Education Opportunities for Customers of The Aerospace Corporation

Catalog of Technical Courses

Updated for Spring 2015
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ABOUT THE INSTITUTE

From the Institute
Space/Technical Education Curriculum
Participation and Registration Guidelines
Classroom Maps and Locations
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.

Cheryl Dematteis
Executive Director
Space/Technical Education Curriculum

The 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 nine 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

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.

Chantilly, Virginia
Most Institute courses offered in Chantilly, Virginia, are held in Greens I and Greens III, located at 15049 Conference Center Dr.
Phone: 571.307.7327

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
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, the class includes a tour of a local ground station facility and uses real-life examples for discussion. 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
  - A tour of a local ground station facility
  - 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:** Space/Technical Education, Systems Orientations and Overviews

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**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:** Space/Technical Education, 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: Business Manager Training, Space/Technical Education, 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: Space/Technical Education, Systems Engineering
**Spacecraft Systems Design**
**S2020**

**Overview**
The Spacecraft Systems Design provides an overview of space systems spanning from microsatellites 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:** Space/Technical Education, Systems Engineering

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**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:** Space/Technical Education, Systems Engineering
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: Space/Technical Education, Systems Engineering

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: Space/Technical Education, Systems Acquisition Management and Programatics
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: Space/Technical Education, 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: Space/Technical Education, Systems Acquisition Management and Programmatic
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.

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: Space/Technical Education, 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: Space/Technical Education, 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 architectin
• Case studies of architectural success and failure
• Software-intensive systems

Length: 80 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: Space/Technical Education, 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: Space/Technical Education, 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: Space/Technical Education, Systems Architecture and Networking
Net-Centricity: Introduction
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 net-centric operations. These changes in military strategy have introduced challenges for national security space programs that are wrestling with what it means to be "net-centric," particularly in regard to a myriad of new mandates regarding net-centric operations. This course discusses the key enabling technologies for net-centricity as well as relevant governance and selected implementations.

Objectives
• Gain a broad knowledge of the policies and technologies that require and enable net-centricity
• Understand the role of net-centricity in the DoD and other government entities and its effect on all of Aerospace's customer communities

List of Topics:
• Motivation for net-centricity
• Service-oriented architecture and web services
• Data management
• Networking technologies
• Information assurance conceptual issues
• Security design for net-centric systems
• Governance
• Implementing net-centricity in GPS
• Data modeling for net-centric sensors and data sources

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: Space/Technical Education, 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: Space/Technical Education, Systems Architecture and Networking
Overview

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. This class is specifically designed with Aerospace program offices, management, and Government leaders in mind. It introduces leaders to the transformative potential that many-objective thinking can bring to their organization. GRIPS does not find a single solution, but rather approximates the optimal trade-off set of solutions. This provides decision makers with 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 real 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.

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

Objectives

- Learn how and when to apply the GRIPS 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: Space/Technical Education, Systems Architecture and Networking

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: Space/Technical Education, Systems Architecture and Networking
Space Protection Awareness: Condensed Version
S4900

Overview
This TS/SCI classified course provides a condensed, executive-level overview of “Space Protection Awareness” (S4905). It touches on a wide range of theoretical threats to space systems, from radio-frequency jamming to co-orbital antisatellite (ASAT) attacks. Each type of threat is examined to present the fundamental physics and technology, a brief history, considerations regarding use and deployment, and potential countermeasures. This 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

List of Topics:
• Introduction
• Nuclear weapon systems
• Direct-ascent antisatellite (ASAT) weapon systems
• Laser weapon systems
• Electronic weapon systems
• High-power microwave weapon systems
• Co-orbital weapon systems

Length: 4 hours

Target Audience: Open to Aerospace employees and government customers, this course is intended for senior space professionals interested in gaining an appreciation for 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/Technical Education, Systems Architecture and Networking

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/Technical Education, 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, Space/Technical Education

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 NRO 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/Technical Education, Systems Architecture and Networking
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, Space/Technical Education

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 knowledgably 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: 16 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, Space/Technical Education
Software: Introduction
S4415

Overview
This course provides an overview of major themes, techniques, and technologies related to software-intensive space systems. It focuses on key characteristics and concepts from the program office perspective. The course provides fundamental knowledge that can be built upon by other software courses. Programmatic considerations and mitigation strategies are highlighted throughout.

Objectives
• Understand the state of the practice in software systems
• Understand how software problems affect program success, cost, and schedule
• Learn to recognize, reduce, and avoid software-related risks
• Acquire a common software vocabulary and usage
• Locate additional resources (courses, journals, books, websites, and people)

List of Topics:
• Software life-cycle and project management
• Approaches for building software
• Software architecture and design
• Programming languages and software development
• Databases and data management
• Software testing
• Types of software
• The future of software

Length: 8 hours
Target Audience: Open to Aerospace employees and government customers. This course is recommended for program, product, and acquisition managers for all space systems; systems and software engineers; and engineers accountable for systems that interface with software.

Category: Computer and Software Systems and Technology, Space/Technical Education
Software Project Management for Mission-Critical Systems  
S4430

**Overview**

This course provides an introduction to software project management for software-intensive space systems. It focuses on what developers should be doing to manage their software-development projects and the role of Aerospace and customer personnel in this process. Key risks and red flags are highlighted throughout.

**Objectives**

- Understand basic principles and best practices for managing software development for software-intensive space systems
- Understand the role of Aerospace and customer personnel in monitoring the management of software projects
- Recognize the key risks and red flags in managing software development
- Locate additional resources both internal and external to Aerospace

List of Topics:

- Software process improvement and Capability Maturity Model Integration
- Software project planning, monitoring, and control
- Software development models
- Software estimation
- Software quality enhancement
- Software metrics and quantitative management
- Software risk management

**Length:** 24 hours  
**Target Audience:** Open to Aerospace employees and government customers, this course will interest program personnel responsible for software as well as engineering group personnel providing software support to programs.  
**Category:** Computer and Software Systems and Technology, Space/Technical Education

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 from different programs. It also provides acquisition guidance.

**Objectives**

- Understand the influence of software architecture on program success
- Know what to include in a software architecture description and how to represent it
- Get exposure to software architecture evaluation techniques and supporting tools
- Appreciate unique considerations regarding the acquisition of software architecture
- Know where to go for more information and help

List of Topics:

- Software architecture and program success
- Software architecture within the overall program life cycle
- Considerations regarding the acquisition of software architecture
- Describing software architecture
- Integrating software architecture with DoDAF views
- Evaluating software architecture: techniques and tools
- Considerations regarding policy and standards

**Length:** 16 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, Space/Technical Education
Software Product Development for Mission-Critical Systems
S4470

Overview

Formerly titled "Software Product Development for Mission-Critical Systems," this course provides an introduction to software development for software-intensive space systems. The focus is on what developers should be doing to develop the software that resides in space systems and on the role of Aerospace and customer personnel in this process. Review criteria for contractor software products are presented.

Objectives

• Understand basic principles and best practices for successful software development
• Understand the role of Aerospace and customer personnel in monitoring software development
• Recognize the key risks and red flags that can indicate software development problems
• Locate resources inside and outside Aerospace

List of Topics:
• The interface between software and systems engineering
• Software requirements development
• Software architecture
• Detailed software/database design
• Software implementation (coding)
• Software testing
• COTS and reuse software
• Software specialty engineering
• Software technical performance Measures
• Software reviews

Length: 24 hours

Target Audience: Open to Aerospace employees and government customers, this course will benefit Aerospace and customer personnel responsible for monitoring the development of contractor-supplied software.

Category: Computer and Software Systems and Technology, Space/Technical Education

Software Acquisition Management for Mission-Critical Systems
S4460

Overview

This course introduces the concept of software acquisition management. The term "software acquisition" encompasses all activities performed by the acquisition team (both government and Aerospace) to implement the software portion of software-intensive space systems. The emphasis is on mission assurance and executability throughout all acquisition phases. Best practices for each acquisition phase are discussed, including RFP development, source selection, and contract monitoring and management. Key risks and red flags are highlighted throughout.

Objectives

• Learn to assess and mitigate risks related to software acquisition
• Improve skills in acquisition activities before and after contract award

List of Topics:
• The acquisition environment
• Improving the software acquisition process
• Acquisition models
• Planning for software acquisition management
• Software acquisition project execution (tracking and control)
• Acquisition metrics and quantitative management
• The influence of software mission assurance on RFPs and contracts
• The use of appraisals for source selection and contract monitoring
• Best practices for all acquisition phases, before and after contract award

Length: 24 hours

Target Audience: Open to Aerospace employees and government customers, this course is primarily intended for those responsible for software acquisition.

Category: Computer and Software Systems and Technology, Space/Technical Education
Software Technology Readiness Assessment
S4475

Overview

Technology readiness assessments on major acquisition programs are mandated by law, but DOD guidance with regard to software maturity is weak and ambiguous. Based on broad experience, this course offers tangible guidance on identifying critical technology elements and establishing technology readiness levels for software. Such guidance has become increasingly important in DOD acquisitions as more and more functionality is implemented in software.

Objectives

Participants will be able to serve as software technology specialists in an independent review team conducting a technology readiness assessment (TRA) or support any software assessment effort required by customers. Participants will gain familiarity with:

- The TRA policy context
- TRA resources
- TRA logistics, including team member roles and responsibilities
- Methods to identify critical technology elements (CTEs) of a software-intensive program
- Methods to determine the maturity of software CTEs

List of Topics:

- What is a TRA and what is software technology?
- Software CTEs
- Risks of software CTE identification
- Crafting RFPs to prevent problems in identifying CTEs
- "Section L" instruction recommendations
- Software technology readiness evaluation dimensions
- Challenging topics

Length: 8 hours

Target Audience: Open to Aerospace employees and government customers, this course is designed for engineering and program management staff members with interests in software technology readiness assessment.

Category: Computer and Software Systems and Technology, Space/Technical Education

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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, Space/Technical Education
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/Technical Education

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/Technical Education
**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, Space/Technical Education

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**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, Space/Technical Education, Systems Acquisition Management and Programatics
Spacecraft Environmental Hazards
T1160

Overview
Formerly titled "Space Environment and Spacecraft Environmental Hazards," this in-depth course identifies areas for concentrated effort and provides specific recommendations to combat space environment hazards. It covers a range of phenomena, the impacts of these phenomena on satellite operations, and lessons learned by satellite builders and operators. Case studies are used to illustrate hazards and mitigation strategies. Note: sessions may be offered at a classified level.

Objectives
- Understand the sources and potential impacts of space hazards
- Understand the benefits and limitations of different mitigation strategies

List of Topics:
- Sources of near-Earth space radiation
- Spacecraft charging, single-event upsets, total radiation dose, and other space hazards
- 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, Space/Technical Education

The Effects of Natural Lightning on Ground and Launch Operations
T1170

Overview
Formerly titled "Electromagnetic Effects of Natural Lightning on Ground and Launch Operations," this course examines the phenomenon of natural lightning and its effects on launch and space vehicles, ground facilities, and launch operations. Students will be introduced to various methods for predicting, detecting, and measuring the induced electromagnetic effects of lightning with an eye toward assessing the vulnerability of space systems and the attendant level of risk. Techniques for protecting systems and mitigating risks are presented, as well as current and proposed lightning standards. This information should provide some practical familiarity in guiding ground and space launch operations during and after major lightning storms.

Objectives
- Gain familiarity with appropriate analytical tools and measurement results
- Learn to protect ground and launch assets through effective monitoring and mitigation of electromagnetic effects
- Define realistic lightning requirements for ground and space assets
- Gain practical knowledge of guiding space launch processing during and after major lightning storms

List of Topics:
- Natural lightning and its impact on space programs
- Lightning-induced electromagnetic effects on ground and space assets:
  — Prediction and detection
  — Device susceptibility and system vulnerability
  — Comparisons of analyses and measurements
  — Dealing with lightning for space launch operations
  — Protection and mitigation
  — Damage search and retest decisions
  — Risk assessment
  — Lightning requirements

Length: 8 hours
Target Audience: Open to Aerospace employees and government customers, this course is intended for program management and engineering staff and others providing direct support to program management and engineering.

Category: Science, Engineering, and Technology Specialities, Space/Technical Education
**Quality for Space Applications**  
*T5000*

**Overview**
Quality has evolved from a purely manufacturing endeavor into an overall business excellence discipline, involving planning, control, and continual improvement. This course explores quality as it applies to launch and space vehicle mission assurance. The topic is presented via a fictional tour through a contractor’s plant that reviews its quality system. The course is structured around a series of case histories that have their origin in the experiences of the trainers, and it has recently been updated to address quality management at Aerospace. The basic concepts pertaining to hardware and software quality assurance and the integral role they play in the contractor’s organization are explored. Basic concepts such as statistical process control, Six Sigma, review boards, and inspection are covered, and implementations of major quality tools are demonstrated. Generic quality systems from prime contractors and subcontractors, as culled from the experiences of the trainers, are discussed.

**Objectives**
- Be able to evaluate a contractor’s quality system
- Understand quality roles and responsibilities from an oversight perspective
- Become familiar with basic quality concepts, tools, approaches, and implementations

List of Topics:
- Historical overview
- Hardware and software quality assurance concepts
- Standards and awards
- Statistical process control
- Procurement and subcontract management
- Failure investigations
- Six Sigma
- Auditing and inspection
- Lessons learned

**Length:** 16 hours

**Target Audience:** Open to Aerospace employees and government customers, this course will benefit program management and engineering staff members who desire a basic understanding of the quality aspects within an organization they are responsible for administering, managing, or evaluating.

**Category:** Science, Engineering, and Technology Specialties, Space/Technical Education

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**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 Specialties, Space/Technical Education
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, Space/Technical Education

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, Space/Technical Education
Physics and Number Theory
T8177

Overview
Several techniques in wide use in physics were originally developed in the context of number theory. Examples include methods for estimating the spectra of dynamical systems based on “trace formulas” and various dualities in physics that can be related to dualities in algebraic number theory (the Langlands Program). The goal of the course is to review the number theory and the physics at an elementary level and illustrate how they shed light on each other.

Objectives
- Gain a greater appreciation for number theory
- Understand the relationship between number theory and physics

List of Topics:
- Symmetries in differential equations
- Analytic number theory (zeta functions, generalizations, applications)
- Algebraic number theory, dualities
- Unifications (Langlands Program)
- Applications

Length: 20 hours
Target Audience: Members of the Technical Staff. Some technical background is desirable.
Category: Science, Engineering, and Technology Specialities, Space/Technical Education

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, Space/Technical Education
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: 20 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, Space/Technical Education
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- 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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