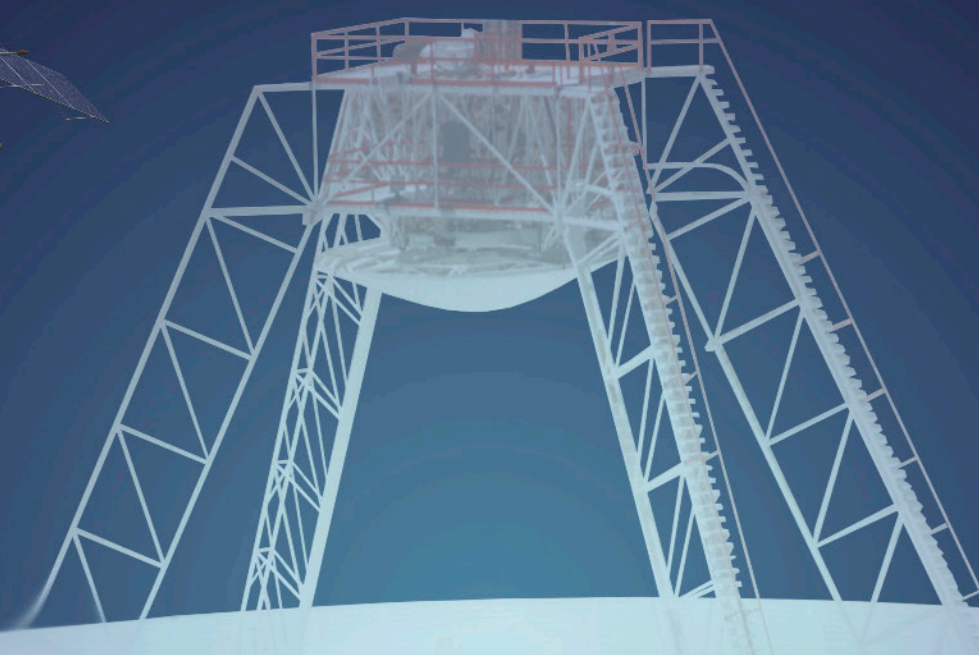
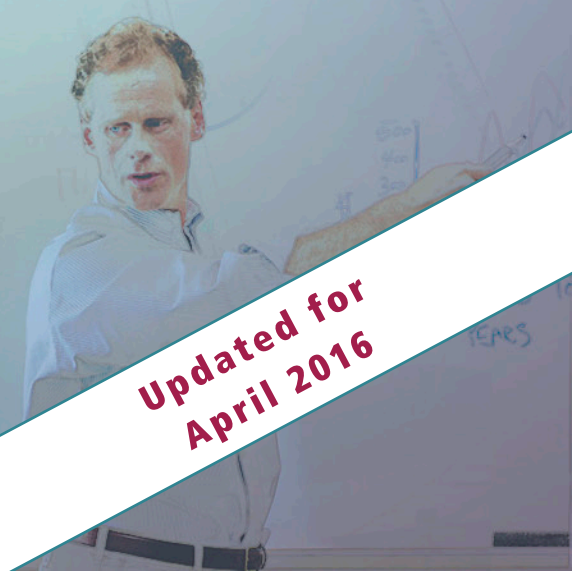


THE AEROSPACE INSTITUTE

# Education Opportunities for Customers of The Aerospace Corporation



## Catalog of Technical Courses



**Updated for  
April 2016**

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## **ABOUT THE INSTITUTE**

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## From the Institute

The Aerospace Institute serves as the key learning and knowledge-sharing resource of The Aerospace Corporation.

The Institute fosters an environment that promotes continuing learning— knowledge acquisition—for all. By making learning an integral, ongoing part of everyone’s career, we help employees deliver maximum value to our customers and help to ensure space mission success.

The Institute supports the corporate vision to provide engineering solutions to the nation’s most complex challenges. The Institute’s charter and accountabilities provide a foundation for the corporate values of Dedication to Mission Success, Technical Excellence, Commitment to Our People, Objectivity, and Integrity. In particular, the Institute’s primary role is to support the corporation’s commitment to maintain and improve our world-class workforce. We provide a great variety of learning opportunities and a broad curriculum of technical education, training, and personal development courses and programs. I encourage you to browse this catalog to learn more about the Institute, the role it plays within the corporation, and the specific products and services it offers. Visit us often and be a life-long learner.



A handwritten signature in dark ink, appearing to read 'Cheryl Dematteis', written over a horizontal line.

Cheryl Dematteis  
Executive Director

# Space/Technical Education Curriculum

**T**HE AEROSPACE INSTITUTE serves as the primary educational resource of The Aerospace Corporation. Its mission is to promote excellence in individual and corporate performance through continuing learning and knowledge sharing. By making professional development an integral part of the corporate culture, the Institute helps employees deliver maximum value to customers as they work to ensure space mission success.

The Institute's technical curriculum addresses core competencies in the application of space technology and covers a wide range of topics in space systems architecting, acquisition, and engineering, as well as the technologies and engineering disciplines associated with space missions and systems. Taught by members of the technical staff, these courses provide instruction in the fundamentals of space technologies and engineering in ten specific categories in three major groupings.

## Space Systems Orientations and Overviews

Courses at this level are especially beneficial to newcomers—those with little or no background in space systems. They provide an overview of the workings and management of space systems.

- Systems Orientations and Overviews

## Space Systems Architecture/Engineering/Acquisition Management

Each of these three disciplines addresses space systems at a high level. There are a series of courses in each of them, combined to give a full understanding of the overall discipline. The courses in these categories are intended for those who need to look across several technologies. They go into some depth of the discipline without being technology specific.

- Systems Engineering
- Systems Acquisition Management and Programmatic
- Systems Architecture and Networking

## Technical Depth and Functional Expertise

These courses are beneficial to generalists as well as subject-matter experts. Courses in this category enhance critical technical knowledge and skills. They address state-of-the-art issues in space and space-related missions and systems, and they provide detailed information and specific competencies. Sequences of technical specialty courses may be planned to develop specific career paths.

- Communication Systems and Technology
- Computer and Software Systems and Technology
- Navigation Systems and Technologies
- Science, Engineering, and Technology Specialities
- Security Systems and Technologies
- Space Security

Government customers are invited to take advantage of technical class offerings, which provide the background and perspective needed to deal effectively with the rapidly changing space-acquisition environment.

# Participation and Registration Guidelines for Customers of The Aerospace Corporation

## Participation

The Aerospace Institute's courses are primarily designed to meet the learning needs of Aerospace employees. Eligible Aerospace customers may participate in any of the courses listed in this course catalog, but attendance by these individuals is limited to 20 percent of class capacity. Eligible customers include active-duty military and government civilian employees. Many courses are delivered via VTC or e-learning to several locations simultaneously.

Due to the protected nature of course materials, Institute courses are not open to reservist, consultant, system engineering and technical assistance (SETA) organizations, or contracted advisory assistance services (CAAS) personnel. Separately priced course offerings may be negotiated with the Institute.

## The Registration/Enrollment Process

To sign up for a class, visit our online enrollment system at: <https://aerospace.csod.com/client/aerospace/> (registration is required). Alternatively, complete the registration form on the last page of this catalog and send it to the appropriate office:

### For all sites except Chantilly:

The Aerospace Institute  
Mail station M3/432  
The Aerospace Corporation  
P.O. Box 92957  
Los Angeles, CA 90009-2957  
fax: 310.336.0167

### For Chantilly:

The Aerospace Institute  
Mail station CH1/630  
The Aerospace Corporation  
15049 Conference Center Dr.  
Chantilly, VA 20151  
fax: 571.307.1040

## Enrollment Confirmation

Enrollment confirmation (via letter, e-mail, or voice mail) will be sent to all participants. Please call

310.336.5504 or 571.307.7327 (for Chantilly) if you have not received a confirmation and want to check the status of your enrollment.

## Late Enrollment

Late enrollments are accepted if space is available. Confirmations are sent in advance of the first class meeting.

## Class Size and Alternates

Once the 20-percent capacity has been reached, customer applicants are designated as alternates. If class capacity allows, or if the attendance limitation is waived, alternates may be moved up to enrolled status. If there is significant interest in a particular course that is either mentioned in the catalog but not currently scheduled, or the 20-percent attendance limitation proves too constraining, a special offering may be negotiated between The Aerospace Institute and Aerospace customer support offices.

## Schedule Changes

The Aerospace Institute course coordinator will notify enrolled students of any changes to the published schedule. Occasionally, new classes are added during a term. Such additions will be publicized on the Institute's website, on the Los Angeles Air Force Base Staff Bulletin, and/or through e-mail.

## Course Completion Criteria

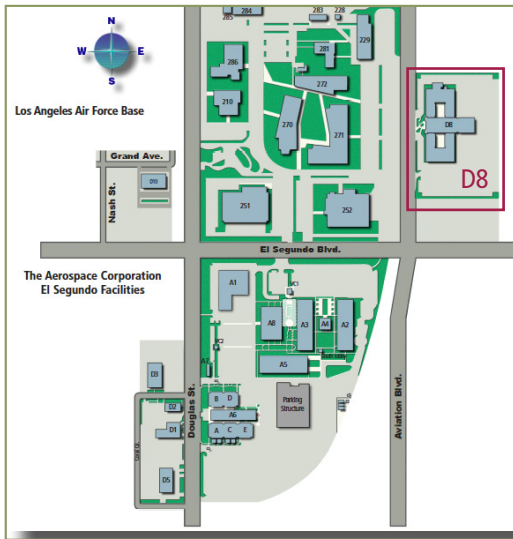
To receive credit for course completion, students are required to attend at least 80 percent of the classroom sessions. In addition, they must meet any other course requirements (for example, completion of exercises, outbriefs, case studies, homework, exams, and delivery of a completed course evaluation form). Determination of course completion is made by The Aerospace Institute and the lead instructor and/or instructor team. Transcripts are available upon request.

Defense Department personnel, please consult your local training manager for details.

# Classroom Maps and Locations

## El Segundo, California

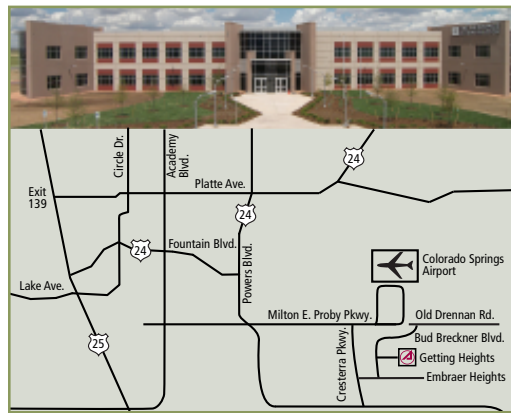
Courses are taught in classrooms in Building D8, located on Aviation Blvd. just north of El Segundo Blvd. Maps showing specific classrooms are posted on walls just inside the main lobby.



## Colorado Springs, Colorado

Courses taught in Colorado Springs are offered in the Aerospace regional office, located at 7250 Getting Heights, Colorado Springs, CO 80916-4931.

Phone: 719.375.6163



## Albuquerque, New Mexico

Courses taught in Albuquerque are offered in the Aerospace regional office located at City Place, 2155 Louisiana Blvd., NE., Albuquerque, NM 87198.

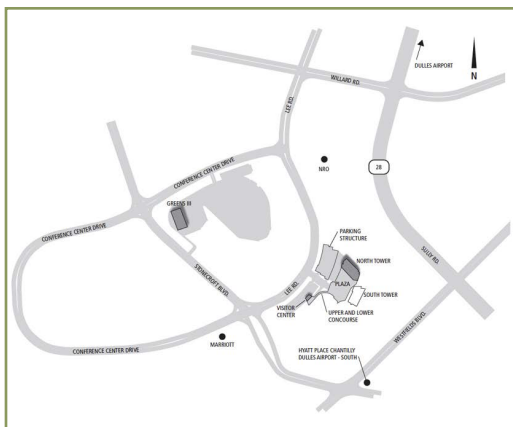
Phone: 505.872.6298.



## Chantilly, Virginia

Most Institute courses are taught in the lower concourse in room L0020 at ACC, located at 14745 Lee Rd., Chantilly, VA 20151.

Phone: 571.304.1821





## **COURSE DESCRIPTIONS**

## Ground Systems Overview

S4000

### Overview

This two-day course provides an overview of satellite ground systems. It examines their major elements and describes the associated Aerospace support capabilities, particularly with regard to design, development, and operation. Emphasizing practical aspects and actual lessons learned. Note: sessions may be offered at a classified level.

### Objectives

- Gain greater knowledge of ground systems (e.g., terminology, functions, modes, architectures, subsystems, and concepts of operations)
- Understand the resources available at Aerospace for supporting ground systems acquisition and development, including advanced trades and risk mitigation
- Become familiar with current and emerging ground system architectures
- Develop a working knowledge of the major factors that influence ground system design, development, and operations

List of Topics:

- Ground system operations:
  - A day in the life of a ground station
  - Basic functions and modes
  - Architecture elements, subsystems, and drivers
  - Discussion of a real-life ground station
  - Cyber security
- Ground system acquisition:
  - Trades and risk mitigation
  - Mission assurance
  - Site selection
  - System design
  - Tools
  - COTS management
  - Implementation, testing, and turnover
  - Life-cycle management and cost control
- Hot topics and trends

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is intended for those who seek to understand satellite ground system design, development, acquisition, and operations—and the vital roles played by Aerospace.

**Category:** Systems Orientations and Overviews

## Launch Systems Overview

S4120

### Overview

This course covers the basics of how launch vehicles work. It discusses subsystem functions, reviews various launch vehicle families, provides operational information for domestic launch facilities, and examines advanced concepts of operations. It also covers the Aerospace role and lessons learned. New launch vehicle developments are highlighted.

### Objectives

- Increase basic knowledge of launch vehicle principles, subsystem design and trades, and launch base operations
- Become familiar with current and emerging launch systems and understand how Aerospace systems engineering support enhances military access to space
- Gain practical insight through case studies
- Understand corporate tools and staffing resources that contribute to successful launches

List of Topics:

- Orientation: missions, subsystems, operations, and supporting systems
- How launch vehicles are used
- Launch vehicles families
- Launch facilities
- Launch vehicle integration with satellites
- Launch vehicle performance, trades, and issues
- Critical resources: corporate personnel, documents, guides, websites, books, and other courses

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit technical personnel and government decision makers who seek to better understand the design, operations, and cost of launch vehicles.

**Category:** Systems Orientations and Overviews

## Space Systems Overview

T7240

### Overview

This course provides a basic introduction to the primary elements of space systems. It investigates their major elements and Aerospace support capabilities.

### Objectives

- Gain a basic understanding of the elements of space systems
- Understand the history of space systems and their applications
- Gain exposure to the key subsystems and their interactions
- Learn about some of the major space systems supported by Aerospace

List of Topics:

- Space systems history
- The space environment
- Astrodynamics
- Mission types
- Spacecraft
- Payloads
- Launch systems
- Mission operations and ground systems
- Programmatic

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward those who are new to Aerospace, new to space, or unfamiliar with space systems.

**Category:** Systems Orientations and Overviews

## Concept Development

S2010

### Overview

This course provides an in-depth look at the methods, tools, organizations, and points-of-contact associated with the concept development process.

### Objectives

- Learn to create a space system concept from a mission statement of need
- Become familiar with the tools and analytic methods used to quantify space system requirements
- Understand the analytical linkage and flow from concept development through mission-level engineering
- Understand the principal elements of a conceptual space system design

List of Topics:

- Architecture alternatives
- Requirements allocation
- Space system concept design
- System cost and risk

**Length:** 32 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is designed for system planners, program managers, and analysts supporting national security space customers.

**Category:** Systems Engineering

## Spacecraft Systems Design S2020

### Overview

This course provides an overview of space systems spanning from microsattellites to large national systems and explains how they are conceived during the conceptual design phase. Students will be instructed by experienced systems engineers and subsystem specialists and will learn the processes used to go from requirements to an initial conceptual design. The course includes hands-on exercises where students will use conceptual design tools similar to those used by Aerospace's Vehicle Concepts Department and will also participate in a spacecraft design session in Aerospace's Concept Design Center. (Formerly "Space Systems Design.")

### Objectives

- Understand spacecraft system design processes
- Gain familiarity with spacecraft conceptual design tools
- Increase awareness of the interactions between spacecraft subsystems

#### List of Topics:

- Spacecraft Systems Overview
- ORS-1 Overview
- Communications Payload/TT&C
- CEM Orientation Exercise
- Communications Payload Design Exercise
- Conceptual Design Processes and Subsystem Introduction
- Astrodynamics
- Command and Data Handling
- Attitude Determination and Control
- Propulsion
- Thermal
- Power
- Spacecraft Conceptual Design Exercise
- Structures
- Software
- Introduction to the Concept Design Center
- Concept Design Center Exercise

**Length:** 24 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is intended for program managers and engineering analysts who support acquisition activities related to space system design and planning.

**Category:** Systems Engineering

## Space Systems Integration and System Test S2030

### Overview

Formerly entitled "Space Systems Development, Integration, and Test," this course examines basic concepts of space systems integration and testing. Participants will gain a better understanding of the key roles, processes, products, and best practices from a systems engineering and overall mission perspective.

### Objectives

- Understand the key processes, products, challenges, and best practices involved in space systems integration and testing
- Understand the importance of integration and system test processes and products and their impact during space systems development, particularly with regard to space vehicles, launch systems, and ground systems
- Understand government, Aerospace, and contractor roles and perspectives in developing and executing space systems integration and test procedures
- Understand the resources available at Aerospace and where to get help in systems development, integration, and verification and validation

#### List of Topics:

- Space Systems Integration
  - Integration: hardware, software, processes
- Practical integration
- Roles and responsibilities
- Planning and products
  - Testing and Evaluation
  - Planning
- Roles and responsibilities
- Best practices

**Length:** 17 hours

**Target Audience:** This course will benefit Aerospace engineers and others who desire a top-level understanding of space systems integration and system testing.

**Category:** Systems Engineering

## Space Systems Modeling, Simulation, and Analysis

S3038

### Overview

This introductory course provides a background in the theory and application of systems modeling, simulation, and analysis.

### Objectives

- Understand a basic approach to the design and development of models and simulations
- Learn of various modeling, simulation, and analysis methods and their application to space systems and architectures
- Become familiar with principal tools and corporate points of contact

List of Topics:

- Terminology and definitions
- A modeling process and practice
- The Concept Design Center
- Space mission simulations

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is intended for program managers and engineering analysts who seek to understand and apply common modeling, simulation, and analysis methods and tools in support of space system planning and acquisition.

**Category:** Systems Engineering

## Multiobjective Systems Engineering Under Uncertainty

T3500

### Overview

This short course introduces emerging multiobjective design tools that enhance systems engineering design under uncertainty. Beyond the focus on multiobjective optimization, the course will cover relevant research related to constructive decision-aiding theory, decision-biases identified in the behavioral economics literature related to risk, and recent advances in visual analytics that have been demonstrated to enhance design processes.

### Objectives

A core goal of this course is to show the state-of-the-art for integrating human intelligence and computational power to effectively explore design hypotheses, discover critical system trade-offs, and facilitate robust design decisions.

List of Topics:

- Introduction and early origins of multiobjective analysis
- MO basics: dominance, Pareto efficiency, and trade-offs in design
- Alternative generation using multiobjective optimization—simulation
- Evolutionary optimization — the basics
- Modern multiobjective evolutionary algorithms (MOEAs)
- MOEA diagnostics: real world applications
- Robust optimization under well characterized uncertainty – the basics
- Decision making under deep uncertainty – the basics
- A taxonomy of robustness frameworks
- Discussion period – optimality vs robustness?

**Length:** 16 hours

**Target Audience:** The course is open to all Aerospace employees and their government customers. It is designed for GRIPS analysts and program office personnel.

**Category:** Systems Engineering

## Requirements Engineering Management: Condensed Version

S3035

### Overview

Formerly titled "Requirements and Modeling," this one-day course introduces the techniques and essential principles that will help develop a structured set of complete and consistent requirements for a system. It is a condensed version of the three-day "Requirements Engineering Management" (S3030) course.

### Objectives

- Become familiar with different specification development strategies
- Understand how system architecture relates to requirements and how various architecture frameworks can be used to organize the development effort
- Learn how operational requirements are derived from the needs of users, operators, and other stakeholders
- Understand the nature of a capstone requirements document and its relation to downstream requirements
- Learn to formulate a concept of operations that captures system interactions and drives architecture development
- Learn to plan, execute, and manage system requirements

List of Topics:

- Characterizing systems from an operational, modeling, and design perspective
- Using a system architecture view to unify various system perspectives
- Modeling and evaluation of architectures
- Specification and flowdown of system requirements
- Support documents

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is intended for systems engineers and managers as well as program, product, and acquisition managers.

**Category:** Systems Acquisition Management and Programmatic

## Program Management Game Changers: Lesson Learned from the Space Test Program

S3075

### Overview

This course looks at program management from the unique perspective of the Space Test Program (STP), which provides mission design, acquisition, integration, launch, and on-orbit operations for DoD's most innovative experimental spacecraft. Due to the nature of the program, the complete acquisition cycle occurs in a relatively short timeframe. Students will learn about the program through the eyes of Aerospace support personnel, who provide key lessons learned. Aerospace support to STP ranges from concept development through satellite acquisition and testing, systems integration, ground systems development, prelaunch and launch support, operations, and data extraction. (Formerly named "A Cradle-to-Grave Program Management Perspective.")

### Objectives

- Comprehend the entire acquisition cycle through firsthand description of activities performed by Aerospace personnel supporting the Space Test Program
- Appreciate the myriad activities that take place throughout the life cycle of a space system
- Become familiar with the DoD's Space Test Program

List of Topics:

- Concept development
- Satellite acquisition
- Testing
- Systems integration
- Ground systems development
- Prelaunch and launch support
- Operations
- Data extraction

**Length:** 5 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit anyone interested in gaining a better understanding of the overall space systems acquisition process.

**Category:** Systems Acquisition Management and Programmatic

## Cost Across the Life Cycle—The Engineering Impact

S4326

### Overview

Formerly titled "Cost Across the Life Cycle: Engineering Considerations and Input," this course investigates how total program cost throughout the life cycle is influenced by technical and acquisition decisions. Basic relationships among cost, schedule, and technical characteristics are explained with an eye toward how these factors influence system design. Participants will examine basic risk management processes as they relate to schedule and cost assessment. Links between risk management and cost/schedule estimation are discussed, with a special focus on how cost and schedule are affected. Methods for estimating cost and schedule at important milestones are illustrated through concrete examples.

### Objectives

- Gain a working knowledge of cost/schedule risk analysis
- Understand basic cost/schedule methodologies used at important program milestones
- Become familiar with the basic concepts of risk management as they relate to cost/schedule analysis
- Practice techniques associated with technical-risk assessment, including the interview process
- Learn to craft the right questions when assessing the technical baseline
- Understand pertinent case studies
- Apply findings of technical-risk assessment to the cost estimate

#### List of Topics:

- Basic cost and schedule estimating methodologies
- Risk management overview
- Technical-risk assessment
- Schedule-risk analysis
- Cost-risk analysis

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is designed for Aerospace technical staff supporting program offices.

**Category:** Systems Acquisition Management and Programmatic

## Smarter Buyer 1: Industry Perspective

S4350

### Overview

This course teaches government acquisition personnel what they should know about industry financials to help them make optimal program decisions. Course material comes from extensive interviews with senior industry and government officials and is based on current reports, economic research, and recent financial news. It includes discussions of international competition and the industrial base, Wall Street, corporate strategic planning, financial management metrics, and business-development decisions—and their influence on contractor program managers. Real-world examples serve to highlight specific concepts that government program managers and their senior staff can use to motivate contractor performance.

### Objectives

- Learn how government program managers can positively influence industry financials and desired contractor behavior
- Gain a better understanding of industry metrics and incentives
- Appreciate the demands and expectations placed on industry counterparts
- Understand industry's financial expectations and how the government can influence them
- Appreciate how finances drive industry's investment decisions, including daily program operations

#### List of Topics:

- International competition and the industrial base
- Wall Street and CEO demands
- Sector financial metrics
- Business development
- Program manager demands

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is recommended for government program managers, acquisition executives, and their Aerospace counterparts. Program control, contract management, and financial management personnel are also encouraged to participate. This course is only open to full-time military, government, or Aerospace employees.

**Category:** Systems Acquisition Management and Programmatic

## The Art and Science of Systems Architecting S4600

### Overview

This course presents the core concepts of systems architecting. It lays out the models and views used in architecting and specifically examines applications to distributed systems of systems. Case studies demonstrating the architect's role are featured.

### Objectives

- Learn a range of definitions of architecture and the architect's role
- Understand the history of architects in successful systems and methods for integrating soft or heuristic approaches
- Become familiar with systems engineering models and their relationship to architecture
- Know the role of architecture and architecting in emerging systems of systems
- Acquire practical strategies for managing architecture and architects

List of Topics:

- Definitions and basics: what are architects, architectures, and architecting
- Architecting methods: how to develop an architecture
- Architecture descriptions: representing architectures through models
- Categories of systems and information technology
- The architect's relationships

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit anyone involved in systems architecting.

**Category:** Systems Architecture and Networking

## Systems Architecting: Introduction S4605

### Overview

Formerly titled "Introduction to Systems Architecting," this intensive course lasts for ten days (two weeks), and students are expected to attend both weeks. The course examines the community landscape of architecture definitions and projects and describes the adaptation of the systems engineering process to architecting. Methods for each major architecting activity (purpose analysis, problem structuring, solution structuring, harmonization, and selection/abstraction) are introduced, and implementations within typical acquisition scenarios are discussed and practiced. Adaptations of the basic methods to more complex situations are taught through case studies, with particular attention to software. A case exercise is wound throughout the course.

### Objectives

- Gain a foundation in methods for systems architecting and addressing ill-structured problems
- Learn a systematic method for approaching ill-structured problem statements, conducting parallel exploration of problem and solution spaces, and creating a rigorous architecture description that can be mapped back to customer-required formats
- Apply the methods to both basic and complex architecting scenarios

List of Topics:

- Fundamental architecting concepts
- The Aerospace Systems Architecting Method:
  - Purpose analysis
  - Problem structuring
  - Solution structuring
  - Harmonization
  - Selection/abstraction
- Domains of systems architecting
- Case studies of architectural success and failure
- Software-intensive systems

**Length:** 88 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is designed for engineers and managers supporting or leading an architecture project or projects involving front-end conceptual design.

**Category:** Systems Architecture and Networking



## Architecture Frameworks

S4620

### Overview

This course provides program and engineering support analysts with increased awareness and understanding of various customer architecture frameworks and gives recommendations on which ones to use for certain applications.

### Objectives

- Learn to facilitate communication within and across space programs using architectural frameworks
- Become familiar with architecture frameworks used by different stakeholder communities, including Department of Defense Architecture Framework (DoDAF)
- Gain a working knowledge of the basic architecture views and interfaces and understand how they are integrated into space system acquisition
- Become familiar with the various tools used for different architecture frameworks

List of Topics:

- Basic terminology
- Principal architecture views
- Architecture description products
- Methods of application involving space systems
- Principal tools and techniques for assessing space systems

**Length:** 24 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit Aerospace technical staff members working as planners, architects, and system program managers as well as analysts supporting national security space customers.

**Category:** Systems Architecture and Networking

## Architecture Design and Evaluation

S4625

### Overview

Through a combination of lectures and exercises, this course examines the architecture design and evaluation process. It teaches students how to apply the process and the associated corporate tools and capabilities. The course ties everything together through a strong narrative of the process and uses class exercises to strengthen understanding.

### Objectives

- Gain experience with the architecture design and evaluation process for conducting a high-level systems or architecture study
- Become familiar with various corporate tools, methods and experts that are needed to conduct architecture studies
- Learn to conduct architecture studies

List of Topics:

- Overview
- Problem definition: user needs, acquisition process, and customer organizations
- Operational context: missions, scenarios, capabilities, and requirements
- Architecture alternatives: trade trees and options screening
- System design and definition: concepts, design, and architectures
- Analysis and evaluation: performance, cost, schedule, risk, and utility
- Alternative comparison and summary: summarizing and communicating results
- Wrap up and review

**Length:** 24 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is intended for systems engineers, program managers, and analysts that support architecture studies.

**Category:** Systems Architecture and Networking

## Survey of Space Policy S4700

### Overview

The course explains the basis for decisions regarding space policy and provides a working knowledge of the relevant decision-making processes. It is designed to help technical personnel, from entry level through top managers, anticipate changes brought about by policy actions and engage effectively with policy makers when needed. Note: sessions may be offered at a classified level.

### Objectives

- Gain a historical perspective that will establish how we got to where we are today and provide the basis for discussion on how current issues are being addressed
- Learn about the major players in U.S. space policy and the processes – formal and informal – used to develop and influence policies
- Understand the interplay between programmatic, budgetary, technical, and policy decisions
- Understand the implications of international cooperation, competition, and law as applied to space policy

List of Topics:

- Space policy history
- Formal and informal policy-making processes
- Policy influencers inside and outside the U.S. government
- Similarities, differences, and interactions of the civil, commercial, and military security space sectors
- International cooperation and competition
- Major issues in civil, commercial, and military space, and Aerospace's involvement in them
- Corporate resources and services in space policy

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit space professionals at all levels and in all disciplines.

**Category:** Systems Architecture and Networking

## Decision Making using Genetic Resources for Innovation and Problem Solving (GRIPS)

S4705

### Overview

Classification Level: TS//SI//TK//REL FVEY

Decision Making using Genetic Resources for Innovation and Problem Solving (GRIPS) is a decision support process designed to determine and communicate the key tradeoffs of complex multi-objective problems to decision makers. GRIPS does not find a single solution, but rather approximates the optimal trade-off set of solutions. This provides information needed to support decisions.

During the first part of the course, attendees will come to understand the GRIPS decision-support process—when to apply it, and how to frame problems for optimal results. Next, attendees will review a diverse portfolio of examples that highlight the real impact of GRIPS on customer decisions and will participate in a panel discussion with Aerospace program office representatives as they describe their experiences applying GRIPS to their customer's problems. Finally, attendees will learn about the development of evolutionary heuristics and the advancements in GRIPS that allow us to deal with the failure modes of multi-objective evolutionary computing.

While GRIPS has extensive embedded features to perform satellite constellation design, a general Application Program Interface (API) is provided so that users can “plug” their model software into the search engine as the objective function evaluators.

### Objectives

- Learn how and when to use the GRIPS decision-support process
- Understand where GRIPS search and optimization algorithms fit into the spectrum of optimization methods
- Learn about classical multi-objective optimization methods and the subsequent development of evolutionary heuristics
- Understand the failure modes of multi-objective evolutionary computing and the tools within GRIPS that were invented to deal with them
- Appreciate the GRIPS impact to Aerospace customers

List of Topics:

- Metaheuristics
- Multi-objective optimization
- GRIPS history and overview
- GRIPS application-programming interface (API)
- GRIPS input file and plug-ins
- Aero Vis

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers who need to discover ways to solve your most challenging problems in a systematic, defensible manner.

**Category:** Systems Architecture and Networking

## DiscoveryDV and AeroVis: From Novice to Power User

S4720

### Overview

This course will provide in-depth training for the DiscoveryDV and AeroVis visual decision support frameworks. Topics will range from the basics of multidimensional plotting, data brushing, Pareto sorting, marking, scatter plotting, an interfacing with Excel to more advanced topics such as data animation, content presentation, and interfacing with SOAP and MATLAB.

### Objectives

Participants will learn to effectively leverage the DiscoveryDV and AeroVis software frameworks to analyze and present multidimensional GRIPS data. Engineers will be able to visualize performance tradeoffs generated by the GRIPS framework and effectively convey these relationships to diverse stakeholder groups ranging from engineers and scientists to senior decision makers.

List of Topics:

- Importing data
- Basic plotting
- Brushing
- Pareto sorting
- Marking
- Scatter plotting
- Adding designs
- Preference vector analysis
- Animating time-varying data
- Creating animations for presentations
- SOAP interface
- MATLAB interface
- Storyboard basics

**Length:** 8 hours

**Target Audience:** This course is intended for engineering staff with knowledge of Genetic Resources for Innovation and Problem Solving (GRIPS).

**Category:** Systems Architecture and Networking

## Digital Communications and Spread-Spectrum Techniques

T2030

### Overview

This course provides comprehensive coverage of digital communications.

### Objectives

- Acquire system-level proficiency in making simple trade-off analysis involving power, bandwidth, hardware complexity, and design of communication systems

List of Topics:

- Signals and Spectra
- Digitization of Analog Signals
  - Sampling, Quantization, A to D converters
  - PCM
- Noise Description
- Modulation and Demodulation
  - Binary and M'ary PSK and FSK, QAM, and GMSK
  - SGLS and SEW
- Link Analysis
- Interference Considerations
  - Intersymbol Interference
  - In-band and Out-of-band Interference
  - Examples
- System Considerations
  - Power/Bandwidth Trade-offs: modulation and coding, losses and gains
  - Link Performance: SNR and Bit Error Rate, Link Margin and Link Availability
- Introduction to Spread Spectrum Systems

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward engineers and technical staff members looking to enhance existing skills or knowledge in the area of digital communications.

**Category:** Communication Systems and Technology

## Spread Spectrum Systems

T2035

### Overview

The explosive growth of personal communication systems has provided a new impetus to the development of spread-spectrum techniques because of their inherent potential for capacity advantage. These techniques are used in communication and navigation applications because of their antijam low-probability-of-intercept properties, and their potential for allowing very precise position location determination.

### Objectives

- Gain and employ an understanding of the various components of spread-spectrum systems
- Be able to make simple performance calculations and system trade-offs

List of Topics:

- Overview of spread-spectrum systems
  - Direct sequence
  - Frequency hopped
  - Hybrid
- Performance of spread-spectrum systems in the presence of interference and jamming
- Types of spreading codes, code generation, and properties
- Spreading code acquisition and tracking
- Early-late-delay tracking loops and their performance
- Spread-spectrum as applied to satellite navigation
- Interference calculations as applied to spectrum management
- Communication applications
- Simulation examples of spread-spectrum systems

**Length:** 24 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward engineers and technical staff members.

**Category:** Communication Systems and Technology

## Principles of Space Communications

T2040

### Overview

This is an intermediate course in space communications. It addresses fundamental parameters and principles and provides insight into the key drivers for communication system design.

### Objectives

- Gain familiarity with space system communication requirements and specifications
- Understand the significance and limitations of communication figures of merit
- Speak knowledgeably with customers, contractors, peers, and technology experts
- Understand top-level trade-offs regarding communication parameters

List of Topics:

- Fundamentals of communications
- Satellite communication architecture
- Frequency spectrum management
- Networks and packet switching
- Communication links and signal propagation
- Modulation/bandwidth
- Coding
- Payloads and ground stations
- Software-defined radio in space communications

**Length:** 18 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is recommended for all engineers and managers who specify, use, or integrate space communication into their projects.

**Category:** Communication Systems and Technology

## Spectrum Management Principles: Introduction T2050

### Overview

Assured access to spectrum is critical to the U.S. space program, whose spectrum needs are among the most demanding in the world. This course examines the policies and major issues associated with spectrum management. It covers general concepts, technical aspects, economic perspectives, and military needs. A particular focus is placed on the threat to military spectral bands. Note: sessions may be offered at a classified level.

### Objectives

- Understand the importance of spectrum management in national security space
- Understand the general principles and disciplines of spectrum management
- Become familiar with the regulatory agencies and processes
- Learn the process of acquiring a license to use spectrum
- Understand the methods for conducting link analysis
- Learn to identify spectrum needs for a specific program
- Learn to work with spectrum managers to attain the requisite spectrum

List of Topics:

- Principles of radio communication
- Spectrum regulations
- Spectrum registration
- Interference analysis
- Federal spectrum management
- The future of spectrum management

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward program managers and engineers involved in electromagnetic spectrum.

**Category:** Communication Systems and Technology

## Spectrum Management: Advanced Topics T2060

### Overview

This course extends the topics presented in “Spectrum Management Principles” into the real world by emphasizing operational spectrum management. It addresses how new technologies pose regulatory challenges even as they increase spectrum availability. Political and economic aspects and issues will also be discussed.

### Objectives

- Develop a general appreciation for the operational aspects of spectrum management beyond the policies and regulations
- Understand how technology enhances spectrum access and how spectrum can be shared
- Understand how technology drives new business opportunities and poses regulatory challenges
- Discuss political and economic aspects of spectrum as a finite resource

**Length:** 4 hours

**Prerequisite:** Spectrum Management Principles (T2050)

**Target Audience:** All Aerospace MTS and U.S. government customers.

**Category:** Communication Systems and Technology

## Advanced EHF Program: An Overview T2080

### Overview

This course provides an introduction to the Advanced Extremely High Frequency (EHF) military satellite communications program. It pays particular attention to the novelty of the AEHF program, the protected communications technology, and the applications to other programs. It is led by those who work in the Aerospace program office supporting AEHF.

### Objectives

- Understand protected satellite communications at Extremely High Frequency (EHF)
- Understand AEHF technology and systems
- Be able to support AEHF and other EHF systems
- Apply AEHF technology and concepts to other programs
- Understand tradeoffs using other technologies for accomplishing the EHF mission
- Be more responsive to program office needs when tasked

#### List of Topics:

- Legacy systems
- Innovative technologies developed for AEHF
- System characteristics
- Space vehicle description
- Payload description
- Terminal
- Control
- Operations
- Performance
- Factory and on-orbit verification methods
- Related follow-on programs

**Length:** 6 hours

**Target Audience:** All Aerospace MTS and government customers.

**Category:** Communication Systems and Technology

## Software Architecture and Application to Space Systems S4440

### Overview

This course provides an introduction to software architecture and its relevance to space programs. It introduces various ways of describing and evaluating software architecture, with practical examples based on program experiences.

### Objectives

- Understand the influence of software architecture on program success
- Learn what information should be included in a software architecture description and various description approaches
- Get exposure to software architecture evaluation techniques
- Know where to go for more information and help

#### List of Topics:

- Software architecture and program success
- Describing software architecture
- Techniques for evaluating software architecture

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward program, product, and acquisition managers; systems and software engineers; and engineers accountable for systems that interface with software.

**Category:** Computer and Software Systems and Technology

## Cloud Computing: Technical Introduction S4480

### Overview

This one-day technical workshop examines the underlying principles of “the cloud.” The class starts with a discussion of the terminology, characteristics, and fundamental concepts of cloud computing. This will include an overview of “infrastructure as a service,” “platform as a service,” and “software as a service.” Participants will then engage in hands-on activities that aim to demonstrate the difference between two of these service models: infrastructure as a service and platform as a service. The Amazon AWS cloud platform will be used for the lab exercises, and detailed instructions are provided for use. As this is an introductory class, the lab activities will not require knowledge of Linux or software programming. The workshop will conclude with a frank discussion about how Aerospace is planning to use cloud services and the issues involved in applying these services to support our mission domains.

### Objectives

- Understand the various types of cloud computing service models
- Gain hands-on experience working with cloud computing services
- Gain insight into how cloud computing can support Aerospace mission objectives

#### List of Topics:

- Defining cloud computing- definitions, service and deployment models
- Infrastructure as a service (exercise): working with Amazon EC2, starting a virtual machine instance and logging into it
- Platform as a service (exercise): use development tools to build and execute a simple web application in the cloud
- Software as a service: using Google’s cloud productivity tools, create a custom web site for running business apps with force.com
- Aerospace planned use of the cloud and its mission applicability

**Length:** 8 hours

**Target Audience:** This course will benefit anyone with an interest in technical computing.

**Category:** Computer and Software Systems and Technology

## Integrated Overview of Mission-Critical Software S4490

### Overview

This course provides an overview of mission-critical software acquisition and development. It focuses on software-related activities and products throughout the life cycle and explores their relationship with:

- Systems acquisition, engineering, and testing
- Specialty engineering (including reliability, maintainability, availability, human systems integration, cybersecurity/software assurance, and supportability)
- Software-related processes and independent assessments
- System and software reviews
- Risk identification, mitigation, and metrics

This course provides insight into the respective roles of the acquisition team and the contractor team. It is a prerequisite for “Software Project Management for Mission-Critical Systems,” “Software Product Development for Mission-Critical Systems,” and “Software Acquisition Management for Mission-Critical Systems.”

### Objectives

At the completion of this course, students should be able to:

- Describe the relationship between software acquisition and software engineering, including basic terminology
- Describe software project management activities and their relationship to product-oriented activities, including planning and metrics
- Describe how software performance can be improved through process management
- Describe commonly used software acquisition and development models and explain how product-oriented activities relate to each
- Describe the roles of the acquisition team and contractor team throughout the software acquisition and development cycles

#### List of Topics:

- The relationship between software acquisition and software engineering
- Software requirements and architecture
- Software design and implementation
- Software testing and project management (including metrics)
- Performance improvement through process management
- Software acquisition and development models

**Length:** 16 hours

**Target Audience:** This course is intended for Aerospace and customer program office personnel who are responsible for software as well as Aerospace engineering personnel who support programs in software.

**Category:** Computer and Software Systems and Technology

## Information Sharing: Technologies and Implementation

S4670

### Overview

Advances in information technologies have radically altered the modern battlefield. The ability to disseminate information quickly has paved the way for a military strategy that empowers commanders at every level to make better decisions faster and to act on them sooner. Ensuring that timely and trusted information is available where and when it is needed is at the heart of modern military and intelligence operations. These changes in strategy have introduced challenges for national security space programs that are wrestling with the implications of the myriad of new mandates regarding information technology and information sharing. This course discusses key enabling technologies as well as relevant governance and selected implementations. Course evolved from "Net-Centricity: Introduction."

### Objectives

- Gain a broad knowledge of the policies and technologies concerning information sharing by the government and the military
- Understand the implications of information sharing by the DoD and other government entities and its effect on all of Aerospace's customer communities

List of Topics:

- Information sharing strategies
- Networking technologies
- Web services
- Data management
- Security design for information sharing
- Governance
- Enterprise services and support
- Program experiences

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will be of interest to engineering and program office staff, including management.

**Category:** Computer and Software Systems and Technology, Security Systems and Technology, Space Security

## The Importance of Software Mission Assurance to Your Program

S5060

### Overview

This course will identify and discuss the tasks and activities critical to mission assurance as they pertain to government acquisition and contractor processes and products.

### Objectives

- To identify and apply mission assurance techniques throughout the program life cycle so as to minimize or avoid adverse outcomes to schedule, cost or critical mission objectives.

List of Topics:

- Government acquisition plans, processes and products critical to mission success
- Software inputs to the acquisition process and RFP preparation
- Government management and technical reviews
- Contractor software project management
- Contractor software process management
- Software quality enhancement
- Risk assessment activities
- Sources of software mission assurance risks

**Length:** 8 hours

**Target Audience:** U.S. government and Aerospace program office personnel with relevant job functions, particularly with the implementation of software mission assurance, or those personnel who support programs in software mission assurance.

**Category:** Computer and Software Systems and Technology



## Global Positioning System (GPS): A More In-Depth Look

S4220

### Overview

This course will explore technical and programmatic details of the Global Positioning System, providing participants with detailed insight into GPS at the program, system, and subsystem levels.

Note: a portion of this class is held at the SECRET level. Students must have a secret clearance to register and attend.

### Objectives

After participating in this course, you will be able to:

- Describe and discuss details of the different GPS signals
- Explain the importance of orbit determination and how it works
- Discuss various aspects of GPS engineering
- Describe critical interfaces between government agencies, user communities, and contractors, as well as between system segments
- Discuss in detail the different GPS segments
- Discuss additional topics related to GPS, including constellation management, atomic clock frequency standards, augmentation with other global navigation satellite systems, and the future of GPS
- Define and explain NAVWAR

List of Topics:

- Signals in space: spreading codes, navigation messages
- GPS signals
- Orbit determination
- Error sources
- Systems engineering overview
- Interfaces
- Ground segment overview
- Space segment overview
- User segment overview
- Navigation exercise
- System security and NAVWAR
- Constellation management
- Space-based atomic clocks
- Augmentation systems and other GNSS
- Future systems

**Length:** 24 hours

**Target Audience:** Aerospace MTS, U.S. government personnel.

**Category:** Navigation Systems and Technology

## Global Positioning System (GPS): An Introduction S4215

### Overview

This course will introduce participants to the technical and programmatic fundamentals of the Global Positioning System—its origins, architecture, acquisition, deployment, operations, applications, and management. It will also provide an overview of the organizational aspects and mission of the GPS program.

### Objectives

- Describe how GPS receivers determine a user's location from satellite signals and explain the sources of error in those signals
- Discuss the different GPS signals
- Describe the overall GPS system, including space, ground, and user segments
- Discuss programmatic challenges to GPS

List of Topics:

- How GPS operational concept
- GPS signals
- GPS system
- GPS challenges

**Length:** 3 hours

**Target Audience:** Aerospace MTS, government personnel who need basic information about the acquisition and operation of the Global Positioning System.

**Category:** Navigation Systems and Technology

## Risk Management Framework Training/ Certification

S4300

### Overview

This in-depth three-day course of SecureNinja's Risk Management Framework for DoD & Intelligence Communities presents an overview of the system authorization process (also known as C&A) and the Risk Management Framework (RMF) for national security systems. It is geared both for those currently working with C&A and those with limited or no C&A experience. Students will participate in several scenario-based hands-on exercises in the implementation of the RMF to provide a clear knowledge bridge to the revised system authorization processes. These exercises will include the development of systems security plans, security assessment reports, and plans of action and milestones. This course meets the requirements of National Security Directive 42 (NSD-42), which outlines the roles and responsibilities for securing national security systems and addresses federal and intelligence community requirements, including NIST SP 800-37, NIST SP 800-39, CNSS 1199 (DRAFT), and CNSS 1253.

### Objectives

At the completion of this course, your team members will receive their National Security Agency (NSA) and Committee on National Security Systems (CNSS) NSTISSI 4011, Information System Security Professional and CNSSI 4012, Senior IA System Manager Certificate. Participants will also earn CPEs to existing certifications with CompTIA, ISC2, and ISACA.

List of Topics:

- Overview of the transition/transformation
- Key policies and definitions
- RMF for DOD IT
- Categorizing, assessing, authorizing and monitoring the information system
- Selecting and implementing security controls
- DoD contractor responsibilities
- ICD 503, JSIG, and overlays

**Length:** 24 hours

**Target Audience:** This course is intended for Aerospace technical staff and government customers.

**Category:** Security Systems and Technology

## Cryptography: Theory and Practice

T4220

### Overview

This course introduces the basic concepts of modern cryptography. It presents sample algorithms and protocols, shows how cryptography is acquired and used in space programs, and examines some new directions in the field.

### Objectives

- Gain a basic understanding of cryptography and its application in space programs
- Obtain definitions of cryptographic terms and types of cryptographic algorithms and devices
- Understand the policies that give the NSA authority over cryptography
- Understand the NSA cryptographic certification process
- Understand the relationship between program acquisition and cryptography acquisition
- Know where to go for further information

List of Topics:

- Symmetric and asymmetric cryptography
- Data protection
- Uses of cryptography (confidentiality, integrity, authentication, etc.)
- Cryptographic algorithms and protocols
- Key management
- Applications to commerce and civilian systems
- Applications to space
- Advanced topics (quantum cryptography, steganography, etc.)
- Space cryptography policies
- Cryptography acquisition processes
- NSA cryptographic certification

**Length:** 12 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is designed for technical staff dealing with the acquisition, development, and maintenance of systems that use cryptography.

**Category:** Security Systems and Technology

## Space Cyber Overview

T4260

### Overview

This TS/SCI Classified fundamental course in space cyber is a prerequisite for any subsequent classwork in the cyber curriculum. It provides an operational overview of the emerging mission area of space cyber and explains how cyber and information operations can affect operations of space systems. Course modules include high-level discussions on the history of the cyber mission area, an introduction to the basic lexicon, a review of government organizational structures, an analysis of space cyber challenges, and a look at Aerospace's strategy for involvement. In addition, there are in-depth discussions of cyber fundamentals, current exercises and operations, and the overall impact to the space operations mission area.

### Objectives

- Understand the emerging mission area of space cyber and how and why Aerospace is involved
- Become familiar with the history of the cyber mission area
- Understand the fundamentals of the cyber mission area
- Recognize how cyber and space operations have become intertwined
- Understand key impacts to the space mission area
- Be able to discuss the main challenges facing this new mission area

List of Topics:

- Introduction
- Brief history
- Basics (domain, definitions, cyber fundamentals, intersection with space)
- Challenges (operational, political, technical)
- Key players
- Cyber threats to space systems
- Key impacts and issues
- Aerospace's role and way ahead

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit those interested in obtaining a solid foundation on the new mission area of space cyber.

**Category:** Security Systems and Technology, Space Security

## Cyber Across the Space System Life Cycle

T4265

### Overview

This course gives acquisition and development engineers who are not cyber experts the skills needed to recognize potential cyber vulnerabilities in their systems as they proceed through the acquisition process. With cyber being such a large part of space systems in today's world, it will help students to know when cyber experts should be called in for support. The course also provides references to the body of cyber knowledge (standards, regulations, instructions, policy, handbooks, Aerospace reports, etc.) that informs and governs the corporation's acquisition work. Students will learn the key program office and ETG tasks and recommended deliverables across the life cycle, including those for the Mission Assurance Baseline.

### Objectives

- Understand what "cyber" means and all it encompasses
- Recognize what comprises the broader cyber domain and how it applies to ground, user, and space elements of space systems and missions
- Understand cyber threats and vulnerabilities in the context of space system acquisition phases
- Understand why cyber security is important in space system acquisition and learn to apply the associated concepts to specific acquisition tasks
- Acquire a broad view of mission assurance to include assuring that systems can perform their core missions even when under cyber attack
- Understand common development practices (both effective and ineffective) from a cyber perspective
- Learn to consider cyber issues during all phases of the space system development life cycle and know when to engage cyber experts

List of Topics:

- Refresher on space cyber threats and vulnerabilities
- Overview of cyber challenges and current practices
- Different customer approaches to life-cycle management
- Addressing cyber issues in space system life cycle

**Length:** 12 hours

**Target Audience:** Open to Aerospace employees and government customers.

**Category:** Security Systems and Technology, Systems Acquisition Management and Programmatic

## Space Protection Awareness S4905

### Overview

This TS/SCI classified course addresses a wide range of threats to space systems, from radio-frequency jamming to co-orbital antisatellite (ASAT) attacks. Each type of threat is examined in detail to present the fundamental physics and technology, a brief history, considerations regarding use and deployment, and potential countermeasures. This seminar is not a survey of current intelligence regarding threats to space systems; rather, it is a foundational presentation of the technology and underlying physics of these potential threats.

### Objectives

- Understand threats to space systems in order to diminish an adversary's ability to surprise
- Increase basic knowledge of space protection
- Develop an awareness of space/link/ground segment vulnerabilities associated with various weapon systems
- Appreciate the relationships among space protection and threat technology approaches

#### List of Topics:

- Introduction
- Policy, law, and doctrine
- Space situational awareness: overview and Aerospace tools
- Nuclear weapon systems
- Electronic warfare and information operations
- High-power microwave weapon systems
- Laser weapon systems
- Direct-ascent antisatellite (ASAT) weapon systems
- Co-orbital weapon systems

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward space professionals interested in understanding the physics, technology, and history of threats to space systems in order to better inform strategies, plans, and actions that enhance their protection.

**Category:** Space Security, Systems Architecture and Networking

## Space Situational Awareness—A Defensive Perspective S4920

### Overview

This two-day, TS/SCI classified course provides an overview of space situational awareness (SSA) with a focus on space protection. The material is presented using the doctrinal method of surveillance, reconnaissance, intelligence, and environmental monitoring and covers each topic in relation to the others. The theoretical elements are balanced and extended by real-life examples to ensure the point of the mission area is fully explained and explored.

### Objectives

- Understand the definition of SSA
- Understand the secondary missions and systems that support SSA
- Become familiar with the various organizations involved in SSA and how they work together to support space operations
- Appreciate the critical importance of the NROC and JSpOC mission areas and AFSPC space protection and space cyber missions

#### List of Topics:

- Introduction to SSA
- Surveillance
- Reconnaissance
- Intelligence
- Environmental monitoring
- Additional topics

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit those who seek to understand Space Situational Awareness and its relationship to the protection of space assets.

**Category:** Space Security, Systems Architecture and Networking

## Space Cyber Warfare C2 S4930

### Overview

Today's space and cyber domains have become inextricably linked. The ability to operate freely in these contested and congested environments is crucial to success in modern warfare. The Department of Defense is actively developing capabilities, plans, and options to thwart efforts to interfere with or attack U.S. and allied space systems. Successful defenses will require a clearly defined, well organized, and pre-planned command and control (C2) infrastructure that integrates the participation of DoD, national, civil, commercial, and allied partners in a timely and effective manner. This TS/SCI-classified course offers insight into the players, activities, authorities, mission partners, and emerging technologies essential for the successful conduct of space cyber warfare.

Recommended prerequisite courses: "Space Protection Awareness" (S4905), "Space Situational Awareness" (S4920), "Space Cyber Overview" (T4260)

### Objectives

- Become familiar with the associated players and their integrated responsibilities
- Develop a working knowledge of C2 and its importance in modern warfare
- Understand the concept of battle management, command, control, and communications (BMC3)
- Learn to recognize trigger points Gain insight into what Aerospace is doing in this area

List of Topics:

- Introduction to C2 in space and cyberspace operations
- Definitions
- The role of C2
- Doctrinal construct and joint concepts
- The role of BMC3
- DoD, national, civil, and allied capabilities and processes
- Space cyber threat trigger points and countermeasures
- The C2 cycle: understand, plan, decide, direct, monitor

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit those interested in obtaining a solid foundation in the space security mission area.

**Category:** Space Security

## Small Satellites: An Overview of History, Capabilities, and the Aerospace Picosatellite Program

T1055

### Overview

This course provides an overview of small satellites in general and CubeSats in particular: a satellite in a 10-cm cubical form factor and mass of ~1 kg that performs missions heretofore flown only on platforms orders of magnitude larger. CubeSats can take high-resolution images of the Earth, track other objects in space, transmit data at high-rates using lasers, maneuver with high- or low-thrust propulsion, and much more. In this course, participants will become familiar with the history of CubeSats, how satellite subsystems (such as three-axis attitude control and propulsion) operate and designed to fit into a box the size of a softball, how program management and mission assurance are applied to a CubeSat-class spacecraft, and how a CubeSat is operated on orbit, with a particular emphasis on the CubeSat and picosatellite activities at The Aerospace Corporation.

### Objectives

- Know the definitions of small satellites and CubeSats
- Know how CubeSats are deployed to orbit
- Understand the breadth of missions a CubeSat can perform
- Understand how satellite subsystems perform and packaged into the CubeSat form factor
- Understand how program management and mission assurance are applied to a CubeSat
- Understand how flight operations are carried out using CubeSats and how it differs from a traditional space mission
- Know the capabilities available at Aerospace to assist program offices and our customers with their own CubeSat, picosatellite, and small-satellite missions.

List of Topics:

- Small satellite definitions and history
- Satellite orbits
- Small satellite systems and subsystems: power; command and control; communications; attitude determination and control; navigation; thermal control; propulsion;
- Payloads
- Ground stations
- Regulatory requirements
- Mission assurance
- Mission operations
- The future of small satellites

**Length:** 8 hours

**Target Audience:** All Aerospace MTS and U.S. government customers.

**Category:** Science, Engineering, and Technology Specialities

## Key Enabling Space Technologies

T1060

### Overview

This course provides an overview of the DoD technology insertion process, focusing on the Air Force and SMC as well as other government technology offices. It presents a collection of key space technologies and provides a short tutorial for each, covering primary goals, projects, approaches, progress, and potential future trends. Some material contains sensitive but unclassified information.

### Objectives

- Learn about technologies that can address program risks and lead to new capabilities and enhanced operational and systems performance
- Understand the basic underpinning of useful technologies via short tutorials and reference lists
- Gain awareness of key enabling space technologies--efforts, progress, maturity, trades, and readiness
- Identify principal technology points of contact within the government and Aerospace
- Learn how program offices can influence technology programs

List of Topics:

- Flight software for defensive counterspace technologies
- Intelligent systems, including satellite as a sensor
- Space-based radar
- Lasercom technology
- Antennas
- High-data-rate RF communications
- Precision clocks
- Radiation-hardened electronics
- Chemical and electric propulsion
- Space power
- Electro-optical sensors
- Structures and materials
- Microelectromechanical systems (MEMS)
- Small satellites

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will interest those who desire an awareness or overview of new trends in space technology as well as those who have some familiarity but would like further knowledge.

**Category:** Science, Engineering, and Technology Specialities

## Spacecraft Environmental Hazards

T1160

### Overview

The effects of space weather on satellites can vary from subtle to profound. Sensor degradation, subsystem failures, loss of data, and even loss of mission have resulted from the complex interactions between space vehicles and the charged particles in the space environment. This in-depth course identifies areas for concentrated effort and provides specific recommendations to address space environmental hazards primarily during system acquisition. Discussion includes 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 illustrate the hazards and mitigation strategies. Note: sessions may be offered at a classified level.

### Objectives

- Acquire an understanding of space radiation hazards, their sources, and potential impacts
- Gain an understanding of alternative mitigation strategies and their limitations and trades

List of Topics:

- Impacts on space systems caused by the space radiation environment
- Sources of near-Earth space radiation environment
- Space hazards, including spacecraft charging, single-event upsets, total radiation dose, and ionospheric effects
- Mitigation tools and techniques

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward individuals responsible for space missions, space systems architecting, engineering, and operations.

**Category:** Science, Engineering, and Technology Specialities

## Environmental Test Requirements for Space Vehicles

T3010

### Overview

Designed for program office personnel, this course examines essential environmental test requirements for space vehicles. It is designed to ensure that program office personnel understand how to manage environmental test risk in a team setting. Course modules and materials are based on applicable corporately recommended command media and are closely coupled to the Mission Assurance Baseline. Case studies, examples, and hands-on exercises are used to illustrate critical concepts and explore the trades for why specific approaches are recommended. The course covers effective implementation of ETG resources and tools and appropriate use of supporting data. To earn course credit, students must complete a final comprehension test.

### Objectives

- Understand the origin and rationale of key environmental test requirements
- Appreciate the intricacies of tailoring requirements to specific programs and representing residual test risk
- Know the responsibilities of the joint program office/ETG implementation team

List of Topics:

- Introduction and overview of environmental test requirements
- Dynamic, structural, thermal, pressure, and electromagnetic test requirements in MIL-STD-1540E
- Implementing MIL-STD-1540E from a program office perspective
- The Environmental Test Thoroughness Assessment methodology

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is geared toward current or prospective program office personnel with relevant job functions—particularly those with responsibility and accountability for implementing MIL-STD-1540E.

**Category:** Science, Engineering, and Technology Specialities

## Applied Estimation Theory

T7205

### Overview

This course presents basic concepts in estimation theory, including least-squares estimation, Kalman filtering, hypothesis testing, the Cramer-Rao bound, maximum-likelihood estimation, and particle filtering. To complement lectures on basic theory, instructors also discuss applications of estimation theory within Aerospace, including hyperspectral detection of chemicals, missile tracking, navigation, and orbit estimation.

### Objectives

- Gain a better understanding of theoretical concepts that are fundamental to many of the projects Aerospace supports
- Learn how estimation theory provides the conceptual basis for projects integral to Aerospace including missile tracking, GPS, attitude determination, control systems, orbit estimation and detection of toxic chemicals

List of Topics:

- Least-squares estimation
- Kalman filters (standard, extended, unscented, ensemble)
- The Cramer-Rao bound
- Maximum-likelihood estimation
- Statistical hypothesis testing
- Bayesian hypothesis testing
- Particle filters
- Moving-horizon estimation

**Length:** 11 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit technical staff members, managers, and program office personnel whose projects involve the application of estimation theory.

**Category:** Science, Engineering, and Technology Specialities

## Orbital Mechanics: Introduction

T7207

### Overview

This course introduces key concepts in orbital mechanics, including orbit geometry, maneuvers, perturbations, ground coverage, constellations, propagation, determination, and disposal. It focuses on anchoring concepts while maintaining technical rigor.

### Objectives

- Orbit terminology
- How orbits behave near Earth
- How mission requirements translate into orbit and constellation design
- How to interpret orbit analyses
- The role of orbits in the space mission life cycle, from concept development to launch, operations, and disposal

List of Topics:

- History of orbital mechanics
- Introduction to conic sections and orbits
- Orbital maneuvers
- Orbit perturbations
- Advanced orbits
- Ground tracks
- Coverage
- Constellations
- Orbit determination and two-line elements (TLEs)
- Tools and propagators
- Debris
- Problem-solving approaches

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is designed for technical personnel who need an introduction to the principles of orbital mechanics and their application to space missions.

**Category:** Science, Engineering, and Technology Specialities

## Why Satellites Fail: Lessons for Mission Success

T7300

### Overview

Satellite failures are primarily caused by subtle engineering mistakes in all development stages—from design and analysis through manufacturing, coding, testing, and operations. This course uses lessons learned from past failures to familiarize students with the good engineering practices necessary to ensure mission success.

### Objectives

- Perform better technical reviews
- Become familiar with good engineering practices in systems development and the resources that are specifically designed to help catch engineering mistakes

List of Topics:

- Overview of failure statistics, lessons learned, and key review questions
- Technical baseline management
- Fault analysis
- Ground operations
- Ground testing
- On-orbit troubleshooting
- Mission assurance resources

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will interest engineering and technical staff members at all levels.

**Category:** Science, Engineering, and Technology Specialities



## Applications of Representation Theory T8155

### Overview

This course introduces group representation theory and discusses its application to physics, engineering, and number theory. Representation theory can be thought of as generalizing Fourier analysis; it represents abstract algebraic structures as linear algebraic objects, which are easier to work with.

### Objectives

- Learn to apply useful techniques for dealing with complex math

List of Topics:

- Introduction to group representation theory
- Application of group representation theory

**Length:** 28 hours

**Target Audience:** Open to Aerospace employees and government customers, this course is recommended for anyone with an interest and background in applied mathematics.

**Category:** Science, Engineering, and Technology Specialities

## Riemann Hypothesis in Physics and Engineering T8165

### Overview

This course provides an elementary discussion of the Riemann Hypothesis—a 150-year-old proposal concerning the location of the nontrivial zeros of the Riemann zeta function. It remains one of the seven unsolved Millennium Prize problems. The class introduces some approaches to it and interpretations from the viewpoint of physics. The goal is to show how wide-ranging these ideas are and to build intuition. If time permits, some other illustrations of the “unreasonable effectiveness of physics in mathematics” will also be presented.

### Objectives

- Learn some of the wide-ranging ideas related to the Riemann Hypothesis

List of Topics:

- Background on the Riemann Hypothesis and some of its generalizations from number theory and analysis
- Examples from physics and factorization/coding that might suggest ways of providing the hypothesis or that would be enhanced if the hypothesis were to be proved

**Length:** 8 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will interest members of the technical staff with a background in high-level mathematics and physics.

**Category:** Science, Engineering, and Technology Specialities

## Applied Quantum Mechanics T8196

### Overview

The aim of this course is to bring out the increasing relevance of quantum physics in engineering applications. The class discussion will cover fundamentals, devices (e.g., sensors), macroscopic quantum effects (e.g., superconductivity), entanglement, quantum information, and computing.

### Objectives

- Gain a greater appreciation for the impact of quantum effects
- Become familiar with the theory needed to understand and exploit quantum effects

List of Topics:

- Quantum theory—interpretation and application to selected types of system
- Non-intuitive behavior—entanglement and its applications

**Length:** 28 hours

**Target Audience:** Open to Aerospace employees and government customers, this course should benefit engineering personnel with an interest in advanced physics.

**Category:** Science, Engineering, and Technology Specialities

## Effective Writing for a Nontechnical Audience: Workshop

T8300

### Overview

This workshop is intended to help technical staff members write more effectively when communicating with non-technical audiences. It consists of two parts: an introduction (T8310) and this four hour workshop. The introduction is a prerequisite for this workshop. Participants will receive a short writing assignment during the Introduction class that must be submitted to the instructor before attending this workshop. Employees performing complex technical work often must communicate the value of that work to a nontechnical audience. This course is designed to help improve writing skills for that purpose.

Employees are encouraged to register for both the Introduction (T8310) and this Workshop.

### Objectives

Provides participants with tools for improving writing skills when communicating the value and impact of complex scientific or technical work to a non-technical audience.

**Length:** 4 hours

**Target Audience:** All Aerospace MTS.

**Category:** Science, Engineering, and Technology Specialities

## Effective Writing for a Nontechnical Audience: Introduction

T8310

### Overview

This course is intended to help technical staff members write more effectively when communicating with non-technical audiences. It consists of two parts: this introduction and a four-hour workshop (T8300). Participants will receive a short writing assignment during the Introduction class that must be submitted to the instructor before attending the workshop.

Employees performing complex technical work often must communicate the value of that work to a nontechnical audience. This course is designed to help improve writing skills for that purpose. The class discusses the concept of value—how it is articulated and measured at Aerospace—while explaining the importance of becoming a better writer for nontechnical audiences.

Employees are encouraged to register for both this introduction and the workshop.

### Objectives

Provides participants with tools for improving writing skills when communicating the value and impact of complex scientific or technical work to a non-technical audience.

**Length:** 2 hours

**Target Audience:** All Aerospace MTS.

**Category:** Science, Engineering, and Technology Specialities

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## The Aerospace Institute Customer Course Registration

PARTICIPANT NAME:		EMAIL:		TELEPHONE NUMBER:	
<input type="checkbox"/> SMC <input type="checkbox"/> NRO <input type="checkbox"/> AFSPC <input type="checkbox"/> OTHER	ORGANIZATION NAME:		COMPLETE MAILING ADDRESS:		SSN (last 4 digits):
	<input type="checkbox"/> MILITARY (Active Duty) <input type="checkbox"/> CIVIL SERVICE	SERVICE	RANK/GRADE	ORGANIZATION SYMBOL	

COURSE INFORMATION*			TAI use only
COURSE NUMBER	START DATE	TITLE	Database entry complete

**Submit to:**

<i>Washington, DC area .....</i>	Mail:	CH1/630
	Fax:	571.307.1040
<i>El Segundo and all other locations .....</i>	Mail:	M3/432
	Fax:	310.336.0167

**Questions? Contact The Aerospace Institute Technical Operations Department at 310.336.5504.**

\* Due to the nature of course materials and classroom discussions, attendance is limited to Aerospace Employees and Customers only. An inclusive list of eligible Aerospace customers may be found in the Aerospace/SMC FFRDC Contract #: FA8802-09-C-0001.



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