mix of active and passive learning, but will be designed to maximize student engagement in the learning process. Representative curricula overviews for the three levels of participation are provided in Appendix A. They are meant to be illustrative and not prescriptive.

The curricula target the senior service college level. However, exposure to S&T should begin much earlier in an officer’s career. Ultimately, this would be more in keeping with the goals of developing a technologically informed joint force able both to understand and operate in a dangerously competitive world. The democratization of technology has narrowed the United States’ comparative advantages in technology and even allowed potentially dangerous technologies to proliferate, leading in some cases to nonstate actors having state-like capabilities.

Why Professional Military Education and Human Resources/Talent Management?

The military officer of today faces a complex and dynamic environment that requires an increasingly broader set of intellectual capacities and experiences. Training in one’s basic military skill area remains necessary, but is not sufficient for the individual, his or her service, or the Department of Defense.

Becoming an expert in a warfighting domain requires training, education, and experiences in a defined area. Examples, such as aviation, have significant upfront investment, require maintaining and improving skills over the length of a career, and the development of tacit knowledge that allows for leadership and command at higher levels. The same can be said for submarine and surface warfare officers in the Navy or infantry and armor officers in the Army and Marines. This specialization requires time and management to ensure that the proper individual and leadership development occurs.

Yet at the 0-4/5 level, a transition should occur where the ability to think more broadly and abstractly takes on an increased importance. During this period of an officer’s career, demands begin to move away from the more-focused skill sets developed in initial operational training, education, and experiences, and instead moves toward complex skills across a more strategic landscape. For example, the pilot assigned to the joint staff as a planner might be required to participate in an arms-control negotiation on nuclear, chemical, or biological weapons. Or
perhaps this individual will be required to have an understanding of the complexities of cybersecurity for a military plan being developed.

However, today’s career-management system values specialization over broader experiences and requires officers to select or be selected for repetitive assignments in their basic branches or specialties. In some cases, officers deviating from this specialization model are discouraged or even penalized for developing, albeit important, “secondary skills.” This system in many cases—either by career timelines or by assignment requirements—can even prohibit movement between operational and nonoperational career paths. True dual-track opportunities are indeed challenging both to create and for the select officers (and NCOs) to pursue and maintain. But they are necessary. Moreover, some intervention, likely at the service secretary level, is necessary to ensure that promotion boards receive instructions designed to reward—and promote these dual-track specialists—at rates comparable to their peers. This needs to occur well before general officer/flag officer selection boards—perhaps as early as promotion to major/lieutenant commander.

Similarly, in our discussions with senior UK military officers (see Appendix E), it became clear that the emphasis on broader and deeper education opportunities and a focused personnel management system is necessary. In a recent UK Ministry of Defence document it states: “A strategic leader...will be aware of the impact of technology in the delivery of Defence output and have been a practitioner in the career field for which he or she will be responsible.” In addition, it continues, “a Service-owned and Service-led robust and objective talent management process is needed...balancing the tension between valuing high performance and developing high potential.”

These examples above demonstrate the value of having broader intellectual capacity (the PME mission) and suggest the necessity of expanding beyond the traditional warfighting proficiencies to include a wider variety of skills and thinking. It also points to the challenge of an individual’s “career ownership” by specialty career HR managers and specialized mentors within that career field. We must produce the best-educated officer possible with both specialized and generalized intellectual skills. This demands a cradle-to-grave approach—conscientious career management of our officers to ensure the nation can discover and apply the knowledge of today and tomorrow to the art and science of war and statecraft.

Waiting until the War College experience is simply too late. This needs to be a priority in our pre-commissioning programs, even reaching into our high schools and JROTC-like programs. Also, we need to leverage and expand existing programs that identify selected officers for special tracking, assignments, education, and other professional development and utilization tours. While restricted to just a few officers, the assignment to gain a master’s or doctoral degree in order to teach at a service academy is such a program.

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The Joint Professional Military Education Conundrum

Preparing our leadership for the challenges and opportunities of S&T carries with it a central role for education—who gets what, how much, and when.

Specifically, joint professional military education (JPME) is faced with internal challenges to its own relevancy in its task of delivering the right material, with appropriate methodologies, at the right times, to the right people. While bedrock seminal content such as Thucydides, Clausewitz, Mahan, or Boyd will endure as critical elements of the curricula over generations, other academic content is more transient as the security environment evolves. Equally important, academic methodologies must also adjust to today's different learning styles. Moreover, increasingly complex problems require multidisciplinary skills and agile minds—truly Renaissance thinkers.

While JPME may be able to address these academic problems, personnel-management systems and service cultures/subcultures constrain opportunities for success. Promotion and assignment rules, regulations, and cultural traditions affect what can be offered, and the student’s perceptions of what should be taken. Paths that would broaden perspectives and peripheral interests are often rejected in favor of those that reinforce and deepen more myopic points of view unique to the individual’s early-on identified career field (specialty). Said another way, the military typecasts too early, does not reward broadening experiences, and in fact promotes those who principally if not exclusively develop and then remain loyal (trapped) to their narrow, essentially stove-piped, specializations. Opportunities for rounding are limited—and perceived as disloyal acts, particularly given the costs associated with producing specialists.

To overcome such obstacles, earlier and more frequent opportunities for well-roundedness need to be balanced against the legitimate need to develop and maintain credibility and deep subject-matter operational expertise. Absent that, the war colleges will inherit and produce a student population year after year that is ill-prepared to effectively bridge both the tactical and operational with the strategic, and to bridge technologies with policy.

JPME does have a central role in this process along with complementary HR department processes.

A Way Forward

Among the steps to be considered:

1. Design early opportunities with identifiable career tracks and promotional opportunities for individuals to self or be system-selected to specialize in S&T; these must have reasonable promotion potential;

2. Craft academic programs that build on each other throughout one's career, culminating with strategic-level perspectives and abilities to integrate S&T knowledge across disciplines and with policy.
3. Create improved opportunities for officers to interact and cross-pollinate with the private sector—both their ideas and their people. Example: some revival of the secretary of defense corporate fellows program. This program could interact with the secretary of defense’s future force concepts of more flexible entry and exit points for military service as well as the natural links to the private sector that the reserve and guard components afford.

4. Utilize tier-one private and public universities for specific S&T advanced degree offerings and programs in lieu of, or in partnership with, existing PME schools. This should include leveraging service ROTC programs to introduce specific S&T topics into curricula and providing more content direction for those pursuing graduate education. It is simply not resource efficient for the military to educate its officer exclusively within its own fences. Furthermore, educational opportunities at civilian universities build additional bridges between the military and civil society.

5. Allow selected officers greater freedom of movement between operational and S&T assignments and educational opportunities to build a cadre of officers who are able to perform at the highest military levels and have private-sector networks and relationships.
Afterword

In the foreword to the phase I study, *Science, Technology, and U.S. National Security Strategy: The Role of the War Colleges* (CSIS, November 2015), I stated that America is now in the most chaotic global environment since the end of the Cold War. America must craft a new grand strategy to meet and overcome the wide range of threats it faces, from cyber defense to counterinsurgency to traditional nation-state security threats to the global order.

This range of threats calls for a far more innovative and dynamic Department of Defense. We have an imperative to identify, adapt, and field advanced technologies at a far faster pace than is our historic norm. In recent years, the Defense Department and the Congress have been creating organizations to help promote innovation—the Defense Innovation Advisory Board, the Strategic Capabilities Office, the Defense Innovation Unit–experimental offices. Congress last year directed the disassembly of the Office of the Under Secretary for Acquisition, Technology and Logistics, in part to heighten the priority of innovation for the department. This year the department will determine how to organize and integrate the stipulated offices created by the National Defense Authorization Act of 2017.

This study looks at leadership—and the role that competent officers and civilians will play to introducing and integrating emerging technologies and advanced sciences into our national security thinking. Organizations are important, but leadership is essential.

It was the late David Abshire who originally proposed this study, and it was he who understood that the human element will always be the key to innovation, determining how best to use and respond to technological advantages in the battlespace, irrespective of domain.

Technology is fundamental to modern warfare. The grand strategy for the Cold War was built on the technological superiority that America used to offset the numerical advantages of the Soviet Union. Now technology is needed to permit the Defense Department to manage a far more complicated and divergent security landscape. This report offers insights into how joint professional military education and human resource systems can promote creative and strategic thinkers who can institutionalize innovation in the department.

*John J. Hamre*
President and CEO
*Center for Strategic and International Studies*
Appendix A. Curriculum for Science and Technology in Military Education Programs

Given the emerging importance of S&T to national security leaders, inclusion in the military curriculum becomes a natural extension. In thinking about what level of engagement in the subject is necessary and desirable from an organizational and personnel perspective, one can conclude that a single approach would be highly limiting. While all students would benefit from a working knowledge of the importance of S&T, others would likely desire to have a greater exposure to and understanding of the topic.

Therefore, in developing a program, several principles should apply. First, all students should have an introduction into the topics of S&T in national security affairs. Second, students might desire to self-select into a deeper examination of the topic. Still others might have a desire to participate in a concentration in the S&T field. Third, regardless of which track a student might decide to pursue, emphasis can be made by infusing S&T discussions into current topics with minimal overhead; an example would be to have an S&T-related learning objective in current courses being offered. Finally, the teaching methodology should be in keeping with the focus on seminars, augmented with lectures given by leading innovators and technologists from the public and private sectors. The curriculum will entail a mix of active and passive learning, but will be designed to maximize student engagement in the learning process.

The curricula developed below are targeting the senior service college level. However, exposure to S&T should begin much earlier in an officer’s career. Ultimately, this would be more in keeping with the goals of developing a technologically informed joint force able to both understand and operate in a world where the democratization of technology has narrowed the United States’ comparative advantages in technology and even allowed potentially dangerous technologies to proliferate leading, in some cases, to nonstate actors having state-like capabilities.

Representative curricula overviews for the three levels of participation are illustrated below. These are meant to be illustrative and not prescriptive:

**Module: Introduction to Science & Technology in National Security Affairs**

Description: Module would provide a focused discussion on S&T including introduction, definitions, and applications in national security affairs. It would be designed to ensure that students have a working understanding of the topic and support making all students more aware of the national security implications of S&T.

Audience: Entire student body would receive this block of instruction.
How to implement: The CJCS emphasis on a strategic leader foundations course offered in the beginning of the first term at National Defense University senior-level colleges is a logical place to begin to seed S&T. It could be followed by concentration programs, increased S&T focus within relevant industry study programs at the Eisenhower School, and selected electives.

Time: Five hours of seminar and lecture time. Notional topics for the five hours are listed below in the diagram. Incorporating S&T discussions into other courses would increase emphasis on the topic and reinforce the learning objectives of this module as well as to highlight the importance of understanding S&T for national security practitioners. Speakers should include prominent CEOs of leading-edge Fortune 500 firms.

Course: Science & Technology in National Security Affairs

Description: Course would include an introduction, definitions, and applications in national security affairs of S&T. The elective would be subdivided into four modules: (1) introduction to S&T, (2) managing S&T, (3) case studies, and (4) future of S&T. The culmination of the course would be a three-hour exercise designed to reinforce the course learning objectives.

Audience: Students self-select into the course.

Time: Forty hours of seminars and lectures.

Concentration: Science & Technology in National Security Affairs

Description: Concentration would provide a focused opportunity for students to delve into the field of S&T. It would build on the earlier course, science and technology in national security affairs, and be designed to allow students to examine an S&T topic of interest in greater detail.

Audience: Students self-select into the course.

Time: Four electives beginning with the elective discussed above allow students to delve deeply into the S&T field. The other three electives would take the students farther into understanding the implications of S&T on national security issues. Elective #2 would expose students to technologies, beginning with historical perspectives of S&T in national security affairs and concluding with examining emerging technologies. Elective #3 would provide the students with an understanding of how the democratization of technology has fundamentally altered relations.
between nations and even allowed nonstate actors to have unprecedented capabilities and reach. Finally, Elective #4 would allow the students to select an S&T issue of interest and delve deeply into the technology as is exists today and also into the future.

Elective #1: Science & Technology in National Security Affairs (As Described Above)

Elective #2: Case Studies in S&T
- Historical Perspective
- Current Trends
- Future Issues

Elective #3: Democratization of S&T
- Asymmetric Warfare
- Non-State Actors
- Third Offset & Innovation

3 cases each

Elective #4: Students select a technology to examine, prepare a paper and provide a presentation to class

Readings would be designed to give students foundations on which to base class discussions. They would expose the students to current principles for understanding the role of technology in a range of societal phenomena and their effect on national security. These readings are representative and not meant to be prescriptive.

- Selected articles on S&T.
Appendix B. Curricula Offered at the War Colleges That Relate to S&T and Strategy¹

U.S. Army War College
Center for Strategic Leadership (CSL):
  Cyber Warfare
  Cyber Warfare Planning
  Futures Seminar
  Wargaming for Strategic Leaders
Department of Command, Leadership, and Management (DCLM):
  Creative Leadership
  Strategic Thinking and Leadership
  Leading Innovation
  The Defense Industrial Base
Department of National Security and Strategy (DNSS):
  Crafting a U.S. Grand Strategy for the 21st Century
Department of Military Strategy, Planning, and Operations (DMSPO)
  Cyber Concepts for Senior Leaders (unclassified)
  Cyberspace and Cyber Operations—What Senior Leaders Need to Know

U.S. National War College
Strategic Leadership Foundational Course
Strategic Leadership Foundational Course II

U.S. Naval War College
MAWS² I – Naval Warfare and Operational Art
MAWS II – The Navy Planning Process and the JFMCC³ Environment
MAWS III – Major Operations and Campaigns – Historical Case Studies
War Gaming Theory and Practice
A Critical Analysis of Air Power since WWI

¹ This list is not exhaustive.
² Maritime Advanced Warfighting School (MAWS).
³ Joint Force Maritime Component Commander (JFMCC).
Science, Technology and Strategy
Unmanned Systems and Conflict in the 21st Century
Seminar on Space Technology and Policy
Cyber-security: Cybered Conflict, Response to Surprise, and Emerging Indicators of Global System Change
Information Operations and Cyberwarfare
Operations in Cyberspace
Biological and Chemical Agents and Their Use in Warfare and Terrorism
Ethics of Technology: Warfare and Society
Halsey A
Halsey B
Halsey Gravely
Strategy and Policy
U.S. Air War College
Foundations of Strategy
Space Operations
Non-Lethal Weapons: Support to 21st Century Warfare and Homeland Defense
Group Research: Blue Horizons
Group Research: Cyberspace
Grand Strategy Program
Military Innovation
U.S. Marine Corps War College
National Security and Joint Warfare
Advanced Studies Program
Future Wars
Dwight D. Eisenhower School for National Security and Resource Strategy
Strategic Leadership Foundational Course
Strategic Leadership Foundational Course II
Defense Strategy, Acquisition, and Resourcing (DSAR) Department
Strategic Acquisition and Resourcing
National Security and the Industrial Base (NSIB) Department
Industry Study
Long-Term Strategy Concentration
Adaptive and Agile Leaders Network (AALN) Concentration

**Joint and Combined Warfighting School**
Preparation for Strategic Surprise: USSTRATCOM\(^4\) perspectives
USSOCOM\(^5\) Joint Special Operations in the 21st Century

Challenges in Cyberspace

**College of International Security Affairs**
Strategic Thought

**U.S. Army Command and General Staff College**
Advanced Studies Program
  - Contemporary Operational Art
Advanced Strategic Leadership Studies Program
  - Twenty-first Century Conflict

\(^4\) U.S. Strategic Command (USSTRATCOM).
\(^5\) U.S. Special Forces Command (USSOCOM).
Appendix C. First CSIS Roundtable Participants (July 25, 2016)

Dr. Shannon Brown, Professor, Industrial College of the Armed Forces, The Eisenhower School, National Defense University

Col. Susan Bryant, Army Senior Fellow, Institute for National Strategic Studies, National Defense University

Dr. R. E. Burnett, Associate Dean of Academics (Faculty) and Professor, National Defense University

Ben FitzGerald, Senior Fellow and Director of the Technology and National Security Program, Center for a New American Security

Dr. T. X. Hammes, Distinguished Research Fellow, Center for Strategic Research, National Defense University

Dr. Nicholas Murray, Professor, U.S. Naval War College

Christopher Zember, Co-Director, Center for Technology and National Security Policy, National Defense University
Appendix D. Second CSIS Roundtable Participants (October 17, 2016)

Max Angerholzer, President and CEO, Center for the Study of the Presidency & Congress (CSPC); and Managing Director, Richard Lounsbery Foundation

Lt. Gen. Daniel Christman (USA Ret.), Senior Counselor to the President, U.S. Chamber of Commerce; and Former Superintendent of the United States Military Academy

Hon. David Chu, President and CEO, Institute for Defense Analyses; and Former Under Secretary of Defense for Personnel and Readiness

Hon. Michael Donley, Vice Chairman, Board of Trustees, Aerospace Corporation; and Former Secretary of the Air Force

Hon. John Hamre, President and CEO, Center for Strategic and International Studies; and Former Deputy Secretary of Defense

Adam Jay Harrison, Director, MD-5 Department of Defense Nation Security Technology Accelerator

Gen. Paul Kern (USA Ret.), Senior Counselor, Cohen Group; and Former Commanding General of the United States Army Materiel Command

Lt. Gen. Ervin Rokke (USAF Ret.), Senior Scholar, United States Air Force Academy Center for Character and Leadership Development; and Former President of the National Defense University

Hon. Walter Slocombe, Senior Counsel, Caplin & Drysdale; and Former Under Secretary of Defense for Policy
Appendix E. Individuals Who Provided Input, But Did Not Participate in CSIS Roundtables

Lt. Col. Andrew Ajamian (USA), Army Strategist (FA59) Proponent Manager, U.S. Army
Col. Charles D. Allen (USA Ret.), Professor of Leadership and Cultural Studies, Department of Command, Leadership, and Management, Army War College
Hon. Brad Carson, Acting Under Secretary of Defense for Personnel and Readiness, Office of the Secretary of Defense, Department of Defense
Dr. Vince Connelly, Programme Lead, Psychology, Oxford Brookes University
Maj. Gen. Tony Cucolo (USA Ret.), Associate Vice Chancellor for Leadership Development and Veterans Affairs, University of Texas-Austin
Harry Foster, Director, Center for Strategy and Technology, Air War College
Vice Adm. Paul Gaffney (USN Ret.), former President, Monmouth University; and former President, National Defense University
Hon. Jacques Gansler, Director, Center for Public Policy & Private Enterprise, University of Maryland; and former Under Secretary of Defense Acquisition, Technology & Logistics
Adm. Edmund Giambastiani (USN Ret.), Director, Board of Directors, The Boeing Company; and Former Vice Chairman of the Joint Chiefs of Staff
Dr. Clark Groves (Col., USAF Ret.), Associate Professor, National Security and Industrial Base, Eisenhower School, National Defense University
Andrew Hunter, Director, Defense-Industrial Initiatives Group and Senior Fellow, International Security Program, Center for International and Strategic Studies
Dr. Bruce Jette, President and CEO, Synovision Solutions LLC; former Director of Army Rapid Equipping Force
Dr. Theodore R. Johnson (Cdr., USN Ret.), Adjunct Professor, McCourt School of Public Policy, Georgetown University
Col. Abigail Linnington (USA), Director, Chairman’s Action Group, Chairman of the Joint Chiefs of Staff
Austin Long, Associate Professor, School of International and Public Affairs, Columbia University
Lt. Gen. Michael Lundy (USA), Commanding General, U.S. Army Combined Arms Center and Fort Leavenworth, Kansas
Adm. Michael Mullen (USN Ret.), Charles and Marie Robertson Visiting Professor, Princeton University; and former Chairman of the Joint Chiefs of Staff
Col. John O’Grady (USA), Chief of Staff of the Army Senior Army Fellow, Center for Strategic and International Studies

Dr. Michael O’Hanlon, Senior Fellow, Brookings Institution

Hon. Sean O’Keefe, former Secretary of the U.S. Navy; former Administrator of the National Aeronautics and Space Administration; and University Professor, Maxwell School of Citizenship and Public Affairs, Syracuse University

Maj. Gen. Frederick M. Padilla (USMC), President, National Defense University

Dr. William Roper, Director, Strategic Capabilities Office, Office of the Secretary of Defense

Vice Adm. Kevin Scott (USN), Director, Joint Force Development, J7 (Pentagon)

Adm. James Stavridis (USN Ret.), Dean, Fletcher School of Law and Diplomacy, Tufts University

Col. William Thigpen (USA), Chief of Staff of the Army Senior Army Fellow, Center for Strategic and International Studies

Lt. Gen. Richard Trefry (USA Ret.), former Army Inspector General

Dale C. Waters, Director, Adaptive Execution Office, Defense Advanced Research Projects Agency

Dr. Jerry West, Education Advisor, Joint Staff J7, Joint Education and Doctrine Directorate Joint Professional Military Education Division

Dr. Alexis Wichowski, Adjunct Assistant Professor of International and Public Affairs, School of International and Public Affairs, Columbia University

Meeting on April 18, 2016, at UK Embassy

Maj. Gen. Richard Cripwell (UK Army), Defence Attaché

Meetings on April 27, 2016, at Army War College

Col. Chris Beckert (USA), Director, Center for Strategic Leadership, U.S. Army War College

Dr. Lance Betros (Brig. Gen., USA Ret.), Provost, U.S. Army War College

Dr. Jeffrey Groh (Col., USA Ret.), Professor of Information and Technology in Warfare, Department of Distance Education, U.S. Army War College

Dr. Richard Lacquement, (Col, USA Ret.), Dean, School of Strategic Landpower, U.S. Army War College

Douglas C. Lovelace, Jr., Director, Strategic Studies Institute, U.S. Army War College

Maj. Gen. William Rapp (USA), Commandant, U.S. Army War College

Col. Sam White (USA Ret.), Deputy Director, Center for Strategic Leadership, U.S. Army War College

Meetings on May 12, 2016, at National Defense University

Dr. Michael Bell, Chancellor, College of International Security Affairs, National Defense University
James Churbuck, Chair, Cyber Security Department, Information Resources Management College, National Defense University
Dr. Carl “Cj” Horn, Chair, Department of Cyber Leadership and Joint Education, Information Resources Management College, National Defense University
Dr. Feza Koprucu, Associate Dean of Faculty, Eisenhower School
Dr. David Tretler, Dean of Faculty, National War College
Dr. John D. Yaeger, Provost, National Defense University

Meetings on May 23, 2016, at U.S. Naval Research Laboratory
Capt. Mark Bruington (USN), Commanding Officer, U.S. Naval Research Laboratory
Stan Chincheck, Director, Center for High Assurance Computer Systems, U.S. Naval Research Laboratory
Dr. Alan Cook, Research Physicist, U.S. Naval Research Laboratory
Dr. Glen Henshaw, Roboticist, U.S. Naval Research Laboratory
Dr. Berry Jonker, Senior Scientist, Materials Science and Technology Division, U.S. Naval Research Laboratory
Dr. Colin Joye, Engineer, U.S. Naval Research Laboratory
Dr. Frank Klemm, Superintendent, Tactical Electronic Warfare Division, U.S. Naval Research Laboratory
Dr. John Montgomery, Director of Research, U.S. Naval Research Laboratory
John Pasour, Research Physicist, U.S. Naval Research Laboratory
Dr. Eric Snow, Director, Institute for Nanoscience, U.S. Naval Research Laboratory

Meetings on May 24, 2016, at U.S. Naval War College
Col. Eric Aslakson (USA), Student, U.S. Naval War College
Cdr. Walter Bonilla (USN Ret.), Deputy Director, Gravely Naval Research Group, U.S. Naval War College
Col. David Brown (USA Ret.), Associate Professor, Advanced Naval Strategist Program (ANSP), U.S. Naval War College
Dr. Lewis M. Duncan, Provost, U.S. Naval War College
Capt. James FitzSimonds (USN Ret.), Director, Halsey Alfa Research Group, U.S. Naval War College
Dr. Tom Gibbons, Associate Professor of Professional Military and Graduate Education Effectiveness, U.S. Naval War College
Dr. James E. "Jay" Hickey, Associate Provost, U.S. Naval War College
Vice Adm. P. Gardner Howe III (USN), President, U.S. Naval War College
Dr. Nicholas Murray, Professor, Department of Strategy and Policy, U.S. Naval War College
Michael J. Sherlock, Professor of Academic Affairs, U.S. Naval War College

Meetings on June 1, 2016, at Marine Corps University
Dr. James Anderson, Vice President for Academic Affairs, Marine Corps University
Col. Keil Gentry (USMC), Director, Marine Corps War College
Dr. Rebecca Johnson, Dean, Marine Corps War College
Dr. James Lacey, Director, War Policy and Strategy Program, Marine Corps University
Brig. Gen. Helen Pratt (USMC), President, Marine Corps University

Meeting on June 2, 2016, at CSIS, UK Director General Joint Force Development & Defence Academy
Col. Mark Cancian (USMC Ret.), Senior Adviser, International Security Program, Center for Strategic and International Studies
Air Vice Marshall Bruce Hedley MBE RAF (UK Royal Air Force), Director, Joint Warfare Joint Forces Command
Col. Stewart McConnell (UK Army), Joint Forces Attaché
Maj. Phil Morgan (UK Army), Staff Officer 2, Development, UK Joint Warfare Directorate, Joint Forces Command
Vice Adm. Duncan Potts CBE RN (UK Royal Navy), Director General, Joint Force Development & Defence Academy
Jeff Rathke, Senior Fellow and Deputy Director, Europe Program, Center for Strategic and International Studies

Meeting on June 6, 2016, at CSIS, Chief of Staff of the Army Strategic Studies Group
Col. Susan Bryant (USA), Senior Military Fellow, Institute for National Strategic Studies, National Defense University
Karen Burke, RDECOM (U.S. Army Research, Development and Engineering Command), Program Analyst, Chief of Staff of the Army Strategic Studies Group
Lt. Col. Ryan Kendall (USA), Chief of Staff, Chief of Staff of the Army Strategic Studies Group
Dr. Christopher Rice, Deputy Director, Chief of Staff of the Army Strategic Studies Group

Meetings on June 14, 2016, at Air University
Brig. Gen. Chris Coffelt (USAF), Commandant, Air War College
Dr. Grant Hammond, Professor of Strategy, Center for Strategy and Technology, Air War College
Dr. Chris Hemmer, Dean, Air War College
Lt. Gen. Steve Kwast (USAF), *Commander and President, Air University*

Dr. Dave Luginbuhl, *Chair, Air Force Research Laboratory; and Adjunct Faculty, Center for Strategy and Technology, Air University*

**Meeting on July 26, 2016, at National Intelligence University**

Dr. Brian Shaw, *Dean, Anthony G. Oettinger School of Science and Technology, National Intelligence University*

Col. Robert J. Smith, Jr. (USAF), *Associate Dean, Anthony G. Oettinger School of Science and Technology, National Intelligence University*

Dr. Susan M. Studds, *Provost, National Intelligence University*

**Meeting on September 20, 2016, at CSIS, UK Director, Development, Concepts and Doctrine Centre**

Scott Badenoch, *CEO, Badenoch LLC*

Col. Mark Cancian (USMC Ret.), *Senior Adviser, International Security Program, Center for Strategic and International Studies*

Col. Richard Carter (UK Army), *Assistant Head Concepts (Joint and Land), Development, Concepts and Doctrine Centre, Defence Academy of the UK*

Air Vice Marshall Bruce Hedley (UK Royal Air Force), *Director, Joint Warfare Joint Forces Command*

Col. Stewart McConnell (UK Army), *Joint Forces Attaché*

Maj. Gen. Mitch Mitchell MBE QCVS (UK Army), *Director, Development, Concepts and Doctrine Centre, Defence Academy of the UK*

Maj. Gen. Stuart Skeates (UK Army), *Commander, Standing Joint Forces HQ*

**Meeting on November 14, 2016, at CSIS, UK Commander, Joint Forces Command**

Capt. Paul Beattie (UK Royal Navy), *Personal Staff Officer to Commander JFC*

Gen. Sir Chris Deverell KCB MBE ADC Gen (UK Army), *Commander, Joint Forces Command*

Col. Stewart McConnell (UK Army), *Joint Forces Attaché*
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About the Authors

Raymond F. DuBois is a senior adviser at CSIS, where he focuses on international security policy, civil-military relations, joint professional military education, and defense management reform. He served as acting under secretary of the army from February 2005 to February 2006. From October 2002 to May 2005, he was director of administration and management, and concurrently, director of Washington Headquarters Services. From April 2001 through November 2004, DuBois served as the deputy under secretary of defense for installations and environment. His prior service in the Pentagon was from 1973 to 1977, when he was a staff assistant to the secretary of defense, followed by service on a special task force for Southeast Asia as special assistant to the Pentagon comptroller, followed by assignment as special assistant to the secretary of the army and as deputy under secretary of the army. He served in the U.S. Army from 1967 to 1969, including nearly 13 months in Vietnam as a combat intelligence operations sergeant in the Central Highlands, where he received the Army Commendation Medal. Mr. DuBois currently serves as a global senior adviser to McKinsey & Co. and on the International Advisory Council of the U.S. Institute of Peace, and he lectures at the Marine Corps War College. Mr. DuBois received a B.A. degree from Princeton University in 1972.

Daniel M. Gerstein works at the RAND Corporation and is an adjunct professor at American University. Previously, he served at the U.S. Department of Homeland Security (DHS) as under secretary (acting) and deputy under secretary in the Science & Technology Directorate. Gerstein began his professional career in the U.S. Army, serving on four continents, participating in combat, peacekeeping, humanitarian assistance, counterterrorism, and homeland security. Following retirement from active duty, he joined L-3 Corporation as vice president for homeland security services. Before joining DHS, Gerstein was the principal director for countering WMD in OSD (Policy). He has authored books and articles on national security topics and is a member of the Council on Foreign Relations. He graduated from West Point and has masters’ degrees from Georgia Tech, National Defense University, and Army Command & General Staff College, and a Ph.D. from George Mason University.

James M. Keagle is university professor at the Eisenhower School of the National Defense University (NDU). He formerly served as director and deputy director of the Emerging Challenges Program at the Center for Technology and National Security Policy at NDU. Dr. Keagle also served for nine years as NDU’s provost and vice president for academic affairs, as well as professor of national security strategy. He is a graduate of the U.S. Air Force Academy and holds an M.A. in political science with a certificate in Latin American studies from the University of Pittsburgh and both an M.A. and Ph.D. in politics from Princeton University. He received an honorary doctorate from the Military Technical Academy of Romania.

Rose Morrissy is a research assistant to Raymond DuBois at CSIS. She holds an M.A. from the Maxwell School of Citizenship and Public Affairs at Syracuse University and a B.A. from the University of Illinois at Urbana-Champaign.
Science, Technology, and U.S. National Security Strategy

Preparing Military Leadership for the Future

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