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Educating and Training Department of Defense Space Professionals

A Report to the
Committees on Armed Services of the Senate
and House of Representatives

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This report on educating and training DoD Space Professionals
is approved.

In accordance with Title V of Conference Report 108-767, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005

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Chapter 1 Task and Methodology

Introduction

This report is directed by Conference Committee Report 108-767, accompanying the *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005* (Public Law 108-375). It assesses the ability of academia, industry and government to educate and train a community of space professionals and recommends corrective actions to address any identified shortfalls. Principally, the report compares requirements as defined by the Services against the capacity of academic institutions to meet these requirements. Each type of institution (whether civil, military or commercial) offers a variety of tools, expertise, skills and unique organizational culture that can benefit the Department of Defense (DoD) space community.

The DoD has numerous avenues to develop space professionals. For example, Air Force Air Education and Training Command (AETC) and Air Force Space Command's National Security Space Institute (NSSI) provide focused space training courses and continuing education to multi-Service space professionals. To meet advanced academic degree requirements, the Air Force Institute of Technology (AFIT) and Naval Postgraduate School (NPS) offer tailored space programs that bolster the warfighting capabilities of DoD and National Reconnaissance Office (NRO) civilian and military personnel. Complementing these programs are civilian universities and colleges that offer an even wider range of curricula including the recently chartered Space Education Consortium (SEC). Often overlooked, but no less important, corporations, industry partners and foundations create short courses, symposia, and conferences as a means to train and educate their customers, employees and community partners. Finally, U.S. Government agencies, such as NASA, also have excellent programs that contribute greatly to the development of an expert space cadre. This report describes each of these providers of space training and education, and assesses their capacity as a whole to meet the needs of DoD space professionals.

Task

As delineated in the FY05 Defense Authorization Conference Committee Bill, Congress directed the Secretary of Defense to deliver a report that:

- Assesses the ability of academia, industry, and government to educate and train a community of space professionals.
- Recommends corrective actions to address any shortfalls identified in these education and training activities.

- Addresses the definition and development of key competencies and skill levels in the areas of systems engineering, program management, financial management, operations and tactics, and other areas relevant to military space systems.

This task was accomplished by the Space Professional Working Group (SPWG), under the leadership of the Space Professional Oversight Board (SPOB). The SPOB, co-chaired by the DoD Executive Agent for Space and the Director of the NRO, has representatives from each of the Services and exercises overall responsibility for the education and training of DoD's space professionals. The complete language on "space cadre" from the subject Conference Report is reproduced in Appendix 1 of this report.

Methodology

The methodology for crafting this report includes:

- Identify the Service-unique education and training requirements for DoD space professionals.

- Assess the availability and adequacy of current space education and training programs to meet these requirements. Include a catalogue of selected and illustrative civil, military and commercial institutions and their relevant course listings.

- Discuss the process for determining key competencies and skill levels for space professionals, recognizing that each Service may have its own additional or unique requirements.

- Make recommendations on corrective actions to address any identified shortfalls.

The results presented in this report reflect current Service, Joint and DoD requirements. As national security space capabilities continue to evolve into more and more complex systems, education and training will have to keep pace. Some factors that will drive the future development of space professionals include technological advances in such areas as automation and dynamically taskable sensors. Possible shifts in the workforce ratios between contractor/government, officer/enlisted and civilian/military will also play a role. Each of these areas should continue to be monitored in order to keep space education and training current and relevant.

We recognize that one size does not fit all, and as such, this report will consider the unique needs and requirements of the individual Services. This approach provides an accurate and fair picture of the state of space professional education and training as it exists today. It also establishes a baseline that will aid future assessments of this critical national asset.

Assumptions

Several assumptions are made for this report.

- The “community of space professionals” in the congressional language refers to DoD space professionals, also known as the DoD space cadre.
- This report does not assign a quality grade to individual institutions or specific courses, but focuses on the availability and capacity of existing programs in total to satisfy education and training requirements.
- To the maximum extent possible, a reasonable representation of available space education and training is identified; however, it still must be viewed as a large, illustrative sampling instead of a complete compendium.

Chapter 2

Space Education and Training Requirements

Different Space Cadres for Different Purposes

While the Services continue to seek synergies and minimize redundancies between their respective space cadres, each is still duty-bound to implement their own professional development programs in accordance with the roles and missions assigned to them. As a result, core space education and training requirements vary significantly from one Service to another. Unquestionably, an understanding of space fundamentals (e.g. orbital mechanics, space environment etc.) is important for all DoD cadre members, but beyond that, the amount and type of space education and training is very Service-specific. For example, the Air Force cadre (over 9,000 strong) accesses newly commissioned lieutenants and junior airmen into the space career field, while the sister Services typically select space cadre members from other specialties at the mid-point in their career. In addition, the "cradle to grave" nature of Air Force and NRO space operations encompasses the entire spectrum of space expertise. Though a much smaller cadre, Navy space professionals also participate in acquiring and operating NRO systems, as well as Navy-managed MILSATCOM systems. Army and Marine priorities, by necessity, focus mainly on traditional warfighter integration activities. These factors create the need for a wide variety of space instruction between the military Services and other DoD organizations. Suffice it to say, in the realm of space education and training, **one size does not fit all**. However, one requirement remains constant across the Services. That is the need to integrate space ever more deeply into American combat operations. In all Services, young space operators must be conversant in how space operations directly and indirectly support theater operations. Space professionals are warriors first and space technologists second.

As an additional factor, Service-trained cadre members are called upon to fill billets across the entire national security space community, including combatant commands, Joint Chiefs of Staff (JCS), OSD and numerous other government agencies. So far, with the exception of NRO-unique training, no additional space knowledge or skills have been levied by these organizations. Historically, they select already-qualified space experts from the Services to satisfy their specific requirements; however, in the future, we may well expect them to develop their own set of space education and training standards.

In the next chapter, we describe the various institutions that provide space-related instruction, along with a sample listing of their course offerings. Before we can assess the adequacy of these existing programs, it is necessary to understand Service requirements, from design and acquisition through employment and sustainment. Following is a primer on each of the Service cadres, highlighting the distinct differences in size, purpose and academic needs.

The Air Force

Composition

A "Total Force" cadre, Air Force space professionals include officers, enlisted personnel, Reservists and National Guardsmen, as well as civilians representing numerous disciplines and specialties. Generally speaking, space education and training standards are well documented for the active, Guard and Reserve force, while requirements are still evolving for civil service members.

Size

The cadre is comprised of more than 9,000 "Credentialed Space Professionals" (CSPs)[1], consisting of enlisted and officer space operators, officer scientists, engineers and program managers. The number is even higher when counting government civilians. Several thousand additional space support personnel contribute in critical areas such as maintenance, communications, weather and intelligence. These additional support personnel are not credentialed members of the space cadre, nor do they participate in the core space education and training programs required of CSPs.

Accession

CSPs are classified as either space operators or space acquirers. The majority of officer and enlisted space operators are new accessions to the Air Force. They begin their careers with an initial space fundamentals course called Space 100, followed by Initial Qualification Training (IQT) at the 381st Training Group (TRG) in a specific mission area. Space operators, with the exception of occasional broadening assignments, serve in space-related duties throughout their careers. Scientists, engineers and program managers make up the acquisition element, which is also composed primarily of new accessions into the Air Force. While members of this group also attend Space 100, they often pursue differing career paths from space operators in order to remain competitive within the larger Air Force acquisition community and in order to meet Defense Acquisition Workforce Improvement Act (DAWIA) standards. However, through proper force development, members of this acquisition group can and will be developed as space professionals. Those assigned to duty as space acquirers at Los Angeles AFB, CA also attend the Space and Missile Systems Center (SMC) Acquisition School (SAS). Similar to IQT for space operators, this course lays a strong foundation in space acquisition.

Purpose

The Space Professional Development Program (SPDP) is an Air Force-level personnel development program designed to build space experts who thoroughly understand the medium of space–from concept to sustainment–including design, acquisition, fielding, operations, and maintenance. The SPDP is a multi-faceted plan to ensure deliberate, purposeful, individual development highlighted by expanded space education, training, and experience-building opportunities. The elements of this program are formalized through a three-level certification program to create and manage a knowledgeable community of CSPs to meet the nation's space needs and national security objectives.

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[1] Credentialed Space Professional (CSP) is a term used by the Air Force to denote all Air Force personnel who are subject to Space Professional Development Program (SPDP) certification requirements.

Certification

There are three levels of Space Professional Certification appropriately tailored for Total Force officers, enlisted, and civilian personnel. CSPs will progress from a foundation of technical competency (Level 1), through demonstrated depth of knowledge and experience in application (Level 2), to extensive knowledge and experience in space and warfighting operations (Level 3). Criteria for the various levels are tied to the three fundamental characteristics of Air Force personnel development–education, training, and experience.

Mandatory Education and Training

Level 1 (Initial Accession)

Operators: Complete Space 100 (Space Fundamentals) followed by IQT conducted by the 381st Training Group (part of AETC) and Unit Qualification Training (UQT) on a specific mission system such as ICBMs, the Global Positioning System, warning radar, etc.

Acquirers: Similar to operators, acquisition professionals also complete Space 100 prior to their initial assignment in a space unit (program office, laboratory, etc). In addition, all core acquirers must complete federally-mandated training (Acquisition 101, etc.) per the DAWIA, which is accomplished through the Defense Acquisition University (DAU). Recently, DAU began offering a more focused, space-centric teaching module. Finally, members assigned to the SMC in Los Angeles also complete the SMC Acquisition School to learn the particular challenges of acquiring military space systems relative to other types of DoD acquisitions.

Level 2 (8-10 years for officers or 9-11 years for enlisted)

Operators: In order to attain a Level 2 space certificate, CSPs complete Space 200 (Space Application) at the National Security Space Institute (NSSI). Space 200 emphasizes space system design and joint warfare integration.

Acquirers: Once again, acquirers must meet additional DAWIA requirements, as appropriate, to maintain their acquisition credentials. Any additional training is dependent on positional and/or organizational requirements. Additional acquisition education, such as ACQ 101 and the DAU Space Acquisition model may be required for space operators.

Level 3 (13-15 years for officers or selection for E-8 for enlisted)

Operators./Acquirers: CSPs complete Space 300 (Space Integration) at the NSSI and, for acquirers, any applicable DAU courses mandated by DAWIA. Space 300 expands the baseline established within Space 200 to encompass a truly national perspective, to include considerations of Joint, national, civil, commercial, and even foreign space, particularly in the areas of space policy and doctrine.

Additional Space Education and Training Opportunities

Advanced Academic Degrees: The Air Force currently has requirements for 13 Advanced Academic Degree (AAD) positions to be filled by space operations officers who have received an AAD. Additionally, AFSPC has 79 AAD positions for 6X officers. An

ongoing Air Force billet validation will further refine Air Force education and training requirements.

Officers are encouraged to complete a space-related master's degree prior to Level 2 space certification (typically at the 8-10 year point). AFIT offers many appropriate degree programs at the masters and doctorate level. In addition, AFIT offers Systems Engineering and Advanced Geospatial Intelligence certificates by distance learning, and is developing a distance learning advanced space systems engineering certificate for space professionals. The NPS offers Master's Degrees in Space Systems Engineering and Space Systems Operations, as well as a Space Systems certificate program. The SEC (described in the next chapter) is also developing space-related degree programs. In some cases, pursuit of an advanced degree can be combined with completion of developmental education. DoD Enlisted personnel have the opportunity to receive a space-related master's degree through AFIT. Additionally, they must complete a Community College of the Air Force (CCAF) degree in their specialty to reach Level 3.

Air Force Weapons School: Approximately 20 space operators are selected each year to attend the Space Weapons School at Nellis AFB. Graduates are ideally trained to integrate space effects into joint warfare operations.

Spacelift Education and Crossover Program (SLEC-P): A total of four space professionals from operations and acquisition are selected each year to participate in the SLEC-P. Candidates first spend 10 months at a contractor facility (either Boeing or Lockheed Martin) learning program management, systems engineering, manufacturing, contracting, launch operations, and other corporate processes. This phase is followed by a three-year developmental assignment in either a launch program office (for operators) or an AF launch squadron (for acquirers).

Defense Acquisition University: Open to Air Force and non-Air Force military members and civilians as well as industry partners, this web-based continuous learning module explains the space acquisition process outlined in National Security Space Acquisition Policy 03-01 (NSS 03-01). This training module outlines the streamlined space acquisition oversight process and the points of departure from the process described in DoDD 5000. NSS 03-01 places heavy emphasis on the earlier phases of space program development because of their high tech nature, small quantity buys, and the increased percentage of cost incurred during development. Upon completion, students receive 4 continuous learning points.

NSSI: In addition to Space 200 and 300, NSSI offers specialized training to multi-Service space cadre members to address a wide range of requirements from basic fundamentals to highly advanced system-specific courses. A complete listing of their curricula and target audiences is contained in the next chapter. As an Air Force school, NSSI course offerings must first meet Air Force requirements, followed by multi-Service and other government agencies' needs. As the NSSI matures with more robust manpower and funding, its capability will increase and enable it to focus on all Services' and agencies' requirements.

Continuing Education: The Air Force is assessing the applicability of a space continuing education requirement for all credentialed space professionals (CSPs). The intent is to keep CSPs current on key developments across the entire space arena, as well as within their chosen area of expertise.

Space Education Baseline: An extensive educational assessment revealed consensus among senior AF space leaders on a common baseline of knowledge for the space cadre. The proposed content supplements Space 100 and other initial qualification training

courses. Under this concept, CSPs could pursue course work in: (1) mathematics, physics and engineering; (2) systems engineering; (3) space system lifecycle; and (4) space's role in national security policy. Details for the program are still being worked between AFSPC and the SEC. Baselines for enlisted space education have been identified and are currently being staffed. Requirements for civilian cadre members are also under development, along with an advanced certificate program for more seasoned individuals. A complete summary of the educational needs assessment is contained in Appendix 2 and 3 at the end of this report. The NSSI website is: https://halfway.peterson.af.mil/nssi/.

AFSPC hosted a Space Education Workshop in Aug 06. The purpose of the workshop was for those DoD organizations that provide space education to give updates on their programs, clarify their roles, communicate broader needs of the Space Cadre community, identify opportunities to provide additional space education, and integrate existing programs.

The Navy

Composition

The Navy's space cadre represents a distinct body of expertise horizontally integrated within the Navy active duty, reserve, and civilian service components organized to make space tactically relevant to naval operations. Efforts are underway to identify and track the enlisted component (active duty and reserve) of the Navy's space cadre.

Size

The current space cadre consists of approximately 550 Navy officers and 85 Navy Reserve officers from a range of primary career fields including the unrestricted line communities (surface, subsurface and aviation) as well as aerospace engineering, engineering, information professional, intelligence, information warfare and meteorology. Additionally, approximately 95 civil service employees have been identified as part of the Navy's space cadre.

Accession

The Navy does not have a separate career designator for the space cadre workforce. Completion of the Space Systems Operations or Space Systems Engineering graduate degree programs at the Naval Postgraduate School (NPS) is a primary method of entry into the space cadre. Navy space professionals include officers who have been designated with 5500 (Space Systems Engineering) and the 6206 (Space Systems Operations) subspecialty codes. Officers are assigned the 5500P code upon completion of the Space Systems Engineering curriculum or the 6206P code upon completion of the Space Systems Operations curriculum at NPS or other accredited institutions. Officers are assigned the 5500S or the 6206S code when they successfully complete at least 18 months in a space-coded billet. There are currently over 300 Navy billets identified with a Space Systems Engineering or Operations education or experience subspecialty code. Billets coded with the education subspecialty code drive the throughput of students in the Space Systems Operations and Engineering curricula at NPS.

In addition to the space subspecialty codes, active duty and reserve officers from many primary career fields with the requisite education and experience are identified with an Additional Qualification Designator (AQD) according to the following criteria:

- VS1 (Recruit) = Officer has completed a space certificate program from NPS.
- VS2 (Apprentice) = Officer has a space-related bachelors degree from an accredited institution or has one tour (minimum of 18 months) in a space-coded billet.
- VS3 (Journeyman) = Officer has a space-related masters degree from an accredited institution, or has two tours (minimum of 18 months each) in a space-coded billet; or a space-related bachelors degree from an accredited institution plus one tour (minimum of 18 months) in a space-coded billet.
- VS4 (Expert) = Officer has a space-related masters or doctorate degree from an accredited institution and has at least one tour (minimum of 18 months) in a space-coded billet.

Purpose

Naval space cadre members leverage their previous operational experience along with formal education to build new expertise in the assessment, requirements, science and technology, research and development, acquisition and operations of space systems. Cadre members are expected to:

- Represent Navy interests and participate as a full partner in the national security space arena to shape future space systems.
- Integrate space capabilities into naval platforms and operations.
- Increase training and awareness of space capabilities throughout the fleet as well as develop a future space cadre who will understand the art of the possible.
- Continue to develop a space cadre knowledgeable in the entire spectrum of joint and naval applications of space.

Mandatory Space Education and Training

Historically, the NPS Space Systems Engineering and Operations curricula have been the primary source of education for the core of the Naval space cadre. NPS has provided post-graduate (MS, Engineer's, PhD) education primarily for Naval officers, but also for officers from other Services and government organizations for over 20 years. The number of space-coded billets drives the number of students in the NPS Space Systems curricula, with the intent to maximize the use of personnel who have earned the associated subspecialty codes through graduate degree programs. The Navy also accesses space cadre members from other career fields who possess a space-related certificate or degree.

Graduates have received follow-on assignments in many organizations in the National Security Space (NSS) community. Program content is driven by Educational Skill Requirements (ESRs) established by sponsoring commands that employ the graduates. Periodic curriculum reviews are held at NPS to review and update the ESRs based on the

current needs of the Naval space community. In addition, the Navy holds periodic curriculum reviews at the United States Naval Academy to ensure the Academy's Astronautical Engineering curriculum is continually updated.

An education and training summit will be held this year to finalize core space competencies and assess current and future education and training needs to meet Navy core space competencies. The goal is to establish a common baseline of space knowledge that will apply to all cadre members throughout their careers. To the extent possible, the Navy plans to use existing Navy, Joint, and multi-Service curricula, courseware and classes to meet their needs.

In addition, all Navy Space Cadre personnel who are also Acquisition Professionals must complete federally-mandated training (Acquisition 101, etc.) per the DAWIA, which is under the purview of the DAU.

Additional Space Education and Training Opportunities

In addition to the graduate and post-graduate degrees mentioned above, NPS also offers a Space Certificate available via distance learning.

The Navy provides additional instruction to space cadre members through NSSI. The Navy is in the process of standardizing additional space cadre education and training opportunities with the following intent:

- Space Fundamentals (Space 101) course as en route training for personnel prior to reporting to their first space-related job
- Space 200 for Apprentice and Journeyman Space Cadre
- Space 300 for Expert Cadre

The Navy is currently identifying training opportunities to be included as part of the Carrier Strike Group's and Expeditionary Strike Group's Interdeployment Readiness Cycle. This will include tactical level training on the integration of space-derived information into fleet operations and planning. It will consist of a combination of introductory classroom training, familiarization visits to key space facilities and service organizations, and the integration of space-related scenarios into pre-deployment exercises and simulations to evaluate the Strike Group's ability to effectively incorporate space knowledge.

The Marine Corps (USMC)

Composition

The Marine Corps space cadre consists of active duty, reserve, and civilian members with a diverse set of primary military occupational specialties (including ground, aviation, combat support, and command and control) who are:

- Trained in Joint space operations and national security space activities.
- Experienced in space requirements generation, concept development, planning, programming, acquisition, and/or operations.

The Marine Corps believes in taking Marine Air-Ground Task Force (MAGTF) officers and making them "space smart." These MAGTF officers use their operational experience coupled with space knowledge to not only increase the effectiveness of Marine Corps operating forces but to also represent the Marine Corps across a broad range of NSS activities.

Enlisted and civilian Marines support space operations and NSS activities by virtue of their space-related training and experience.

Purpose

The purpose of the Marine Corps space cadre is to:

- Support the vision and goals of *Marine Corps Strategy 21* by creating a cadre of Marines who understand both the capabilities of a MAGTF and the unique advantages to be gained by fully exploiting current and future space-based systems.

- Increase the integration of current and future space-based capabilities into Marine Corps systems to support the Corps' *Expeditionary Maneuver Warfare* capstone concept and to enable *FORCEnet* and the transformational naval operational concepts of *Sea Strike, Sea Basing and Sea Shield*.

- Shape the development of future space systems to meet Marine Corps war fighting needs through increased collaboration with the Air Force and other space partners.

- Increase the effectiveness of U.S. operating forces through more effective planning, integration and coordination of space-based capabilities and forces.

- Increase the distribution of Marines with space training and experience throughout the operating forces to inject space-knowledge at the individual unit level.

Size

Thus far, 31 active duty and reserve space operations officers and 77 space operations staff officers have been identified for inclusion in the cadre.

Accession

The Marine Corps space cadre currently includes officers who have been designated with the 9666 and the 9933 Military Occupational Specialty (MOS), as described below. The 9666 MOS is assigned upon completion of the space systems operations curriculum and graduation from NPS. The 9933 MOS is assigned upon completion of a 2-week space fundamentals course and 6 months in a space-related billet.

Since the Marine Corps wants MAGTF officers to have primary MOS credibility and operational experience prior to being designated a member of the space cadre, it is envisioned that most officers will not be designated as space cadre until the rank of major. Even then, they typically will only serve one or two space-related assignments and then return to their primary MOS.

MOS 9666, Space Operations Officer (Masters Degree Program)

Space operations officers actively participate in the development, management, operation, and use of space systems for the accomplishment of Marine Corps missions, to include support for strategic defense.

MOS 9933, Space Operations Staff Officer (Non-Masters Program)

Space operations staff officers develop requirements for space systems, make recommendations to decision makers in space systems acquisition management, conduct space application training, and participate in space operations planning. This MOS is to be assigned as a skill designator MOS only.

How to access enlisted members and civilians into the space cadre has yet to be determined. An effort to identify a process to include them is currently under way.

Mandatory Space Education and Training

Similar to the Navy, Marine space cadre members are selected from other primary career specialties at around the mid-point in their career based on completion of a space-related masters degree at NPS for MOS 9666 officers or attendance at the NSSI-instructed Space Fundamentals course for MOS 9933 officers. Once again, like the Navy, the Marines are currently analyzing results from a recent summit to determine future education and training requirements for cadre members. The goals of that assessment are to:

- Improve space operations professional military education for all Marine Corps officers to ensure future Marine Corps leaders understand the importance and criticality of space capabilities.
- Focus the graduate education of Marine Corps space operations students to support Marine Corps needs.
- Leverage inter-Service space training to ensure the development and proficiency of the space cadre.

Essentially, Marines require practical education on the capabilities of space assets , how to plan for space support, and how to request it. Their emphasis is primarily in the force enhancement arena, particularly operational planning, satellite communications, navigation, intelligence/surveillance/reconnaissance, space control and environment. They are interested in lessons pertaining to launch systems, missiles, satellite acquisition and satellite command and control as they relate to space support to MEUs, MAGTFs, the Joint Space Operations Center, Combat Air Operations Centers, USSTRATCOM, DIRSPACEFOR etc.

Additional Space Education and Training Opportunities

- HQ USMC has a requirement for 12 seats per year for Marine students in Space 200 and 2 students per year for Space 300.
- They are currently discussing with NSSI the possibility of creating a two-week space-planning course designed for officers assigned to Joint Force or component headquarters staff.

- They are also considering the U.S. Army Space and Missile Defense Command/U.S. Army Forces Strategic Command (SMDC/ARSTRAT) Space Operations Officer Qualification Course (SOOQC) as yet another avenue. FA40 space qualification course as yet another avenue for selecting officers from other primary career specialties at around the mid-point in their career.

Additional training opportunities for 9933 and 9666 staff officers will continue to be evaluated.

The Army

Composition

The Army Space Cadre consists of military and civilian Space Professionals and Space Enablers. Space Professionals are career specialists whose principal duties include planning, developing, resourcing, acquiring, integrating, or operating space forces, concepts, applications or capabilities. Space Enablers are personnel assigned to positions whose primary career field is not space, but perform unique tasks or functions or may require skills to apply space capabilities.

Size

Currently, the Army Space Cadre contains 158 Space Professionals (Army Functional Area 40 Space Operations Officers). Approximately 1500 Space Enablers will be included as they are officially identified and will be comprised of such positions as satellite payload controllers, Joint Tactical Ground Station (JTAGS) operators, Army Space Support Team (ARSST) members, Army NRO elements and the TRADOC system manager for satellite communications.

Accession

Space professionals (FA40s) are accessed into Functional Area 40 through a board selection process at the seventh year of service. The Reserve and National Guard Officers are granted entrance into the space operations career field upon written request and completion of specified training beginning at the rank of major. Personnel proponents are responsible for the personnel life-cycle management functions of Space Cadre members within their respective career fields. As such, they take the lead in defining developmental needs, refining requirements in the field and providing assistance to improve all aspects of the Army's personnel management system. The training/education/experience that these individuals acquire while assigned to space positions will be tracked in order to enable the Army to effectively use these skills for potential future reassignment to Space Cadre positions.

Purpose

The purpose of the Army Space Cadre is to plan, develop, resource, acquire, integrate and operate space forces, concepts, applications or capabilities (in accordance with DoD Directive 3100.10, Space Policy, and and Joint Publications 3-14, Joint Doctrine for Space Operations) to advance the use of space capabilities to fully support our nation's warfighters.

Mandatory Space Education and Training

Army personnel have career specific training which they must complete for career field qualification and job assignment. For the Army Space Professional it is the Space Operations Officer Qualification Course (SOOQC). The specific training for Space Enablers will depend on their branch or position requirements. Examples of such training are: Army Space Support Team Certification, Satellite Systems/Network Coordinators Course, Satellite Control Unit Certification and Army Joint Tactical Ground Station Course.

The Army currently accesses training at NSSI. Space 200 is part of the mandatory SOOQC. As soon as adequate seats are available, Space 300 will be required for all senior FA40s.

Additional Space Education and Training Opportunities

The Army takes advantage of other opportunities including:

- Fostering a strong partnership with the NSSI through:
  - Increased Army throughput in NSSI courses
  - Establishment of a permanent, fulltime Army Element at NSSI
  - Designation of on-site Army LNO to NSSI
  - Participation in the development of new space professional courses (Space 300, Advanced Course, etc.)
  - Instructional responsibilities in NSSI courses
  - Selection of NSSI space professionals attending Army FA40 qualification training

- Sponsorship of five FA40s per year to advanced space degrees programs through the Army's Advanced Civil Schooling Program. Typically the officers attend the Space Systems Operations or Space Systems Engineering curricula at the Naval Postgraduate School, Air Force Institute of Technology, and the Industrial College of the Armed Forces. Select civilian institutions (e.g. Stanford, Univ. of Southern California) with qualifying space advanced degree programs are also eligible ACS options. Through cooperative degree credit agreements with Webster University and American Military University, graduates of the FA40 qualification course are granted fifteen credit hours that can be applied to the respective university's MS Space program. Many Army Cadre members pursue this avenue through personal initiative, time and costs.

- FA40/space professionals participating annually in the Army Training with Industry program. A number of industries have established contact with the space operations office but assignment obligations have limited the participation to one a year.

- Developing internal Distance Learning (DL) web-based training products and establishing a dialogue with the Air Force Institute of Technology and Naval Postgraduate School for tailored DL space education.

- Sponsoring Mobile Training Teams to other schools to foster greater Army understanding of space operations support to the war fighter and integration of space as a supporting battlefield operating system.

- Offering two Space Electives within the Army Command and General Staff Officers Course. The 24-hour Space Orientation A537 Course (200 students per year) and the 48-hour Space Operations A543 Course (80 students per year). The completion of both electives earns students the Army Additional Skill Identifier 3Y-Space Activities which is coded in their personnel records and allows their secondary use of these skills in Army assignments.

- Annual Army FA40 Training Conference: this conference provides a week of Army Space Operations briefings, discussions, working groups and education and training forums that accord an annual opportunity for Army's Space Professional Cadre (FA40) to meet as a group for the professional exchange of ideas, initiatives, program updates, lessons learned, and tailored education and training.

- Army FA40 Space Operations Officers Qualification Course (SOOQC) Field Experience Trips: Imbedded with the curriculum for the 11- week SOOQCs are several field experience trips to both industry and national space agencies/facilities. These hands-on experience trips complement traditional in-class instruction and allow FA40 to meet in person with their industry, national and DoD counterpart space professionals and see their operations first hand. Visits include: Digital Globe, Northrop-Grumman, Boeing, Cheyenne Mountain Operations Center, High Energy Laser System Test Facility/White Sands Missile Test Range, National Reconnaissance Office, National Security Space Office, National Ground Intelligence Center, Army Space Program Office, 1st Information Operations Command, National Security Agency, Defense Special Missile and Astronautics Center, National Security Operations Center, Johns Hopkins Applied Physics Lab, Joint Space Operations Center, 14 AF Vandenberg AFB, DoD Space Test Program Office Kirtland AFB, ADF Buckley AFB.

Chapter 3

Space Education and Training Institutions and Course Offerings

Introduction

Chapter 2 delineated the various Service requirements for space professionals. In this chapter, we describe the primary institutions that provide space-related instruction, along with a partial listing of their course offerings at Appendix 4. This list is intended to demonstrate the range of available classes, but is not exhaustive.

Background

There are numerous schools and other venues that offer a wide range of courses and programs for space professionals. The key question is what specific education and training courses or programs will be required for various space professionals and whether these courses or programs will be accessible when they are needed in the career of a developing Space Professional. It is important to note that a robust space professional community requires not only general and specific training programs for various subspecialties, but also undergraduate and graduate level education, to provide a foundation of theoretical and analytical skills necessary for the development and application of future capabilities. It is necessary to specify the requirements in terms of throughput and competencies for both space education and space training programs. The Air Force, as the EA for Space, offers a great number of space training courses. Many of these courses are available and used by officer, enlisted and civilian personnel of all Service branches and NASA. The depth and breadth of these courses, along with training and education programs offered by other DoD and civilian institutions provide numerous opportunities to educate and train a DoD cadre of space professionals capable of keeping this nation preeminent in space.

Discussion

Below is a representative listing of DoD and DoD-affiliated institutions and programs that provide lifetime education opportunities for space professionals.

381st Training Group (Vandenberg AFB): Provides initial space education (Space 100) to all AF space operators and acquirers. In addition, the 381st conducts initial qualification training for most AF space operations missions for Air Force Specialty Code (AFSC) award. In addition, the 381st conducts initial qualification training for most AF space operations missions.

AFIT: Offers masters degrees and doctoral degrees in a range of engineering and systems acquisition to military officers and select non-commissioned officers. It also has a Center for Space Studies and Research and a Center for System Engineering. Other programs applicable to space, such as directed energy and electrical engineering, exist at the AFIT campus on Wright Patterson AFB (WPAFB) and through affiliated civilian institutions. Finally, AFIT offers distance learning certificates in Systems Engineering and Advanced Geospatial Intelligence, and is developing an advanced space certificate program for Air Force space professionals.

USA Space and Missile Defense Command/Army Forces Strategic Command (SMDC/ARSTRAT). SMDC/ARSTRAT executes its space education and training proponency mission through the Future Warfare Center Directorate of Combat Development (FWC DCD). FWC DCD executes all combat development associated with DOTMLPF. Executing its education, training and leader development responsibilities, FWC DCD has program oversight of courses that support Army Space Cadre development to include FA40 Space Operations Officer Qualification Course, JTAGS Initial Qualification Training, Command and General Staff College Courses (JPME Intermediate Level Education, ASI 3Y, Advanced Military Studies Program, School of Command Prep), Army War College Space Seminar, Space Support Element/Army Space Support Team Tactical Space Operations Course, DL, mobile training teams in support of Army schools, and all future courses that will support training the Space Cadre.

American Institute of Aeronautics and Astronautics (AIAA): AIAA offers courses in aerospace power systems, astrodynamics, space environments, missile systems and others.

Applied Technology Institute (ATI): ATI specializes in short course technical training in numerous space, satellite and aerospace engineering subject areas, including: space, communications, defense, sonar, radar, and signal processing. Since 1984, ATI has provided leading-edge public courses and on-site technical training to defense and NASA organizations, as well as to DoD and aerospace contractors. The courses provide a clear understanding of fundamental principles and a working knowledge of current technology and applications.

DAU: Provides space acquisition professionals with a full range of basic, intermediate, and advanced certification training, assignment-specific training, performance support, job-relevant applied research, and continuous learning opportunities. Subject areas include: system acquisition, cost analysis, business financial management, economic analysis, information systems acquisition, program management and others. DAU offers a Space Acquisition Course.

NASA: Training and development activities are designed to help employees and partners fulfill mission requirements through formal education, training and on-the-job developmental experiences. The focus is on both employee and organizational development, based on a culture of learning and knowledge sharing. The means may be university coursework, traditional classrooms, online learning, satellite broadcast, blended models, or on-the-job training.

NPS: NPS offers graduate level education in aeronautical and astronautical engineering, math, physics, space systems engineering, space systems operations, systems engineering, ops analysis and research, computer science and other related areas.

Space Systems Certificate Program: NPS offers a certificate program in space Systems via an on-line, distributed learning environment. The Space Systems

Certificate provides the foundation to understanding the integration of space capabilities across combined arms forces, involving networks, sensors, and weapons. As documented in the Navy Space Cadre Human Capital Strategy, completion of the NPS Space Systems Certificate program qualifies an officer for initial entry into the Naval Space Cadre. Additionally, this program can be used as the basis for entry into a graduate education program.

NSSI: NSSI is the DoD's single focal point for space education and training, complementing existing space education programs at Air University, NPS, and AFIT. Its students represent multi-Service units and other government agencies. Its staff is multi-Service and also has representatives from NASA, DAU and the NRO. NSSI added a Reserve Associate Unit in January 2006 to provide needed augmentation to the staff. The school is on track to offer space professional instruction to over 2,000 students in FY06. Eventually, NSSI hopes to assimilate other space programs from across the DoD. For now, Space 200 and 300 are its keystone courses.

SEC: To meet the needs of space professional continuing education, the SEC consists of a network of 12 teaching and research institutions focused on promoting space education, research, analysis, development and publication. Member schools include: University of Colorado at Colorado Springs, University of Colorado at Boulder, George Washington University, University of North Dakota, Embry Riddle Aeronautical University, University of Central Florida, Pennsylvania State University, University of Southern California, the International Space University, and the Florida Institute of Technology. The United States Space Foundation and the Aerospace Institute are also SEC members. A Memorandum of Agreement (MOA) has been established between the SEC and AFIT/NPS to facilitate cooperation. SEC member schools offer course credit through a variety of delivery media, allowing individuals to plan educational programs compatible with mission needs, assignment locations and personal interests. The SEC is also exploring course credit for selected NSSI courses and is gearing up to play a major role in space research and symposium activities.

Aerospace Corporation: As a Federally Funded Research and Development Center (FFRDC) for DoD, the corporation's primary customer is the Air Force's Space and Missile Systems Center. The Aerospace Institute promotes learning to enhance its capabilities as a national center for space technology, systems architecture, and engineering. Catalog courses, as currently constructed, are open only to FFRDC government customers, but can be tailored for others. The Aerospace Institute is a member of the SEC.

International Space University (ISU): ISU provides graduate-level training to future leaders of the emerging global space community at its central campus in Strasbourg, France, and at locations around the world. In its two-month summer session and one-year masters program, ISU offers its students a unique core curriculum covering all disciplines related to space programs and enterprises – space science, space engineering, systems engineering, space policy and law, business and management, and space and society. Both programs involve an intense student research team project giving international graduate students and young space professionals the opportunity to solve complex problems together in an intercultural environment. Since its founding in 1987, ISU has graduated more than 2200 students from 87 countries. Together with hundreds of ISU faculty and lecturers from around the world, ISU alumni comprise an extremely effective network of space professionals and leaders that actively facilitates individual career growth, professional activities and international space cooperation. ISU is a member of the SEC.

University of North Dakota: This interdisciplinary program in an in-depth study of the implications of humankind's entry into space: the scientific, technical, political, and legal impacts, on a national and international level, that are associated with the evolutionary development of a new frontier away from Earth. The Master of Science in Space Studies gives students a working knowledge of these disciplines so they may become the scientists, engineers, planners, managers, troubleshooters, negotiators and communicators of the space community.

University of Colorado at Colorado Springs (UCCS): Master's Degree in Space Studies in Science Education.

SLEC-P: SLEC-P assigns select AF officers to a ten-month fellowship (one year for civilians) with civilian institutions and defense companies. During this time, the student is immersed in management methods, industry organizational structures, and state-of-art technologies which will benefit them in future AF leadership positions.

United States Air Force Academy: The Academy provides space-related engineering opportunities for officer candidates in their department of Astronautics. The goal is to graduate officers with a fundamental knowledge of orbital mechanics, space environment, attitude control, telecommunications, space structures and rocket propulsion to solve astronautical engineering problems.

Center for Space and Defense Studies: Located at the U.S. Air Force Academy, its mission is to provide an intellectual foundation for the integration of space policy in the overall national security policy of the United States, define the curriculum for space policy studies in higher education and produce successive generations of Air Force officers with a vocation for space. The CSDS hosts an annual forum on Space and Defense Policy, is authoring a textbook on space defense policy, and is establishing internships for USAFA cadets with NASA, NRO, and AFSPC.

United States Naval Academy: The Naval Academy provides engineering opportunities for officer candidates in Aerospace Engineering. The program is structured to produce naval officers who will meet the challenges of serving in the areas of naval aviation and space. Students in the aeronautics track will study aerodynamics, structures, propulsion, and flight vehicle performance. Students in the astronautics track focus on the space environment, astrodynamics, spacecraft systems, and spacecraft attitude dynamics and control.

SUMMARY

Together, these institutions and their course offerings fulfill the current depth and breadth requirements mandated by the Services and other space organizations. Numerous processes and affiliated organizations are in place e.g. Joint Space Academic Group (JSAG) and SEC to adapt to changing DoD requirements.

Chapter 4 Competencies and Skill Levels

As the Services continue to build and implement their own unique versions of a National Security Space Human Capital Strategy, they first had to determine the purpose and functions of their respective space cadres as outlined in Chapter 2 of this report. Each is now busy translating this work into the specific knowledge and skills needed by cadre members in order to carry out the roles and missions assigned to them. While analysis is still ongoing by the Services, the Air Force, as EA for Space, has already conducted quite a bit of research on the subject of core competencies and skill levels for DoD space professionals.

In terms of practical application, competencies are formulated into educational objectives for the initial and follow-on space cadre qualification courses (e.g. Space 100, 200, 300, FA40, SMC Acquisition School, etc) as appropriate to each Service. With regard to the Committee's specific reference to systems engineering, program management and financial management, these competencies are dictated first and foremost by the requirements of DAWIA with course content provided by the DAU. These mandated courses are not specifically addressed in this report; however, additional acquisition instruction is included in the space professional qualification courses to highlight the unique challenges of procuring space systems relative to other military programs.

Space Professional Competencies	Space 100	Space 200	Space 300
Space Science - Applies principles of physics, chemistry, and the environment including astrodynamics, orbital mechanics, and physical features to space operations and space systems.	X	X	
Evolution of Space Programs and Organizations - Knowledge of the history of space organizations and key programs to include the U.S. Military and Intelligence Community, civil and commercial sectors, and foreign space efforts.	X	X	
Space Development and Acquisition - Understand the processes utilized in the design, development, procurement, testing, deployment and acquisition logistics of space programs.	X	X	X
Space Mission Areas - Knowledge of mission areas to include Force Application, Force Enhancement, Space support and Space Control, and the systems that support each mission.	X	X	X

Space Professional Competencies	Space 100	Space 200	Space 300
Value of Space to User - Knowledge of the utility and effect of space systems and the information and services they provide at the international, national (to include military intelligence, civil, and commercial levels) and local levels.	X	X	X
Space System Design - Knowledge of the space system design and that of the subsystems or components.	X	X	X
Space Policy, Doctrine and Law - Understand the policies, doctrines, and laws governing operation and employment of U.S. space programs to include the National Security Space Policy, applicable Presidential Directive, U.S. laws as well as international laws and treaties. Understand the roles and relationships of and among organizations such as the Departments of State, Defense, Commerce, and Transportation, the Congress, United Nations, and foreign governments.	X	X	X
Space Systems Architecture - Knowledge of the content and structure of a system's architecture and how it is developed.	X	X	
Sustainment - Knowledge of various space system sustainment processes and procedures as they relate to the system's life cycle. Include initial logistics planning associated with systems under development, varied sustainment practices related to ICBMs, launch vehicles, satellite ground stations, on-orbit space vehicles and ground-based sensors, software maintenance practices and the role of industry/contractors in space system design.	X		
Information Technology - Knowledge of networks, infrastructures, programs and applications/utilities, and communications transfer.		X	X
Contract/Contractual Workforce Management - Understands the various types of contracts and has the ability of correctly complete contractual actions within legal, regulatory and ethical constraints. This includes financial and business management as well as the ability to interact with contractors.	X		
Space Operations Environment - Understands the operations chain of command, the reporting responsibilities for various situations, and how to utilize operations discipline to execute the mission.	X		

Space Professional Competencies	Space 100	Space 200	Space 300
Financial Management - Uses various techniques and systems, applying knowledge of public law, funding policy, congressional authorizations and appropriations, PPBS systems and contractor reports to formulate, execute, and coordinate program office budget with internal and external customers.	X	X	
Program Management - Knowledge of and the ability to manage all areas of acquisition; ability to manage people and properly and effectively interact with all levels across organizations and agencies.	X		
Systems Engineering - Knowledge of the science, technology, processes, and procedures throughout a system's life cycle, and the progression through the acquisition milestones.	X	X	
Test and Evaluation - Knowledge of the management and engineering principles, policies, and practices used by the DoD to ensure the systems under development or in operation meet the defined requirements. Ability to identify and establish the performance of a new system using the appropriate tools of test development including Test and Evaluation Basic Plans, test reports, test integrated product teams, and operational test and evaluation using systems simulations (including live fire operational testing).	X	X	
Logistics Planning - Knowledge of policies, constraints, and other considerations affecting logistics planning and integrated product and process development, including Integrated Logistics Support Plan.	X	X	
Operations Concept Translation - Knowledge of the operational concept within which the system that is being procured will be employed. Knowledge of the operational interfaces and procedures that drive design requirements.	X	X	
Operations Planning - Plan and detail key events in a system's lifetime, such as testing, launch, early orbit checkout, routine operation, and end-of-life activities.	X	X	
Systems Knowledge/System Integration - Knowledge of specific technology inherent in a particular space or missile system.	X	X	
Operational Testing - Knowledge of the deliberate and precise means by which modifications and repairs are made to an operational system, while minimizing impact to the mission.		X	
Training and Standardization/Evaluation – Develop, execute, and plan training and evaluation plans and programs.		X	

Space Professional Competencies	Space 100	Space 200	Space 300
Support Infrastructure - Knowledge of system infrastructure to include facility/base support, physical and information security, contracts, human resources, and networks.		X	
Campaign Planning - The process and procedures used by a joint Combatant Commander to plan for the conduct of military operations in response to requirements established by the Chairman, JCS.		X	
Tactics, Techniques, and Procedures Development - Knowledge of the creation, validation, and implementation of tactics, techniques and procedures to address the role of the Space Innovation and Development Center, 14th AF, the Command and Control Training and Innovation Group, and Tactics Review Board and other organizations in the TT&P processes, including understanding the processes involved in Wargaming, TENCAP, ACTDs and other capability prototyping activities.		X	X
AF/Joint Doctrine Development - Knowledge of both the Air Force doctrine and Joint doctrine relevant to effective space systems planning and integration.		X	X
Air Operations Center Operations - Knowledge of the inner workings of an AOC, including the organizational structure; planning; execution processes; timelines; and interfaces with other organizations and agencies.	X	X	
Command and Control Relationships - Addresses these various relationships, including the meaning of each, who can establish the appropriate relationships and restrictions inherent in each.	X	X	
Intelligence Preparation of the Battlefield - Understanding and executing space's role in the IPB process, including how these systems are tasked and respond to the IPB functions of: (1) defining the battlefield environment; (2) describing the battlefield's effects; (3) evaluating the threat; and (4) determining the threat's courses of action. Also included developing the Blue, Red and Gray Space Orders of Battle.		X	
Campaign Logistics Planning - Planning and executing the deployment of space forces near/into the Joint Operations Area, including mobility, bed-down, and continuing sustainment issues.		X	

Table 1. Representative DoD Space Professional Core Competencies and the applicable NSSI and AETC space professional courses in which they are taught

Once educational competencies are mastered, the attendant skills are developed through repetitive training, exercises and longevity in the job (i.e., experience). Generally speaking, mandated skill levels are dictated by rank and by individual position. The Services are currently evaluating and refining their requirements via a billet-by-billet review.

Army Core Competencies and Skills: similar to Table 1, the Army also applies a systematic process to developing space cadre core competencies and the attendant education and training that meets these requirements. Courses such as the FA40 Space Operations Officer Qualification Course base core competency requirements on precisely articulated tasks, conditions and standards. These training statements supported by terminal and enabling learning objectives and performance steps translate into specific course Programs of Instruction which guide course content. The 2006 annual Critical Task Selection process applied to the FA40 course validated the Tasks and Performance Steps contained in Appendix 5.

Chapter 5

Conclusions and Recommendations

The 2001 Space Commission Report prompted a rapid expansion of space education and training. Many new courses have been developed and new institutions formed,. New relationships and consortia are emerging to further the education of all DoD space professionals. Space education and training are areas that will benefit greatly from cooperation across the DoD and civil space institutions, agencies and corporations. Based on evolving Service requirements, the amount and type of space education and training programs must be geared to raise the technical competency of our DoD space professionals. As missions become more complex and requirements evolve, the need for more specialized academic programs will likely emerge, not only for the individual Services, but also for OSD, Joint and Combatant Commands, and a number of other government organizations. As a result, periodic reviews are necessary to ensure all forms of space instruction remain current and relevant to DoD roles and responsibilities.

For now, the three biggest challenges for space organizations are: (1) securing an adequate budget to send students to all of the mandatory and desired selective space instruction; (2) deconflicting work schedules to allow students the necessary time to attend important classes (some courses last several months); and (3) securing adequate funding, manpower, and facilities to meet all Services' throughput requirement at the National Security Space Institute (NSSI) (an alternative to limited NSSI in-residence capability is a robust distance learning capability). While these are not insignificant obstacles, careful planning and a strong commitment by senior leaders can help overcome the barriers.

Cooperation in space education and training is at an all-time high. For example, the DoD EA for Space chairs two forums that help share best practices and eliminate duplication of effort across the space professional arena. First, the Space Professional Oversight Board (SPOB) holds regularly scheduled meetings to review each Service's progress in developing their cadre and to discuss other DoD space workforce issues. The JSAG, is chartered to review and validate advanced space degree requirements and to minimize redundancies between the AFIT, NPS and other academic institutions of higher learning. Another group designed to recommend, develop and provide academic solutions to meet space knowledge requirements is the SEC. Together, these three forums are poised to keep DoD space instruction on the cutting edge in the decades to come.

The Air Force, with approximately 9,000 space cadre members, has made significant progress in identifying educational requirements identification and funding for space education and training. The Air Force education needs assessment (Appendix 2) focused on establishing a knowledge baseline for all space officers. This, in turn, resulted in SEC program development in response to those requirements. AFIT and NPS are also exploring additional avenues to provide innovative education programs to space professionals and are fostering cooperation with the SEC. Separate Air Force enlisted and civilian educational requirements must follow, but will continue to be a challenge in the current fiscally-constrained environment. For now, the continuum of space education (Space 100, 200 and 300) available to all the Services is a giant step in the right direction and represents a significant accomplishment. Cooperation among the Services and agencies with the NSSI is clearly evident – students from the Army, Navy, Marines, NASA

and NRO not only participated in the development of Space 200 and 300, they regularly attend both courses.

The rapidly growing demand for NSSI class seats and new courses warrants the focused attention of the whole space community. As their reputation for creating and delivering top-quality space instruction flourishes, their funding, manpower and classrooms are quickly becoming stressed. If the trend continues for the Services and other government space organizations to use NSSI for portions of their cadre qualification and unique space training, a review may be necessary to determine if the scope of their mission and resources is adequate to the task. The presence of well-qualified personnel from all Services on the NSSI staff would ensure a joint teaching perspective, while offsetting the manpower shortfall. Addition of a robust distance learning capability would increase student throughput. As the parent agency, AFSPC should continue to closely monitor class usage and report this metric to the SPOB as part of their annual update.

The Services will also need to determine goals for both undergraduate and graduate level education. Although NSSI has provided significant opportunities for education, the programs there do not address the requirements for space-related and technical undergraduate and graduate degrees.

In summary, DoD space education and training programs are currently meeting emerging needs. While far from robust, the trend is continuing upward. With the solid review processes and procedures already in place and with aggressive resource allocations, current and future space cadre members can depend on world-class space instruction throughout their careers.

Appendix 1 Congressional Language

From Title V of Conference Report 108-767, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 [To accompany H.R. 4200], October 8, 2004.

Space Cadre (Report pg 663)

The conferees appreciate the submission by the Secretary of Defense of the human capital resources strategy for space personnel, as required in section 547 of the *National Defense Authorization Act for Fiscal Year 2004* (Public Law 108–87). The conferees note, however, that the strategy lacks a detailed implementation plan and direct the Secretary to develop such an implementation plan. The conferees further direct the Secretary of Defense to submit this plan and the Secretary of the Air Force to submit the detailed career planning guidance for the Air Force space cadre, consistent with direction in the Senate report accompanying S. 2400 (S. Report. 108–260).

The conferees believe that a comprehensive view of the military space community must also consider competencies and skills embodied in academia and industry. These institutions have valuable tools, expertise, and a skill base that contribute to the military space community, as well as unique organizational cultures with which the military space cadre must interact. The conferees are concerned that the human capital resources strategy lacks breadth and depth with respect to the relationship of academia and industry to the development, education, and training of the space cadre.

The conferees direct the Secretary of Defense to provide the Committees on Armed Services of the Senate and the House of Representative a full report that: (1) assess the ability in academia, industry, and government to educate and train a community of space professionals; and (2) recommend corrective actions to address any shortfalls identified in these education and training activities. The report should also address the definition and development of key competencies and skill levels in the areas of systems engineering, program management, financial management, operations and tactics, and any other areas deemed necessary by the Secretary of Defense as they relate to military space systems.

Appendix 2 Air Force Education Needs Assessment

I. Executive Summary

As the Space Professional Development Program (SPDP) continued to evolve, the need to identify—and eventually satisfy—the educational needs of the Credentialed Space Professional Community (CSPC) became increasingly more critical to the long-term success of the program. To do this, Air Force Space Command (AFSPC) Space Professional Management Office (SPMO) representatives interviewed senior Air Force space leaders to determine if those educational needs could be translated into a common baseline of knowledge, its content and depth, and the appropriate timing in each CSP's career.

The focus of this keystone effort was on CSPC officers. The results of this assessment will serve as a point of departure for determining the educational needs of enlisted and civilian CSPs.

Although a consensus was not reached on all accounts, identification of several common themes surfaced from the wide variety of perspectives and opinions. The overall findings composed from the interviews are:

- A knowledge baseline is required.
- Changes in accession prerequisites are not required.
- The baseline should be achieved relatively soon after entry on active duty.
- Flexibility should be a key element of baseline achievement, allowing CSPs to tailor competencies while fulfilling qualifications.
- Link broader educational competency and the hands-on application of this knowledge in real world settings.
- Be careful not to overload CSPs with too many educational, training and mission requirements.

Determining baseline content and depth was more challenging. The general consensus cited the need for a technical requirements baseline, i.e., engineering, calculus and physics; while policy, doctrine and law were cited less frequently. The baseline should be space-focused, highlighting the unique aspect of space systems operation, acquisition and sustainment. Another recurring theme was the need to integrate warfighting applications with academic knowledge. As warriors, future space professionals must know how to — think, react, understand and engage their systems against a thinking opponent.

SPMO presented the following recommendations:

Establish an initial space certificate program to ensure a CSP educational baseline. The certificate program should allow flexibility in satisfying requirements and tailoring to individual CSP's educational background while providing a space perspective. Students would choose course options from five categories: theatre applications, technical, systems engineering, system lifecycle and space's role in national security.

Establish a four year cutoff for completion of the initial space certificate program. This will ensure completion of baseline requirements in a timely manner while avoiding conflict with Developmental Education and Space 200.

Establish an advanced space certificate program. This program would further develop CSPs who possess the necessary qualifications upon entry on active duty or through completion of higher-level courses in the initial space certificate program.

Categorize Space Professional Certification Program educational standards as "expected" versus "desired". Communicate to the CSPC the importance of continuing education and space-related degrees to mission needs and personal development.

Maximize use of opportunities for AFIT and NPS programs. Student slots are available each year for several programs at no cost to the command. However, availability of personnel for 18-24 month programs constricts student throughput.

As potential actions, the SPMO will work with key space leaders and the educational community to define the depth required for the initial certificate program. In addition, SPMO will develop a management process to determine individual requirements, validate credentials and document achievement of the education baseline. Other potential actions:

- Determine educational requirements for the enlisted and civilian CSPs.
- Determine funding options for the education programs.
- Explore expansion of Space 100 or adding academics during initial training at Vandenberg AFB.
- Conduct periodic research to validate course content and timing.
- Establish metrics to measure accomplishment of objectives.
- Assess aptitude for space duty via existing tests (i.e., AFOQT) or a "space aptitude" test as recommended by 381st TRG.
- Interact with Air Force Officer Accession and Training Schools to increase candidates' awareness of baseline requirements.
- Create alternatives for completion of baseline requirements by those entering the CSPC later in their careers.

The United States needs creative, energetic, and well-educated professionals to ensure unopposed national supremacy in space. Therefore, our CSPs must be grounded in science and management principles unique to space operations, acquisition and sustainment. In short, they must possess the intellectual capacity and agility for timely decision making, innovative problem solving, and critical thinking. Translated into effects

for the warfighters, these intellectual capabilities will result in better system design, more effective time-sensitive operations, and enhanced effects-based capabilities available to national decision-makers.

Appendix 3

Air Force Space Professional Education Follow-Up Survey

I. Introduction

In March 2005, the Air Force Space Command (AFSPC) Space Professional Management Office (SPMO) completed an educational needs assessment for officer Credentialed Space Professionals (CSP) based on interviews of senior Air Force space leaders. Key elements of SPMO's recommendations:

Establish an *initial space certificate program* to ensure a CSP educational baseline, allowing flexibility and tailoring to individual CSP educational backgrounds. Categories: Technical (math, science, engineering), Systems Engineering, System Lifecycle and The Space Role in National Policy.
Establish a *four year cutoff* from entry on active duty for completion of the initial space certificate program.
Establish an *advanced space certificate program* to further develop CSPs who have met the initial space certificate program requirements.

As a follow-up, the SPMO conducted an educational survey with selected CSP officers to fine-tune the recommendations and provide additional detail for program development by space education institutions.

II. Approach

SPMO representatives developed a survey that sought CSP inputs on the *importance* and *knowledge level* required in space-related subject areas from the needs assessment categories. The survey (Attachment 1) asked CSPs to rate the importance of specific areas on a 1-5 scale and then rate the associated level of knowledge for these areas as low, medium or high. The survey included space for comments on each item. SPMO consolidated the responses and converted them into numeric values for comparison to determine appropriate subject areas for the initial space certificate program.

SPMO transmitted the surveys via e-mail to 400 field grade CSP officers in August 05. The target number for responses to determine course content was 150. The addressees were randomly selected using a Visual Basic for Applications program which was randomized each time the program was run. This ensured the sequence generated was different each time. SPMO generated two random selections proportional to the population of the CSP Community (CSPC)--40% of the addressees were 6X officers, 60% were 13SX. The SPMO also reviewed the addressees' organizations to ensure that individual units did not have a disproportionate number of respondents. Due to inadequate responses to the initial e-mailing, SPMO retransmitted the survey to the same addressees in September with a new suspense. A number of addressees had difficulty opening the survey in its original format. As a result, SPMO e-mailed an additional 200 reformatted surveys to new addressees in October to increase the number of responses. As of 5 November 05, the final deadline, 133 responses had been received. Those responses were used as the basis for the findings below.

III. Findings

The results of the survey are illustrated in Attachment 2, including respondents' comments. In several instances the respondents rated areas as important, but only in a job-specific context that did not apply across the entire CSPC. The number of comments was minimal, and several respondents applied their comments across all subject areas, diffusing the focus. Some respondents also provided general comments (Attachment 3). The key emphasis subjects for each of the initial space certificate program areas are highlighted below, using cutoff scores of 3 for Importance and 2 for Level of Knowledge (some values were rounded).

- Technical/Math: Algebra, Business Math, Probability and Statistics, Trigonometry
- Technical/Sciences: Basic Physics, Astrodynamics, Electromagnetics, Optics/Remote Sensing, Weather
- Technical/Engineering: Astronautical, Computer Science, Electrical
- Systems Engineering: Project Management, Systems Engineering Process, Engineering Management
- System Lifecycle: Program Management, Acquisition, Test and Evaluation
- Space Role in National Policy: Doctrine, National Security Strategy, Domestic Laws and Policies, International Law

IV. Recommendation

Working in conjunction with the SPMO, the Space Education Consortium (SEC) should develop an initial space certificate program that addresses the needs identified by the survey. SPMO will develop implementation guidelines for the certificate program and assist the SEC by disseminating program information and guidelines to the CSPC. The SEC, the Air Force Institute of Technology or the Naval Postgraduate School could develop advanced certificate programs, depending on each organization's priorities.

Appendix 4

Current Space Education and Training Courses

The following pages provide a representative listing of civil, military and commercial institutions that provide education and training programs to DoD space professionals.

Course Name	Course Description
315 Training Squadron	
XXAAL1N1X1 0A7A - Offensive Missiles and Space Systems, Joint Imagery Analysis	Provides training for Air Force and other DoD and U.S. Intelligence Community personnel in the knowledge and skills necessary to perform duties as accomplished imagery analysts. Provides intermediate imagery analyst training on intercontinental ballistic missiles.
533 TRS	
V3AZR1C651 0E1A – Enlisted Space 100	Course Description: This course provides prerequisite career field training for enlisted in the basic knowledge needed to develop, acquire and operate space systems. Includes an introduction in career paths, organizations, technical space fundamentals, doctrine and history. The students receive an orientation in three of the four mission areas: Force Enhancement, Space Support and Space Control. Required for Space Professional Level 1 Certification.
392 TRS	
V3OQR13S1X 0A1A – Prerequisite Officer Space 100 (Space Operations Officers) V3OZR13S1XOA1A – Supplemental Officer Space 100 (Acquisition Officers)	Course Description: This course provides prerequisite career field training for officers in the basic knowledge needed to develop, acquire and operate space systems. Includes an introduction in career paths, organizations, technical space fundamentals, doctrine and history. The students receive an orientation in three of the four mission areas: Force Enhancement, Space Support and Space Control. Required for Space Professional Level 1 Certification.
Aerospace Institute	
Business Case Analysis for Space Systems	Government/industry space system partnerships require an understanding of the partner's business case in order to mitigate risk. The tutorial covers basic market research, cost engineering and financial analysis, and provides the building blocks for development.
S1011 - Aerospace Roles in Space Systems, Architecting, and Engineering	Topics include: Customer needs and the Aerospace technical mission. Aerospace systems engineering job: what, why, who? Aerospace's role in: Systems architecture, acquisition management and development, space systems engineering management.

S1030 - Defense and Intelligence Systems Acquisition Overview	Interactive lectures by company technical experts on topics such as: Acquisition management (DoD 5000, Directive 7, agency, and commercial acquisitions), Analysis of alternatives(AF), Budgeting, Requirements generation, Modernization, Technology injection.
S2010 - Concept Development	Provides an in-depth look at the methods, tools, organizations, and points-of-contact associated with the concept development process. Key topics include: Mission Definition, Space Environments, Architecture alternatives, Requirements Allocation.
S2020 - Space Systems Design	Describes the space systems design process, how it fits into the space mission time line, and how requirements flow between the vehicle payload, spacecraft, and ground system. Focuses on interactions and dependencies between subsystems.
S2030 - Space Systems Development, Integration and Test	Topics include: Hardware development cycle, Software development cycle, Integration and test system perspectives, space systems test assessment, test requirements and guidelines, satellite integration and test process, program risks and reliability.
S2040 - Space Systems Operations	In-depth description of space and launch vehicle operations and ground systems. Key topics include: launch system and processing at the major launch sites, systems operational effectiveness, space assets, satellite processing/on-orbit activities.
S3000 - Team/SMC Aerospace	Topics include: the unique space business at SMC and the organizations, authorities, and people in acquisition, the Unique team - goals, expectations, and frustrations. The changing environment and its effect on roles. Business perspectives. Shared operations.
S3010 - Introduction to Program Office Roles and Processes	Introduction to the space system political and physical environment. Critical processes, including: Mission partner collaboration in systems engineering, System performance/requirements management, risk management, verification and test management, cost analysis.
S3020 - Intro to Program Office Data and Controls	Topics include: Constructing the program baselines, Defining government-contractor involvement, Having it in writing - contractors and contract changes, Information to manage the program, Independent SPO work, Shared information, Providing feedback to contactors.
S3030 - Requirements Engineering Management	Topics include: AF integrated planning process and requirements generation system. Mission needs. Operations requirements and concept of operations. Technical Requirements Document (TRD). System specifications and interface requirements.
S3040 - Risk Management	Review of Risk Management processes: - Program Requirements for risk management; U.S. laws and regulations, DoD 5000, Directive-7, others - Determining program RM objectives -Risk identification and assessment -Risk management models and resources.

S3050 - Cost and Schedule Engineering Management	Providing integrated assessments of cost, schedule, risk, and performance are increasingly required to support our customers. This course will specifically address the cost and schedule-related issues from a management standpoint.
S3060 - Space Systems Test Management	Topics include: Practical aspects of test program management, Issues and drivers associated with testing, Insight into test strategies and processes for all aspects of space systems. How to determine whether a test should be performed.
S4210 - Introduction to Global Positioning System	History of navigation. Overview of GPS system. Orbits, reference frames, and station-keeping, GPS signal description and introduction to GPS receivers. GPS data message. GPS navigation, GPS clocks and time, GPS applications, GPS lab class.
S4320 - Cost Estimation and Analysis	Introduces the foundations, methods, specialized jargon, and applications of cost estimation and analysis of space, launch, and ground systems. Describes the type and significance of historical cost data available to the analyst.
S4325 - Cost Risk Analysis	Course presents the state of the art in all aspects of cost-risk analysis. Topics include: Statistical method of rolling up costs of individual work-breakdown structure (WBS) elements into a total system cost. Correlation among WBS-element costs.
S4340 - Earned Value Management	Covered areas include how EVMS fits into the entire "cost continuum" of acquisition costing. - The cost continuum begins with cost estimating and cost-risk, which transitions to cost analysis and database creation.
S4411 - Software Acquisition and Software Engineering in Today's World	Focuses on software acquisition for DoD software-intensive systems in general and the current SMC and NRO acquisition environments in particular. Covers the entire system life cycle, from mission need identification through system retirement.
S4500 - Spacecraft Payloads Review	This course reviews payloads on a number of spacecraft. Topics include: Missions to be performed. Types of instruments used. Impact on spacecraft bus design. Topics on a number of spacecraft, both the large prestige systems and smaller vehicles.
S4600 - Art and Science of Systems Architecting	Provides an understanding of the core ideas of systems architecting. Features case studies demonstrating the architect's role. Lays out the models and views used in architecting. Specifically examines applications to distributed systems-of-systems.
S4610 - Aerospace Systems Architecting Program	Provides an enhanced understanding of national security systems architecting concepts, methodologies, and players. Teaches basic skills in the application of systems architecting methodologies and resources to very ill-defined, multi-faceted problems.
S8180 - Applications of Physics to Mathematics	Advanced Space System Concepts for 2000-2030.
T1010 - Computer Systems Technologies	Lecture series on new technology aspects of computer systems highlights, Consists of one-hour,

	standalone sessions, each devoted to a single computer technology topic.
T1030 - Communication Systems Technologies	Highlights emerging technologies, architectures, and concepts in the very active commercial and military communication arenas. Consists of one-hour, standalone sessions, each devoted to a single communications technology topic.
T1050 - Collocation of Geostationary Satellites	Provide an overview of conventional station-keeping strategies and a detailed assessment of strategies that can be used for efficient management of collocated satellites. It will provide case studies of various techniques.
T1115 - Global Positioning System for Attitude Determination	Review of GPS principles. Approaches to measuring attitude. Ambiguity resolution. Augmentation with other sensors (IMU, magnetometer, others) Estimation and filtering.
T1150 - Introduction to Gravitation	This course provides an elementary introduction to General Relativity, with application to GPS, astrophysics and cosmology. A brief introduction to various approaches to quantum gravity will also be given.
T1160 - Space Environment and Space Environment Hazards	An overview of the range of environments, the impacts of these environments on satellite operations, and lessons learned by satellite builders and operators. Case studies and in situ observations will be discussed to illustrate hazards and mitigation strategies.
T2011 - Introduction to Space Communications	An overview of space communications systems and technologies in the context of global (terrestrial and space telecommunications. Discusses background and evolution of major functional aspects of telecommunications leading up to contemporary space systems.
T2030 - Digital Communications & Spread Spectrum	This course provides comprehensive coverage of digital communications. Topics include: Signals and spectra -Modulation/demodulation -Coding/decoding -Multiplexing and multiple access -Packet switching -Quantization -PCM -Encryption/decryption.
T2031 Advanced Digital Communications	Focuses on advanced studies in digital signaling methods, error-correction coding, spread-spectrum techniques, and bandwidth-efficient signaling for high-rate and bandwidth-limited channels. Deals with wireless systems, telephony and satellites.
T2035 - Spread Spectrum Systems	The explosive growth of Personal Communication Systems (PCS) has provided a new impetus to the development of spread spectrum techniques for the inherent potential for capacity advantage.
T2110 - Traveling Wave Tube Principles	Gain a top-level working knowledge of traveling wave tube (TWT) design and manufacturing practice, and spacecraft interfaces.
T2120 - Microwave Principles and Applications	This course provides a top-level working knowledge of microwave theory and practice. Emphasizes practical applications and addresses theoretical principles. Provides descriptions of various microwave and millimeter-wave components.

T3120 - IR Systems and Technology	Topics include: IR phenomenology (targets, backgrounds, and atmospheric effects) systems design, Focal planes, Active and passive cooling, Focal plane testing, IR System Simulation, Performance analysis
T4030 - Object-Oriented Overview	This course gives an overview of OO technology and its programmatic impact. Explains how an OO approach differs from traditional software approaches. Provides exposure to OO concepts and underlying principles.
T4032 - Object-Oriented Concepts and Applications	This course gives practical knowledge and experience with OO, design, concepts, methods, and applications. Presents techniques for effectively communicating OO designs to others. Features realistic exercises to give you firsthand experience.
T4040 - Reviewing Unified Modeling Language (UML) Work Products	This course provides engineers with a set of review criteria for assessing the quality, completeness, and consistency of object-oriented models created in the UML.
T4210 - DoD Information Security	Purpose of course is to describe some of the circumstances that can lead to unauthorized use or abuse of information systems. Survey existing information security technologies and practice. Describe information security policies that apply to SMC and NR.
T4220 - Cryptography: Theory and Practice	Introduce the basic concepts of modern cryptography. Present example algorithms and protocols. Show how crypto is acquired and used in space programs. Mention some new directions for cryptography.
T4310 - Practical Software and System Measurement	Introduces the PSM issue-driven measurement process for systems and software. Includes practical, hands-on exercises in measurement selection, tailoring, and application. Topics include: The significance of measurement, Overview of the PSM approach
T6010 - Elements of Homeland Security	This course provides an overview of these issues, the nature of the new threats involving terrorist use of WMDs and challenges and opportunities for Aerospace that arise from the changing defense focus.
T6020 - Biological Weapons and Warfare	The course addresses the technical and operational issues involved in developing and employing biological weapons. It also will review ongoing efforts by several agencies in the area of proliferation control, protection, and consequence management.
T6030 - Chemical Weapons and Warfare	This course addresses the technical and operational issues involved in developing and employing chemical weapons. It will also review ongoing efforts by several agencies in the area of proliferation control, protection, and consequence management.
T6040 - Nuclear and Radiological Weapons and Warfare	Nuclear weapons remain a basic concern of U.S. nonproliferation efforts. In addition, radiological weapons (conventional explosives surrounded by residual radioactive materials) can cause considerable fallout damage. Nuclear effects are also of concern

T7210 - Orbital Mechanics	Emphasizes Earth-orbiting satellites. Covers practical methods for solving orbital mechanics problems related to mission planning, design, and analysis of orbital systems. Topics include: Two-body problem, Orbits and orbit changes
T7220 - Spacecraft Attitude Dynamics and Control	Provides a basic understanding of the spacecraft attitude-control concepts and design approaches. Learn to interpret kinematics and dynamics of angular motion, evaluate effects of environmental torques on system performance, and select design approaches.
T7230 - Attitude Determination Systems	This course is an introduction and overview of spacecraft attitude determinations. It describes, on the hardware side, the main types of attitude sensors, including Sun, Earth and star sensors, several types of gyroscopes, and the use of GPS receivers.
T7240 - Space Systems Overview	Includes a technical orientation to some of the major space systems supported by Aerospace. Discusses some of the key subsystems and their interactions. Describes the Aerospace space systems engineering capabilities and resources.
T8120 - Introduction to Wavelets	Wavelets, Introduction.
T8130 - Precision Pointing Systems	This course covers the main control and control structures interaction issues involved in the precision pointing of space payloads (typically optical payloads). Attention is given to analytical and hardware aspects.
T8140 - Nonlinearity Analysis and Applications	Discusses methods of analyzing nonlinear systems and properties of some specific models. Provides examples and applications drawn from the fields of mechanics, control systems, signal processing, and communications.
T8150 - Applications and Number Theory	This course will review some aspects of number theory that are important for applications. Topics include: Classical applications of number theory to cryptography, computing, and signal processing. Links between analysis and number theory.
T8160 - Geometrical Aspects of Dynamics	Review the application of differential geometrical ideas in mechanics. Applications include: group methods in kinematics and dynamics, algebras in perturbation theory.
T8170 - Statistical Physics Review	
The Space Environment and Spacecraft Environmental Hazards	The effects of the space environment on satellites can vary from subtle to profound. Sensor degradation, subsystem failures, loss of data, latch-ups, and even loss of mission can result from radiation, cosmic rays, and high-energy particles.
AFIT	
AERO 622 – Introductory Hypersonics	Characteristics of hypersonic flow and assumptions underlying hypersonic flow theories. Small disturbance and surface inclination methods. The equivalence principle, blast wave methods, low density aerodynamics, high temperature aerodynamics and reentry trajectories.

AERO 698 – Graduate Seminar in Aeronautics and Astronautics	Current problems and solutions in the design of Air Force aeronautical and astronautical systems, by representatives of USAF agencies and the aerospace industry.
AERO 999 – Dissertation Research	Topic for dissertation research is selected from a wide variety of problems of current interest to the Air Force. The results of the study are reported in a dissertation written under the supervision of a member of the department faculty and are defended in a formal oral defense.
CHEM 675 – Upper Atmospheric Chemistry	Physics and chemistry of the upper atmosphere, of which the ionosphere is a vital and integral part of this region. A variety of processes that operate in the upper atmosphere will be identified and related to input and output parameters by detailed mathematical and physical descriptions of the processes.
CSCE 525 – Introduction to Information Warfare	Defines Information Warfare (IW) and its ramifications for information security and assurance. Understanding of C4ISR (command, control, communications, computing, intelligence, surveillance and reconnaissance), the relationship of EW (electronic warfare) to C2W (command and control warfare) and IW, active and passive IW, information operations, deception and PSYOPS.
EENG 529 – Remote Surveillance	Presents models and methods required for and used in remote surveillance systems, such as satellite-based sensors and processors that acquire and recognize patterns in ground imagery.
EENG 532 – Introduction to Radar and Synthetic Aperture Systems	Provides the basis for understanding radar systems, including conventional range-azimuth, Moving Target Indicator Doppler, synthetic aperture, phased-array, bistatic, and over-the-horizon radars. MASINT by signature exploitation of radar cross-sections and wideband signal interpretation.
EENG 533 – Navigation Using the Global Positioning System	User position and velocity relative to the local navigation frame of reference (latitude, longitude, altitude, and their time derivatives). Basic properties, navigation solution theory, satellite orbits and positioning, signal structure, code generation, code correlation, receiver design, ranging errors, geometrical errors, differential GPS, relative GPS, and carrier-phase GPS.
EENG 535 – Radar Systems Analysis	This course covers all aspects of basic radar from a systems viewpoint, beginning with the definition and concluding with signal processing.
EENG 536 – GPS Laboratory	Hands-on laboratory with variety of GPS receivers and data collection systems. Write MATLAB programs to perform such tasks as calculating satellite orbits, evaluating satellite coverage, calculating position and clock error from pseudorange measurements, and performing differential positioning.
EENG 538 – Synthetic Aperture Radar MASINT Lab	Calculation and demonstration of radar cross-sections for simple and composite targets and synthetic aperture scene generation. Demonstrations and experience with X-Patch and Case Executive radar data exploitation tools and techniques,

	including quality control and verification, digital elevation map gridding, orthorectification, and multi-color displays.
EENG 571 – Satellite Communications	Modern communication principles with emphasis on applications to satellite and space communication systems. Modulation, signals, multiplexing, demodulation, multiple access, coding, orbits, look angles, satellite hardware, earth station hardware, and link analysis.
EENG 574 – Command, Control, Communications, and Computer C4 Warfare	Command and control is treated as a problem in generating, transferring, and managing information. Fundamental communication engineering theories and techniques, satellite, terrestrial, ionospheric, and optical communication systems; radar, infrared, electro-optical, and electronic combat systems; Army, Air Force, Navy, Marine, and Joint tactical and strategic communication systems and their performance in recent conflicts.
EENG 625 – Antennas I	Electromagnetic field produced by known source distributions, and fundamental antenna concepts such as gain, reciprocity, equivalence, duality, polarization and radiation pattern. The behavior of dipoles, loops, and wire antennas. Arrays of identical antennas. Aperture antennas, including horns and reflectors, and their feed structures.
EENG 631 – Advanced Antennas	Transform methods for analyzing antennas. Broadband and frequency independent antennas, such as biconical, bow-tie, traveling wave, spiral, and log-periodic antennas. Frequency domain analysis, time domain techniques, including solving Maxwell's Equations in the differential time domain form.
EENG 633 – Advanced GPS Theory and Applications	A precise description of each of the GPS observables, with an emphasis on differential positioning. Real world error sources, including satellite position, ionospheric, tropospheric, multipath, and receiver measurement noise errors. Receiver design and signal processing methods used by GPS receivers. Current literature and laboratory projects provide enhanced insights into GPS receivers and systems.
EENG 635 – Inertial Navigation Subsystems	Space stabilized, local level and strapdown configurations. Perturbation techniques in the derivation of unified INS error models. Earth's gravitational field model. Advantages/disadvantages of various configurations. Methods of system alignment. System response to inertial instrument errors, initial misalignments, and other sources in frequency and time domains
EENG 700 – Seminar in Remote Sensing and Communications Systems	Student-participation seminar in the areas of antennas, propagation, electromagnetics, microwaves, communications, information and coding theories as applied to the broad areas of remote sensing and communications systems. The goal of this course is to foster an awareness of the open literature and IEEE publication standards for papers and presentations.

EENG 716 – Imaging Through Turbulence	Adaptive, speckle and hybrid imaging in the presence of the atmosphere. Basic effects of atmospheric turbulence on optical propagation and conventional imaging; advanced imaging applications such as adaptive optical, speckle, and hybrid imaging, used to mitigate the detrimental effects of the earth's atmosphere on conventional imaging.
EENG 735 – Inertial Navigation System Analysis and Integration	Optimal filtering. Kalman filter. Class project focuses on the benefits of INS integration with external measurements, such as from GPS.
EENG 737 – Digital Methods of Aerospace Guidance	Implicit guidance, explicit guidance, targeting and error analysis for ballistic missiles, optimal control, and steering commands. Considerations required to achieve the ultimate objective of reaching the intended target. Series of computer projects in which the elements of an overall missile guidance system are developed and simulated.
LOGM 650 - Seminar in Space Logistics	Logistical support for spacecraft, satellites, stations, facilities, or other entities on earth orbits, or on orbits/trajectories associated with or situated on other celestial bodies. Planning for total life cycle support, continued support of operation and maintenance, and current issues in space logistics.
MECH 505 – Introduction to Aircraft Structural Analysis and Mechanics	Structural analysis for understanding response characteristics of aircraft/spacecraft components and materials. Definitions and applications of stress, stiffness, strength, environmental aspects, failure analysis, impact response, fatigue and fracture, and relevant algorithms. Metallic and nonmetallic materials and their composites. All these aspects related to tools development for optimum design, residual life evaluation, hazard detection, information evaluation and risk management.
MECH 521 – Intermediate Dynamics	Three-dimensional kinematics using generalized vector rotation, rotating and translating coordinate frames, particle and rigid body dynamics, equations of motion via direct and indirect methods, equations of motion via Langrangian approach, aerospace vehicle applications.
MECH 532 – Introductory Space Flight Dynamics	Formulation and solution of the two-body problem in three dimensions. Orbital elements, reference frames, coordinate transformations, orbit determination methods, basic orbital maneuvers. Formulation and description of basic attitude dynamics and control concepts, including spin, dual-spin, three-axis, and gravity gradient stabilization.
MECH 537 – Introduction to Astrodynamic Re-entry	Astrodynamic re-entry into a planetary atmosphere. Three-dimensional equations for flight over a spherical planet. Basic equations for planar entry trajectories with first order analysis. Loh's Second Order Theory, Yaroshevskii's Theory, and aerodynamic heating. Trades made between heating, dynamic loads, etc. when designing entry trajectories.
MECH 545 – Aerospace Structural Analysis	External loads on the aircraft, forces and load factors on space structures, spanwise airload distribution, shear and bending in symmetrical and unsymmetrical beams, analysis of typical semimonocoque

	structures, wing beam theory, deflections in aircraft structures, energy methods, introduction to structural stability and structure-aerodynamic interactions.
MECH 581 – Introduction to CAD-CAE	Introduction to Computer Aided Design (CAD) and Computer Aided Engineering (CAE). Graphics software such as SDRC-IDEAS to model three-dimensional bodies. Advanced concepts of display manipulation to obtain desired presentation. Preprocessors to convert CAD model to finite element model for CAE. Analysis programs such as MSC/NASTRAN and postprocessing of data. Finite element mass and stiffness matrices. Contour plotting, x-y plotting.
MECH 632 – Intermediate Space Flight Dynamics	Rigorous development of equations of motion of a rigid body in a gravitational field. Decoupling the translational and rotational equations of motion. Ballistic missile and interplanetary trajectories. The three-body problem and perturbation methods. Analysis of important problems in attitude dynamics and control, including reorientation, despin, control moment gyros, and reaction wheel systems. Introduction to attitude determination methods.
MECH 637 – Astrodynamic Re-Entry	Planetary atmospheres and aerodynamic forces. Equations for flight over a spherical planet. Performance in extra-atmospheric flight. Return to atmosphere. Basic equations for planar entry trajectories. Analysis of first-order planetary entry solutions. Loh's Second-Order Theory. Yarosheevskii's Theory. Chapman's Theory. Entry corridors. Unified theory of Re-Entry. Orbit contraction due to atmospheric drag.
MECH 642 – Finite Element Methods for Structural Analysis I	Energy principles. Stiffness analysis of structural members. Formulation of structural problems using finite element methods. Analysis of trusses, frames, plane stress and plane strain problems.
MECH 644 - Finite Element Methods for Structural Analysis II	Advanced topics in finite elements techniques. Formulation and solution of the system equations. Application to free forced response, stability, and nonlinear analysis.
MECH 646 – Structural Optimization	General formulation of optimal design. Approaches to structural design and optimization. The min-max problem. Direct and indirect methods. Multicriterion optimization.
MECH 719 – Vibration Damping and Control	Vibration damping and control providing the necessary background to analyze structural vibrations and design effective and efficient vibration suppression using passive or active means. Modal analysis,viscoelastic damping treatments, vibration absorbers, vibration isolators, and active feedback control using traditional and adaptive structures technology.
MECH 720 – Analytical Mechanics	Elements of the calculus of variations virtual work, D'Alemberts' principle, Lagrange's and Hamilton's equations of motion; applications to holonomic and nonholonomic systems with emphasis on rigid body motion and gyroscopic instruments.

MECH 731 – Modern Methods of Orbit Determination	Probability theory. Statistical mission assessment. Derivation of the method of least squares in linear and nonlinear problems. Sequential estimation methods, including numerical instabilities and time weighting. Applications to the problem of determining and updating the orbital elements of satellites.
MECH 732 – Advanced Astrodynamics	Canonical dynamics and applications to the two body problem. Classical and canonical variation of parameter equations of motion. Forces influencing earth satellite motion are surveyed. Application to earth satellite motion. Additional topics from resonance, stability, periodic motion.
MENG 501 – Aerospace Propulsion	Essential elements of airbreathing and non-airbreathing propulsion systems. Thermodynamics and fluid dynamics applied to analysis of on-design and off-design performance of turbojet systems (turbojet, turbofan, turboprop), to performance parameters of ramjet and scramjet engines and to fundamentals of chemical and non-chemical rocket propulsion. Performance trade-offs relative to military applications.
MENG 530 – Chemical Rocket Propulsion	Development of performance parameters, analyses of combustion, fluid mechanics, and heat transfer as they pertain to rocket engines and motors, comparison of propellants, and analysis of simple rocket flight and staging.
MENG 531 – Space Propulsion and Power Systems	Concept, theory, and performance of chemical and nonchemical propulsion systems. Electrical, nuclear, liquid propellant, and exotic space propulsion systems. Power generation methods. Low and high power systems intended for short or long term applications. Chemical, solar and nuclear devices and the energy conversion means for converting energy from these sources into useful electrical power. Space mission requirements and how they impact propulsion and power system selection. Current and future trends in spacecraft propulsion and power generation.
MENG 571 – Fundamentals of Heat Transfer	Conduction, convection and radiation heat transfer. Derivation and solution of the general heat conduction equation for one and two dimensional, steady and unsteady conduction problems. Analytical and numerical solution techniques. Forced convection in laminar and turbulent flows on internal and external surfaces. Radiation heat transfer among surfaces. Application to thermal processes in variety of systems.
MENG 633 – Fundamentals of Combustion	Combustion and combustion aerodynamics: (1) Chemical thermodynamics: heats of reaction and flame temperature; (2) Chemical kinetics: rates of reaction, reaction order, chain reactions, and explosions; (3) Gas dynamics of reaction flows; (4) Deflagration and detonation of premixed gases: the Hugonoit Curve; (5) Laminar flames; and (6) Turbulent flames.
MENG 673 – Radiation Heat Transfer	Methods for calculating heat transfer by thermal radiation. Integral equations are formulated for thermal radiation among surfaces with and without an intervening gas. Approximate engineering methods

	of solution are emphasized and applied to components of satellite, propulsion, and solar energy systems.
METG 505 –Atmospheric and Space Environment Effects on Military Operations, Systems, and Plans	Advantageous exploitation of weather effects at the operational level of war. Historical cases are surveyed to highlight both successful and unsuccessful environmental adaptations. Future systems and plans in terms of weather exploitation and applicability within a Combined Air Operations Center (CAOC) structure.
METG 611 – Atmospheric and Space Environmental Effects on Electromagnetic Propagation	Propagation properties of laser, radar, optical, and IR systems in the atmospheric and near-earth space environment. Weather and environmental effects on ground-based, airborne and spaceborne platforms. Signal processing to characterize both discrete and distributed targets, and inversion methods to retrieve atmospheric parameters. Focus is on the UV to microwave portion of the spectrum.
NENG 597 – Nuclear Weapons Effects, Technology and Non-Proliferation	Effects of nuclear weapons, the technology necessary to produce nuclear weapons, and the current status of international nuclear weapon proliferation. Energetics of nuclear weapons, specific effects of, and differences between, the various classifications of explosions (i.e., Air, Surface, sub-surface and high altitude bursts), the technology of producing nuclear weapons, the nuclear fuel cycle, and future trends.
NENG 625 – Electromagnetic Pulse Effects	Source, propagation, and interaction of the electromagnetic pulse (EMP) generated by nuclear weapons. Source generation for high altitude EMP, and the characteristics of other types of EMP (source region, hydrodynamic, system generated, etc.). Coupling of EMP to systems, topological models of shielding, external interaction, penetration through shielding surfaces, general hardening methods, and examples of the analysis of realistic systems.
NENG 631 – Prompt Effects of Nuclear Weapons	Source, transmission and mechanisms of interaction of x-ray, blast, thermal, neutron and prompt gamma radiation. X-ray interactions, shock generation and propagation, air and underwater shock, shock “jump conditions” and scaling laws, thermal transmission, thermal interaction, buildup factors, neutron and gamma transmission and interaction. In the case of each effect, system response, hardening techniques, and design trade-offs.
NENG 660 – Radiation Effects on Electronics	Fundamentals of damage mechanisms to electronic devices from gamma rays, neutrons and charged particles. Solid state physics, the physics of bipolar and metaloxide-semiconductor, ionization and displacement damage resulting from irradiation, effects of particular types of radiation such as neutron and gamma radiation, annealing of neutron effects, gamma ray effects on field-effect transistors (FETs), and transient radiation effects such as latchup, upset, and single-event upset (SEU).
NENG 664 – Radiation Effects on Electronics Laboratory	Experimental procedures used in radiation effects testing. Typical projects: ionizing and non-ionizing radiation dosimetry, optical and electrical measurements, and irradiation of devices. Practical

	dosimetry, device modeling, characterization, development of a test plan, modeling device changes, irradiation of devices, and interpreting data. Special techniques include: calibrating a PIN diode dosimeter, foil activation dosimetry, device irradiation, and development of test systems and controls.
NENG 721 – Space Nuclear Power Systems	Current and future nuclear power systems such as radioisotope thermal generators, solid core, fluidized bed and gas core reactors. Converter and heat rejection theory, nuclear heat sources.
OENG 530 - Fundamentals of IR and MASINT Technology	Solving MASINT remote sensing problems, with emphasis on IR technology. Both the signature and metric aspects of MASINT. Source characteristics, radiometry, atmospheric and propagation effects, optics, detectors, and elementary signal / image processing.
OENG 531 – Non-imaging IR and MASINT Collection Systems	Current technology for collecting, processing, and exploiting MASINT data for Missile Warning, Missile Defense, Battlespace Characterization, Support for Military Operations, Technical Intelligence, and Environmental Monitoring using National Technical Means.
OENG 533 – Multispectral and Hyperspectral MASINT Exploration	Information that can be extracted from multispectral and hyperspectral data sets collected by MASINT sensors. Signature exploitation for materials identification and pattern recognition. Background suppression, principle components, Bayesian statistics, and neural network processing.
OENG 650 – Optical Radiometry and Detection	Radiation source characterization and the transport of that radiation through free space. Principles of optical detection; various types of detectors. Design a simple radiometer based upon the requirements of a specific mission.
OENG 780 – Infrared Technology	Principles and technology required for design and analysis of electro-optic systems, with emphasis on those operating in the infrared. Sources of radiation, targets and backgrounds, atmospheric propagation, optics, detectors, detector performance criteria, scanning and tracking techniques. Design of a representative IR system such as imaging system (FLIR) or tracking system.
PHYS 519 – The Space Environment	Radiation, particles, and general conditions encountered in the Earth's atmosphere, ionosphere, and magnetosphere. Spacecraft thermal equilibrium, orbit decay, spacecraft charging, space-to-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena.
PHYS 521 – Space Surveillance	Physics necessary for understanding the remote sensing process with an emphasis on visible and infrared systems. Interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors.
PHYS 775 – Ionospheric Electrodynamics	The basic fluid and electrodynamic equations appropriate for the weakly-ionized plasma of the earth's ionosphere are derived and steady-state forms of these equations as well as linear instability theory are applied to operationally-relevant

	ionospheric phenomena. E and F-region dynamo theory; equatorial "spread F" and the General Rayleigh Taylor (GRT) instability; the Equatorial Anomaly; mid-latitude nocturnal plasma drifts; intermediate layers and the F-region valley; sporadic E and tidal/gravity waves; high-latitude plasma convection; radiowave scintillation.
PHYS 776 – Structure and Dynamics of the Magnetosphere	Physics of solar wind, formation of the magnetosphere, and properties of magnetosphere. Solar wind flow, solar wind-earth magnetic field interaction, magnetosphere plasma-wave interactions, Van Allen belts, auroral Phenomena.
PHYS 777 – The Solar Atmosphere	Outer solar regions including the "quiet" photosphere, the chromosphere, the corona, and solar wind. Descriptions of instrumentation and data used to observe solar conditions and the "active" sun which perturbs the earth's environment, quantitative description of solar events that impact the forecaster's missions. Sunspot activity, flares, prominence, coronal mass ejections, coronal holes, and other pertinent observables that indicate active conditions on the sun's surface.
PHYS 791 – Operational Assessment in the Space Environment	Current operational aspects of USAF/NOAA space environmental forecasting and observing. Solve a current or future DoD operational space environment related problem through a class design study.
PHYS 792 – Space Weather Lab	Space weather computer codes used to provide operational space weather support to DoD, solar wind, magnetospheric, ionospheric, and thermospheric models. Required inputs for each model, running the codes, and evaluate the output. Instrumentation used to assess space weather storm intensity, such as the fluxgate magnetometer. How space weather affects the accuracy of operational technologies such as GPS receiver.
SENG 520 – Systems Engineering Design	Structured approach for the design of complex systems. Formulation of systems problems and the approach to their solution. Basic mathematical techniques. The design process will be illustrated through the review of past design efforts, and the application to a problem of current interest.
SENG 530 – Introduction to Space Programs and Operations	History and current status of military space operations. History of space flight, the relationships between military and civil space programs, space law, U.S. space policy, military space missions, U.S. military space organizations, and non-U.S. space programs. Introduction to standard space mission analysis software.
SENG 535 – Military Space Systems and Applications	Worldwide space activities, with an emphasis on military space operations. Seminars will include classified presentations by intelligence analysts. Operational and technical aspects of U.S. and foreign space systems and related topics of DoD interest.
SENG 565 – Control and State Space Concepts	Interrelation between conventional and modern approaches. Feedback system analysis; root locus, Bode, and Nyquist analysis. State feedback control and observers; control system compensation design.

SENG 610 – Systems Engineering Process and Mgmt	Systems Engineering process, and selected topics from Systems Engineering Management. Model based-approach to key systems engineering design activities, process modeling, requirements analysis and functional allocation, trade-off analysis, and management of cost, schedule, and risk.
SENG 631 – Spacecraft Systems Engineering	Detailed introduction to the design of complex space systems. The key elements and subsystems of several important classes of space systems. The systematic approach necessary to effectively design space systems is illustrated through case studies. Individual or group design projects are conducted and presented.
SENG 640 – Systems Architecture	Generating a functional, physical and operational architecture from top level operations concept. Structured analysis and object oriented approaches to generating architectures applied to DoD concept problems. Generation of required DoD architecture products. Generation of executable architecture models for evaluating the behavior of candidate system concepts.
SENG 765 – Robust Control	Unified theory in which performance and robustness to plant uncertainties and/or input disturbances are handled directly. Modeling of uncertainty, signal and transfer function norms are used to quantify both levels of uncertainty and robustness to it. Lyapunov and Riccati theory; parameterizing all stabilizing compensators, linear fractional transforms, linear matrix inequalities, and Hamiltonian matrices. H-2, H-infinity, mu-synthesis techniques.
SENG 798 – Group Design Study	A design study on a topic of current Air Force interest is selected as a class project. The class develops its own organizational structure to suit the problem, develops a statement of work and conducts the study. Progress reports and final reports are given to the sponsoring organization, as required.
Air University	
6525 - Space Issues	AWC Elective: Intended for officers with a space background.
ACSC 5631- World Space Issues for International Officers	This course will focus on the space contribution to airpower from an international perspective. It will include military applications of space systems, distribution of space-based information and the increased role of commercial space systems.
ACSC 5620 - Advanced Space Studies: Policy and Applications.	This course is designed for students who already have a strong understanding of space policy and systems. It will leverage the collective experiences of the class to create a collaborative learning environment for advanced discussion on all areas of space
ACSC 5626 - Military and Commercial Uses of Space	This course is designed for students who have a limited understanding of space systems and policy. It will examine in detail current and future space capabilities of the United States and the world.
ACSC 6524 - Space Fundamentals	The course focuses on the elements of spacepower, military applications of space systems, and availability of civil and commercial space systems to

	all nations and non-government organizations (NGOs).
AWC 6424 - Space: Air Power's New Horizon	Understand the increasingly important role played by space capabilities in contemporary military operations. Analyze the contributions of space in a variety of military operations. Assess the implications of the reliance on space
AWC 6529 - Space Support & Warfighting	Synthesize Service efforts to integrate information operations and space capabilities in joint theater-level operations. Analyze the impact of offensive counterspace operations on national policies, regional alliances, and theater campaign objectives.
AWC 6532 - World Space Issues	The course will focus on the elements of spacepower, military applications of space systems, distribution of space-based information, increased role of commercial systems and international space issues.
Space Elective	Analyzes the fundamentals and issues of space operations, including civilian and military uses of space.
Space Issues - AWC Elective (Correspondence)	This course examines issues related to the military applications of space, including space-based information and commercial systems. Information on space characteristics, limitations, orgs, missions, and functions, followed by types of space systems.
American Institute of Aeronautics & Astronautics	
Collocation of Geostationary Satellites	Geostationary space is becoming crowded--how can we safely operate in this orbital band? What strategies are available for operating multiple satellites in an orbital slot and how do they compare?
Economics of Space Transportation	Lowering the cost of space transportation, although widely perceived as necessary, has proven intractable as a technical problem: after four decades effort the cost of space travel remains essentially unchanged.
Elements of Spacecraft Design	Home Study Correspondence course
Elements of Spacecraft Propulsion	Home Study Correspondence course
Fundamentals of Orbital Mechanics	Home Study Correspondence course
Fundamentals of Satellite Communications Subsystems	This course provides an overview of the design and operations of spacecraft communication subsystems. Design information related to subsystem configuration choices and component selection is augmented with detailed operations information
Fundamentals of Space Exploration	
Introduction to Satellite Thermal Control	Gain a basic understanding of spacecraft thermal design, describing active and passive hardware and the thermal analysis tools used in the aerospace industry, and a complete overview of satellite thermal control.

Spacecraft Charging and Mitigation	
Tactical Missile Design	Tactical Missiles are a vital part of the world's armed forces. The design of these missiles is role-dependent, and the number of roles being satisfied by tactical missiles is constantly increasing. This two-day course will explore a broad range of alternatives.
The Space Environment: Implications for Spacecraft Design	This course is designed to provide an introduction to the subject of spacecraft-environment interactions, also known as space environments and effects or space weather effects. The course addresses each of the major environments: vacuum, neutral and plasma.
Theory of Random Vibration	Random Vibration is the study of vibration systems where there are uncertainties in either loading forces or in the system properties. This short course will introduce ideas from probability and apply them to the study of structures.
Applied Technology Institute	
Advanced Synthetic Aperture Radar	Designed for people who already have a working knowledge of Synthetic Aperture Radar. The course will introduce advanced systems design and associated signal processing concepts and implementation details.
Aerospace Power Systems Engineering	This course is structured for engineers, managers, and scientists who are involved with or deal with spacecraft programs, including those who are responsible for selection, development, procurement, and application of spacecraft hardware.
Applications-Oriented Kalman Filtering	Provides a comprehensive overview of the Kalman filter. The course begins with a brief review of probability, stochastic processes, dynamics and modeling of systems. This is followed with an in-depth discussion of estimation theory and methods.
Attitude Determination and Control	Provides a detailed introduction to spacecraft attitude estimation and control. Estimation theory is discussed along with various deterministic and optimal estimation techniques, including GPA attitude estimation, controller design and stability analysis.
Fundamentals of Orbital and Launch Mechanics	Participants will become acquainted with the major tools and analysis techniques necessary to make the design choices and operational decisions required for overall space flight mission success. Teaches tools and analysis techniques needed for design choices.
Fundamentals of Synthetic Aperture Radar	The principles of Synthetic Aperture Radar (SAR) and system design tradeoffs are presented. The principles of SAR are presented system design tradeoffs are illustrated for various mission requirements.
Geomatics - GIS, GPS, and Remote Sensing	Technical Overview of Geographic Information Systems. This 3-day course will provide a technical overview of the current state of Geographic Information Systems and the integration of this powerful tool with GPS, remote sensing, and other data.

GPS Technology	An overview of the Global Positioning System, basic radio navigation principles and applications. Explanation of how the GPS system works.
Ground System Design and Operation	Practical introduction to all aspects of ground system design and operation. Starting with basic communications principles, an understanding is developed of ground system architectures and system design issues.
Hyperspectral & Multispectral Imaging	3 day class is designed for engineers, scientists and other remote sensing professionals who wish to become familiar with multispectral and hyperspectral remote sensing, and data processing. Students will learn the basic physics of optical remote sensing.
Internet-Over-Satellite Fundamentals	Designed for satellite engineers and managers who want to increase their understanding of the Internet and how Internet Protocols (IP) can be used to transmit data and voice over satellites. How internet protocols can be used to transmit data and voice over IP.
Introduction to Control Systems	This is an introduction to classical and modern control theory. The course emphasizes essential concepts. These concepts are illustrated by using numerous graphics, block diagrams, and simple examples.
Launch Vehicle Design, Selection, Performance & Use	This course provides the practical knowledge to understand the design, performance, selection and use of current and future (within 5 years) launch systems. Designed for designers, operators, users, and investors of launch vehicle services.
Multi-Sensor Data Fusion & Kalman Filtering	The objective of this course is to introduce personnel to the field of data fusion and to the key technologies which are available today for application to this field. The course will identify and characterize the principal components of typical data fusion.
Practical Statistical Signal Processing Using MATLAB	This course covers signal processing systems for radar, sonar, communications, speech, imaging and other applications based on state-of-the-art computer algorithms. This course will take the mystery out of these designs by introducing the algorithms.
Remote Sensing for Earth Science Applications	this course is for those who need to understand the basics of remote sensing including the instrument capabilities and limitations, how the data can be processed and used. The course covers the basic concepts of passive and active sensing.
Risk Assessment for Space Flight	The course is for those who need to understand the realities of risk-taking in space projects that fact tight schedule and budget constraints. Informed risk management is now a vital part of mission design and tradeoff analysis.
Satellite Communications Systems Engineering	Designed for satellite communications engineers, spacecraft engineers, and managers who want to obtain an understanding of satellite communications. A technically oriented course for understanding 'big picture' of how communications satellites work.
Satellite RF Communications and Onboard Processing	The course covers both theory and practical understanding of communications satellites and onboard data processing. Emphasis is on the important system engineering principles, tradeoffs,

	and rules of thumb. The latest technologies are covered.
Space Systems I	This multi-disciplinary course provides a complete summary of the technologies needed to understand and develop spacecraft systems and instrumentation. The curse presents a systems engineering approach for understanding the design and testing of spacecraft.
Space Systems II	The course is the second part of the Space Systems Seminar series. The courses provide a strong technical base for leadership in systems engineering or the management of space systems. Complete summary needed to understand and develop spacecraft systems.
Spacecraft Quality Assurance, Integration & Testing	This course uses case studies and examples from recent space missions to pinpoint the key issues and tradeoffs in design reviews, quality assurance, and testing of spacecraft. Uses case studies and examples to teach quality assurance, reliability and test.
Spacecraft Systems Design & Engineering	This course is for technical and management people who want to remain up to date on spacecraft design for both the conventional missions and the new small-set applications to communications, remote sensing, science and spacecraft platform design principles.
Army Command & General Staff School	
A537 -Space Orientation Course	A537 is a 24-hour course conducted in Term II and III. The goal of this course is to provide students with a basic understanding of U.S. and international space policy, the physical characteristics of space, and an in-depth understanding of space forces.
A543 - Space Operations Course	This is a 48-hour TS/SCI course conducted during Term III. This course provides students with a knowledge of space that allows them to function as a staff officer in space-related positions.
Det 1, 338 TRS	
E3ABP2E131 001 Satellite, Wideband and Telemetry Systems Apprentice Course	Provides apprentice level training for airmen in the satellite, wideband and telemetry systems ladder of the airman communications-electronics systems career field. Completion of a basic satellite, wideband and telemetry systems course is mandatory.
ECAZP2E151 01AA AN/TRC O/I MAINTENANCE (ARMY #101-F36(0S))	Training for personnel in AFSC 2E151/71 in the knowledge and skills needed to perform the duties of operating and maintaining the to operate and maintain the AN/TRC-170. Includes TRI-TAC system concepts and equipment configuration and digital techniques.
ECAZP2E151 01BA Tactical Satellite Communications System O/I Maintenance	Training for personnel in AFSC 2E151/71 in the knowledge and skills needed to perform the duties of operating and maintaining the maintain and operate Tactical Satellite Communication Terminals AN/TSC-85B(V)2, AN/TSC-93B(V)2, AN/TSC-94A(V)1 and AN/TSC-10.

ECAZP2E151 01CA Lightweight Multi-band Satellite Terminal (LMST) O/I Maintenance (Army #101-F44 (OS))	Training for personnel in AFSC 2E151/71 in the knowledge and skills needed to perform the duties of operating and maintaining the AN/TSC-152A Lightweight Multi-band Satellite Terminal (LMST).
E3AZP2E151 O1DA MILSTAR Organizational Maintenance (Army #101-F33)	Training for personnel in AFSC 2E151/71 in the knowledge and skills needed to perform the duties of maintaining the MILSTAR Command Post Terminal. Training includes system theory, EHF/UHF command post operations and EHF/UHF organizational maintenance theory.
ECAZP3C151 01AA MILSTAR Command Post Terminal Operator (Army #201-F10(OS))	Training for personnel in AFSC 3C151/71 in the knowledge and skills needed to perform the duties of operating the MILSTAR Command Post Terminal. Training includes equipment identification, location and operation of the Milstar terminal, using the AN/ARC-2.
EBAZA2E151 01BA SATCOM Strategic Terminals AN/GSC-52(V)	This is an Army course with AF instructor personnel assigned. It is designed to train tri-Service personnel to operate and maintain, through the Direct Support / General Support level, the SATCOM terminal AN/GSC-52(V).
E9AZA2E151 01AA MILSTAR SMART-T Operator/Maintainer (Army #260-F9(OS))	This is an Army course with AF instructor personnel assigned. It is designed to train tri-Service personnel operator, organizational and intermediate level maintenance on the AN/TSC-154 Secure Mobile Anti-Jam Reliable Tactical Terminal (SMART-T).
EBAZA2E151 01EA MILSTAR Communications Planning System (CPS) (Army #4C-F64/260-F20(CT))	MILSATCOM planning abilities for the SMART-T.
Industrial College of the Armed Forces	
5112 - Space and National Security	Outlines a user's guide to space and national security. Builds from the basics of orbits and the space environment, through the history of space exploration to today's issues. Examines the role and relationships of the different players in space.
5114 - Space : The New Frontier	Explores a more in depth view of space and national security. This course is a stand alone elective. Elective 5112 (Space and National Security) is not required as a prerequisite. Students may take either 5112 or 5114 or both depending on security clearance.
Launchspace	
1010 Accelerometers, Gravimeters, Gradiometers, and Drag-Free Systems	This course takes you on a walk through a class of inertial instruments that tread the fine line between acceleration and gravity. The basic theory of each instrument type is described and explained, together with relevant history.
1020 - Astronomy and Planetary Science for the Space Professional	This course provides a high-powered overview of modern astronomy and planetary science to professionals in engineering, management and policy fields. The course begins with a survey of the universe, the astronomical community and astronomical facilities.

1030 - Composite Materials for Spacecraft and Launch Vehicles	This course provides a comprehensive introduction to composites technology for spacecraft, launch vehicles and their subsystems. Participants are invited to bring issues for class discussion.
1040 - Electromagnetic Environment Effects Testing	This workshop covers the application of Military and Space EMC Standards in the design, development, fabrication, testing and maintenance of space equipment and systems. The material is presented at the intermediate level.
1050 - Intellectual Property - Valuing and Licensing	This course offers a detailed look at the United States intellectual property protection system. It addresses the forms and merits of obtaining protection, as well as the methods to enforce it.
1070 - Life Support and Protective Systems Design	The design of life support systems is a uniquely multi-disciplinary field that is not taught in any university. This course should be attended by technical professionals with an interest or need to improve their skills in life support and system design.
1080 - Optimal Estimation and Control - A Fresh Look	This course is designed to show you how to design optimal regulators and observers for stationary systems, based on knowledge of the all the noise power spectra, and using performance measures that are much more sensitive to your actual engineering needs.
1090 - Political Process in Systems Architecture Design	This course focuses on the fire zone between the political process and the engineering design process. Its basic thrust is that the political system is a determining design factor in any high-tech, high-cost, high-profile program.
1100 - Pyrotechnic Design, Development and Qualification	All aspects of pyrotechnic applications will be addressed--functional principles, safety, testing, demonstration of functional margins, integration and lessons learned. An approach will be presented that allows reliability predictions in excess of 99%.
1110 - Space Industry Update, Trends and Commercial Opportunities	This course is a highly popular presentation offering a fresh look at the international space community, technology trends and future commercial opportunities. Relevant issues affecting technology, policy and economic trends are addressed.
1120 - Space Materials	This course covers the concepts and procedures used to make logical decisions on material selections. In the material selection decision process, there are numerous factors which must be considered.
1125 - Space Principles and Operations for the Non-Technical Professionals	This course is designed for professionals in space and related industries who do not have an engineering or technical background. The presentation will help you to quickly develop insight into space issues and technologies.
1128 - An Introduction to Satellite Technology	This is the highly-acclaimed, one-day, intense seminar for non-technical professionals in the satellite and related industries who are not familiar with, or knowledgeable in, satellite technology or business.
1130 - Space Radiation Protection	You will learn The general characteristics of nuclear (ionizing) radiation and how it interacts with living matter, as well as important spacecraft components. The types and levels of ionizing radiation that may be encountered during future long-duration missions.

1135 - Space Vehicle Mechanisms: Elements of Successful Design	This course explores the technologies required for the successful design of moving mechanical assemblies in the space environment and offers a detailed look at many of the key components common to most mechanisms, such as ball bearings, motors and feedback loops.
1140 - Structural Analysis using NASTRAN	This course covers the fundamentals of structural analysis using the NASTRAN finite element analysis program. The class presents basic NASTRAN capabilities for solving structural engineering problems and will give hands-on experience in preparing and running analyses.
1150 - Structural Dynamics Analysis and Design	This course offers an in-depth overview of analytical and numerical methods used on aerospace structures subjected to dynamic loads. These methods form the basis of most existing large computer programs in general use for setting up and solving complex problems.
1155 - Introduction to Systems Engineering	This course acquaints both the engineer and support personnel with the meaning, terms used, techniques, advantages and challenges of Systems Engineering for space and related industries. The course deals with the systems approach and management
1160 - Systems Engineering and Design	This course focuses on the theory of engineering design. Reduced to its simplest form, engineering design consists of generating design options and selecting the preferred option. But, simple as these steps may sound, they are very complex.
2010 - Basic Spacecraft Bus Systems Design	This course helps to explain satellite technologies and systems to both the beginner and expert. Discussions will involve many true-to-life examples about how satellite companies got started and the impact of patent litigation.
2015 - Earth Station Principles for the Space Professional	This course provides the program manager or project professional with introductory and in-depth knowledge of the configuration and operation of a typical earth (ground) station for both geosynchronous (GEO) and low-earth orbit (LEO) satellites.
2020 - Fundamentals of Orbital Mechanics	This professional course covers orbital dynamics from development of the equations of motions to the inclusion of the major perturbations. The dynamics of the fundamental systems and reference planes will be investigated and discussed.
2025 - Analysis and Design of Spaceflight Missions	This course introduces the participants to a process beginning with an idea for a space flight mission, then a concept, then to the fundamental architecture, and finally to a conceptual system design.
2030 - LEO Constellation Systems: Design, Analysis and Application	This course brings you up to date on all the subtleties of a commercial space constellation design, and the impacts of constellation configuration on the spacecraft design. Mission requirements drive the constellation selection process.
2040 - Microsats: Design, Development and Execution of Minimum Missions	Definitions of microsatellites and how they differ from conventional spacecraft. How microsatellite missions are planned to achieve minimum cost with high reliability. Specific technological approaches used in

	microsatellites.
2050 - Payload Integration and Processing	This is a practical course on understanding the mission integration and launch vehicle/spacecraft integration process. The course examines the evolution of mission integration functions, the structure of the integration team and roles and responsibilities
2060 - Precision Orbit Determination	This course prepares orbit analysts, satellite operations professionals, and satellite operations managers to cope with the complexities and unique problems of attaining and maintaining sub-meter orbit accuracy. The approach focuses on case studies
2070 - Satellite Attitude Control and Attitude Determination Systems	The purpose of flying satellites is to carry instruments for various purposes- to do scientific and reconnaissance work, to provide communication links, to perform weather observation. All of these require that the attitude of the satellite be controlled.
2080 - Space Systems Avionics Design and Applications	This course offers a detailed look at basic satellite and launch vehicle avionics design and engineering requirements. Design practices for satellites and launch vehicles are addressed, and a discussion of the differences and similarities of the two systems.
2085 - Space Environment Requirements Engineering	The course will concentrate primarily on the natural environments associated with the Sun, neutral atmospheres, the space plasma environment, trapped radiation, cosmic rays, solar proton events, meteoroids, and space debris.
2090 - Spacecraft Systems Design: Lessons Learned	What worked and what didn't for spacecraft development programs in the past. How to avoid those mistakes and set up a successful spacecraft development program.
2100 - Spacecraft Dynamics and Attitude Control	This professional course brings you up-to-date on important space flight issues while providing a complete description of satellite mission types, orbit establishment and maneuvers, attitude dynamics and control systems, attitude determination and control.
2110 - Spacecraft Power System Design and Analysis	This course provides comprehensive coverage of the spacecraft power system operation, design and analysis. You will be exposed to system level design trades and major design drivers, as well as detailed design methods for various power systems for LEO, GEO and MEO.
2120 - Spacecraft Propulsion Systems	This course teaches the fundamentals of spacecraft propulsion with emphasis on engineering and systems design. The basic theory of rocket propulsion is presented to enable an understanding of system selection, sizing, and hardware design methodology.
2125 - Electric Propulsion for Earth-Orbiting Satellites	This course covers the basics of electric propulsion (EP) for near-Earth space. It will get you calibrated in a hurry on all important aspects of the complex interactions among launch vehicles, spacecraft, EP maneuvers and EP devices.

2130 - Spacecraft Thermal Design and Analysis	This course will provide an overall view of the means to design and analyze the thermal control of various types of satellites, from communication satellites in geosynchronous orbits to mini-satellites in low-Earth orbit.
3010 - Introduction to Remote Sensing	This course provides a broad knowledge of the principles and techniques associated with the scientific instruments that produce high resolution images of planetary surfaces. The instruments considered, chiefly space borne, operate in the visual and IR.
3020 - Modern Satellite Communications	This course provides the basics of satellite communications, with emphasis on modern communication satellites and systems operating in low, medium, highly elliptical and geostationary orbits applicable to mobile, fixed and broadcasting satellite services.
3025 - Satellite Communications Payload and Systems Design	The course begins from a systems engineering standpoint by identifying the requirements for the satellite payload and end-to-end system using current applications in digital video and broadband media, voice communication, mobile services, and interactive devices.
3030 - Satellite Communications: Status and Trends	The satellite communications industry is experiencing major expansion. This seminar covers the entire business, which includes regulatory and financial issues, vendors, operators and service providers it includes but is not focused on engineering and technology.
3035 - Telecom Network Architecture for the Space Professional	Understanding the fundamentals of the telecom network as relevant to the space professional. System characteristics are analyzed in great detail using real operating networks as models.
3050 - Space Flight Robotics and Teleoperation	Many factors influence where and how to apply robotic systems. Understanding the technology is crucial to determining effective applications. Participants in this course receive a review of the basics of robotics.
4000 - MATLAB: An Introduction to Scientific Programming	MATLAB is both an intuitive language and a technical computing environment, providing core mathematics and advanced graphical tools for data analysis, visualization, and algorithm and application development.
4010 - Computer-Aided Control Systems Design using MATLAB	This course introduces you to MATLAB for multivariable control systems design, including classical and modern control methods, modeling of dynamic systems, pole placement and linear quadratic techniques, and symbolic mathematics.
4020 - Design Optimization by Genetic Algorithm	This course is aimed at the design engineer who uses a computer and simulation software to analyze his design in order to evaluate its compliance with required specifications.
4030 - Image Processing using MATLAB	Image Display: Display single image, multiple images, or display image as a texture-mapped surface. Image Conversion: Change any type of image (indexed, intensity, or RGB) into another type, or create and image deck. Color map Operations:

	Modify color maps.
4040 - Kalman Filter with Aerospace Applications using MATLAB	This course introduces you to the Kalman filter and its applications to aerospace guidance, navigation and control problems. The Kalman filter has become the standard tool for error analysis, design of data processing algorithms, navigation systems.
4050 - Nonlinear Simulation using MATLAB and Simulink	An introduction to MATLAB and how to use it. Review of classical and modern design methods. The development of Simulink block diagrams for complex, nonlinear systems. The extraction of linear models from nonlinear Simulink models.
4055 - Real-Time Flight Software Engineering and Development	Over the years, many effective software and project engineering practices and systems have been designed and implemented for the development of critical software.
4060 - Signal Processing using MATLAB	An introduction to MATLAB and how to use it. Comprehensive treatment of a wide variety of signal processing operations using the MATLAB Signal Processing Toolbox.
4070 - Wavelets: A New Tool for Signal Analysis using MATLAB	An introduction to MATLAB and how to use it. Review of basic signal processing and graphics capability. The use of the MATLAB Wavelet Toolbox for Synthesis and Analysis of Wavelets and Wavelet packets.
5005 - Ascent Trajectory Design for Launch Vehicles	This course addresses trajectory issues which are only touched upon by other launch vehicle design and space mission analysis courses.
5010 - Advanced Launch Systems - Reusables	This course offers a detailed look at reusable launch vehicles, how they function, insight into limitations and opportunities for the future. Technology requirements and design challenges are addressed.
5020 - Flight Dynamics Design and Analysis for Target Vehicles	This is a practical course on understanding the flight dynamics of suborbital launch vehicles and approaches to their design and analysis. The course examines aerodynamic design, stability criteria, flight environments, dispersion and reentry and recovery
5030 - Launch Control System Design	This course covers how launch operations work - from system integration and vehicle pre-launch processing to countdown and lift-off - and how to implement a control system to meet the multiple complex requirements of this operation.
5040 - Launch Vehicle Aerodynamics: Theory, Ground Testing and CFD	The space launch industry is undergoing rapid change with the privatization of many government operated space activities, commercialization and the growth of demand for satellites for communications, remote sensing, weather, etc.
5045 - Launch Vehicle Environments, Loads, and Testing	This professional course covers the lift-off and launch trajectory environments and their effects on the design and testing of launch vehicles and payloads.
5060 - Launch Vehicle Services Selection, Contracting and Technical Oversight	National space transportation strategy as defined in its policies and laws. Key considerations when selecting your launch service. The capabilities, constraints and prices of all national and international

	vehicles. Prices not just for the launch service.
5070 - Launch Vehicle Systems Design and Engineering	This course offers a detailed look at basic expendable launch vehicle design and engineering requirements. All launch vehicle types are included, with emphasis on highly volatile issues such as small launchers and new systems.
5080 - Propulsion Systems for Launch Vehicles	This course takes a detailed look at the propulsion requirements for launch vehicles, the trades necessary to establish propulsion system characteristics, and the current status of potential engines and motors.
5085 - Cryogenic Propulsion System Design	New all-cryogenic launch vehicles are being added to the world's stable at a rapid rate. Delta 4, Arianne V, H-2, and others are joining the STS and a number of upper stages in using liquid hydrogen and oxygen propellants.
5090 - Solid Rocket Motor Design and Applications	This seminar provides a detailed look at solid rocket motors and the sensitivity of system performance requirements on their design, reliability and cost insight into their limitations and a general understanding of solid propellant motor.
5095 - Liquid Rocket Engine Design	This course explores the liquid rocket engine design problem from a system level. The requirements, issues, problems, and criteria that define and shape a new engine system design are covered in detail.
5098 - Advanced Liquid Rocket Engine Design Workshop	This course builds on the liquid rocket engine design factors developed in Course 5095, Liquid Rocket Engine Design.
6010 - Aerospace and Construction Cost Estimating	This powerful seminar concentrates on the preparation of a detailed construction cost estimate for a 4100 SF reinforced concrete masonry, steel joint roof system for a propellant component office laboratory building, using an 11 page set of plans.
6020 - Management of Advanced Technology and Creative People	This course is a highly interactive learning experience which provides technical team leaders, small group managers and emerging strategic planners with an essential understanding of the principles, techniques, and roles of innovation.
6030 - Space Systems Cost and Economic Issues	This course will emphasize the role of economics in space transportation related decisions ranging from the formulation of a technology program to improving transportation system performance, to establishing the potential role of government.
6040 - Proposal Preparation for Space Industry Projects	This intense, hands-on workshop provides a comprehensive overview of the preparatory and execution tasks associated with writing winning commercial proposals. The course highlights key elements of the new business life cycle.
6050 - Design to Cost for Space Industry Projects	This course is a combination of lecture, workshop and consulting, concerning user-specific project requirements and is available on a client-site basis only. What worked and what didn't for spacecraft development programs in the past.

6070 - Facilitating Export Licensing for Space Systems	This course offers a detailed look at the U. S. Government's controls over the export of space systems and related technology. The role of the Department of State's Office of Defense Trade Controls is explained.
6080 - Space Business Development in Today's Tight Market.	Space Business Development in Today's Tight Market is a unique, intense one-day course for space industry professionals who are charged with the identification, marketing and development of new business and contract acquisitions.
9000 - Management Insight Series: Space Industry Update	Space Industry Update is a unique presentation offering a fresh look at the international space community, technology trends and opportunities for the future. Relevant issues affecting technology, policy and economic trends are addressed.
9050 - Management Insight Series: Satellite Communications Industry Trends	Today, there is a vibrant GEO, growing and adjusting among the established services such as the Fixed Satellite Service (FSS), Broadcast Satellite Service (BSS), and Mobile Satellite Service (MSS). The past decade has seen growth in conventional services.
9100 - Management Insight Series: The Facts about Reusable Launch Vehicles	Finally, the truth about reusable launch vehicles (RLVs). This may be the only presentation offering a detailed, realistic look at the business and technology aspects of reusable launchers. In recent years, a great deal of hype and excitement has been generated.
9150 - Management Insight Series: Modern Proposal Technology.com	This seminar, Modern Proposal Technology.com, addresses the use of web-compatible technology to plan, support, prepare and submit proposals to both business and commercial customers. The discussion covers intranet solutions and web-site approaches.
9200 - Management Insight Series: Smart Networks	Management Insight Series: Smart Networks.
9250 - The Rocket Scientist and the Entrepreneur	The Rocket Scientist and the Entrepreneur is a unique, intense one-day course for space industry professionals who are charged with the development of new commercial business ventures. Over the past decade the old contractor culture of the space industry has evolved.
McGill University	
Institute for Air and Space Law	
Montana State University	
Physics 580 Comparative Planetology: Establishing a Virtual Presence in the Solar System	Comparative Planetology: Establishing a Virtual Presence in the Solar System - Upper division courses and others as determined for each offering. Courses not required in any curriculum for which there is a particular one time need, or given on a trial basis.
Physics 580 Studying the Universe with Space Observations	Studying the Universe with Space Observations - Upper division courses and others as determined for each offering. Courses not required in any curriculum for which there is a particular one time need, or given on a trial basis to determine acceptability.

NASA	
Alliance Strategy at NASA: Partnerships for the Commercial Use of Space	Leading high-tech companies have discovered that well-managed alliance strategies can help them grow, diversify, and apply their capabilities in new areas. Yet, when poorly managed, alliances can be distracting and destroy company value.
Astronomy for the Space Professional	This course provides a high-powered overview of modern astronomy and planetary science to professionals in engineering, management, and policy fields needing a solid grounding in these areas. Basic elements of stellar physics and evolution, galaxy formation.
Designing Cost Effective Space Missions	This course provides an integrated view of space mission design and operations from conceptual design and requirements definition, through spacecraft design, development and test, to development of mission operations concepts and ground infrastructure.
Hands-On Space Mission Design	This course provides participants with an opportunity to exercise creative and technical skills by developing a conceptual design for a specified mission, and allows participants to enhance communication, interpersonal, and team skills.
Introduction to Remote Sensing	This course provides a broad knowledge of the principles and techniques associated with the scientific instruments that produce high resolution images of planetary surfaces. The instruments considered, chiefly space-borne, operate in the visual and IR.
Risk Assessment for Space Flight	The fundamentals of risk assessment and decision making in the face of uncertainty will be covered, including technical schedule, cost risk, and programmatic risk. Tools and techniques, including available PC software for risk assessment, will be covered.
Satellite Communications: Systems, Technology, and Application	This course covers the fundamentals of satellite communications and demonstrates the process for building an architecture for a space communication system. You will learn how a satellite architecture is put together to perform link budget calculations.
Space Environment Interactions	This course presents an introduction to the space environment and its effect on spacecraft. Emphasis is placed on problem solving techniques and design guidelines that will provide the student with an understanding of how space environment effects may be.
Space Systems I	This multi-disciplinary course provides an in-depth summary of the technologies needed to understand and develop spacecraft systems and instrumentation. The course presents a system engineering approach for understanding the design and testing of spacecraft.
Space Systems II	This multi-disciplinary course is a continuation of Space Systems I, and provides an in-depth summary of the technologies needed to understand and develop spacecraft systems and instrumentation. The course presents a system engineering approach.

Understanding Space	This course takes a fresh look at space missions by emphasizing a process-oriented approach for creating mission to meet broad, often poorly-defined objectives. You will learn: history of space exploration, big-picture view of orbits, and interplanetary transfers
Naval Postgraduate School	
SS0810 Thesis Research	Thesis Research for Space Systems Degree.
SS3001 Military Applications of Space	Space systems and technology of interest to the military. Strategic and tactical Imagery and SIGINT requirements. Tasking and use of national space systems and ground support elements. Vulnerability considerations and impact of current R&D programs.
SS3011 Space Technology and Applications	An intro to space mission analysis with an emphasis on those space missions supporting military operations. Topics include space history, doctrine and organizations, orbital mechanics, communication link analysis, space environment, spacecraft technology.
SS3035 Microprocessors for Space Applications	An intro to microprocessors at the hardware/software interface. Machine language programming, assembly language programming, I/O systems and interfacing, and operating systems.
SS3041 Space Systems and Operations I	Space systems mission analysis and design. Mission characterization, mission eval, requirements determination, cost analysis and estimating, cost and operational effectiveness analysis.
SS3051 Space Systems and Operations II	This course covers joint space doctrine, space policy, and applications of selected military space systems. Topics include the space mission areas of space control and space force enhancement to include space-based navigation, environmental monitoring, and space surveillance systems along with satellite command and control networks. Additional topics include space threats, tactics, ground application tools and the space annex for an operations plan.
SS3500 Orbital Mechanics and Launch Systems	Fundamentals: conic sections, coordinate systems and transformations, time. The two-body problem: Newton's laws and their solution, Kepler's equation. Orbital maneuvering. Orbit determination. Perturbations. Mission design. An overview of the performance and selection of launch vehicles. Launch profile and basic terminology (GLOW, mass ratio, injected weight, etc.). Ascent and payload delivery performance. Launch windows, Future launch systems.
SS3525 Air/Ocean Remote Sensing for Interdisciplinary Curricula	Principals of radiative transfer and satellite sensors, and methods used to measure the atmosphere and ocean; visual infrared and microwave radiometry, and radar systems. Laboratory sessions illustrate lecture concepts using interactive displays of satellite data. Course designed for Space Systems Operations, Space Systems Engineering, Undersea Warfare, Underwater Acoustics and other interdisciplinary curricula.

SS3613 Military Satellite Communications	MILSATCOM mission analysis, systems design, and applications. This course will cover requirements, tactical employment, system architectures, satellite design and performance, terminal design and performance, associated information systems, link budget calculations, telemetry and control and IO/IW implications. The student will be expected to create SATCOM solutions for Navy and Marine Corps scenarios.
SS3900 Special Topics in Space Systems	Directed study either experimental or theoretical in nature.
SS4000 Space Systems Seminars and Field Trips	Seminars consist of lectures to provide perspective on Space Systems. Field trips expose the student to various space activities such as industry, NASA and DoD labs and commands.
SS4051 Military Space Systems and Architectures	This course covers the system level architectural design of selected Space Systems. Emphasis is on a balanced design of all seven components of space system: space, launch, ground, mission ops, C3 arch., subject, and orbit and constellation.
SS4900 Advanced Study in Space Systems	Directed graduate study based on journal literature, experimental projects, or other sources.
AE0810 Thesis Research	Thesis Research for Aeronautical Engineering Degree.
AE2440 Introduction to Digital Computation	Introduction to system operations and program development on the department UNIX workstations and the NPS computer facilities. High-level programming languages, including C, MATLAB, and FORTRAN. Development of computer programs, subroutine organization, input and output. Applications of programming techniques to the solution of selected problems in engineering.
AE2820 Introduction to Spacecraft Structures	Review of statics and strength of materials. Beam theory: axial, bending, shear and torsional loading, stress analysis and deflection of beams. Design of spacecraft structures for launch loads and a survey of typical launch vehicles. Beam buckling and vibration, critical buckling loads, natural frequencies, and mode shapes. Truss structures and introduction to the finite element method.
AE3804 Thermal Control of Spacecraft	Conduction, radiation, thermal analysis, isothermal space radiator, lumped parameter analytical model, spacecraft passive and active thermal control, heat pipes, and louvers.
AE3811 Space Systems Laboratory	Principles of spacecraft test programs; component, subsystem, and system level tests; military standard test requirements for space vehicles, laboratory experiments in Fltsatcom Laboratory on satellite performance, in Spacecraft Test Laboratory for vibration, modal and thermal tests; and in spacecraft attitude control laboratory for spacecraft control performance.
AE3815 Introduction to Spacecraft Dynamics	Coordinate system transformations (GCI, LVLH, etc.), time differentiation operator, velocity and acceleration in 3D-frames of reference, Poisson's equations, spacecraft application examples (strapdown INS, etc.), angular momentum, inertia tensor

	transformations, Newton-Euler equations of motion, spin stability, single-spin spacecraft, nutation and precession, energy-sink analysis, passive nutation control, dynamics and stability of dual spin spacecraft, gravity-gradient stabilization.
AE3818 Spacecraft Attitude, Dynamics and Control	Stability of dual-spin stabilized spacecraft, active nutation control, disturbance torques: solar, magnetic, gravity gradient, and aerodynamic, attitude sensors, antenna beam pointing accuracy, three-axis-stabilized spacecraft, fixed momentum wheel with thrusters, three reaction wheel system, attitude control pointing requirements for military spacecraft.
AE3820 Dynamics of Space Systems	This course is an intermediate level analysis of the dynamics of space systems, including: ascent and descent of rockets, tethers, yo-yo despin, spinning hubs with flexible appendages, single stage to orbit, and various problems in spacecraft attitude dynamics such as nutation dampers. The analysis will include developing the equation of motion, equilibrium and stability analysis, solutions of nonlinear systems using perturbation methods and numerical techniques. Computational and symbolic manipulator packages will be used extensively.
AE3830 Spacecraft Guidance and Control	Overview of the Spacecraft Guidance, Navigation and Control System. Sources and effects of navigation and modeling errors on guidance and control systems. Error propagation techniques: linearization of spacecraft dynamical equations, covariance propagation and Monte Carlo simulations. Applications to spacecraft rendezvous and attitude control. Introduction to optimal control theory. Optimal bang-bang control for spacecraft thrusters. Linear-quadratic control problems and feedback control. Selection of weights and performance analysis. Perturbation guidance. Application of the matrix Riccati equation to spacecraft stability, control and guidance.
AE3851 Spacecraft Propulsion	Introduces concepts and devices in spacecraft propulsion. It reviews fundamental fluid mechanics, electricity and magnetism, and thermodynamics with molecular structure. Conventional chemical means such as H2/O2 and monopropellants are discussed. Electric propulsion schemes (resistojets, arc-jets, ion, magneto-plasma-dynamic, etc.) are introduced and their performances contrasted with chemical schemes. Characteristics of more advanced concepts (laser, solar, nuclear, etc.) are also considered.
AE3852 Propulsion for Launch Vehicles	Introduction to propulsion for launch vehicles, beginning with mission energy requirements and an overview of current and proposed launch propulsion devices. Performance analysis, operating characteristics and propellant selection criteria are considered for propulsion systems. Advanced cycles and concepts are presented. Design of components and subsystems.
AE3870 Computational Tools for Spacecraft Design	In this course, the students become familiar with the use of computer aided design tools for spacecraft subsystems and system design. The tools are for conceptual spacecraft design trade-offs and detailed

	subsystem design, such as for structures, thermal, attitude control, and communications.
AE4362 Astrodynamics	Review of the two-body problem. The effects of a third point mass and a distributed mass. Expansion of the disturbing potential in series of Legendre functions. Variation of parameter equations for osculating orbital elements. Perturbation and numerical solution techniques. Statistical orbit determination. Codes used by the military to maintain the catalog of artificial satellites and space debris.
AE4452 Advanced Missile Propulsion	Analysis and design of solid propellant rockets, ramjets, dual-combustion ramjets, scramjets and ducted rockets. Propellant selection criteria and characteristics, combustion models and behavior, performance analysis, combustor design, combustion instabilities and damping, mission and flight envelope effects on design requirements and technology requirements. Use of performance and grain design codes (SPP, PEP, and NASA SP233) and laboratory test firings for comparison with measured performance.
AE4502 Supersonic and Hypersonic Flows	One-dimensional, compressible flow is reviewed. Two-dimensional and axis-symmetric supersonic of ideal gases. Oblique shocks and expansion waves. General compressible flow equations. Potential supersonic and conical flows. Compressible scaling and transonic area ruling. Effects of very high velocity and low density. Hypersonic flow. Mach number independence and equivalence principles. Newtonian method. Blunt and slender body solutions. Real gas behavior and effect on shock and boundary layers. Applications are presented to satellite parasitic drag and re-entry flows.
AE4506 Rarefied Gas Dynamics	Topics include advanced thermodynamics with molecular structure, kinetic theory, distribution functions, Boltzmann equation and transport phenomena from a kinetic theory point of view. Types of flow range from free-molecule to transition, to high temperature continuum. Numerical approaches are discussed. Applications to space problems and hypersonics are treated.
AE4816 Dynamics and Control of Smart Structures	Review of dynamics, finite element method, structural natural frequencies, mode shapes, and control of flexible structures. Smart sensors and actuators and applications to active vibration control, shape control, vibration isolation and fine beam pointing. Equation of motion of spacecraft with flexible structures, and control of spacecraft and flexible structures. The interaction of flexibility and control. Impact of flexibility of on the performance of military spacecraft and future trends.
AE4818 Acquisition, Tracking and Pointing of Military Spacecraft	Acquisition, tracking, and pointing (ATP) requirements for military spacecraft, effects of jitter on ATP performance, jitter control, acquisition system, tracking algorithms, laser beam control, spacecraft attitude control using control moment gyros, example

	of ATP designs for military spacecraft, laboratory experiments on spacecraft attitude control and laser beam control.
AE4830 Spacecraft Systems I	This course emphasizes the systems analysis of geosynchronous spacecraft and covers the analysis of GNC (orbit and attitude control), structures, propulsion, thermal and electrical power subsystems. Basic mathematical equations will be used in the preliminary design of the subsystems and the tradeoff studies involved. The differences and similarities between dual-spin and three-axis stabilized spacecraft will be covered in detail. Systems aspect of a typical mission profile will be illustrated. Throughout, emphasis will be on the spacecraft bus. Students will be engaged in problem solving during most of the laboratory period.
AE4831 Spacecraft Systems II	In this course, students will be involved in a group project to design a spacecraft to meet mission requirements. Material presented in AE4830 as well as AE4831 will be utilized. In parallel, this course covers some or all of the following aspects of spacecraft systems: spacecraft testing, TT&C subsystem, and design of observation payloads. Differences and similarities between geosynchronous spacecraft and LEO/HEO spacecraft will be discussed. Topics include gravitational perturbation (J2 effects), gravity-gradient stabilization and atmospheric drag effects.
AE4850 Astrodynamics Optimization	This course develops basic measures of performance of a space vehicle (including launch vehicles) with methods to target a set of conditions and optimize the performance. Topics include an overview of the Guidance, Navigation and Control System, fundamentals of nonlinear programming, state-space formulation, vehicle and environmental models, performance measures, problem of Bolza, the Maximum Principle, and transversality conditions. A significant focus of the course will be in practical methods and numerical techniques, particularly pseudospectral methods. Computational methods will be used to solve a wide range of problems in astrodynamic optimization arising in military space such as rapid spacecraft reorientation and targeting problems, launch-on-demand, strategic low-thrust orbital maneuvers and optimal formation-keeping strategies. Where appropriate, the course will illustrate systems aspects of mission design.
AE4860 Military Space Maneuvers	This course develops the fundamentals of tactical and strategic space maneuvers and addresses the issues pertaining to space warfare. The course covers a wide range of specific military maneuvers that include their mathematical modeling, mission definitions, mission design and optimization. Special attention will be paid to the class of following maneuvers: pursuit-evasion problems, orbital intercept, destructive and nondestructive asset denial problems, rapid retargeting and minimum-time space maneuvers. These maneuvers and certain elements of high-speed velocity guidance will be modeled,

	simulated, optimized and analyzed as part of the laboratory sessions. Students will also gain practical experience in a state-of-the-art software t analyze the implementation of future military space maneuvers. Additional details pertaining to the course are classified.
AE4870 Spacecraft Design and Integration I	Principles of spacecraft design considerations, spacecraft configurations, design of spacecraft subsystems, interdependency of designs of spacecraft subsystems, launch vehicles, mass power estimation, and trade-offs between performance, cost, and reliability. The emphasis is on military geosynchronous communications satellites. The course includes an individual design project.
AE4871 Spacecraft Design and Integration II	A team project oriented course on design of non-geosynchronous spacecraft systems. Provides understanding of the principles of space system design, integration, and systems engineering, and their application to an overall spacecraft mission. Considerations are given to cost, performance, and test plan. Several DoD/NASA organizations, such as Naval Research Laboratory and Jet Propulsion Laboratory, provide support in the definition of the mission requirements for the project, spacecraft design, and design reviews.
AE4902 Advanced Study in Astronautical Engineering	Directed advanced study in Astronautical Engineering on a subject of mutual interest to student and staff member after most of a student's electives have already been taken. May be repeated for credit with a different topic.
EC3230 Space Power and Radiation Effects	Fundamentals of different power systems utilized in spacecraft; photovoltaic power technology; solid-state physics, silicon solar cells, solar cell measurement and modeling, gallium arsenide cells and II-V compounds in general, array designs and solar dynamics. Radiation effects on solid state devices and materials. Survivability of solar cells and integrated circuits in space environment and annealing method. Other space power systems including chemical and nuclear (radioisotope thermoelectric generators and nuclear reactors). Energy storage devices and power conversion. Spacecraft power supply design.
EC4590 Communications Satellite Systems Engineering	Communication satellite systems including the satellite and user terminals. Subjects include orbital mechanics, satellite description, earth terminals, detailed link analysis, frequency division multiple access, time division multiple access, demand assignment, random multiple access, and spread spectrum multiple access. Various military satellite communications systems are introduced.
PH1051 Physics Refresher for Space Sciences	This calculus-based course covers the fundamentals of mechanics and electricity and magnetism: Kinematics and dynamics of particles, work, energy, rotations of rigid bodies, angular momentum and torque, gravity, electric charge, electric and magnetic fields, forces on charges in fields, electric potential, Gauss' law, Ampere's law, Faraday's law, Maxwell's equations, and electromagnetic waves. Mathematical

	concepts will be briefly reviewed as needed. PREREQUISITES: College algebra, some calculus.
PH2511 Introduction to Orbital Mechanics	The gravitational two-body problem. Elliptic orbits and orbital elements. Orbital maneuvers and transfers. Time of flight. Ground track. Additional topics selected from the following: suborbital trajectories, hyperbolic trajectories, orbit determination from radar data, sun synchronous orbits, Molniya orbits and orbital perturbations.
PH2514 Introduction to the Space Environment	Plasma concepts. Solar structure and magnetic field, particle and electromagnetic emissions from the sun, the geomagnetic field, and the magnetosphere, radiation belts, structure and properties of the earth's upper atmosphere, ionosphere, implications of environmental factors for spacecraft design.
PH3052 Physics of Space and Airborne Sensor Systems	Explores the physical principles underlying the sensor systems needed for satellites and tactical aircraft as well as limitations imposed by the atmosphere and operating environment on these systems and their communication links. Satellite orbits, the satellite environment, ionospheric interactions.
PH3513 Intermediate Orbital Mechanics	Orbital perturbations due to various sources, such as atmospheric drag and lunar tidal effects. Interplanetary trajectories.
PH3516 Environmental Factors in Spacecraft Design and Operation	The environmental effects covered in this course include spacecraft charging, space radiation effects, natural and artificial space debris, and atmospheric effects. The nature of the physical interactions is emphasized.
PH4515 Physics of the Satellite Environment	A graduate level treatment of the structure and properties of the near earth space environment and some aspects of solar physics. Topics (usually two per quarter) are chosen from: ionospheric composition, ionospheric radio wave propagation, structure of the magnetosphere, the geomagnetic field, solar structure and emissions, spacecraft/environment interactions.
PH4531 Introduction to Astrophysics	Introduction to theories of stellar structure, energy transport in stars, and stellar evolution; recent advances in solar physics; supernovae, pulsars, black holes, and the origin of the universe will be topics of discussion.
Naval War College	
EL 580 - Seminar on Space Technology and Policy	The presumption is that space technologies and policies influence U.S. national security and military capabilities in comprehensive terms. The problem, however, is that space technologies and policies are often shrouded from view.
Air University School of Advanced Airpower Studies	
SAAS 665 - Space and Information Power	This course examines the development of military space operations, organizations, and strategy. It also traces the recent evolution of information operations through these same areas. The course integrates the two themes by requiring students to think critically

Space and Missile Systems Center	
SMC Acquisition School	This course is geared for personnel who are new to the space acquisition arena. Its focus is on basic concepts and the unique aspects that make space programs different from other military procurements.
Acceptance/Protoflight/Qual	Space Vehicle Test Training
Acoustics/Vibration	Space Vehicle Test Training
Aerospace Vehicle Test Course	
Control & Electromechanics	Space Vehicle Test Training
Electronics/Electrical	Space Vehicle Test Training
EMC/EMI	Space Vehicle Test Training
Environment & Survivability	Space Vehicle Test Training
Environmental Test Evaluation	Space Vehicle Test Training
Explosive Ordinance	Space Vehicle Test Training
Launch Vehicle Propulsion	Space Vehicle Test Training
Launch Vehicle Test Requirements	Space Vehicle Test Training
Mass Properties	Space Vehicle Test Training
Moving Mechanical Assemblies	Space Vehicle Test Training
Piece Part Testing	Space Vehicle Test Training
Satellite Propulsion	Space Vehicle Test Training
Shock	Space Vehicle Test Training
Storage	Space Vehicle Test Training
Structural Dynamics	Space Vehicle Test Training
Structures	Space Vehicle Test Training
The Business of Space Program	The Business of Space Course is designed to provide an overall picture of the Space and Missile Systems Center, its space partners, and customers.
Thermal Environment Test	Space Vehicle Test Training
National Security Space Institute (NSSI)	
Space Operations Course (SOC)	SOCs are geared for those with an existing foundation of basic space operations knowledge. This course highlights capabilities, limitations, vulnerabilities, applications and employment

	considerations of the numerous space systems integrating space power into military operations.
Director of Space Forces (DIRSPACEFOR)	DIRSPACEFORs provide selected senior leaders (O-6 and above), in identified positions of leadership, education and training in preparation to serve as senior space officers in an Air Operations Center, or on a unified staff during large-scale contingencies. This course's focus is on how space assets are leveraged in AOC-specific operations.
Counterspace Planning and Integration Course (CPIC)	3-day advanced education course, which provides a comprehensive look into the space control mission area. Intent is to keep MAJCOMs, headquarters and theaters informed and up to date on space control capabilities.
Space in the Air Operations Center Course	An introduction to personnel with space background and expertise on the unique ops and processes used to successfully employ air and space assets in support of theater military operations.
Space Operations Executive Level Course (SOCE)	SOC-Es are designed for senior MAJCOM staff personnel, NAF and CAF commanders, senior-ranking individuals new to the space operations career field, or those simply requiring a refresher course in the capabilities, limitations and vulnerabilities of critical DoD, National, civil and commercial space systems.
Space 200	Officer/Enlisted/Civilian space professionals with 8-10 years of service - required for Space Professional Level 2 certification. The Space 200 course provides training on various DoD, civil and commercial, national and foreign space systems. The Space 200 course emphasizes technical knowledge; design, development and acquisition of space systems; and space integration and tactics in joint warfare.
Space 300	Officer/Enlisted/Civilian space professionals with 13 - 15 years of service - required for Space Professional Level 3 certification
Space Fundamentals Course (SFC)	3 –day advanced education course, which provides a comprehensive look into the space control mission area. Intent is to keep MAJCOMs, headquarters and theaters informed and up to date on space control capabilities.
Space Policy Institute - George Washington Univ.	
International Affairs 223 - U.S. Space Policy	Overview of U.S. space activities in their international context
United States Army Signal Center	
102-31S10 CC P-AOT SATCOM SYSTEMS OPERATOR/MAINTAINER (COMMON-CORE P-AOT)	PURPOSE: To train Active Army and Reserve Component personnel to operate and maintain the strategic satellite communications (SATCOM) terminals AN/GSC-52(V), AN/GSC-52A, AN/FSC-78B, AN/GSC-39B and their associated equipment.
USA Space and Missile Defense Command/Army Forces Strategic Command (SMDC/ARSTAT)	

FA40 Space Operations Officer Qualification Course	11-week IQT for Army Space Operations Officers. Includes Space 200.
JTAGS IQT	7-week course for new JTAGS system operators and crew leaders.
Tactical Space Operations Course:	5-week course for Army Space Support Elements and Army Space Support Teams focused on operational applications of space operations support to the warfighter.
Mobile Team Training (MTT) in support of Fort Sill Field Artillery School Joint Operational Fires and Effects Course	
MTT in support of USA Intelligence Center and School Imagery Course (35C)	
Military Intelligence Captains Career Course (MICC)	
SIGINT Course (35G)	
Strategic Intelligence Course (FA34) G2/ACE Chief Course	
Pre-Command Course	
Army War College Space Seminar	
Army Command and General Staff Officers Course, Elective A537, Space Orientation, 24-hours	The completion of both electives earns students the Army Additional Skill Identifier 3Y-Space Activities which is coded in their personnel records and allows their secondary use of these skills in Army assignments.
Army Command and General Staff Officers Course, Elective A543, Space Operations, 48-hours	The completion of both electives earns students the Army Additional Skill Identifier 3Y-Space Activities which is coded in their personnel records and allows their secondary use of these skills in Army assignments.
USAF Special Operations School	
Special Operations Forces Senior Space Course	The course is conducted in seminar format with no more than 25 students per class. Instruction is accomplished through lectures, panel discussions and subject matter expert interviews. The student will gain exposure to the full DoD spectrum of space asset.
Special Operations Space Planner Course	The course is conducted in seminar format with no more than 25 students per class. Instruction is accomplished through lectures, panel discussions and subject matter expert interviews. The student will gain exposure to the full DoD spectrum of space asset.
USAF Test Pilot School	

Aerospace Vehicle Test Course	U.S. Air Force Test Pilot School at Edwards AFB will offer a 4-week Aerospace Vehicle Test Course. The course is intended to educate select USAF engineers to plan, provision, execute, and report on testing of the next generation of USAF space vehicles. The course will consist of approximately 80 hours of academics supplemented with projects, simulation, fieldtrips, and flying. Attendees must either have a degree in Aeronautical, Aerospace, or Astronautical Engineering, or have considerable experience in one of these fields. A general working knowledge of these areas is assumed. The course will be funded by the attendee's unit.
USAF Weapons School	
SPACE WIC USAF Space Weapons Instructor Course	Trains qualified space and missile operations officers to be experts in the full array of space capabilities, limitations, and employment considerations, and the integration of those capabilities with air-breathing CAF operations.

Appendix 5

Army Space Core Competencies and Skills for FA40 Space Operations Officer Qualification Course

Following are the 2006 approved Army FA40 Space Operations Officer Qualification Course critical tasks, conditions and standards statements and supporting performance steps.

TASK NUMBER: 129-140-1001 **Effective Date: Mar 2006**

TASK TITLE: *PLAN Space Control Effects*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access such as SECRET Internet Protocol Router Network (SIPRNET) and Joint Worldwide Intelligence Communications System (JWICS) to space agencies (United States Strategic Command (USSTRATCOM), U.S. Army Forces Strategic Command (ARSTRAT), United States Space Command Air Force (AFSPACE), Joint Space Operations Center (JSPOC), Naval Network and Space Operations Command (NNSOC), National Reconnaissance Office (NRO), National Geospatial-Intelligence Agency (NGA), etc.) and given a military operation and commander's intent.

STANDARD: Space control planning process will support the commander's intent and will consider the complete realm of space control options (space surveillance, protection of space system assets, prevention of enemy space use, negation of enemy space systems).

REFERENCES: Field Manual (FM) 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), Joint Publication (JP) 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army Military Satellite Communication (MILSATCOM) Architecture, Joint Operation Planning and Execution System (JOPES) volumes 1-4, and Concept Plan 8035.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process (MDMP) **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Review the scheme of maneuver and concept of operations to determine the mission for space control to support the operation.
    a. Determine the unit's mission and desired end-state.
    b. Determine the higher headquarters (HQ) mission and desired end-state.
2. Analyze/develop space control mission.
    a. Determine facts, assumptions, higher mission, and intent.
    b. Determine what assets are available to provide space control operations.
        i. Consider internal units (such as the 1st Space Brigade) assets and capabilities (capabilities to protect friendly and negate (deny, degrade, disrupt, destroy) enemy satellite user, ground, or space segments).
        ii. Consider external capabilities (primarily U.S. Air Force).
        iii. Consider and regulatory measures.
        iv. Consider the need to teach and/or familiarize the classification level guide.
    c. Assess supported unit's desire to negate Red/Gray space capabilities.
3. Create and continually update space intelligence preparation of the battlespace (IPB).
    a. Identify threat space control capabilities and limitations (protection, surveillance).
    b. Identify enemy counterspace courses of action (COAs) that include,, at a minimum, the most likely COA and most dangerous COA (protection, prevention, surveillance).
    c. Identify enemy space-based high-payoff targets (HPTs).
    d. Identify enemy terrestrial space-related HPTs (surveillance, negation).
    e. Analyze Blue Force space control capabilities and limitations (negation).
4. Identify space control tasks.
    a. Review higher HQ mission and intent.
    b. Derive specified tasks (i.e., assure access to space systems).
    c. Derive implied tasks.
    d. Derive essential tasks.
5. Identify constraints.
6. Develop, analyze, and compare space control COAs.
    a. Include space surveillance (i.e., when are Red/Gray intelligence, surveillance, and reconnaissance (ISR) satellites overhead).
    b. Include prevention (i.e., how do we prevent Red/Gray use of U.S. or third party space systems).
    c. Include protection (i.e., how do we protect our space assets and our freedom to use them).
    d. Include negation (i.e., how do we deceive, deny, degrade, or destroy an adversary's space systems or use of space).
    e. Each COA must support the commander's intent and be feasible, acceptable, sustainable, distinguishable, and unique.
7. Present recommended COA to the commander for inclusion in the planning process.

TASK NUMBER: 129-140-1002 **Effective Date: Mar 2006**

TASK TITLE: *COORDINATE Space Control Effects*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Coordinate space control actions with higher, adjacent, and subordinate units.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Army Space Support to Operations), Army Space Reference Text, Army MILSATCOM Architecture Book.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Identify organizations and their missions that need to be included in the space control planning process. These include:
    a. Theater Space Coordinating Authority (SCA).
    b. Combatant commanders staff.
    c. Component staffs –joint force land component commander (JFLCC), joint force air component commander (JFACC), joint force marine component commander (JFMCC).
    d. USSTRATCOM.
    e. ARSTRAT.
    f. JSPOC.
    g. National intelligence agencies.
    h. Appropriate J2/G2 staffs.
    i. Legal authorities.
2. Identify planning/coordination issues to potentially work with the above elements to include:
    a. Nomination of space control effects.
    b. Request for forces (RFF) for tailored space support.
    c. Reception, staging, onward movement, and integration (RSOI) of deploying space forces.
    d. Possible integration of space control concept into the appropriate plan/annex of another command.
    e. Identify essential, specified, and implied tasks needing coordination with external agencies.
    f. Ensure issues related to protection, prevention, negation, and surveillance are all included in the coordination effort.
    g. Current space doctrine and tactics, techniques, and procedures.
    h. Identify collection requirements to J2 collection manager. These include:

            i. Negation – collection necessary in support of targeting (technical data) and battle damage.
            ii. Prevention/protection – collection necessary to verify if Red/Gray ISR is directing efforts against specific friendly high value forces in support of commander's essential elements of friendly information.
        i. Understand the purpose of the Rear Area Protection (RAP), correct format, and how to submit in support of operations.
3. Identify and use appropriate communication means as part of coordination effort. These include:
    a. SIPRNET.
    b. JWICS.
    c. Space control-specific communication systems.
4. Input space control requirements into the space tasking order (STO) to include:
    a. Task organization of space forces that are relevant to accomplishment of the tasks identified in the STO.
    b. Specific space control tasks that need to be executed as part of the STO.
    c. Other commands/organizations with which coordination needs to be conducted and that have a mission interest in the STO-identified requirements.
5. Understand the joint targeting process.

TASK NUMBER: 129-240-2001 **Effective Date: Mar 2006**

TASK TITLE*: PROVIDE Space Planning Support to the Military Decision-Making Process*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Provide accurate and timely space information, advice, and products in support of the commander's guidance, intent, and plan.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Army Space Support to Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4, MDMP.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Receive the mission.
    a. Assess time available to gather or produce space products and to plan space support missions.
    b. Coordinate with the operations officer for initial planning guidance.
    c. Coordinate with staff elements to determine space product support.
    d. Determine space resource allocations.
2. Coordinates with the operations officer for space input to warning order.
3. Conduct space mission analysis.
    a. Review higher headquarters order and any supporting space orders and annexes.
    b. Conduct initial space IPB. IPB includes:
        i. Define the battlespace environment-operational area of operations, identify space area of interest (AOI).
        ii. Conduct space/terrestrial weather, and terrain analysis of space AOI.
        iii. Evaluate the Blue/Red/Gray space order of battle, space control capabilities, threat space tasking, processing, exploitation, and dissemination (TPED) timelines, and space HVTs.
        iv. Determine threat COAs.
        v. Conduct friendly space force enhancement mission area analysis through:
            1. ISR
            2. Position, navigation, and timing.
            3. Communications.
            4. Weather, terrain, and environmental monitoring.
            5. Missile warning.

        vi. Provide input to operational decisional support matrix – develop space situation template and event template.
    c. Determine specified, implied, and essential tasks from a space perspective.
    d. Review available space assets.
    e. Identify space support enhancements.
    f. Identify critical facts and assumptions.
    g. Conduct risk assessment.
    h. Determine space support requirements to support commander's critical information requirements identification.
    i. Recommend theater space architecture needed to support the operation.
4. Identify space support that can assist the commander and staff with:
    a. Initial IPB products (see step above).
    b. Restated mission (concentrate on what, when, and where).
    c. Commander's intent (scheme of maneuver and timing).
    d. Commander's guidance (specific instructions and key tasks).
    e. Warning order.
    f. Battlefield framework.
5. Receive the restated mission and commander's guidance.
6. Participate in unit COA development process.
    a. Identify force enhancement and space control capabilities available to support each of the COAs.
    b. Recommend space products that enhance COA statements and sketches.
7. Develop space staff estimate to compare COAs.
8. Recommend potential space products that may be of use to other staff element COA analysis efforts.
9. Participate in unit COA analysis and comparison process. Steps include:
    a. Identify COA most supportable from a space force enhancement/control perspective.
    b. Include analysis of enemy space capabilities that could impact COA success (in coordination with (ICW) intelligence staff).
    c. Identify space-related advantages/disadvantages for each COA.
    d. Rank order COAs from space perspective.
10. Receive the final approved COA from the G3 and begin development of Space Annex/Appendix (see task to support annex).
11. Finalize space input to the warning order.
12. Coordinate with the rest of the battle staff to insure space-related input is integrated into their appropriate annex and/or appendix developed as part of the base plan and/or order.

TASK NUMBER: 129-240-2002 **Effective Date: Mar 06**

TASK TITLE: *ASSESS Blue Space System Capabilities and Limitations*

COVERED IN: SOOQC (TS/SCI)

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Provide an assessment of space-based blue systems, relevant to operations, to include availability, status, capabilities, and limitations to include potential target vulnerabilities of Blue space systems.

REFERENCES: FM 34-130 (Intelligence Preparation of the Battlefield), FM 100-15 (Corps Operations), FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), FM 100-7 (Decisive Force: The Army in Theater Operations), FM 71-100 (Division Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), TRADOC Pamphlet 525-3-14 (Concept for Space Operations in Support of the Objective Force) Space Databases, Army Space Reference Text, Army MILSATCOM Architecture Book, and FM 3-14 (Space Support to Army Operations).

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Define mission pertinent Blue space capabilities and limitations, including TPED.
    a. Identify pertinent space systems (satellite, user, and control segments):
        i. Communications.
        ii. Position, velocity, navigation, and timing (PVNT).
        iii. Environmental monitoring/meteorological and oceanographic (METOC) conditions.
        iv. ISR to include tactical exploitation of national capabilities (TENCAP) operations and systems.
        v. Missile warning.
    b. Determine for each of the above:
        i. Availability.
        ii. Status.
        iii. Capabilities.
        iv. Issues requiring space operations officer (SOO) involvement.
        v. Staff coordination responsibilities.
            1. G6/SOO regarding satellite communications (SATCOM).
            2. G2/SOO regarding ISR and TENCAP.
            3. Staff weather officer (SWO) and SOO regarding METOC conditions.
            4. Air and missile defense officer, G3, and SOO regarding missile warning.
            5. PVNT with G3 and effects/targeting cell.

c. Assess impact on commander's planning and operations.
d. Assess the impacts of denial of access to/loss of space systems to friendly forces.
e. Identify primary and backup strategy for continuous space posture support.

2. Advise the commander/staff.

TASK NUMBER: 129-240-2003 **Effective Date: Mar 06**

TASK TITLE*: ASSESS Red Space Systems Capabilities, Limitations, and Vulnerabilities*

COVERED IN: SOOQC (TS/SCI)

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Provide an assessment of pertinent Red space systems, satellite user, control system, and ground-based system relevant to operations that could pose a military threat to U.S. forces to include potential target vulnerabilities of Red space systems. (The information in this task is used in space planning/IPB.)

REFERENCES: FM 34-130 (Intelligence Preparation of the Battlefield), FM 100-15 (Corps Operations), FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), FM 100-7 (Decisive Force: The Army in Theater Operations), FM 71-100 (Division Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), TRADOC Pamphlet 525-3-14 (Concept for Space Operations in Support of the Objective Force) Space Databases, Army Space Reference Text, Army MILSATCOM Architecture Book, FM 3-14 (Space Support to Army Operations).

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Determine Red space capabilities and limitations.
    a. Identify space systems (satellite, user, and control segments).
        i. Communications.
        ii. PVNT.
        iii. Environmental monitoring.
        iv. ISR.
        v. Missile warning.
    b. Determine (as the operational situation requires)
        i. Availability.
        ii. Status.
        iii. Capabilities.
        iv. Limitations.
        v. How the enemy tasks, processes, exploits, and disseminates space-derived information.
    c. Assess impact on friendly planning and operations (IPB).
    d. Determine coordination responsibilities with the G2 concerning analysis of Red space and impacts on Blue operations.
    e. Include enemy space-related HPTs into the space targeting process.
2. Advise the commander/staff.

TASK NUMBER: 129-240-2004 **Effective Date: Mar 06**

TASK TITLE: *ASSESS Gray Space System Capabilities, Limitations, and Vulnerabilities*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Provide an assessment of other than Red and Blue systems relevant to operations of direct interest to the U.S. military.

REFERENCES: FM 34-130 (Intelligence Preparation of the Battlefield), FM 100-15 (Corps Operations), FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), FM 100-7 (Decisive Force: The Army in Theater Operations), FM 71-100 (Division Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), TRADOC Pamphlet 525-3-14 (Concept for Space Operations in Support of the Objective Force) Space Databases, Army Space Reference Text, Army MILSATCOM Architecture Book, FM 3-14 (Space Support to Army Operations).

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Determine Gray space capabilities and limitations.
    a. Identify space systems (satellite, user, and control segments):
        i. Communications.
        ii. Environmental monitoring.
        iii. ISR.
        iv. PVNT.
    b. Determine:
        i. Process for tasking/obtaining commercial, civil, and foreign space systems of direct interest to the U.S. military.
        ii. Availability.
        iii. Status.
        iv. Capabilities.
        v. Limitations.
        vi. Applicable TPED.
        vii. Disclosure/release of Gray space products (legal issues).
    c. Assess impact on plans and operations:
        i. Assess enemy use of Gray space capabilities.
    d. Include Gray space vulnerabilities/HPTs into the space targeting process.
2. Advise the commander/staff.

TASK NUMBER: 129-240-2005 **Effective Date: Mar 2006**

TASK TITLE: *DETERMINE the Impact of Space Weather on Space Operations*

COVERED IN: SOOQC (S)

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Provide relevant space weather impact assessments and products to the staff and show how space weather may impact current and future courses of action.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Understand the solar environment to include:
    a. Understanding of the Sun and its effects on satellite, user, and control segments.
    b. How solar particles travel through space and their interaction with the Earth's atmosphere.
    c. Impact of solar flare on satellite, user, and control segments.
2. Describe potential space weather effects on Red, Blue, and Gray systems.
3. Coordinate with appropriate staff sections to ensure space weather effects are understood and accounted for in the current and future plans and operations.
    a. Coordinate with communications officer for effects on communication systems.
    b. Coordinate with intelligence officer for effects on ISR systems.
    c. Coordinate with operations officer for global positioning systems (GPSs) and air defense artillery for effects on missile warning.
    d. Coordinate with SWO on space weather.
4. Advise/brief the Command and staff as appropriate.
5. Include space weather analysis into IPB.

TASK NUMBER: 129-240-2006 **Effective Date: Mar 2006**

TASK TITLE: *DETERMINE the Effect of Terrestrial Weather on Space Operations*

COVERED IN: SOOQC (S)

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Provide relevant information concerning the effects of terrestrial weather on space operations supporting current and future operations based on current and forecasted weather.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Gather current and forecasted relevant weather products.
    a. Coordinate with the SWO.
    b. Collect data from weather-related websites.
2. Review current and forecasted terrestrial weather.
3. Assess terrestrial weather impacts to space support to operations to include:
    a. Cloud cover impact on satellite based imagery collection (radar, electro-optical, infrared (IR), Multispectral Imagery (MSI).
    b. Cloud cover impact on space-based missile warning detection.
    c. Weather impacts on SATCOM, PVNT, and commercial satellite systems.
4. Identify space system, user, and control segments that are affected by terrestrial weather.
5. Coordinate with appropriate staff elements to ensure weather effects on space operations are understood and accounted for in the current and future operation and planning. At a minimum:
    a. Coordinate with G2/G3/G6.
    b. Coordinate with operations and air defense staffs for effects on missile warning systems.
    c. Coordinate with communications officer for effects on SATCOM.
    d. Incorporate weather analysis into IPB.
6. Advise/brief commander and staff as necessary.

TASK NUMBER: 129-240-2007 **Effective Date: Mar 2006**

TASK TITLE: *PRODUCE Space Staff Estimate*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Write a **s**pace staff estimate that identifies the most supportable course of action from a space perspective.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Prepare for space estimate (gather information).
    a. Gather space support information.
    b. Review space IPB and translate applicable space IPB data from a graphic to a written format, then include in the written space estimate.
    c. Produce analysis products to support the estimate process.
2. Review the mission, commander's intent, and commander's guidance.
3. Analyze the situation.
    a. Identify threat space capabilities and vulnerabilities.
    b. Identify friendly and civil commercial space asset availability, capabilities, and limitations.
    c. Review friendly COAs from a space force enhancement and space control perspective.
    d. Review operational facts and assumptions.
    e. Discuss issues, deficiencies, and risks.
4. Provide estimate and supporting space analysis products to the G3 and staff that identify most supportable COA from a space perspective.

TASK NUMBER: 129-240-2008 **Effective Date: Mar 2006**

TASK TITLE: *PROVIDE Space Support Inputs to Estimates/Operation Plans/Operation Orders/Fragmentary Orders/Warning Orders*

COVERED IN: SOOQC (S)

CONDITION: Equipped with space analysis tools and communications access, a concept of operations, staff estimates and higher headquarters estimates, and plans or orders.

STANDARD: Complete a product in coordination with all staff elements to ensure space is addressed in appropriate paragraphs and annexes.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Prepare input to operation plans (OPLANs)/operation orders (OPORDs)/fragmentary orders (FRAGOs)/warning orders.
    a. Determine the unit's mission and desired end-state.
    b. Review existing staff estimates.
    c. Review higher HQ orders/plans.
    d. Review USSTRATCOM and ARSTRAT supporting plans as required.
    e. Review space analysis materials completed during mission analysis/IPB.
2. Recommend task organization of assigned and attached space assets (i.e., Army space support team (ARSST), joint tactical ground station (JTAGS)).
3. Develop and write Space Annex to include in base plan. Use basic format of five-paragraph order to:
    a. Consider INCULAINE as supplement appendixes to the base annex. These appendixes cover force enhancement and space control areas that need emphasis for this operation.
4. Review other staff annexes. Below are suggestions for ways the SOO can incorporate space considerations into other staff annex(s). Because these are suggestions, the incorporation of space into another staff annex should only be done when there is definite value added.
    a. Review the intelligence estimate and Annex B to incorporate space-related data. This could include Red space order of battle, Red space COAs for inclusion in the estimate, and space-related priority intelligence requirements/specific information requirements, tasking requirements, and space-related ISR considerations.
    b. Review the Engineer Annex to identify how space capabilities may assist engineer operations (i.e., GPS for exact location info (minefields, obstacles), remote sensing for terrain (trafficability and soil conditions).
    c. Review the Air Defense Annex for complete information of space capabilities. Primary considerations would include JTAGS role in support to Patriot

operations, status of Defense Support Program (DSP) and its capabilities/limitations against threat surface-to-surface missiles, and impact of weather on space-based missile warning.

d. Review the Signal Annex for complete information. Focus will be to ensure that this annex covers all pertinent SATCOM data. SOO can recommend additional space input based on any noted shortfalls (i.e., enemy SATCOM jamming capability may affect UHF communications).
e. Review and incorporate space capabilities into the Deep Operations Annex of the OPLAN/OPORD.
f. Review and incorporate space capabilities into the Rear Operations Annex of the OPLAN/OPORD.
g. Review and incorporate space capabilities into the Airspace Command and Control (AC2) Annex of the OPLAN/OPORD.
h. Review and incorporate space capabilities into the Command and Control Warfare (C2W) Annex of the OPLAN/OPORD.
i. Review and incorporate space capabilities into the Operations Security Annex of the OPLAN/OPORD.
j. Review and incorporate space capabilities into the Psychological Operations (PSYOP) Annex of the OPLAN/OPORD.
k. Review and incorporate space capabilities into the Deception Annex of the OPLAN/OPORD.
l. Review and incorporate space capabilities into Electronic Warfare (EW) Annex of the OPLAN/OPORD.
m. Review and incorporate space capabilities into Information Operations (IO) Annex of the OPLAN/OPORD.
n. Input to Annex S as appropriate.

TASK NUMBER: 129-240-2009 **Effective Date: Mar 2006**

TASK TITLE: *REQUEST External Space Support*

COVERED IN: SOOQC **(S)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Coordination is conducted in sufficient time to provide space related products/information in support of planning and operations.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Production), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**; PROVIDE Space Related Products **(40-8-0002)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Understand the theater space architecture.
    a. Role of the Space Coordinating Authority and the Director of Space Forces (DIRSPACEFOR).
    b. Role of USSTRATCOM's Joint Functional Component Command for Space and Global Strike (JFCC-SGS).
    c. JSPOC roles and responsibilities.
    d. Combatant command space staff roles/responsibilities.
    e. Request for information (RFI) submittal process from division space support element (SSE) to sanctuary.
    f. Determine how to leverage other staff sections (G2, G6, AD, G3, G7).
2. Understand key national space organizations, what capabilities they provide, and how they disseminate information in support of military operations.
    a. National Reconnaissance Office.
    b. National Security Agency.
    c. National Geospatial Intelligence Agency.
    d. National Security Space Office.
    e. Buckley Air Force Base.
    f. National Air and Space Intelligence Center.
    g. Joint Space Operations Center and SMDC Operations Center (OC).
3. Establish communications with identified units/organizations.
    a. Establish non-secure internet protocol router network (NIPRNET) and SIPRNET communications.
    b. Establish communications with identified units/organizations.
    c. Establish JWICS communications if required (through use of J2/G2).
4. Request space-related products to support planning and operations.
5. Identify key Web sites to pull space data from in order to support planning/operations.
6. Describe how to task space systems.
    a. National technical means.

    b. Civil and commercial satellites.
    c. Department of Defense (DoD) satellites.
7. Describe the collection management process and organizations involved with space asset tasking.
    a. Overhead Collection Management Center.
    b. Requirements Management System for national and commercial imagery.
    c. Regional and global SATCOM support centers.
    d. SMDC OC.
8. Receive and disseminate products or information from external agencies as necessary in support of operational requirements.

TASK NUMBER: 129-240-2010 **Effective Date: Mar 2006**

TASK TITLE: *INTEGRATE Space Forces and Operations*

COVERED IN: SOOQC (TS/SCI)

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Integration is accomplished exercising approved C2 and in sufficient time to ensure all space assets have clear command relationships, concise mission tasks, and necessary Service support.

REFERENCES: FM 3-0 (Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**; Produce Space Support Annex **(240-2012)**; PROVIDE Space-Related Products **(40-8-0002)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Plan for employment of space forces.
    a. Prepare RFF to be forwarded to Army Strategic Command.
    b. Coordinate initial deployment (consider collocating C2 with SCA, logistic requirements, RSOI, and synchronization with other assets flowing into theater).
    c. Understand and establish a command and control relationship of space forces.
2. Understand the role of theater joint SCA and DIRSPACEFOR.
3. Recommend location of the SCA and Service component lead.
4. Understand the missions and plan for the employment of space forces.
    a. Understand the mission functions of Army space capabilities and recommend command relations, location, and mission for these capabilities.
        i. ARSTRAT Regional SATCOM Support Center (RSSC), Measurement and Signature Intelligence (MASINT), National Geospatial Imagery (NGI) Node, OC, and Mission Management Center (MMC)).
        ii. 1ST Space Brigade (Commercial Exploitation Team, SIGS, ARSSTs, and JTAGS).
        iii. SSE
            1. Division.
            2. Corps.
            3. Army.
    b. Understand the roles and relationships between the SSE and ARRSTs.

TASK NUMBER: 129-240-2011 **Effective Date: Mar 2006**

TASK TITLE: *ADVISE the Commander and Staff on Missile Warning*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Describe the warning architecture and recommend the most effective means of warning, capabilities (including overhead non-imaging infrared) and dissemination.

REFERENCES: FM 3-0 (Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Understand the theater missile warning plan.
    a. Describe the theater voice warning architecture and plan.
    b. Describe the theater missile warning data architecture.
    c. Describe the capabilities and limitations of each element of the theater event system to include:
        i. DSP satellites (number, location, detection capabilities, and limitations).
        ii. JTAGS/multimission mobile processor (M3P) mission, manning, tasking, and dissemination.
        iii. Familiarization with radar missile detection capabilities.
        iv. Other IR missile detection capabilities available on other than DSP space-based assets.
2. Understand:
    a. USNORTHCOM integrated tactical warning and attack assessment mission.
    b. ARSTRAT Ground-Based Midcourse Defense (GMD) Brigade organization, mission, and capabilities.
3. Understand the mission, plan, order, etc., of the supported unit.
    a. Determine the scheme of support.
    b. Determine key subordinate units and their current and projected locations.
4. Understand and analyze threat theater ballistic missile capabilities based on probable launch locations, targets, and specific missile types. This includes:
    a. ICW the G2, conduct IPB of possible launch locations.
    b. Determine ability of DSP and other missile warning to locate, tag, and type Red Force missile launches.
5. Understand unit communication architecture.
    a. Determine the means that could be used to disseminate voice warning.
    b. Determine what elements have the capability to receive warning data.

c. Determine the effect on warning timelines for key subordinate unit locations.

6. Assess the current and forecasted space and terrestrial weather impacts on missile warning timelines (component of IPB).
7. Recommend changes in unit force protection posture based on current missile warning timelines.
8. Define the four mission areas associated with space-based infrared system (missile warning, missile defense, technical intelligence, and battlespace characterization (BSC)). Determine the role of the SOO in providing BSC data to Army operational forces.

TASK NUMBER: 129-240-2012 **Effective Date: Mar 2006**

TASK TITLE: *BRIEF Future/Emerging Space Capabilities and Concepts*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Effectively describe and explain the future space capabilities and limitations in support of Army requirements.

REFERENCES: FM 3-0 (Operations, JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported:

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Understand that explanations should be tailored by the FA40 to be focused in support of command interests and applicability to mission requirements.
2. Understand future and emerging force enhancement capabilities:
    a. SATCOM – transformational communications, laser communications.
    b. ISR.
    c. Missile warning.
    d. PNVT.
    e. METOC.
    f. Commercial.
3. Understand the roles of the relevant organizations (SMDC/Directorate of Combat Development, AFSPACE, and JFCC-SGS) in emerging space control capabilities.
4. Understand where to get information on future capabilities (Web sites/points of contact).

TASK NUMBER: 129-240-2013 **Effective Date: Mar 2006**

TASK TITLE: *EXPLAIN the Role of ARSTRAT as the Army Service Component Command in Support of STRATCOM Missions*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Space officers must be able to understand their roles in executing or explaining USSTRATCOM missions to their supported organization or as a member of the ARSTRAT/USSTRATCOM staff.

REFERENCES: FM 3-0 (Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported:

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Identify ARSTRAT C2 relation with USSTRATCOM. Explain typical command relationships between ARSTRAT and other combatant commands.
2. Understand the roles and functions of the USSTRATCOM mission areas and the primary component elements related to each of these JFCCs.
    a. Space and Global Strike.
    b. Intelligence, Surveillance, and Reconnaissance.
    c. Network Warfare.
    d. Joint Information Operations Center.
    e. Integrated Missile Defense.
    f. Global Network Operations.
    g. Weapons of Mass Destruction.
3. Understand USSTRATCOM's integration into other unified or combatant commands.
4. Define the role of ARSTRAT as the Army Service component command to USSTRATCOM.
5. Define the role of SMDC/ARSTRAT in supporting each of the JFCCs.

TASK NUMBER: 129-240-2014 **Effective Date: Mar 2006**

TASK TITLE: *UNDERSTAND the Space Support Mission Area*

COVERED IN: SOOQC **(S/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Explain the roles of the primary space support organizations and be familiar with U.S. booster and launch facilities.

REFERENCES: FM 3-0 (Operations), FM 5-0 (Army Planning and Orders Organization), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported:

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Understand the roles of the following organizations in the area of space support:
    a. AFSPACE – specifically the 30th and 45th Space Wings and JSPOC.
    b. ARSTRAT – primary focus on the mission and role of 53rd SATCON Battalion.
    c. Naval Network Warfare Command.
    d. Army Space Program Office – role in space acquisition in support of tactical warfighting elements.
    e. SMDC – role of battle lab and technology center.
2. Understand:
    a. Continental United States (CONUS) launch facilities – Vandenberg Air Force Base and Cape Canaveral.
    b. Trajectories and orbits obtained from each of the above launch sites.
    c. Orbitology factors related to successful space launch.
    d. Satellites and orbits (low Earth, mid-Earth, high Earth, and geosynchronous Earth) and implications for military operations (IPB).
    e. U.S. booster and lift capabilities.
    f. Costs associated with launch.
    g. Satellite acquisition process.

TASK NUMBER: 129-240-2015 **Effective Date: Mar 2006**

TASK TITLE: *MANAGE Space Support*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Given a fully manned team and equipped with a space support element tool set.

STANDARD: Fully integrate with the staff. The staff is aware of space-related products and information that the team can provide and is using those products and information.

REFERENCES: JP 3-14 (Joint Doctrine for Space Operations) and FM 3-14 (Space Support to Army Operations).

Collective Task Supported:

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Brief Command on space support to include its reach-back to national/strategic levels and capability to support the following:
    a. Understand collection management process.
    b. Assist with expertise on national systems and employment in support of Army operations.
    c. Architecture support (dissemination).
    d. Space threat awareness.
    e. Satellite reconnaissance advanced notice (SATRAN) (warning dissemination, IPB).
    f. Support to operations.
        i. Space input to planning.
        ii. Imagery – Engagement Areas (EA), key terrain, etc.
        iii. Terrain visualization.
        iv. Space threat awareness.
        v. Current space impacts.
    g. Logistics
        i. Imagery – seaport of debarkation/aerial port of debarkation, log base.
        ii. Main supply route/alternate supply route fly-through.
        iii. Navigation/accuracy for convoys.
    h. Communications
        i. Space weather impact on communications.
        ii. Space-based architecture support.
        iii. High frequency (HF)/ultrahigh frequency (UHF) propagation windows.
        iv. Communication satellite health/status and details.
    i. Aviation
        i. GPS accuracy.
        ii. GPS jamming awareness.
        iii. Terrain visualization.
        iv. Combat Search and Rescue (CSAR) support.
    j. Information operations.

i. Computer Network Attack (CNA)/Computer Network Defense (CND) nominations.
ii. SATRAN impact on friendly forces deception operations.
iii. Space control support to EW.

k. Fires/targeting.
i. Space target nomination (space and terrestrial).
ii. GPS accuracy for deep attack.
iii. Space and terrestrial weather impacts on space systems that support targeting.

l. Air defense/theater missile defense.
i. Missile profiles and analysis.
ii. Early warning architecture (capabilities and limitations).
iii. Theater event system health/status.

m. Engineers
i. Imagery support for obstacles/bridges/crossings.
ii. Production assistance for geospatial operations .
iii. Site visualization.

n. Weather
i. Terrestrial weather forecast impacting space assets (i.e., DSP, optical).
ii. Space weather forecast and effects.

TASK NUMBER: 129-340-3001 **Effective Date: Mar 2006**

TASK TITLE: *EMPLOY Space Analysis Tools*

COVERED IN: SOOQC **(S)**

CONDITION: Equipped with space operations system, Space Battle Management Core System (SBMCS), Space Common Operating Picture Exploitation System (SCOPES), Satellite Tool Kit (STK), Joint Worldwide Intelligence Communications System (JWICS), and other appropriate software, and communications access.

STANDARD: Produce accurate and timely space analysis products to support planning and operations.

REFERENCES: FM 34-130 (Intelligence Preparation of the Battlefield), FM 100-15 (Corps Operations), FM 5-0 (Army Planning and Orders Production), FM 3-0 (Operations), FM 100-7 (Decisive Force: The Army in Theater Operations), FM 71-100 (Division Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), TRADOC Pamphlet 525-3-14 (Concept for Space Operations in Support of the Objective Force), Army Space Reference Text, Army MILSATCOM Architecture Book, FM 3-14 (Space Support to Army Operations).

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**; PROVIDE Space-Related Products **(40-8-0002)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Use Internet and SIPRNET to perform space missions.
2. Participate in planning and operations to determine space product support requirements.
3. Understand the capabilities of the SSE toolkit.
4. Attain basic operator familiarization of the following space analysis tools:
    a. SBMCS.
    b. SCOPES.
    c. STK.
5. Understand the space products available using the above capabilities.
6. Know the space-related Web sites and the type information and products available from these Web sites (Internet, NIPRNET, SIPRNET, and JWICS sites).
7. Attain and understand Web Access and Retrieval Portal (WARP), and the Unclassified Web Access and Retrieval Portal (U-WARP) and how to use them as an FA40.
8. Become familiar with JWICS capabilities and how to use them as an FA40.

TASK NUMBER: 129-340-3002 **Effective Date: Mar 2006**

TASK TITLE: *EMPLOY Army and Joint Command and Control Systems*

COVERED IN: SOOQC **(S)**

CONDITION: Equipped with Global Command and Control System (GCCS), command and control personal computer (C2PC) software and appropriate communications access.

STANDARD: Explain Army and joint communication system GCCS and C2PC information as it relates to space analysis.

REFERENCES: FM 3-0 (Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**; PROVIDE Space-Related Products **(40-8-0002)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Become familiar with Army SATCOM architecture to include:
    a. UHF.
    b. Super-high frequency.
    c. Extremely high frequency.
2. Become familiar with the following tactical SATCOM and how they support military operations.
    a. Global Broadcast System.
    b. Tactical satellite radio.
    c. Trojan Spirit.
    d. Single channel antijam man portable.
    e. Secure mobile antijam reliable tactical terminal.
    f. Second-generation antijam tactical UHF radio for NATO.
3. Understand Integrated Broadcast System/international broadband services switch and application to the common operational picture (COP).

TASK NUMBER: 129-340-3003 **Effective Date: Mar 2006**

TASK TITLE: *EMPLOY Blue Force Tracking Systems in Support of Operational and Tactical Warfighting Requirements*

COVERED IN: SOOQC **(S)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Define the capabilities of the Blue Force tracking (BFT) system architecture and understand BFT and the role of the SOO in accomplishing BFT mission requirements.

REFERENCES: FM 3-0 (Operations, JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported:

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Define the responsibilities of ARSTRAT in executing the BFT mission area.
    a. Role in executing DoD- and USSTRATCOM-directed tasking.
    b. Mission and functions of the MMC.
2. Define the roles/responsibilities of the space operations officer regarding BFT
    a. Knowledge of BFT architecture.
    b. Staff subject matter expert.
    c. Ability to troubleshoot both conceptual and technical issues.
    d. Ability to articulate BFT requirements to the collection manager.
3. Understand joint Blue Force situational awareness, its architecture and how it integrates all BFT into a COP.
4. Understand the capabilities and limitations of BFT devices.

TASK NUMBER: 129-440-4001 **Effective Date: Mar 2006**

TASK TITLE: *EXPLAIN Missions and Functions of Joint and Service Information Operation Organizations*

COVERED IN: SOOQC **(SECRET)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Explain organization structures, capabilities, doctrinal responsibilities, and specific tasking procedures for organizations that perform IO missions.

REFERENCES: FM 3-0 (Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture Book, DoD Directive 3600.1 (Information Operations) (CNO, CND, CNA, EW, PSYOP, OPSEC), Defense Planning Guidance 04-09, FM 3-13 (Information Operations).

Collective Task Supported: PROVIDE Space Input to the Military Decision-Making Process **(40-8-0001)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Identify key joint, national, and Service IO organizations.
2. Describe each organization, C2 structure, capabilities, and how space supports mission accomplishment.
    a. Office of the Secretary of Defense (Joint Task Force-Computer Network Operations, Joint Information Operations Center (JIOC)).
    b. USSTRATCOM.
    c. National intelligence agencies.
    d. G2/G3.
3. Describe mission roles/relations among the Army SSEs, 1st Information Operations Center (IOC) field support teams, and JIOC planners.
4. Understand the five pillar areas of IO:
    a. EW.
    b. CNO.
    c. PSYOP.
    d. Operations security (OPSEC).
    e. Military deception.

TASK NUMBER: 129-440-4002 **Effective Date: Mar 2006**

TASK TITLE: *UNDERSTAND How Joint Organizations Execute Planning*

COVERED IN: SOOQC **(TS/SCI)**

CONDITION: Equipped with space analysis tools and communications access to space agencies (USSTRATCOM, ARSTRAT, AFSPACE, JSPOC, NNSOC, NRO, NGA, etc.) and given a military operation and commander's intent.

STANDARD: Perform Joint Operations Planning and Execution System (JOPES) procedures in support of the joint commander. Support must include integration of space operations in deliberate planning process (DPP) and crisis action planning.

REFERENCES: FM 3-0 (Operations), JP 3-0 (Doctrine for Joint Operations), JP 5-0 (Doctrine for Planning Joint Operations), JP 3-14 (Joint Doctrine for Space Operations), FM 3-14 (Space Support to Army Operations), Army Space Reference Text, Army MILSATCOM Architecture, JOPES volumes 1-4.

Collective Task Supported: PROVIDE Space-Related Products **(40-8-0002)**

Safety Factors/Hazards: None

Environmental Considerations: None

PERFORMANCE STEPS

1. Understand the mission and roles of the following organizations:
    a. Joint staff.
    b. Combatant commands
    c. Joint/combined force air component commander, joint/combined force land component commander, joint/combined special operations task force, joint/combined force marine component commander.
    d. Service components.
    e. Battlefield coordination detachment.
2. Understand space responsibilities to:
    a. Space Coordinating Authority – mission, functions, and C2.
    b. Provide space input to joint planning (JOPES)
    c. Provide space input to joint IPB and MDMP. These include:
        i. Phase I – Situation Development.
        ii. Phase II – Crisis Assessment.
        iii. Phase III – Course of Action Development.
        iv. Phase IV – Course of Action Selection.
        v. Phase V – Execution Planning.
        vi. Phase VI – Execution.
    d. DPP
        i. Phase I – Initiation.
        ii. Phase II – Concept Development.
        iii. Phase III – Plan Development.
        iv. Phase IV – Plan Review.
3. Understand the joint requirements process as it applies to space.
    a. Joint Requirements Oversight Council.
    b. Army Requirements Oversight Council.
    c. Integrated Product List (IPL).
    d. Joint Capabilities Integration Development System.

4. Understand the joint targeting process and how space supports this process.