# ATIcourses · Applied Technology Institute

# TECHNICAL TRAINING
(public & onsite)
*SINCE 1984*

- Space & Satellite Systems
- Radar, Missile, GPS & Defense

*Valid through March 2006*

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21st Anniversary

**Applied Technology Institute**
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*Jim Jenkins, Executive Director*

Technical Professionals,

Now is the time to think about bringing an ATI course to your site! If there are 8 or more people who are interested in a course, you save money if we bring the course to you. If you have 15 or more students, you save over 50% compared to a public course.

This catalog includes upcoming open enrollment dates for many courses. We can teach any of them at your location. Our website, www.ATIcourses.com, lists over 50 *additional* courses that we offer.

For 21 years, the Applied Technology Institute (ATI) has earned the TRUST of training departments nationwide. We have presented on-site training at all major DoD facilities and NASA centers, and for a large number of their contractors.

Since 1984, we have emphasized the big picture systems engineering perspective in:

- Defense Topics
- Engineering & Data Analysis
- Space & Satellite Systems
- Sonar & Acoustic Engineering

with instructors who love to teach! We are constantly adding new topics to our list of courses - please call if you have a scientific or engineering training requirement that is not listed.

We would love to send you a quote for an onsite course! For on-site presentations, we can tailor the course, combine course topics for audience relevance, and develop new or specialized courses to meet your objectives.

Regards,

Jim Jenkins

P.S. We can help you arrange on-site courses with your training department. Give us a call.

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## Space & Satellite Systems Courses



## Defense, Missiles, Radar



## Engineering & Analysis

# Advanced Topics in Launch Vehicle Design

## Analysis and Optimization

**February 13-15, 2006**

Beltsville, Maryland

$1290 (8:30am - 4:00pm)

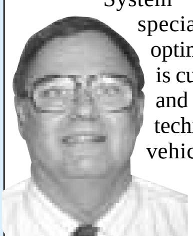
## Summary

This 3-day course provides an examination of the most important topics of modern launch vehicle design, analysis and optimization. It offers a focus on critical topics that lead to optimization of a launch vehicle design through such issues as staging optimization. The seminar provides a wealth of new material about the essential issues that have caused so many costly projects to fail. You will learn a wide spectrum of new solutions to problems in modern launch vehicle design. Revolutionary new techniques and concepts will be taught, with all material subject to strict application of modern science.

## What You Will Learn

- The most advanced topics of launch vehicle optimization, design and analysis.
- Advanced concepts in Modeling Launch Vehicle Projects.
- Modern rocket science applications.
- New techniques in launch vehicle design, optimization and analysis.
- Popular theories of rocket design not supported by scientific evidence.

## Instructor



**Edward L. Keith** is a multi-discipline Launch Vehicle System Engineer and Rocket Scientist, specializing in launch vehicle design optimization, modeling and technology. He is currently an independent consultant, writer and teacher of rocket system design and technology. He is experienced in launch vehicle operations, design, testing, optimization, research, business analysis, risk reduction, modeling, safety and reliability. Mr. Keith's experience extends to both reusable and expendable launch vehicles, as well as to solid liquid and hybrid rocket systems. Mr. Keith has designed complete rocket engines, rocket vehicles, small propulsion systems, and composite propellant tank systems, especially designed for low cost, as a propulsion and launch vehicle engineer. Mr. Keith worked on the Rascal Launch Vehicle Program and Launch Vehicle design lead, the Space Launch Initiative and the Liquid Fly-Back Booster programs for Boeing, originated the Scorpius Program for Microcosm, worked on the Brilliant Eyes and the Advanced Solid Rocket Motor Programs for Rockwell and worked on the Aerojet DSP Satellite program. He also has 13-years of government experience including five years working launch operations at Vandenberg AFB. Mr. Keith has written 22 technical papers on various aspects of low cost space transportation over the last decade.

## Course Outline

1. **The current state of Rocket Science.** Objective and metrics of optimization. Need for improvement in optimization.
2. **Advanced Topics of Mass Properties, Scaling Issues and High-Tech Materials.** Essential parameters of analysis. Theory of mass properties. Accurate mass properties as starting point and critical parameter.
3. **Advanced Topics in Propellant Volume Theory.** The theory that propellant volume is the most significant mass driver of launch vehicle design. Bulk density of propellants in the "rocket equation."
4. **Advanced Topics in Stage Mass Properties.** Separating engine mass properties from stage mass properties. Volume theory and propellant bulk density. Stages without engines. Implications of propellant volume scale, bulk density, and physical properties. Advanced modeling algorithms for top-down analysis.
5. **Advanced Topics in Engine Mass Properties.** Selected rocket engines ranked for thrust-to-weight ratio to hypothesize engine mass property relationships to specific impulse, engine cycle, cryogenic nature and bulk density of propellants, and engine design era.
6. **Advanced Topics in ELV Stage Mass Properties.** Expendable Launch Vehicle (ELV) theory. Simplification theory. Big Dumb Booster concept. Evaluation of mass suboptimization. Solid and hybrid propulsion.
7. **Advanced Topics in RLV Mass Properties.** Popular RLV theory. Fatal flaws. Classification of RLV systems. Theory for mass relationships to convenience of recovery. RLV and ELV alternatives.
8. **Current and Advanced Topics in Cost Model Theory.** Modern cost models as science. Use and abuse of cost analysis. Cost Models as self-fulfilling prophecies. Advanced relationships.
9. **Current Topics in Performance Model Theory.** Utility and value of current performance modeling. Problems with the models. Simplifying assumptions as an introduction to optimization searches.
10. **Advanced Topics in Optimization and Modeling Theory.** Virtual development exploration. Relationships and algorithms for advanced optimization by computer modeling.
11. **Staging Optimization Theory and Practical Procedure.** Current procedures and theories. Using computer programs. Determining optimum staging.
12. **Learning Curve Theory and Advanced Optimization.** Production and Launch Operations. The relationship with Economies of Scale.
13. **Advanced Topics in Engine Cluster Reliability Theory.** Modeling to optimize the number of engines/stage. Learning curve effects. Life Cycle costs and DDT&E Cost implications. The Russian paradigm of engine clusters. NASA employment of moderate engine clusters.
14. **Advanced Reliability Design & Analysis Integration for Launch Vehicles.** The reliability of rocket systems, particularly engine clusters. The optimization of engine numbers as a function of Catastrophic Fraction to achieve maximum reliability.
15. **Advanced Integration of Safety into Launch Vehicle Design and Analysis.** Integrating safety into optimization, with identifiable common denominators. The relationships between safety and cost.
16. **Integrated Modeling.** Specialty models to an integrated, high-fidelity, multi-discipline, comprehensive model. Advancing from analysis to gaming to analyze the reacting strategies of competitors.
17. **Deterministic Optimization.** Sweep optimization. Sample computer programs. Applications and requirements for sweep modeling. Determining the optimum payload scale for an RLV Point Design.
18. **Advanced Topics in Strategy in the Optimization Process.** The use of strategy to achieve superior results with inferior optimization. Clean sheet vs. existing building blocks. The strategy of evolution. Modularity as a strategy. Alternate strategies. Alternatives that reduce the costs of DDT&E, Production and Operations. Inferred relationships.

# Attitude Determination and Control

## Summary

This three-day course provides a detailed introduction to spacecraft attitude estimation and control. This course emphasizes many practical aspects of attitude control system design but with a solid theoretical foundation. The principles of operation and characteristics of attitude sensors and actuators are discussed. Spacecraft kinematics and dynamics are developed for use in control design and system simulation. Attitude determination methods are discussed in detail, including TRIAD, QUEST, Kalman filters. Sensor alignment and calibration is also covered. The various types of spacecraft pointing controllers and design, and analysis methods are presented. Students should have an engineering background including calculus and linear algebra. Sufficient background mathematics are presented in the course but is kept to the minimum necessary.

**February 21-23, 2006**
8:30am - 4:00pm
Beltsville, Maryland

$1290

## What You Will Learn

- How time and coordinate systems are relevant to pointing control.
- Characteristics and principles of operation of attitude sensors and actuators.
- Kinematics and dynamics.
- Attitude determination methods, algorithms, and limits of performance;
- Pointing accuracy, stability (smear), and jitter definitions and analysis methods.
- Various types of pointing control systems and hardware necessary to meet particular control objectives.
- Back-of-the envelope design techniques.

## Instructor

**Dr. Mark E. Pittelkau** is a staff engineer at the Applied Physics Laboratory in Laurel, Maryland. He has worked for the Department of the Navy, FMC Corporation Defense Systems, Swales Aerospace, CTA Space Systems, and Orbital Sciences Corporation. His experience in satellite systems includes the design, implementation, and testing of attitude control algorithms, attitude and orbit determination algorithms and attitude sensor alignment and calibration algorithms, control-structure interaction analysis, and stability and jitter analysis. His current interests are precision attitude determination and system calibration. Dr. Pittelkau earned the Bachelor's and Ph. D. degrees in Electrical Engineering from Tennessee Technological University and the Master's degree in EE from Virginia Polytechnic Institute and State University.

Recent attendee comments ...

"Very thorough!"
"Relevant and comprehensive."

## Course Outline

1. **Time and Coordinate frame definitions.** Time metrics, J2000 Inertial Coordinates, Mean-of-Date, True-of-Date, Earth-Centered-Earth-Fixed, Orbit and Attitude frames, and more!
2. **Attitude Sensors.** Sun sensors, Earth Horizon sensors, Magnetometers, Gyros of various types, Star Trackers. Principles of operation and sensor error modeling.
3. **Attitude Representations.** Vectors, direction-cosine matrices, Euler angles, quaternions. Conversion between attitude representations.
4. **Spacecraft Kinematics and Dynamics.** Kinematic equations using direction-cosine matrices and quaternions. Rigid-body rotational dynamics, Euler's equation.
5. **Attitude Determination.** Kalman Filtering, Extended Kalman Filter, computational algorithms for Kalman filtering. TRIAD, QUEST algorithms. Attitude determination and system calibration.
6. **Environmental Disturbance Torques.** Aerodynamic, solar pressure, gravity-gradient, and magnetic torque modeling.
7. **Attitude Control Hardware.** Reaction and momentum wheels, magnetic torque rods, reaction control jets. Principles of operation and modeling.
8. **Accuracy, Stability (Smear), and Jitter.** Definitions and methods of design and analysis for verification of requirements.
9. **Stabilization Techniques and Controllers.** B-dot and H X B rate damping laws. Gravity-gradient, spin stabilization, and momentum bias control. Three-axis zero-momentum control. Controller design and stability. Flexible-body modeling and flex-mode filters. Back-of-the envelope equations for actuator sizing and controller design.

# Fundamentals of Orbital & Launch Mechanics

## Military, Civilian and Deep-Space Applications

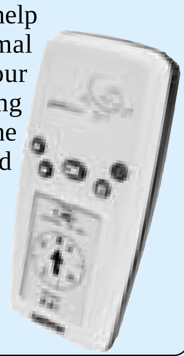
**Sept. 27-30, 2005**
Beltsville, Maryland

**Jan. 9-12, 2006**
Colorado Springs, Colorado

$1495 (8:30am - 4:00pm)

### Summary

Award-winning rocket scientist Thomas S. Logsdon has carefully tailored this comprehensive 4-day short course to serve the needs of those military, aerospace, and defense-industry professionals who must understand, design, and manage today's increasingly complicated and demanding aerospace missions. Armed with 400 full-color visuals, Logsdon will emphasize the practical rules of thumb and physical insights that will help you understand the mysteries of powered flight maneuvers and the beneficial properties of space. The lessons learned will help you lay out performance-optimal missions in concert with your professional colleagues, including President Bush's initiative to fix the shuttle, revisit the moon and conquer Mars.



Each student will receive a complete set of course notes and a new personal GPS Navigator with multi-channel capability.

### Instructor

**Thomas S. Logsdon** has accumulated more than 30 years experience with the Naval Ordinance Laboratory, McDonnell Douglas, Lockheed Martin, Boeing Aerospace, and Rockwell International. His research projects and consulting assignments have included the Tartar and Talos shipboard missiles, Project Skylab, and various interplanetary missions.

Mr. Logsdon has also worked on the Navstar GPS project, including military applications, constellation design and coverage studies. He has taught and lectured in 31 different countries on six continents and he has written and published 1.7 million words, including 29 technical books. His textbooks include *Striking It Rich in Space*, *Understanding the Navstar*, *Mobile Communication Satellites*, and *Orbital Mechanics: Theory and Applications*.

### Course Outline

1. **Concepts from Astrodynamics**. Kepler's Laws. Newton's clever generalizations. Evaluating the earth's gravitational parameter. Launch azimuths and ground-trace geometry. Orbital perturbations.
2. **Satellite Orbits.** Isaac Newton's vis viva equation. Orbital energy and angular momentum. Gravity wells. The six classical Keplerian orbital elements. Station Station-keeping maneuvers.
3. **Rocket Propulsion Fundamentals.** Momentum calculations. Specific impulse. The rocket equation. Building efficient liquid and solid rockets. Performance calculations. Multi-stage rocket design.
4. **Enhancing a Rocket's Performance.** Optimal fuel biasing techniques. The programmed mixture ration scheme. Optimal trajectory shaping. Iterative least squares hunting procedures. Trajectory reconstruction. Determining the best estimate of propellant mass.
5. **Expendable Rockets and Reusable Space Shuttles.** Operational characteristics, performance curves, and mission descriptions for the Atlas, Delta, and the Titan Launch vehicle families. The European Arian, the Japanese, H-2, Pegasus and Taurus. Reusable space shuttles: The SST, Russia's Space Shuttle.
6. **Powered Flight Maneuvers.** The classical Hohmann transfer maneuver. Multi-impulse and low-thrust maneuvers. Plane-change maneuvers. The bi-elliptic transfer. Relative motion plots. Military evasive maneuvers. Deorbit techniques. Planetary swingbys and ballistic capture maneuvers.
7. **Optimal Orbit Selection.** Polar and sun-synchronous orbits. Geostationary orbits and their major perturbations. ACE-orbit constellations. Lagrangian libration point orbits. Halo orbits. Interplanetary trajectories. Mars-mission opportunities and deep-space trajectories.
8. **Constellation Selection Trades.** Existing civilian and military constellations. Constellation design techniques. John Walker's rosette configurations. Colonel Draim's constellations. Repeating ground-trace orbits. Earth coverage simulation routines.
9. **Cruising along JPL's Invisible Rivers of Gravity in Space.** Equipotential surfaces. 3-dimensional manifolds. Developing NASA's clever Genesis mission. Capturing stardust in space. Simulating thick bundles of chaotic trajectories. Experiencing tomorrow's unpaved freeways in the sky.
10. **New Ways to Conquer Space.** Solar electric propulsion. Mass drivers. Electromagnetic catapults. Fission and fusion propulsion sources. Anti-matter space drives. Tethered satellites. Project Skyhook. The Skyhook complex. Two dozen promising alternatives to today's inefficient chemical rockets.

### *Comments from recent attendees:*

*"Excellent course. Can't imagine anyone with more knowledge."*

*"Friendly instructor .. excellent speaker .. extremely knowledgeable."*

### What You Will Learn

- How do we launch a satellite into orbit and maneuver it to a new location?
- How do we design a performance-optimal constellation of satellites?
- How can we switch from one orbit to another using the Hohmann transfer maneuver, the bi-elliptic transfer maneuver, the plane-change maneuver, and various combinations of these three maneuvers?
- Why do planetary swingby maneuvers provide such profound gains in performance, and what do we pay for these important performance gains?
- How to deorbit hazardous space debris using equipment that never leaves the ground.
- How can we design the best multistage rocket for a particular mission?
- What are Lagrangian libration-point orbits? Which ones are dynamically stable? How can we place satellites into halo orbits circling around these moving points in space?
- What are JPL's gravity tubes? How were they discovered? How are they revolutionizing the exploration of space?

# Fundamentals of Rockets and Missiles

**Dec. 13-15, 2005**
Beltsville, Maryland
**Feb. 7-9, 2006**
Los Angeles, California

$1290 (8:30am - 4:00pm)

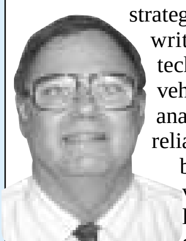

## Summary

The seminar is designed for engineers, decision makers and managers of current and future projects needing a more complete understanding of the complex issues of rocket and missile technology. This course is also relevant for government and industry officials who need an understanding of rocket and missile technology. It provides a foundation in the use, regulation and development of rocket systems of the future. You will learn a wide spectrum of problems, solutions and choices in the technology of rockets and missile used for military and civil purposes.

The seminar is taught to the point-of-view of a decision maker needing the technical knowledge to make better informed choices. How rockets and missiles work, why they are built the way they are, what they are used for and how they differ. How rockets and missiles differ when used as weapons, as launch vehicles, and in spacecraft or satellites.

Attendees will receive a complete set of printed notes. These notes will be an excellent future reference for current trends in state-of-the-art rocket and missile technology and decision making.


## Instructor



**Edward L. Keith** is a multi-discipline Launch Vehicle System Engineer, specializing in integration of launch vehicle technology, design, modeling and business strategies. He is an independent consultant, writer and teacher of rocket system technology. He is experienced in launch vehicle operations, design, testing, business analysis, risk reduction, modeling, safety and reliability. Mr. Keith's experience extends to both reusable and expendable launch vehicles, as well as to both solid and liquid rocket systems. Mr. Keith has designed complete rocket engines, rocket vehicles, small propulsion systems, and composite propellant tank systems, especially designed for low cost. Mr. Keith has worked the Space Launch Initiative and the Liquid Fly-Back Booster programs. He also has 13-years of government experience including five years working launch operations at Vandenberg AFB. Mr. Keith has written 18 technical papers on various aspects of low cost space transportation over the last decade.

## Course Outline

1. **Introduction to Rockets and Missiles** Introduction to the practical uses of rocket systems as weapons of war, commerce and the peaceful exploration of space. Classifications of guided, and unguided, missile systems.
2. **Rocket Propulsion made Simple.** How rocket motors and engines operate to achieve thrust. Use of the rocket equation and staging theory for rockets and missiles. Introduction to rocket efficiency metrics. Propellant tanks. Introduction to Mass Properties.
3. **Introduction to Propellant Performance, Utility and Applications.** Propellant performance and mixture ratio issues. Propellant density and specific impulse theory.Hypergolic propellants.Propellant storability cryogenic propellants.
4. **Introducing Solid Rocket Motor Technology.** Advantages and disadvantages of solid rocket motors.Solid rocket motor materials, propellant grains and construction. Applications for solid rocket motors as weapons and as cost-effective space systems.
5. **Liquid Rocket System Technology.** Cryogenic and non cryogenic liquid rocket systems. Turbo pumps vs pressure-fed rocket engines. Propellant tanks.
6. **Foreign vs. American Rocket Technology.** Examination of the strengths, and weaknesses, of Domestic, and foreign, rocket technology, and the value of import or export of technology. How the former Soviet aerospace diverged from American systems. Discussion of the issue of developing a space program to disguise a weapons program.
7. **Rockets in Spacecraft Propulsion.** Examination of the differences between launch vehicle booster systems and that found on spacecraft, satellites and transfer stages. The use of storable and hypergolic propellants. Operations of rocket systems in microgravity.
8. **Rockets and Missiles as Weapons.** Surface to surface, surface to air, ABM and air to surface weapons. Technology for short, intermediate and long-range weapons. Examination of lethality, probability of kill and accuracy. Active and passive guidance strategies. Technologies supporting delivery systems for weapons of mass destruction.
9. **Rockets and Missiles as Commerce.** Civil uses for rockets and missiles, and how they differ from systems designed as weapons. Uses for satellites in communications, navigation, and imaging.
10. **Rockets Systems for Space Exploration and Exploitation.** Issues of expendable and reusable launch vehicles for future space missions. Missions beyond earth from the USA and other nations.
11. **Useful Orbits and Trajectories Made Simple.** Introduction to simplified orbital mechanics. Orbital coordinate elements of Inclination, Apogee, Perigee, xxx. Special orbits; geostationary, sun synchronous and Molnya.
12. **Reliability and Safety of Rocket Systems.** Introduction to the issues of safety and reliability of rocket and missile systems. A study of the hazards of rocket operations. The causes of failures in rocket systems and strategies to improve reliability is discussed.
13. **Expendable Launch Vehicle Theory, Selection, Performance and Uses.** Understanding the continued dominance of expendable launch vehicles in the field of transportation from earth to low earth orbit.
14. **Reusable Launch Vehicle Theory and Performance.** Provide an appreciation and understanding of why Reusable Launch Vehicles have had difficulty replacing expendable launch vehicles since the first operational space shuttle began service, and how the performance of Reusable Vehicles differs from Expendable systems.
15. **The Direction of Technology.** A final open discussion regarding the direction of rocket technology, science, usage and regulations of rockets and missiles is conducted to close out the class study.

## Who Should Attend

- Aerospace Industry Managers.
- Government Regulators & Administrators.
- Engineers supporting rocket and missile projects.
- Contractors or investors involved in missile development.

## What You Will Learn

- Fundamentals of rocket and missile systems.
- The spectrum of rocket uses and technologies.
- Differences in technology between foreign and domestic rocket systems.
- Fundamentals and uses of solid and liquid rocket systems.
- Differences between systems built as weapons and those built for commerce.

# Geomatics - GIS, GPS, and Remote Sensing
## Principles and Applications of Integration

**January 23-26, 2006**
8:30am - 4:00pm
Beltsville, Maryland
$1495

### Summary

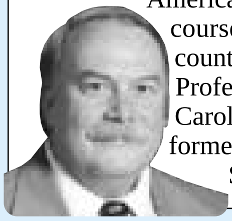
This four-day course will provide a technical overview of the current state of Geographic Information Systems and the integration of this powerful tool with GPS, remote sensing, and other data. This course is designed for those currently using GIS, those who are considering purchasing GIS systems, and managers who wish to better understand the issues involved in properly utilizing these tools.

The course provides an overview of the origins, current status, and future directions and applications of Geomatics tools. Information on GIS resources and making these tools work well in your own organization are highlighted.

***From this course you will obtain a good overview of the origins, current status and future directions of GIS and how the functional integration with remote sensing, GPS and other tools will develop new commercial markets and applications.***

### Instructor

**Dr. Scott Madry** is president of Informatics International, Inc., an international consulting firm in Chapel Hill, NC. Dr. Madry has over 20 years experience in remote sensing and GIS applications and has conducted a variety of research and application projects in Europe, Africa, and North America. He has given over 125 short courses and seminars in over 25 countries. He is a Research Assoc. Professor at the University of North Carolina at Chapel Hill and is a former member of The International Space University.



### Course Outline

1. **Principles of GIS**. Maps, scale, GIS origins, the development of GIS, map decomposition, map algebra, current GIS market estimates, future market projections and trends. Major players.
2. **GIS Data.** Point, line, and polygon data. Raster, vector and voxel data. Database structures. Data types: continuous, ordinal and discrete data. Integrating different data structures and data types.
3. **General Overview of GIS Capabilities and Functions.** Data collection, management, manipulation, analysis, display and visualization.
4. **Components of GIS Systems.** Software, operating systems, hardware, peripherals, data, people, management, infrastructure.
5. **Data Types and Data Sources.** Raster, vector, point data sources. Government sources (USGS, etc.) Commercial sources, Sources of international data, remote sensing data sources.
6. **GIS Data.** GIS digitizing. Digitizing paper map data. Incorporating existing database information. Incorporating GPS data.
7. **GIS Resources.** Web resources, journals, magazines, societies, meetings and conferences.
8. **Remote Sensing and GIS.** ncorporation of remote sensing data into GIS. Remote sensing data types and sources, issues of incorporating and processing raster remote sensing data with vector GIS.
9. **GPS and GIS.** Incorporation of GPS and other telemetry data into GIS. GPS, Gloanas, Argos, and other data types and sources, issues of incorporating and processing point and time data within the GIS environment.
10. **Visualization and Simulation.** The role of visualization and simulation technologies in GIS.
11. **Practical Issues in successfully and productively using these technologies.** Where do I start? Defining a plan to choose the right software/hardware/data, common problems and issues in organizing your GIS operation. Successes and horror stories.
12. **Applications to Homeland Defense.** Practical examples of using GIS and GPS in crisis management. What has been accomplished. What is new and upcoming.
13. **The Future of Geomatics.** Where is this all going? What are the major new issues and developing technologies? What are the new commercial, scientific, and governmental applications and markets? Trends in software and hardware.

### What You Will Learn

- What is GIS, and how does it work?
- What is the current status of these tools?
- What are the areas of future growth and new commercial markets for Geomatics?
- How are GIS/GPS/remote sensing and other tools functionally integrated?
- How can I successfully harness these tools and avoid problems?

# GPS Technology

## GPS Solutions for Military, Civilian & Aerospace Applications

### Summary

Nearly every military vehicle and every satellite that flies into space uses the GPS to fix its position. In this popular 4-day short course, GPS expert Tom Logsdon will describe in detail how those precise radionavigation systems work and review the many practical benefits they provide to military and civilian users in space and around the globe.

**Each student will receive a new personal GPS Navigator with a multi-channel capability.**

Through practical demonstration you will learn how the receiver works, how to operate it in various situations, and how to interpret the positioning solutions it provides.

Students receive a free GPS Navigator!

**October 3-6, 2005**
Beltsville, Maryland

**January 17-20, 2006**
San Diego, California

**Feb 27-Mar 2, 2006**
Cape Canaveral, Florida

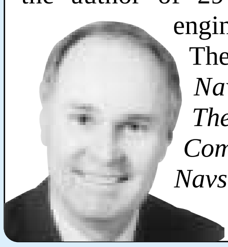
$1595 (8:30am - 4:00pm)

### Instructor

For more than 30 years, **Thomas S. Logsdon, M. S.,** has worked on the Navstar GPS and other related technologies at the Naval Ordinance Laboratory, McDonnell Douglas, Lockheed Martin, Boeing Aerospace, and Rockwell International. His research projects and consulting assignments have included the Transit Navigation Satellites, The Tartar and Talos shipboard missiles, and the Navstar GPS. In addition, he has helped put astronauts on the moon and guide their colleagues on rendezvous missions headed toward the Skylab capsule.

Some of his more challenging assignments have centered around constellation coverage studies, GPS performance enhancement, military applications, spacecraft survivability, differential navigation, booster rocket guidance using the GPS signals and shipboard attitude determination.

Tom Logsdon has taught short courses and lectured in 31 different countries. He has written and published 40 technical papers and journal articles, a dozen of which have dealt with military and civilian radionavigation techniques. He is also the author of 29 technical books on various engineering and scientific subjects. These include *Understanding the Navstar, Orbital Mechanics: Theory and Applications, Mobile Communication Satellites,* and *The Navstar Global Positioning System.*



### Course Outline

1. **Radionavigation Principles.** Active and passive radionavigation systems. Spherical and hyperbolic lines of position. Position and velocity solutions. Spaceborne atomic clocks. Websites and other sources of information. Building a $104 billion business in space.
2. **The Three Major Segments of the GPS.** Signal structure and pseudorandom codes. Modulation techniques. Military performance enhancements. Relativistic time dilations. Inverted navigation solutions.
3. **Navigation Solutions and Kalman Filtering Techniques.** Taylor series expansions. Numerical iteration. Doppler shift solutions. Satellite selection algorithms. Kalman filtering algorithms.
4. **Designing an Effective GPS Receiver.** Annotated block diagrams. Antenna design. Code tracking and carrier tracking loops. Software modules. Commercial chipsets. Military receivers. Shuttle and space station receivers.
5. **Military Applications.** The worldwide common grid. Military test-range applications.Tactical and strategic applications. Autonomy and survivability enhancements. Precision guided munitions. Smart bombs and artillery. projectiles.
6. **Integrated Navigation Systems.** Mechanical and Strapdown implementations. Ring lasers and fiber-optic gyros. Integrated navigation. Military applications. Key features of the C-MIGITS integrated nav system.
7. **Differential Navigation and Pseudosatellites.** Special committee 104's data exchange protocols. Global data distributions. Wide-area differential navigation. Pseudosatellite concepts and test results. Indoor GPS systems.
8. **Carrier-Aided Solutions.** The interferometry concept. Double differencing techniques. Attitude determination receivers. Navigation of the Topex and NASA's twin Grace satellites. Dynamic and Kinematic orbit determination techniques. Motorola's Spaceborne Monarch receiver. Relativistic time dilation derivations.
9. **The Navstar Satellites.** Subsystem descriptions. On-orbit test results. The Block I, II, IIR, and IIF satellites, Block III concepts. Orbital Perturbations and modeling techniques. Stationkeeping maneuvers. Earth shadowing characteristic. Repeating ground-trace geometry.
10. **Russia's Glonass Constellation.** Performance comparisons between the GPS and Glonass. Orbital mechanics considerations. Military survivability. Spacecraft subsystems. Russia's SL-12 Proton booster. Building dual- capability GPS/Glonass receivers.
11. **Precise Time Synchronization.** John Harrison's marine chronometer. Time synchronization methodologies. Test results. Tomorrow's ultra precise spaceborne arrays. Time sync for the International Space Station.
12. **Digital Avionics and Air Traffic Control.** The FAA's response to the GPS. Dependent surveillance techniques. 3D video displays. The wide-area augmentation system. Local area augmentation. Europe's Galileo constellation.
13. **Using the GPS for Satellite Orbit Determination.** Today's spaceborne receivers. Designing satellites to cover the geosynchronous flight regime. Positioning the International Space Station. Precise attitude determination. Space shuttle navigation.

# Ground System Design and Operation

**September 19-21, 2005**
Colorado Springs, Colorado

**November 15-17, 2005**
Beltsville, Maryland

$1290 (8:30am - 4:00pm)

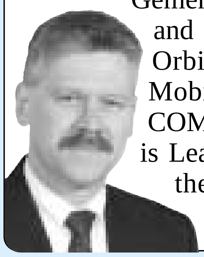
## Summary

This course provides a practical introduction to all aspects of ground system design and operation. Starting with basic communications principles, an understanding is developed of ground system architectures and system design issues. The function of major ground system elements is explained, leading to a discussion of day-to-day operations. The course concludes with a discussion of current trends in Ground System design and operations.

This course is intended for engineers, technical managers, and scientists who are interested in acquiring a working understanding of ground systems as an introduction to the field or to help broaden their overall understanding of space mission systems and mission operations. It is also ideal for technical professionals who need to use, manage, operate, or purchase a ground system.

## Instructor

**Steve Gemeny** is a senior member of the Professional Staff at The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. He is an experienced professional in the field of Ground Station and Ground System design in both the commercial world and on NASA Science missions. Prior to joining the Applied Physics Laboratory, Mr. Gemeny held numerous engineering and technical sales positions with Orbital Sciences Corporation, Mobile Telesystems Inc. and COMSAT Corporation. Mr. Gemeny is Lead Ground System Engineer on the New Horizons mission to explore Pluto by 2020



## What You Will Learn

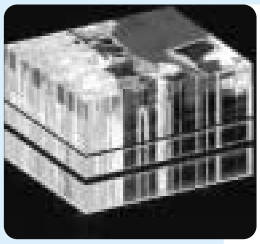
- The fundamentals of ground system design, architecture and technology.
- Cost and performance tradeoffs in the spacecraft-to-ground communications link.
- Cost and performance tradeoffs in the design and implementation of a ground system.
- The capabilities and limitations of the various modulation types (FM, PSK, QPSK).
- The fundamentals of ranging and orbit determination for orbit maintenance.
- Basic day-to-day operations practices and procedures for typical ground systems.
- Current trends and recent experiences in cost and schedule constrained operations.

## Course Outline

1. **The Link Budget.** An introduction to basic communications system principles and theory; system losses, propagation effects, Ground Station performance, and frequency selection.
2. **Ground System Architecture and System Design.** An overview of ground system topology providing an introduction to ground system elements and technologies.
3. **Ground System Elements.** An element by element review of the major ground station subsystems, explaining roles, parameters, limitations, tradeoffs, and current technology.
4. **Figure of Merit (G/T).** An introduction to the key parameter used to characterize satellite ground station performance, bringing all ground station elements together to form a complete system.
5. **Modulation Basics.** An introduction to modulation types, signal sets, analog and digital modulation schemes, and modulator - demodulator performance characteristics.
6. **Ranging and Tracking.** A discussion of ranging and tracking for orbit determination.
7. **Ground System Networks and Standards.** A survey of several ground system networks and standards with a discussion of applicability, advantages, disadvantages, and alternatives.
8. **Ground System Operations.** A discussion of day-to-day operations in a typical ground system including planning and staffing, spacecraft commanding, health and status monitoring, data recovery, orbit determination, and orbit maintenance.
9. **Trends in Ground System Design.** A discussion of the impact of the current cost and schedule constrained approach on Ground System design and operation, including COTS hardware and software systems, autonomy, and unattended "lights out" operations.

# Hyperspectral & Multispectral Imaging

Taught by an internationally recognized leader & expert in spectral remote sensing!



**November 15-17, 2005**
Chantilly, Virginia

**April 25-27, 2006**
Beltsville, Maryland

$1395 (8:30am - 4:00pm)

## Summary

This three-day class is designed for engineers, scientists and other remote sensing professionals who wish to become familiar with multispectral and hyperspectral remote sensing technology. Students in this course will learn the basic physics of spectroscopy, the types of spectral sensors currently used by government and industry, and the types of data processing used for various applications. Lectures will be enhanced by computer demonstrations. After taking this course, students should be able to communicate and work productively with other professionals in this field. Each student will receive a complete set of notes and the textbook/CD Rom set, *Imaging Spectrometry, Basic Principles and Prospective Applications*.

## Instructor

**Dr. Richard Gomez** is a Research Professor at George Mason University (GMU) and Principal Research Scientist at the Center for Earth Observing and Space Research (CEOSR). At GMU he teaches and is actively involved in the scientific and technology fields of hyperspectral imaging and high resolution remote sensing. He has also served in industry and government (Texas Instruments and USACE). Dr. Gomez is internationally recognized as a leader and expert in the field of spectral remote sensing (multispectral, hyperspectral and ultraspectral) and has published extensively in scientific journals. He has organized and chaired national and international conferences, symposia and workshops. He earned his doctoral degree in physics from New Mexico State University. He also holds an M.S. and a B.S. in physics. Dr. Gomez has served as Director for the ASPRS for Potomac Region and currently serves as Defense Aerospace Chair for the IEEE-USA Committee on Transportation and Aerospace Technology Policy.

## Course Outline

1. **Introduction to multispectral and hyperspectral remote sensing.**
2. **Sensor types and characterization.** Design tradeoffs. Data formats and systems.
3. **Optical properties for remote sensing.** Solar radiation. Atmospheric transmittance, absorption and scattering.
4. **Sensor modeling and evaluation.** Spatial, spectral, and radiometric resolution.
5. **Statistics for multivariate data analysis.** Scatterplots. Impact of sensor performance on data characteristics.
6. **Spectral data processing.** Data visualization and interpretation.
7. **Radiometric calibration.** Partial calibration. Relative normalization.
8. **Image registration.** Resampling and its effect on spectral analysis.
9. **Data and sensor fusion.** Spatial versus spectral algorithms.
10. **Classification of remote sensing data.** Supervised and unsupervised classification. Parametric and nonparametric classifiers. Application examples.
11. **Hyperspectral data analysis.**

## What You Will Learn

- The limitations on passive optical remote sensing.
- The properties of current sensors.
- Component modeling for sensor performance.
- How to calibrate remote sensors.
- The types of data processing used for applications such as spectral angle mapping, multisensor fusion, and pixel mixture analysis.
- How to evaluate the performance of different hyperspectral systems.

# IP Networking Over Satellite

## For Government, Military & Commercial Enterprises

**March 14-16, 2006**

Beltsville, Maryland

$1390 (8:30am - 5:00pm)

## Summary

This three-day course is designed for satellite engineers and managers in government and industry who need to increase their understanding of the Internet and how Internet Protocols (IP) can be used to transmit data and voice over satellites. IP has become the worldwide standard for data communications. Satellites extend the reach of the Internet and Intranets. Satellites deliver multicast content efficiently anywhere in the world. With these benefits come challenges. Satellite delay and bit errors can impact performance. Satellite links must be integrated with terrestrial networks. Space segment is expensive; there are routing and security issues. This course explains the techniques and architectures used to mitigate these challenges. Quantitative techniques for understanding throughput and response time are presented. System diagrams describe the satellite/terrestrial interface. The course notes provide an up-to-date reference. An extensive bibliography is supplied.

## Instructor

**Burt H. Liebowitz** is Principal Network Engineer at the MITRE Corporation, McLean, Virginia, specializing in the analysis of wireless services. He has more than 30 years experience in computer networking, the last six of which have focused on Internet-over-satellite services. He was President of NetSat Express Inc., a leading provider of such services. Before that he was Chief Technical Officer for Loral Orion (now Cyberstar), responsible for Internet-over-satellite access products. Mr. Liebowitz has authored two books on distributed processing and numerous articles on computing and communications systems. He has lectured extensively on computer networking. He holds three patents for a satellite-based data networking system. Mr. Liebowitz has B.E.E. and M.S. in Mathematics degrees from Rensselaer Polytechnic Institute, and an M.S.E.E. from Polytechnic Institute of Brooklyn.

*After taking this course you will understand how the Internet works and how to implement satellite-based networks that provide Internet access, multicast content delivery services, and mission-critical Intranet services to users around the world.*

## Course Outline

1. **Introduction.**
2. **Fundamentals of Data Networking.** Packet switching, circuit switching, Seven Layer Model (ISO). Wide Area Networks including, Frame Relay, ATM, Aloha, DVB. Local Area Networks, Ethernet. Physical communications layer.
3. **The Internet and its Protocols.** The Internet Protocol (IP). Addressing, Routing, Multicasting. Transmission Control Protocol (TCP). Impact of bit errors and propagation delay on TCP-based applications. User Datagram Protocol (UDP). Introduction to higher level services. NAT and tunneling. Impact of IP Version 6.
4. **Quality of Service Issues in the Internet.** QoS factors for streams and files. Performance of voice and video over IP. Response time for web object retrievals using HTTP. Methods for improving QoS: ATM, MPLS, Differentiated services, RSVP. Priority processing and packet discard in routers. Caching and performance enhancement. Network Management and Security issues including the impact of encryption in a satellite network.
5. **Satellite Data Networking Architectures.** Geosynchronous satellites. The link budget, modulation and coding techniques, bandwidth efficiency. Ground station architectures for data networking: Point to Point, Point to Multipoint. Shared outbound carriers incorporating Frame Relay, DVB. Return channels for shared outbound systems: TDMA, CDMA, Aloha, DVB/RCS. Meshed networks for Intranets. Suppliers of DAMA systems.
6. **System Design and Economic Issues.** Cost factors for Backbone Internet and Direct to the home Internet services. Mission critical Intranet issues including asymmetric routing, reliable multicast, impact of user mobility. A content delivery case history.
7. **A TDMA/DAMA Design Example.** Integrating voice and data requirements in a mission-critical Intranet. Cost and bandwidth efficiency comparison of SCPC, standards-based TDMA/DAMA and proprietary TDMA/DAMA approaches. Tradeoffs associated with VOIP approach and use of encryption.
8. **Predicting Performance in Mission Critical Networks.** Queuing theory helps predict response time. Single server and priority queues. A design case history, using queuing theory to determine how much bandwidth is needed to meet response time goals in a voice and data network. Use of simulation to predict performance.
9. **A View of the Future.** Impact of Ka-band and spot beam satellites. Benefits and issues associated with Onboard Processing. LEO, MEO, GEOs. Descriptions of current and proposed commercial and military satellite systems. Low-cost ground station technology.

## What You Will Learn

- How packet switching works and how it enables voice and data networking.
- The rules and protocols for packet switching in the Internet.
- How to use satellites as essential elements in mission critical data networks.
- How to understand and overcome the impact of propagation delay and bit errors on throughput and response time in satellite-based IP networks.
- How to link satellite and terrestrial circuits to create hybrid IP networks.
- How to select the appropriate system architectures for Internet access, enterprise and content delivery networks.
- How to design satellite-based networks to meet user throughput and response time requirements.
- The impact on cost and performance of new technology, such as LEOs, Ka band, on-board processing, inter-satellite links.

# Launch Vehicle Systems - Reusable

## Technology, Decisions, Design

**October 18-20, 2005**

Houston, Texas

$1290 (8:30am - 4:00pm)

### Summary

This course provides the practical knowledge to understand the issues of costs, performance, technology, operation and utility of reusable launch systems. The seminar is designed for engineers, decision makers and managers of current and future projects needing a better understanding of the complex issues involved in the optimization of reusable launch vehicles. The seminar describes the choices and consequences of options facing those seeking to improve space transportation through decreased dependence on expending launch vehicle hardware. You will learn a wide spectrum of problems of, and solutions to, reusable launch vehicle technology and how the choices stack up against current expendable vehicle systems.

The seminar is taught from the point-of-view of reusable launch vehicle decision makers. What do you need to know to achieve a practical and cost-effective reusable launch vehicle, given performance reliability, safety and cost trade-offs? What do you need to know to make the proper decisions - from propellant selection and architecture to the level of new technology needed to achieve the desired degree of success? The similarities, and differences between expendable and reusable vehicle systems, design and performance are compared and explained to help understand the optimum launch vehicle design.

Attendees will receive a complete set of printed notes. These notes will be an excellent future reference for current trends to the state-of-the-art in reusable launch vehicle modeling, design, development, operations and decision criteria.

### Instructor

**Edward L. Keith** is a multi-discipline Launch Vehicle System Engineer, specializing in the integration of launch vehicle technology, design, and business strategies. He recently retired from business case strategic analysis, risk reduction and modeling for the Boeing Space Launch Initiative Reusable Launch Vehicle team. For the past five years, Ed has supported the technical and business case efforts at Boeing to advance the state-of-the-art for reusable launch vehicles. Mr. Keith has designed complete rocket engines, rocket vehicles, small propulsion systems, and composite propellant tank systems, especially designed for low cost, as a propulsion and launch vehicle engineer. His travels have taken him to Russia, China, Australia, and many other launch operation centers throughout the world. Mr. Keith has worked as a Systems Engineer for Rockwell International, on the Brilliant Eyes Satellite Program and on the Space Shuttle Advanced Solid Rocket Motor project. Mr. Keith served for five years with Aerojet in Australia, evaluating all space mission operations that originated in the Eastern hemisphere. Mr. Keith also served for five years on Launch Operations at Vandenberg AFB, California. Mr. Keith has written 18 papers on various aspects of Low Cost Space Transportation over the last decade.

### Who Should Attend

- Reusable Launch Vehicle Project Designers, Managers and Decision makers
- Commercial and Government sponsors of Reusable Launch Vehicles
- Modelers or simulation analysts for RLV technology Projects
- RLV Technology specialists needing broader understanding of the "Big Picture"

### Course Outline

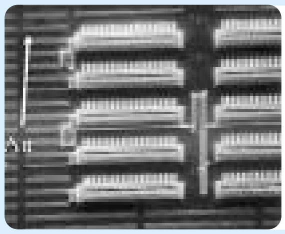
1. **Introduction to Launch Vehicle Technology.**
2. **Expendable Launch Vehicles (ELV) as the Baseline for RLV Technology.**
3. **Unique RLV Systems.**
4. **Propellant Selection as Technology and Performance Drivers.**
5. **Mass Properties and Scaling Issues.**
6. **Basic modeling of RLV systems and simplifying assumptions.**
7. **Business Models and Business Case Closure.**
8. **Operational Issues and the Turn-Around Process.**
9. **Performance Differences between ELV and RLV Systems.**
10. **The SSTO vs. TSTO Decisions.**
11. **Reliability Issues with RLV Systems.**
12. **Practical Engine Selection Issues.**
13. **OMS and RCS issues for RLV technology.**
14. **Safety Issues and the RLV.**
15. **Launch site selection issues for RLV Systems, including inland launch sites.**
16. **Mixed Expendable and Reusable Decisions.**
17. **Risk Issues and Risk Reduction.**
18. **Opportunities For Revolutionary RLV Technology, including where to start and what technologies are critical.**

### What You Will Learn

- Modeling Reusable Launch Vehicles, and how they differ from Expendable Vehicles
- Tradeoffs in performance, cost, reliability, safety and utility
- Business justification for next generation reusable launch vehicles
- Technology, design, development, production and operations decisions
- Working with a large reusable launch vehicle design team

# Micro Electro Mechanical Systems (MEMS) in Space

## MEMS and Microstructures enabling future Satellites and Space Science



**February 22-24, 2006**

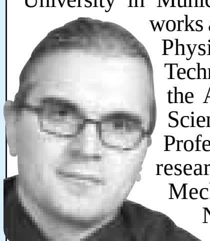
**Beltsville, Maryland**

**$1290 (8:30am - 4:00pm)**

### Summary

Micro Electro Mechanical Systems (MEMS) and Microstructures for Aerospace Applications establish a strong foundation for current and future practitioners. MEMS is an interdisciplinary field requiring knowledge in electronics, micro mechanisms, processing, physics, fluidics, packaging and materials just to name a few of the skills. It is to that group of broad ranging disciplines that this course is directed to. The material is designed and presented for the: systems engineer, flight assurance manager, project lead, technologist, program management, system lead engineers and others including the scientist searching for new instrumentation capabilities as a practical guide to MEMS in aerospace applications. The course provides a mix of general background and specific details to envision and support the insertion of MEMS in future flight missions. In order to nurture the vision to use MEMS in micro spacecraft – or even as spacecraft –an overview of the demonstrations of MEMS in space is provided. This highly topical course provides guidelines and materials for the end user to draw upon in order to conceive, implement, integrate and qualify MEMS for future space missions.

### Instructors



**Dr. Robert Osiander** received his Ph.D. at the Technical University in Munich, Germany, in 1991. Since then he works at the Johns Hopkins University Applied Physics Laboratory Research and Technology Development Center, where is the Assistant Group Supervisor for Sensor Science and a member of the Principal Professional Staff. Dr. Osiander's current research interests include Micro-Electro-Mechanical Systems MEMS), Nanotechnology, and Terahertz Imaging and Technology for Applications in Sensors, Communications, Thermal Control, and Space. He is the PI on "MEMS Shutters for Spacecraft Thermal Control", which is one of NASA's New Millennium Space Technology Missions, to launch in 2005. Dr. Osiander has also developed a research program to develop carbon nanotube based thermal control coatings.

**Ann Garrison Darrin** is a member of the Principal Staff and Program Manager for the Research and Technology Development Center at the Johns Hopkins University Applied Physics Laboratory. She has over 20 years experience in both government (NASA, DoD) and private industry in particular with technology development, application, transfer and insertion into space flight missions. She holds an M.S. in Technology Management and has authored several papers on technology insertion along with co-authoring several patents. Ms. Darrin was the Division Chief at NASA Goddard Space Flight Center for Electronic Parts, Packaging and Material Sciences from 1993-1998. She has extensive background in aerospace engineering management, microelectronics and semiconductors, packaging, and advanced miniaturization. Ms. Darrin co-Chairs the MEMS Alliance of the Mid Atlantic.

### Course Outline

1. **Overview** of Micro Electro Mechanical Systems and Microstructures for Aerospace Application. Understanding of MEMS and the MEMS Vision. Space demonstrations of MEMS; past, current and emerging flight opportunities. Identification of the long-term, disruptive or revolutionary impacts that MEMS technology has in space applications.
2. **Fundamentals of MEMS.** Understanding of the MEMS fabrication processes. Bulk micromachining, sacrificial surface micromachining and LIGA. Capability differences including achievable device aspect ratio, materials, complexity, and integration with microelectronics.
3. **MEMS and the Space Environment.** Overview of the space environment and its effects upon the design of Micro Electro-Mechanical Systems (MEMS). Thermal, mechanical, and chemical effects that impact reliability. Mission environmental influences including radiation, zero gravity, zero pressure, plasma and atomic oxygen.
4. **MEMS in Space craft and in Science Instruments.** Size, power, volume and weight reduction offered by micro-machining and the multiple insertion points into spacecraft and science instrumentation. New capabilities and increased functionality of MEMS and Microsystems.
5. **MEMS in Satellite Subsystems.** Satellite subsystems including communication (both RF and Optical), guidance, navigation and control, thermal and micro propulsion.
6. **Insertion of MEMS in Aerospace Applications.** Materials guidelines, packaging requirements, handling and contamination control requirements.
7. **Quality Assurance and Reliability.** Review requirements, screening and qualification regimes. Tailoring requirements for mission success. Terrestrial, launch and on orbit reliability concerns.

### What You Will Learn

- Role of MEMS and Microsystems in enabling future spacecraft visions
- Comprehensive understanding of MEMS technology
- Knowledge of the space environment and its effect on MEMS devices
- Insertion points for MEMS in spacecraft and instrument systems
- Practical insight into nuts and bolts topics such as: packaging, materials, handling and contamination control
- Reliability and Quality Assurance topics

# Modern Missile Analysis & Technology

## Guidance, Control, Seekers & Technology

**December 5-8, 2005**
Arlington, Virginia

**Feb. 27-Mar. 2, 2006**
Beltsville, Maryland

8:30am - 4:00pm

$1495


### Summary

This course provides a broad introduction to homing missiles operating in the atmosphere and in space. The topics are described in practical terms with relevant examples. In addition to practical explanations, relevant analytical techniques are included. Starting with a historical perspective, the course emphasizes today's homing missiles and future trends. Major sections on missile propulsion, autopilots, homing guidance, seekers, and testing are presented, along with their roles and interactions in overall missile performance. Missile integration, tradeoffs, and comparisons of different design approaches are discussed. This is an introductory course for technical managers, analysts, engineers, physicists, and technicians interested in learning basic missile technology. A complete set of lecture notes including illustrative examples will be provided.

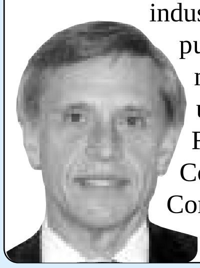

### What You Will Learn

You will gain an understanding of the design and analysis of homing missiles and their major subsystems including propulsion, autopilots, instruments, guidance, control, seekers, power, warheads, simulation, and testing.

- Operational principles of homing missiles.
- Guidance and control.
- Missile types and tradeoffs in design.
- Use of missile simulation.
- Latest developments and future trends.

### Instructor

**Dr. Walter R. Dyer** is a graduate of UCLA in Control Systems Engineering and Applied Mathematics. He has thirty years of industry, government and academic experience in the analysis and design of tactical and strategic missiles. His experience includes Standard Missile, Stinger, AMRAAM, HARM, MX, Small ICBM, and ballistic missile defense. He is currently Technical Advisor to the Deputy for Advanced Systems at the Missile Defense Agency in Washington, DC. He has authored numerous industry and government reports and published prominent papers on missile technology. He has taught university courses in Kalman Filtering and Random Processes, Control Systems, Electromagnetics, Computer Simulation, and Circuit Theory.



### Course Outline

1. **Introduction.** Brief history of missiles. Types of guided missiles. Introduction to ballistic missile defense. Missile basing. Endoatmospheric and exoatmospheric missile operation. Missile basing. Missile subsystems overview.
2. **Warheads and Lethality.** Warhead types. Warhead vs hit-to kill missiles. Directional warheads. Lethality analysis, testing, and enhancement.
3. **Missile Propulsion.** Missile uses of rocket propulsion. The rocket equation. Solid and liquid systems. Single stage and multistage boosters. Ramjets and scramjets. Axial and divert propulsion. Divert and attitude control systems. Effects of gravity and atmospheric drag.
4. **Missile Airframes, Autopilots and Control.** Phases of missile flight. Purpose and functions of autopilots. Missile control configurations. Autopilot design. Inertial instruments and autopilot feedback. Autopilot response, agility, and stability. Body modes and rate saturation. Roll control and induced roll in high performance missiles. Adaptive autopilots. Rolling airframe missiles.
5. **Exo-atmospheric Missiles.** Exo-atmospheric missile analysis and performance. Divert propulsion and attitude control. Pulse width modulation. Exo-atmospheric missile autopilots and limit cycles.
6. **Missile Guidance.** Boost and midcourse guidance. Zero effort miss, proportional navigation, and augmented proportional navigation. Biased proportional navigation. Predictive guidance. Optimum homing guidance. Guidance filters including Kalman filters. Radomes and their effects on missile performance. Miss distance and missile trajectories with different homing guidance laws. Sources of miss and miss reduction. Beam rider, pure pursuit, and deviated pursuit guidance. Keplarian motion and launch vehicle guidance.
7. **Missile Seekers.** Seeker types and operation for endo- and exo-atmospheric missiles. Passive, active, and semi active missile guidance. Radar basics and radar seekers. Passive sensor basics and passive seekers. Scanning seekers, and focal plane arrays. Signal processing and noise reduction.
8. **Power and Power Conditioning.** Missile power requirements, sources, power conditioning and distribution. Electromagnetic compatibility.
9. **Simulation and testing.** Overview of missile simulation, applications, and future trends. Two to six degree of freedom simulations and hardware in the loop. Missile system and subsystem testing. Wind tunnel-, hover-, and flight testing.

# Planetary Exploration Mission Success:
## Systems Engineering Best Practices

### Summary

This three-day course is designed for aerospace engineers, and managers who wish to enhance their understanding of how planetary mission success can be facilitated by implementing high-quality systems engineering practices of Requirements Engineering, Risk Management, and Verification Synthesis. During this course each systems engineering best practices' methodology is explored and its mission success connection is illustrated by relevant examples or by using published data.

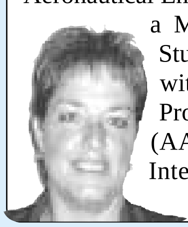
This course provides a comprehensive overview of modern planetary science to professionals in engineering, management and policy fields. The student will receive the basic elements of planetary physics, planetary origins, the content and geography of our planetary system, and a state of the art survey about what is known about extra-solar planetary systems. At every step we will show how these fields relate to existing and planned missions and new ground-based facilities. In our solar system, we will focus on what has been learned through NASA exploration missions ranging from Apollo to Voyager, Viking, Magellan, Galileo, and the Pathfinder/MER Mars landers. The attendee will leave this course with a state-of-the-art overview of modern planetary science, as well as a mastery of the terminology, instrumentation needs, and science goals of this important scientific field.

### Instructor

**Nancy J. Lindsey** has spent 20+ years in aviation and aerospace engineering performing a variety of engineering tasks across the entire gamut of space vehicle life cycles and program types (civil, defense & commercial) and she is currently involved with the ISRU capability road-mapping committee on lunar habitat construction.

As a seasoned aviation and aerospace systems engineering professional she has expertise in launch vehicle integration analyses, spacecraft design, operations, and launch support, mission success/safety analyses, flight environmental analyses, and risk/failure analyses.

Mrs. Lindsey has a Bachelor of Science Degree in Aeronautical Engineering and Computer Science and a Masters of Science degree in Space Studies. She is a published researcher with her latest work: Lunar Station Protection: Lunar Regolith Shielding (AAS-03-720), released at the International Lunar Conference ILC2003/ILEWG5, 2003.



**November 8-10, 2005**
**Beltsville, Maryland**
$890 (8:30am - 5:00pm)

### Course Outline

1. **Introduction.** System Engineering's role in mission success assurance. Best Practices Overview.
2. **Requirements Engineering.** Requirement Derivation – Why derive requirements? – Requirements as definers of Mission success, Benefits and Value. What is a requirement? - Understandable, Quantifiable/Measurable, Specific, Unambiguous, Verifiable, Complete, Traceable, and Rational/ Relevant. Derivation, Refinement, Allocation/Decomposition - Performance/interface. Requirement Validation - Evaluate Requirement Decomposition and Traceability. Exercises & Common Pitfalls.
3. **Risk Management.** Risk Quantification - Why quantify risks? – Benefits and Value. Design Analysis/Threat Assessment – FMEA, Single Point Failure Analyses, etc. Environmental Analysis/Threat Assessment: atmospheric, thermal, meteoroids/debris, radiation, magnetic field, geologic and gravitational field; using the Moon as a reference system. Define occupant's systems' environmental interactions/needs? Define each activity's environmental interactions/needs? Risk Tolerance? Systematic Analysis/Threat Assessment – Collision Analyses, Probabilistic Risk Assessment (PRA), etc. Programmatic Analysis/Threat Assessment – Independent Management Plan Assessments, Decision Analyses. Operational Risk/Hazard Quantification. Design and Operations Safety/Analysis/Hazard Assessment. Risk Control – Mitigation (requirements adjustments, design changes, operational restrictions, etc), Tracking, Tolerance, Refinement or waivers? Exercises & Common Pitfalls.
4. **Verification Synthesis.** Evaluate system designs/performance - Test or Analyses decisions. Synthesis - Documentation, Documentation, Documentation. Refinement or waivers? Exercises & Common Pitfalls.
5. **Summary.** Mission Success is a process not a result. Lessons Learned, knowledge management- interaction of best practices throughout life cycle.

### What You Will Learn

- What is an effective/valid requirement?
- What are the planetary environmental mechanisms that must be considered for any planetary mission?
- How to use systems engineering analysis to ensure mission success in a planetary mission.
- How to evaluate designs and operations based on systems engineering best practices for mission success.

From this course you will obtain the knowledge and ability to manage system requirements and risks to ensure mission success, interact meaningfully with colleagues, evaluate systems, and understand related analyses.

# Planetary Science for Aerospace Professionals

## Mastering Modern Planetary Science

NEW!

**November 15-16, 2005**

Denver, Colorado

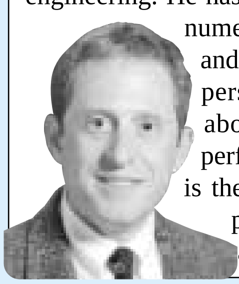
$890 (8:30am - 5:00pm)

### Summary


This course provides a comprehensive overview of modern planetary science to professionals in engineering, management and policy fields. The student will receive the basic elements of planetary physics, planetary origins, the content and geography of our planetary system, and a state of the art survey about what is known about extra-solar planetary systems. At every step we will show how these fields relate to existing and planned missions and new ground-based facilities. In our solar system, we will focus on what has been learned through NASA exploration missions ranging from Apollo to Voyager, Viking, Magellan, Galileo, and the Pathfinder/MER Mars landers. The attendee will leave this course with a state-of-the-art overview of modern planetary science, as well as a mastery of the terminology, instrumentation needs, and science goals of this important scientific field.


### Instructor

**Dr. S. Alan Stern** is a planetary scientist, writer, NASA spaceflight experiment and mission PI, and the Executive Director of the Space Science and Engineering Division of the Southwest Research Institute. Dr. Stern, a PhD. in astrophysics with an M.S. in Aero Engineering, has over 20 years experience in space science and spaceflight engineering. He has been principal investigator of numerous instruments on NASA and ESA planetary missions, has personally flown experiments aboard numerous high-performance NASA aircraft, and is the author of over 170 technical publications in planetary and astrophysical research.



### Course Outline

1. **The architecture of our solar syetem.**
2. **The formation of the solar system.**
3. **Overview: NASA's planetary exploration plans: 2005-2015.**
4. **Mercury.**
5. **Venus.**
6. **The Moon.**
7. **Special Topic: Lunar polar volatiles.**
8. **Near Earth Asteroids — An Overview.**
9. **Mars.**
10. **The NASA Lunar and Mars exploration roadmap.**
11. **The giant planets.**
12. **The satellites of the giant planets.**
13. **Comets.**
14. **Pluto-Charon.**
15. **The Kuiper Belt and Oort Cloud.**
16. **Special Topic: The New Horizons Pluto-Kuiper Belt Mission.**

### What You Will Learn

- The state-of-the-art details of the architecture of our solar system, from Mercury to Pluto to the Oort Cloud.
- The various types of planetary atmospheres, interiors, and surfaces.
- The goals behind and plans for NASA's planetary exploration program in the coming decade, including plans for near-term robotic lunar and Mars orbiters and landers..
- The structure of the asteroid belt and Kuiper belt.
- Up-to-date concepts of planetary formation.

# Remote Sensing for Earth Science Applications

## Optical, IR, Passive Microwave, SAR & Hyperspectral Sensing

## February 13-17, 2006

Beltsville, Maryland

$1695 (8:30am - 4:00pm)

5 top experts in 1 week!

### Summary

This course is for those who need to understand the basics of remote sensing including the instrument capabilities and limitations, and how the data can be processed and used. The course covers the basic concepts of passive and active sensing. The pros and cons of various orbits and the launch techniques to attain them are explained. Typical sensor designs, operational features, and constraints are discussed for low-cost, low-weight LANDSAT-type sensors. The all-important issue of sensor data processing is highlighted, including unique characteristics of each sensor.

This course is presented by top experts in satellite remote sensing systems, with many years of hands-on experience. It is recommended for management and technical people who wish to enhance their understanding of engineering concepts and applications of remote sensing systems. The course bridges the knowledge needed to understand both the sensors and the data processing for earth remote sensing and sciences. All attendees will receive a complete set of course notes.

### Instructors

**Dr. Scott Madry** is president of Informatics International, Inc., an international consulting firm in Chapel Hill, NC. Dr. Madry has been involved in remote sensing and GIS applications for over 20 years and has conducted a variety of research and application projects in Europe, Africa, and North America. He is a Research Assoc. Professor at the University of North Carolina at Chapel Hill.

**Marvin Maxwell** has over 20 years in spacecraft systems and instrument development while at NASA's Goddard Space Flight Center. He was directly involved in supporting the development of the AVHRR, Multispectral Scanner, Thematic Mapper, and the GOES I-M Imager and Sounder. He provided the instrument expertise which developed the MODIS requirements.

**Dr. Barton D. Huxtable,** has over ten years experience in concept development and performance prediction for remote sensor systems including radars, passive millimeter wave imagers, sonars, and lidars. His career has emphasized signal processing and numerical algorithm design and implementation for application-specific data processing and analysis, concentrating on remote sensor processing systems.

**Dr. Calvin Swift** is a professor emeritus at the University of Massachusetts, Amherst. His research career has focused on the development of novel instrumentation with applications to passive and active remote sensing of terrain, ocean, sea and glacial ice, and the atmosphere. He has authored numerous book chapters, journal articles, and conference papers in the area of remote sensing.

**Dr. Richard Gomez** is a Professor at George Mason University, and a Principal Research Scientist at the Center for Earth Observing and Space Research.

### Course Outline

1. **Scope of Applications.** Overview of remote sensing systems and applications. What systems are and will be in orbit. Cost constraints for operational systems and scientific programs. Orbits:LEO vs GEO sunsynchronous, equational, inclined, elliptical, repeating ground track, non-diurnal/non-monthly/non-seasonal.
2. **Current Programs and New Trends.** TIROS, GOES, DMSP, EOS, LANDSAT, TOPEX, SSTI, New Millenium, MSTI, SSPT, ERS, RADARSAT, and other Canadian, European, and Japanese programs. Small-Sats, sensors, launch vehicle options, new design trends for miniaturization, techniques for shorter program development.
3. **Sensing Fundamentals and Techniques.** Radiation, blackbody and electromagnetic, spectral regions. Detection techniques: imagery, radiation measurement, thermal detection, photon detection, and coherent techniques. Radiation detectors: photo-conducting and photo-emissive detectors, thermal detectors, thermopiles, bolometers, pyroelectric detectors, charge transfer devices. Passive systems: microwave, IR, UV, X- and gamma rays, particles. Active systems: lidar, radar, synthetic aperture, altimeters, scatterometers. System issues: cooling, multi-spectral sensing, detection statistics, and data fusion.
4. **Fundamentals of SAR.** The principles of SAR are presented and system design tradeoffs are illustrated for various mission requirements. Examples and case studies are used. Contemporary technology capabilities are discussed for NASA, DOD and commercial applications.
5. **Microwave Radiometry.** Thermal emission and emissivity. Brightness temperature and antenna temperature. Radiative transfer. Conventional types of receivers, sensitivity, and calibration. The synthetic aperature radiometer. Passive Microwave Remote Sensing of the Atmosphere. Integrated cloud liquid and water vapor measurements. Remote sensing of precipitation. Temperature and water vapor profiling. Passive Microwave Remote Sensing of Earth Surface. Sea-surface wind speed, temperature, and salinity. Sea ice concentration and age. Glacial inclusions. Soil-moisture measurements and limb sounding.
6. **Multispectral & Hyperspectral Imaging.** The limitations on passive optical remote sensing. The properties of current sensors. Component modeling for sensor performance. How to calibrate remote sensors. The types of data processing used for applications such as terrain material mapping, multisensor fusion, and pixel mixture analysis. How to evaluate the performance of data processing algorithms.

# Satellite Communication
## An Essential Introduction

### Summary

This introductory course has recently been expanded to three days by popular demand. It has been taught to thousands of industry professionals for more than two decades, to rave reviews. The course is intended primarily for non-technical people who must understand the entire field of commercial satellite communications, and who must understand and communicate with engineers and other technical personnel. The secondary audience is technical personnel moving into the industry who need a quick and thorough overview of what is going on in the industry, and who need an example of how to communicate with less technical individuals. The course is a primer to the concepts, jargon, buzzwords, and acronyms of the industry, plus an overview of commercial satellite communications hardware, operations, and business environment.

Concepts are explained at a basic level, minimizing the use of math, and providing real-world examples. Several calculations of important concepts such as link budgets are presented for illustrative purposes, but the details need not be understood in depth to gain an understanding of the concepts illustrated. The first section provides non-technical people with the technical background necessary to understand the space and earth segments of the industry, culminating with the importance of the link budget. The concluding section of the course provides an overview of the business issues, including major operators, regulation and legal issues, and issues and trends affecting the industry. Attendees receive a copy of the instructor's new textbook, *Satellite Communications for the Non-Specialist,* and will have time to discuss issues pertinent to their interests.

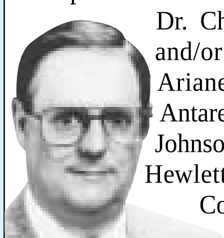
**Dec 6-8, 2005,**
Colorado Springs, Colorado

**Feb. 13-15, 2006**
Beltsville, Maryland

$1390 (8:30am - 4:30pm)

### Instructor

**Dr. Mark R. Chartrand** is a consultant and lecturer in satellite telecommunications and the space sciences. For a more than twenty years he has presented professional seminars on satellite technology and on telecommunications to individuals and businesses throughout the United States, Canada, Latin America, Europe and Asia.



Dr. Chartrand has served as a technical and/or business consultant to NASA, Arianespace, GTE Spacenet, Intelsat, Antares Satellite Corp., Moffett-Larson-Johnson, Arianespace, Delmarva Power, Hewlett-Packard, and the International Communications Satellite Society of Japan, among others. He has appeared as an invited expert witness before Congressional subcommittees and was an invited witness before the National Commission on Space. He was the founding editor and the Editor-in-Chief of the annual *The World Satellite Systems Guide*, and later the publication *Strategic Directions in Satellite Communication*. He is author of six books and hundreds of articles in the space sciences. He has been chairman of several international satellite conferences, and a speaker at many others.

### Course Outline

1. **Satellites and Telecommunication.** Introduction and historical background. Legal and regulatory environment of satellite telecommunications: industry issues; standards and protocols; regulatory bodies; satellite services and applications; steps to licensing a system. Telecommunications users, applications, and markets: fixed services, broadcast services, mobile services, navigation services.
2. **Communications Fundamentals.** Basic definitions and measurements: decibels. The spectrum and its uses: properties of waves; frequency bands; bandwidth. Analog and digital signals. Carrying information on waves: coding, modulation, multiplexing, networks and protocols. Signal quality, quantity, and noise: measures of signal quality; noise; limits to capacity; advantages of digital.
3. **The Space Segment.** The space environment: gravity, radiation, solid material. Orbits: types of orbits; geostationary orbits; non-geostationary orbits. Orbital slots, frequencies, footprints, and coverage: slots; satellite spacing; eclipses; sun interference. Out to launch: launcher's job; launch vehicles; the launch campaign; launch bases. Satellite systems and construction: structure and busses; antennas; power; thermal control; stationkeeping and orientation; telemetry and command. Satellite operations: housekeeping and communications.
4. **The Ground Segment.** Earth stations: types, hardware, and pointing. Antenna properties: gain; directionality; limits on sidelobe gain. Space loss, electronics, EIRP, and G/T: LNA-B-C's; signal flow through an earth station.
5. **The Satellite Earth Link.** Atmospheric effects on signals: rain; rain climate models; rain fade margins. Link budgets: C/N and Eb/No. Multiple access: SDMA, FDMA, TDMA, CDMA; demand assignment; on-board multiplexing.
6. **Satellite Communications Systems.** Satellite communications providers: satellite competitiveness; competitors; basic economics; satellite systems and operators; using satellite systems. Issues, trends, and the future.

### What You Will Learn

- How do commercial satellites fit into the telecommunications industry?
- How are satellites planned, built, launched, and operated?
- How do earth stations function?
- What is a link budget and why is it important?
- What legal and regulatory restrictions affect the industry?
- What are the issues and trends driving the industry?

# Satellite Communication Systems Engineering: LEO, MEO, GEO

## A comprehensive, quantitative tutorial designed for satellite professionals

**Sept. 20-22, 2005**
Boulder, Colorado

**Dec. 6-8, 2005**
Melbourne, Florida

**March 20-22, 2006**
Beltsville, Maryland

$1290 (8:30am - 4:30pm)

### Summary

This three-day course is designed for satellite communications engineers, spacecraft engineers, and managers who want to obtain an understanding of the 'big picture' of satellite communications. Each topic is illustrated by detailed worked numerical examples, using published data for actual satellite communications systems. The course is technically oriented and includes mathematical derivations of the fundamental equations. It will enable the participants to perform their own satellite access and link budget calculations and will especially appeal to those whose objective is to develop quantitative skills in addition to a qualitative familiarity with the basic concepts.

### Instructor

**Dr. Robert A. Nelson** is president of Satellite Engineering Research Corporation, a consulting firm in Bethesda, Maryland, with clients in both commercial industry and government. Dr. Nelson holds the degree of Ph.D. in physics from the University of Maryland and is a licensed Professional Engineer. He is coauthor of the textbook *Satellite Communication Systems Engineering*, 2nd ed. (Prentice Hall, 1993) and is Technical Editor of *Via Satellite magazine*. He is a member of IEEE, AIAA, APS, AAPT, AAS, IAU, and ION.

### Course Outline

**PART 1: THE SPACECRAFT AND ITS ORBIT**

1. **Mission Analysis.** Kepler's laws. Newton's laws. Circular orbits. Altitude regimes. Period of revolution. Low Earth Orbit (LEO). Medium Earth Orbit (MEO). Geostationary Orbit (GEO). Elliptical orbits. Orbital elements. Ground trace.
2. **Transfer Orbit.** Geostationary Transfer Orbit (GTO). Supersynchronous transfer orbit. Effect of launch site latitude.
3. **Orbital Perturbations and Stationkeeping.** Perturbations due to the atmosphere and Earth oblateness. Sun synchronous orbits. Effects of the Sun and Moon, Earth triaxiality, and solar radiation pressure. Inclined orbit operation.
4. **The Spacecraft Environment.** Van Allen belts. Eclipse time and duration.
5. **Earth-Satellite Geometry.** Earth central angle. Coverage area. Slant range. Azimuth and elevation.
6. **Constellation Design.** Walker constellations. Iridium. Sirius Satellite Radio.

**PART 2: PRINCIPLES OF SATELLITE COMMUNICATION**

7. **Signals and Spectra.** Properties of a sinusoidal wave form. Synthesis and analysis of an arbitrary wave form. Fourier Principle. Harmonics. Fourier transform. Frequency spectrum.
8. **Analog Modulation.** AM, FM. Applications to radio and television.
9. **Digital Modulation.** Analog to digital conversion. BPSK, QPSK, FSK, QAM. Spectral power density. Bandwidth. Data rate. Bit Error Rate.
10. **Coding.** Shannon's theorem. Hamming, BCH, and Reed-Solomon block codes. Convolutional codes. Viterbi algorithm. Hard and soft decisions. Concatenated coding. Coding gain.
11. **The Electromagnetic Spectrum.** Frequency bands used for satellite communication. Fixed Satellite Service. Direct Broadcast Service. Digital Audio Radio Service. Mobile Satellite Service.
12. **The RF Link.** Decibel (dB) notation. Antenna properties. Equivalent isotropic radiated power (EIRP). Power flux density. G/T. Free space loss. Noise temperature. C/No. Eb/No. The RF link equation. Uplink, downlink, and composite performance. Intermodulation products. SFD. Backoff.
13. **Earth Stations.** Block diagram. KPA, TWTA, and SSPA HPAs. Interference.
14. **Multiple Access.** Frequency division multiple access (FDMA). Time division multiple access (TDMA). Code division multiple access (CDMA).
15. **Antennas.** Antenna patterns. Half power beamwidth. Directivity. Gain. Taper. Aperture efficiency. Antenna size. Horn antennas. Phased arrays. Shaped beams.
16. **System Temperature.** Antenna temperature. Noise figure. Total system temperature.
17. **Polarization.** Linear and circular polarization. Misalignment angle.
18. **Rain Loss.** Rain attenuation. Crane rain model. Effect on G/T. Frequency dependence.

**PART 3: APPLICATIONS TO SATELLITE COMMUNICATION SYSTEMS**

19. **Link Budgets for Geostationary Satellite Systems.** Worked examples for DirecTV and Astrolink.
20. **Link Budgets for LEO and MEO Satellite Systems.** Worked example for Iridium.

### What You Will Learn

- How is the spacecraft deployed in its required orbit?
- How is the Earth-satellite geometry calculated?
- How are the antenna gain and size determined?
- What are the methods of modulation, coding, and multiple access?
- How is the link budget calculated?
- What data rate is supported by the communications system?

# Satellite Laser Communications

**February 22-24, 2006**
Beltsville, Maryland

$1290 (8:30am - 4:30pm)

## Summary

This three-day course is designed for engineers and technical managers unfamiliar with the field of optical communications (but who have a general background in EE or physics) who want to understand and apply some of the basic knowledge and analytical tools to the use of this technology in spacecraft communications. All the basic information on optics, lasers, detectors, beamsteering, pointing and tracking, modulation techniques, and system performance prediction will be covered. Examples will be worked using MATHCAD and MATLAB.

## Instructor

**Dr. Bradley G. Boone** has 26 years experience in electro-optical systems development. He is author of over 40 publications, one textbook, and holds five patents in the field. He has worked on a variety of projects spanning laser radar, passive infrared sensors, microwave radar, missile guidance, signal and image processing, pattern recognition, superconducting electronics, and most recently laser communications. He teaches a course in electro-optical systems in the Whiting School of Engineering Part-Time Programs in Engineering and Applied Science, and is currently working on a textbook in electro-optical systems.

## What You Will Learn

- The basic components of optical communications architectures.
- How do each of these components work?
- What critical system functions are required for free-space optical communications?
- What are the functional requirements for spacecraft-based optical communications terminals?
- What are the technologies appropriate for each function?
- What are the key measures of performance?
- How do you estimate system performance?

*From this course you will acquire the basic knowledge and principles of laser communications needed to perform basic engineering tradeoffs, perform system conceptual design, and interpret current technical literature in the field. You will also become familiar with the basic technology options available to the optical communication system developer, especially in the context of spacecraft constraints.*

## Course Outline

1. **Synopsis of Fundamentals.** Basic concepts and equations for reflection, refraction, and diffraction will be described to establish the basis for further discussion of the components and system functional performance of laser communications. A little quantum theory will be introduced to prepare for describing the operation of lasers, detectors, and optical amplifiers. Finally, some basic communication and control theory will be reviewed.
2. **Applications and Requirements.** The two basic application environments are near terrestrial and deep space, and the two major areas are military and civilian. These will be discussed in terms of their impact on system functional requirements, which are delineated in terms of the basic tasks of acquisition, pointing and tracking.
3. **Essential Optical Components.** The key individual optical components used will be explained, which include simple lenses, collimators, and beam expanders, as well as fiber components and diffractive optics. Although both refracting and reflecting telescopes will be reviewed, the principal type used is the Cassegrain, which will be described in greater detail.
4. **Lasers.** Several types of lasers can be used in satellite optical communication. Although Nd:YAG lasers have been used and will be described briefly, semiconductor and laser diodes are increasingly being used. Combined with optical amplifiers they constitute a new class of sources know as fiber lasers.
5. **Detectors.** The two basic types of detectors used are PIN photodiodes and avalanche photodiodes. They will be described in terms of their basic principles of operation and distinguished in terms of their responsivity, noise characteristics, gain, and bandwidth, and how these parameters influence the achievable signal-to-noise ratio (SNR).
6. **Transmitter and Receiver Electronics.** Several important electronic functions and components will be described, including: modulation, demodulation, mixers, and pre-amplifiers. Key modulation techniques and formats will be described and compared.
7. **Beamsteerers.** Three types of laser beam steering technologies will be described, which are tip/tilt, linear position, and electro-optical (EO). The first two can be implemented using piezoelectric actuators, and tip/tilt mirrors can also be implemented using MEMS technology. EO types include liquid crystals and photonic crystals.
8. **System Functions: Acquisition.** Acquisition is a key prerequisite to communicating optically in free-space and differs in terms of the optical power, angle coverage, and bandwidth requirements from the other system functions.
9. **System Functions: Pointing and Tracking.** Pointing and tracking must be established and maintained to enable communication. The two basic alternatives for the tracking sensor are the quad photodetector and the focal plane array. The basic features and operation of these will be described, including their electronic and algorithmic functions of monopulse arithmetic and centroiding. The adjunct function of inertial reference measurements will also be described briefly.
10. **System Functions: Communications.** Three basic types of receiver architectures will be described: direct detection, direct detection with optical amplifiers, and heterodyne (coherent). They will be distinguished in terms of their SNR performance and limitations in reaching the ideal quantum limit of performance.
11. **System Performance: The Link Equation.** The most important tool used by satellite communication engineers is the link equation, which brings together all the parameters of the system components and establishes the overall link margin required. All terms that are used will be described and quantified, including space loss.
12. **System Performance: Data Rate versus Bit Error Rate.** To completely characterize system performance the link equation must be combined with a noise model to establish a relationship between the desired data rate and the required bit error rate. This relationship will be explored using examples from near terrestrial space (a geosynchronous earth orbit to ground downlink), and a deep space example (to/from the outer planets).

# Satellite RF Communications and Onboard Processing

## Effective Design for Today's Spacecraft Systems

**Oct. 4-6, 2005**
Beltsville, Maryland

**Dec. 6-8, 2005**
Beltsville, Maryland

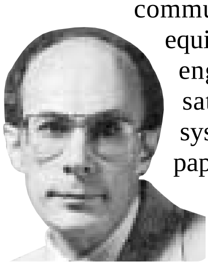
$1290 (8:30am - 4:00pm)

### Summary

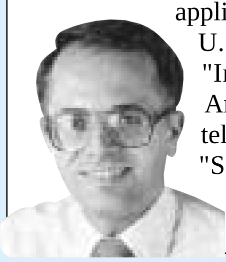
Successful systems engineering requires a broad understanding of the important principles of modern satellite communications and onboard data processing. This course covers both theory and practice, with emphasis on the important system engineering principles, tradeoffs, and rules of thumb. The latest technologies are covered, including those needed for constellations of satellites.

This course is recommended for engineers and scientists interested in acquiring an understanding of satellite communications, command and telemetry, onboard computing, and tracking. Each participant will receive a complete set of notes.

### Instructors



**Eric J. Hoffman** has degrees in electrical engineering and over 40 years of spacecraft experience. He has designed spaceborne communications and navigation equipment and performed systems engineering on many APL satellites and communications systems. He has authored over 60 papers and holds 8 patents in these fields. Mr. Hoffman recently retired after 19 years as APL Space Dept Chief Engineer.



**Robert C. Moore** has worked in the Electronic Systems Group at APL since 1965. He designs embedded microprocessor systems for space applications. Mr. Moore holds four U.S. patents. He teaches "Introduction to Computer Architecture" and the command-telemetry-processing segment of "Space Systems" at the Johns Hopkins University Whiting School of Engineering.

***This course will give you a thorough understanding of the important principles and modern technologies behind today's satellite communications and onboard computing systems.***

### Course Outline

1. **RF Signal Transmission.** Propagation of radio waves, antenna properties and types, one-way radar range equation. Peculiarities of the space channel. Special communications orbits. Modulation of RF carriers.
2. **Noise and Link Budgets.** Sources of noise, effects of noise on communications, system noise temperature. Signal-to-noise ratio, bit error rate, link margin. Communications link design example.
3. **Special Topics.** Optical communications, error correcting codes, encryption and authentication. Low-probability-of-intercept communications. Spread-spectrum and anti-jam techniques.
4. **Command Systems.** Command receivers, decoders, and processors. Synchronization words, error detection and correction. Command types, command validation and authentication, delayed commands. Uploading software.
5. **Telemetry Systems.** Sensors and signal conditioning, signal selection and data sampling, analog-to-digital conversion. Frame formatting, commutation, data storage, data compression. Packetizing. Implementing spacecraft autonomy.
6. **Data Processor Systems.** Central processing units, memory types, mass storage, input/output techniques. Fault tolerance and redundancy, radiation hardness, single event upsets, CMOS latch-up. Memory error detection and correction. Reliability and cross-strapping. Very large scale integration. Choosing between RISC and CISC.
7. **Reliable Software Design.** Specifying the requirements. Levels of criticality. Design reviews and code walkthroughs. Fault protection and autonomy. Testing and IV&V. When is testing finished? Configuration management, documentation. Rules of thumb for schedule and manpower.
8. **Spacecraft Tracking.** Orbital elements. Tracking by ranging, laser tracking. Tracking by range rate, tracking by line-of-site observation. Autonomous satellite navigation.
9. **Typical Ground Network Operations.** Central and remote tracking sites, equipment complements, command data flow, telemetry data flow. NASA Deep Space Network, NASA Tracking and Data Relay Satellite System (TDRSS), and commercial operations.
10. **Constellations of Satellites.** Optical and RF crosslinks. Command and control issues. Timing and tracking. Iridium as a system example.

### What You Will Learn

- The important systems engineering principles and latest technologies for spacecraft communications and onboard computing.
- The design drivers for today's command, telemetry, communications, and processor systems.
- How to design an RF link.
- How to deal with noise, radiation, bit errors, and spoofing.
- Keys to developing hi-rel, realtime, embedded software.
- How spacecraft are tracked.
- Working with government and commercial ground stations.
- Command and control for satellite constellations.

# Solid Rocket Motor Design and Applications

## Summary

This three-day course provides a detailed look at the design of solid rocket motors (SRMs), a general understanding of solid propellant motor and component technologies, design drivers, critical manufacturing process parameters, sensitivity of system performance requirements on SRM design, reliability, and cost; and transportation and handling, and integration into launch vehicles and missiles. The approaches used in the development of new SRMs are covered, including the balance of customer vs. SRM manufacturer requirements, design and cost trade-studies, and timelines.

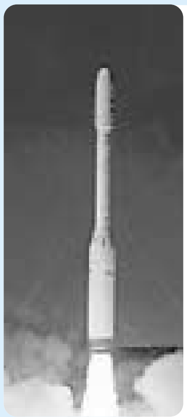
All current types of SRMs are included, with emphasis on the motors for the small-to-medium class of commercial and DoD/NASA launch vehicles such as Lockheed Martin's LMLV (Athena) series, Orbital Sciences' Pegasus and Taurus series, the strap-on motors for the current Delta series and Titan V. The course includes the usage of surplus military motors for DoD target and sensor development and university research programs.

## What You Will Learn

- Solid rocket motor principles and key requirements.
- Motor design drivers and sensitivity on the design, reliability, and cost.
- Detailed propellant and component design features and characteristics.
- Propellant and component manufacturing processes.
- SRM/Vehicle interfaces, transportation, and handling considerations.
- Development approach for qualifying new SRMs.

## Instructor

**Richard Lee** has over 38 years of experience in the space and missile industry. He was a Senior Program Manager at Thiokol, where he was instrumental in the development of the Castor 120 SRM. His experience includes managing the development and qualification of DoD SRM subsystems and components for the Small ICBM, Peacekeeper. Mr. Lee has extensive experience in developing and coordinating SRM performance and interface requirements at all levels in the space and missile industry, including government agencies, prime contractors and suppliers. He has been very active in coordinating functional and physical interfaces with the commercial spaceports in Florida, California, and Alaska. He has developed safety critical industry standards with the participation of government agencies (USAF SMC and 45th Space Wing, FAA/AST, and NASA centers at Headquarters, KSC, JSC, and JPL, and Army Space and Strategic Defense Command) and private industry representatives. He has also consulted with launch vehicle contractors in the design, material selection, and testing of SRM propellants and components. Mr. Lee has a MS in Engineering Administration and a BS in EE from the University of Utah.



**January 24-26, 2006**
Beltsville, Maryland

**March 27-29, 2006**
Huntsville, Alabama

$1290 (8:30am - 4:00pm)

*For onsite presentations, course can be tailored to specific SRM applications and technologies.*

## Course Outline

1. **Introduction to Solid Rocket Motors (SRMs).** SRM terminology and nomenclature, survey of types and applications of SRMs, and SRM component description and characteristics.
2. **SRM Design and Applications.** Fundamental principles of SRMs, key performance and configuration parameters such as total impulse, specific impulse, thrust vs. motor operating time, size constraints; basic performance equations, internal ballistic principles, preliminary approach for designing SRMs; propellant combustion characteristics (instability, burning rate), limitations of SRMs based on the laws of physics, and comparison of solid to liquid propellant and hybrid rocket motors.
3. **Sensitivity of SRM Requirements.** Impact of customer/system imposed requirements on design, reliability, and cost; SRM manufacturer imposed requirements and constraints based on optimization studies and general engineering practices and management philosophy.
4. **SRM Design Drivers and Technology Trade-Offs.** Interrelationship of the performance parameters, component design trades versus cost and maturity of technology; exchange ratios and "Rules of Thump" used in "back-of-the-envelope" preliminary design evaluations.
5. **Key SRM Component Design Characteristics and Materials.** Detailed description and comparison of performance parameters and properties of solid propellants including composite (i.e., HTPB, PBAN, and CTPB), nitro-plasticized composites, and double based or cross-linked propellants and why they are used for different motor and/or vehicle objectives and applications; motor cases, nozzles, thrust vector control systems, and motor initiation and flight termination devices and ordnance.
6. **SRM Manufacturing/Processing Parameters.** Description of critical manufacturing operations for propellant mixing, propellant loading into the SRM, propellant inspection and acceptance testing, and propellant facilities and tooling, and component fabrication.
7. **SRM Transportation and Handling Considerations.** General understanding of requirements and solutions for transporting, handling, and processing different motor sizes and propellant explosive classifications and licensing and regulations.
8. **Launch Vehicle Interfaces, Processing and Integration.** Key mechanical, functional, and electrical interfaces between the SRM and launch vehicle. Comparison of interfaces for both strap-on and "straight stack" applications.
9. **SRM Development Requirements and Processes.** Approaches and timelines for developing new SRMs. Description of a demonstration and qualification program for both commercial and government programs. Impact of decisions regarding design philosophy (state-of-the-art) versus advanced technology and design safety factors. Motor sizing methodology and studies (using computer aided design models). Customer oversight and quality program. Motor cost reduction approaches through design, manufacturing, and acceptance. Castor 120 development example.

# The Space Environment –
## Implications for Spacecraft Design

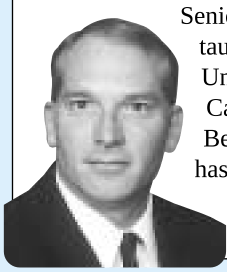
## Summary

Adverse interactions between the space environment and an orbiting spacecraft may lead to a degradation of spacecraft subsystem performance and possibly even loss of the spacecraft itself. This course presents an introduction to the space environment and its effect on spacecraft. Emphasis is placed on problem solving techniques and design guidelines that will provide the student with an understanding of how space environment effects may be minimized through proactive spacecraft design.

Each student will receive a copy of the course text, a complete set of course notes, including copies of all viewgraphs used in the presentation, and a comprehensive bibliography.

## Instructor

**Dr. Alan C. Tribble** has provided space environments effects analysis to more than one dozen NASA, DoD, and commercial programs, including the International Space Station, the Global Positioning System (GPS) satellites, and survival surveillance spacecraft. He holds a Ph.D. in Physics from the University of Iowa and has been twice a Principal Investigator for the NASA Space Environments and Effects Program. He is the author of four books, including the course text: *The Space Environment - Implications for Space Design*, and over 20 additional technical publications. He is an Associate Editor of the Journal of Spacecraft and Rockets, and Associate Fellow of the AIAA and a Senior Member of the IEEE. He has taught a variety of classes at the University of Southern California, California State University Long Beach, the University of Iowa, and has been teaching courses on space environments and effects since 1992.



## Who Should Attend:

Engineers who need to know how to design systems with adequate performance margins, program managers who oversee spacecraft survivability tasks, and scientists who need to understand how environmental interactions can affect instrument performance.

## Review of the Course Text:

*"There is, to my knowledge, no other book that provides its intended readership with an comprehensive and authoritative, yet compact and accessible, coverage of the subject of spacecraft environmental engineering." – James A. Van Allen, Regent Distinguished Professor, University of Iowa.*

**February 6-7, 2006**
Beltsville, Maryland
$940 (8:30am - 4:00pm)

### Recent attendee comments ...

*"I got exactly what I wanted from this course – an overview of the spacecraft environment. The charts outlining the interactions and synergism were excellent. The list of references is extensive and will be consulted often."*

*"Broad experience over many design teams allowed for excellent examples of applications of this information."*

## Course Outline

1. **Introduction.** Spacecraft Subsystem Design, Orbital Mechanics, The Solar-Planetary Relationship, Space Weather.
2. **The Vacuum Environment.** Basic Description – Pressure vs. Altitude, Solar UV Radiation.
3. **Vacuum Environment Effects.** Solar UV Degradation, Molecular Contamination, Particulate Contamination.
4. **The Neutral Environment.** Basic Atmospheric Physics, Elementary Kinetic Theory, Hydrostatic Equilibrium, Neutral Atmospheric Models.
5. **Neutral Environment Effects.** Aerodynamic Drag, Sputtering, Atomic Oxygen Attack, Spacecraft Glow.
6. **The Plasma Environment.** Basic Plasma Physics - Single Particle Motion, Debye Shielding, Plasma Oscillations.
7. **Plasma Environment Effects.** Spacecraft Charging, Arc Discharging.
8. **The Radiation Environment.** Basic Radiation Physics, Stopping Charged Particles, Stopping Energetic Photons, Stopping Neutrons.
9. **Radiation in Space.** Trapped Radiation Belts, Solar Proton Events, Galactic Cosmic Rays, Hostile Environments.
10. **Radiation Environment Effects.** Total Dose Effects - Solar Cell Degradation, Electronics Degradation; Single Event Effects - Upset, Latchup, Burnout; Dose Rate Effects.
11. **The Micrometeoroid and Orbital Debris Environment.** Hypervelocity Impact Physics, Micrometeoroids, Orbital Debris.
12. **Additional Topics.** Design Examples - The Long Duration Exposure Facility; Environmental Space Station; Models and Tools; Available Internet Resources.

# Space Mission Structures: From Concept to Launch


**November 14-17, 2005**
8:30am - 4:30pm
Beltsville, Maryland

$1595

## Summary

This course provides the big picture of designing, analyzing, and testing flight structures for space missions. The objectives are to improve your understanding of how structures behave, how they fail, how to design them to be efficient and dependable for space missions, and how to build confidence through analysis and test. Emphasis throughout is on understanding the problem and finding good solutions. The course is highly interactive. Numerous examples, case histories from the instructor's experience, and class problems drive home the key points. Bring a calculator to work problems.

The course is aimed at mechanical design engineers, stress analysts, dynamics and loads engineers, test engineers, mechanical systems engineers, and others interested in the topic. The course will appeal to engineers of all levels of experience.

Each participant will receive a copy of the presentation material as well as a copy of the instructor's book, *Spacecraft Structures and Mechanisms: From Concept to Launch*.

## Instructor

**Tom Sarafin**, President of Instar Engineering and Consulting, Inc., has worked full time in the space industry since 1979, including over 13 years at Martin Marietta Astronautics. Since forming Instar in 1993, Mr. Sarafin has consulted for DARPA, Space Imaging, Digital Globe, the Air Force Academy, and other organizations. He is the editor and principal author of the book *Spacecraft Structures and Mechanisms: From Concept to Launch* and is a contributing author to *Space Mission Analysis and Design* (all three editions) and *Human Spaceflight: Mission Analysis and Design*. He has taught over 100 courses to more than 2200 aerospace engineers.

## Course Outline

1. **Introduction to Spacecraft Structures.** Structural functions and requirements, effects of the space environment, effects of launch, typical design criteria, understanding verification.
2. **Review of Statics and Dynamics.** Static equilibrium, the equation of motion, modes of vibration, loads analysis.
3. **Launch Environments and How Structures Respond.** Quasi-static loads, transient loads, coupled loads analysis, sinusoidal vibration, acoustics, random vibration, shock.
4. **Mechanics of Materials.** Stress and strain, interaction of stresses, failure theories, bending and torsion, deflections and strain energy, thermoelastic effects, composite materials, identifying and avoiding weak spots.
5. **Assessing Structural Integrity: Strength Analysis** An effective process, common modes of failure, fastened joints, buckling, suggested design criteria.
6. **Structural Life Analysis.** Fatigue, fracture mechanics, fracture control.
7. **Overview of Finite Element Analysis.** Idealizing structures, introduction to FEA, limitations, strategies, ensuring quality.
8. **Preliminary Design.** Process, configuring a spacecraft, deriving requirements, types of structures, materials, methods of attachment, preliminary sizing, designing efficient structures.
9. **Avoiding Problems with Loads and Vibration.** Controlling the forcing function, locating components, adding passive damping, isolating modes of vibration.
10. **Integrating the Loads-cycle Process.** Overview, output transformation matrices, integrating stress analysis with loads analysis.
11. **Designing for Producibility.** Guidelines, designing for manufacturing processes, dimensioning and tolerancing.
12. **Verification and Quality Assurance.** The building-blocks approach, verification methods and logic, product inspection, types of structural tests, designing an effective test.
13. **A Case Study:** FalconSAT-2 Overview, approach to design and verification, simplifying the design loads, roles of testing, designing and testing the flight structure.
14. **Final Verification and Risk Assessment.** Overview, addressing late problems, estimating the probability of failure implied by a negative margin of safety, making the launch decision.

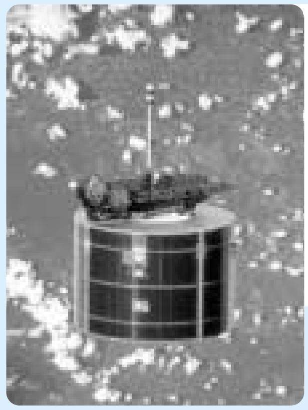
# Space Systems - Intermediate Design

## Summary

This multi-disciplinary course provides a complete summary of the technologies needed to understand and develop spacecraft systems and instrumentation. The course presents a systems engineering approach for understanding the design and testing of spacecraft systems. The course highlights the underlying scientific and engineering foundations needed to develop space systems, as well as current practices. Case studies are used to pinpoint the key issues and trade-offs in modern design, and to illustrate the lessons learned from past successes and failures.

This course provides a strong technical base for leadership in systems engineering or the management of space systems. Technical specialists will find the broad perspective and knowledge useful in communicating with other space system specialists in analyzing design options and trade-offs.

The emphasis will be on how today's technology is incorporated into the planning, designing, fabrication, integration, and testing of modern space systems. Each participant will receive a complete set of notes and the award-winning textbook *Space Systems* written by the instructors. The textbook and course notes provide an authoritative reference that focuses on proven techniques and guidelines for understanding, designing, and managing modern space systems.



**Jan. 30-Feb. 3, 2006**

8:30am - 4:00pm

Last Day 8:30am - 12:30pm

Beltsville, Maryland

$1595

***5 top experts in 1 week!***

## Instructors

**Dr. Vincent L. Pisacane** is a fellow of the AIAA, and is the R.A. Heinlein Professor of Aerospace Engineering at the United States Naval Academy. He was formerly Head of the APL Space Department. He has 35 years of experience in space research and the development of spacecraft and instrumentation. He is the editor of the textbook *Space Systems* published by Oxford Press.

**Dr. Mark E. Pittelkau** is a staff engineer at the Applied Physics Laboratory in Laurel, Maryland. His experience in satellite systems includes the design, implementation, and testing of orbit determination algorithms, attitude determination, and control systems. His current work in attitude control systems includes control-structure interaction, pointing jitter and stability analysis, concept studies for various attitude control systems, and sensor alignment calibration.

**Jay Jenkins** is a power system engineer at JHU/APL with 15 years of experience in design and analysis of aerospace power systems with an emphasis on battery and solar array technology.

**William E. Skullney** is Supervisor of the Mechanical Systems Group at JHU/APL and has over 20 years experience in the design, analysis and testing of spacecraft mechanical systems. He specializes in structural engineering and analysis and has led structural engineering efforts for the Delta 180 series programs and the Midcourse Space Experiment Program.

**Clarence Wingate** has 35 years of space experience and specializes in the thermal design, analysis and testing of spacecraft. He is retired from JHU/APL.

## Course Outline

1. **Space Systems Engineering.** Fundamentals of systems engineering. System development process. Engineering reviews. Management of space systems.
2. **Orbital Mechanics.** Fundamentals of dynamics. Reference frames. Time. Two-body central force motion. Two-body problem. Trajectory perturbations. Orbit determination. Interplanetary missions and patched conics.
3. **Spacecraft Propulsion/Rocket Propulsion.** Force-free rocket motion. Rocket motion with gravity. Launch flight mechanics. Transfer trajectories.
4. **Flight Mechanics and Launch Systems.** Hohman transfer orbits. Reaching a target orbit. Solid and liquid propellant systems. Other propulsion systems. Selected launch systems.
5. **Spacecraft Attitude Determination.** Attitude sensors and kinematics. Attitude determination systems. Attitude estimation and system identification. Attitude error specification and analysis. Mission experiences.
6. **Spacecraft Attitude Control.** Rotational dynamics and environmental disturbance torques. Attitude actuators. Passive and active attitude control methods. Attitude controllers and stability. Mission experiences.
7. **Configuration and Structural Design.** Structural design requirements and interfaces. Requirements for launch, staging, spin stabilization stages. Acoustics, acceleration, transients and shock. Designing and testing. Stress-strain analysis. Margins of safety. Finite Element Analysis. Structural dynamics. Testing.
8. **Space Power Systems.** Energy storage, distribution, and control. Environmental effects on solar cells. Orbital considerations. Energy converters. Solar cells and solar arrays. Batteries and energy storage. Characteristics of different batteries. Strong emphasis on translating mission requirements into a power system design.
9. **Space Thermal Control.** Radiation and thermal fundamentals. Heat transfer and energy balance. Choice of thermal materials. The thermal design and testing process.

# Space Systems - Subsystems Design
## with Detailed Case Study


## Summary

This multi-disciplinary course provides a complete summary of the technologies needed to understand and develop spacecraft systems and instrumentation. The course presents a systems engineering approach for understanding the design and testing of spacecraft systems. The course highlights the underlying scientific and engineering foundations needed to develop space systems, as well as current practices. Case studies are used to pinpoint the key issues and trade-offs in modern design, and to illustrate the lessons learned from past successes and failures.

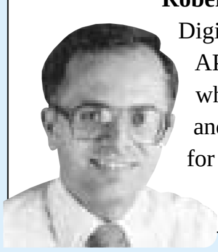
This course is recommended for engineers, scientists, or managers who wish to broaden their perspectives and capabilities. The course provides a strong technical base for leadership in systems engineering or the management of space systems. Technical specialists will find the broad perspective and knowledge useful in communicating with other space system specialists in analyzing design options and trade-offs.

The emphasis will be on how today's technology is incorporated into the planning, designing, fabrication, integration, and testing of modern space systems. Each participant will receive a complete set of notes and the award-winning textbook *Fundamentals of Space Systems* written by the instructors. The textbook and course notes provide an authoritative reference that focuses on proven techniques and guidelines for understanding, designing, and managing modern space systems.


## Instructors

**Eric Hoffman** joined JHU/APL in 1964, designing high-reliability spacecraft command, communications, and navigation equipment. He recently retired after 19 years as Chief Engineer of the Space Department, which has designed and built 61 spacecraft.

**Richard H. Maurer** joined JHU/APL in 1981. He is responsible for the reliability and survivability of space systems and components. He has worked with different missions including AMPTE, GEOSAT, HUT, TOPEX, and MSX; specializing in spacecraft reliability.



**Robert C. Moore** has worked in the Digital Flight Systems Group of the APL Space Department since 1965, where he designs electronic circuitry and embedded microprocessor systems for space flight data processing.

**February 6-10, 2006**

8:30am - 4:00pm

Last Day 8:30am - 12:30pm

Beltsville, Maryland

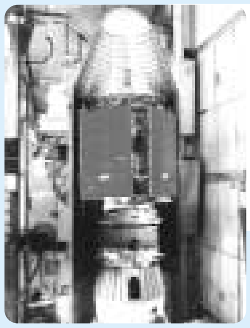
$1595

***3 top experts in 1 week!***

## Course Outline

1. **The Space Environment.** Vacuum and drag. Temperature and thermal gradients. Magnetic field. Ultraviolet and ionizing radiation. Pre-launch and launch environments.
2. **Space Communications/Part I.** RF signal transmission. Antenna properties. One-way range equation. Properties and peculiarities of the space channel. Modulation of RF. Sources of noise. Signal-to-noise ratio. Link margin.
3. **Space Communications/Part II.** Communications link design example. Error correction. Encryption and authentication. Covert communications. Anti-jam techniques.
4. **Spacecraft Command and Telemetry.** Command receivers, command decoders, encrypted links. Command messages. Synchronization, error detection and correction. Command logic. System requirements. Telemetry Systems. Sensors and signal conditioning. Frame formatting, data compression.
5. **Spacecraft On-Board Processing.** Central processing units for space. Software development and engineering. Memory types. Mass storage. Processor input and output. Fault tolerance and redundancy. Radiation hardness and upset, latch-up. Error correction.
6. **Spacecraft Integration & Test.** Planning for I&T. Electrical, thermal, and mechanical design interactions. Ground support systems. I&T facilities. Verification and test plans. Testing at subsystem and spacecraft level. Dealing with anomalies. Test and readiness reviews. Safety aspects. Launch site activities.
7. **Reliability & Quality Assurance.** Modern performance assurance principles. System reliability prediction. Using redundancy wisely. Component selection, margins, and quality assurance. Software assurance. Inspections and reviews.
8. **Space Mission Operations.** Mission analysis and planning, mission control center. Communications. Pre-launch, launch, and post-launch operations. Problems, contingencies, and anomalous operations.
9. **Detailed Case Study.** Systems engineering example for a launched spacecraft. Trade-offs, risk assessments and design margins. Software management. Integration and testing. Lessons learned for future system engineers.

# Spacecraft Quality Assurance, Integration & Testing

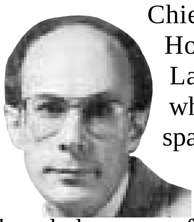


**March 8-9, 2006**
8:30am - 4:00pm
Beltsville, Maryland
$890

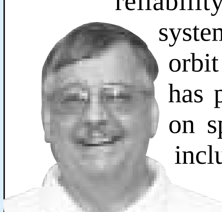
## Summary


Quality assurance, reliability, and testing are critical elements in today's space missions. The selection of lower cost parts and the effective use of redundancy require careful tradeoff analysis when designing new space missions. Designing for low cost and allowing some "prudent risk" are new ways of doing business in today's cost and schedule constrained missions. This course uses case studies and examples from recent space missions to pinpoint the key issues and tradeoffs in design, reviews, quality assurance, and testing of spacecraft. Lessons learned from past successes and failures are discussed and trends for future missions are highlighted.


## Instructors



**Eric Hoffman** recently retired after 19 years as Chief Engineer of The Johns Hopkins Applied Physics Laboratory Space Department, which has designed and built 61 spacecraft. His experience includes systems engineering, design integrity, and test standards. He has led many of APL's system and spacecraft conceptual design programs. Associate Fellow of the AIAA and co-author of *Fundamentals of Space Systems*.



**Richard Maurer** is responsible for the reliability and survivability of space systems and components on low earth orbit and interplanetary missions. He has published more than 30 articles on space reliability. His experience includes AMPTE, GEOSAT, HUT, TOPEX, MSX, NEAR and satellites used in the Delta experiments. He is co-author of *Fundamentals of Space Systems.*

## Recent attendee comments ...

*"Instructors demonstrated excellent knowledge of topics."*

*"Material was presented clearly and thoroughly. An incredible depth of expertise for our questions."*

## Course Outline

1. **Spacecraft Systems Reliability and Assessment.** Reliable design techniques. Using redundancy wisely. Heritage designs. Reliability prediction and confidence levels. Environmental stress and derating.
2. **Quality Assurance and Component Selection.** Screening, qualification, and accelerated testing. Using plastic parts (PEMs) reliably.
3. **Radiation and Survivability.** Characteristics of the space environment. Total dose. Stopping power. MOS response. Annealing and super-recovery. Displacement damage. Hardening and shielding.
4. **Single Event Effects.** Latch-up, transient upset, burn-out. Critical charge. Testing single event effects. Upset rate.
5. **ISO 9000.** Identifying, controlling, and improving your processes.
6. **Software Quality Assurance & Testing.** The magnitude of the software QA problem. When is testing finished?
7. **The Role of the I&T Engineer.** Why I&T planning must be started early. Integrating I&T into electrical, thermal, and mechanical designs. Coupling I&T to mission operations.
8. **Ground Support Systems.** Electrical and mechanical ground support equipment (GSE). I&T facilities. Clean rooms. Environmental test facilities.
9. **Test Planning and Test Flow.** Which tests are worthwhile? Which ones aren't? What is the right order to perform tests? Verification matrix, test plans, and other important documents.
10. **Spacecraft Level Testing.** Ground station compatibility testing and other special tests.
11. **Launch Site Operations.** Launch vehicle operations (includes videotape). Safety. Dress rehearsals. The Launch Readiness Review. Reducing human error.
12. **Case Studies.** Galileo, Hubble, NEAR, Ariane 5.

# Advanced Developments in Radar



NEW!

**Feb. 28-Mar. 2, 2006**
Beltsville, Maryland
$1290 (8:30am - 4:00pm)


## Summary

This three-day course provides students who already have a basic understanding of radar a valuable extension into the newer capabilities being continuously pursued in our fast-moving field. While the course begins with a quick review of fundamentals - this to establish a common base for the instruction to follow - it is best suited for the student who has taken one of the several basic radar courses available.

In each topic, the method of instruction is first to establish firmly the underlying principle and only then are the current achievements and challenges addressed. Treated are such topics as pulse compression in which matched filter theory, resolution and broadband pulse modulation are briefly reviewed, and then the latest code optimality searches and hybrid coding and code-variable pulse bursts are explored. Similarly, radar polarimetry is reviewed in principle, then the application to image processing (as in Synthetic Aperture Radar work) is covered. Doppler processing and its application to SAR imaging itself, then 3D SAR, the moving target problem and other target signature work are also treated this way. Space-Time Adaptive Processing (STAP) is introduced; the resurgent interest in bistatic radar is discussed.

The most ample current literature (conferences and journals) is used in this course, directing the student to valuable material for further study. Instruction follows the student notebook provided.


## Instructor

**Bob Hill** received his BS degree in 1957 (Iowa State University) and the MS in 1967 (University of Maryland), both in electrical engineering. After spending a year in microwave work with an electronics firm in Virginia, he was then a ground electronics officer in the U.S. Air Force in the late 1950s and began his civil service career with the U.S. Navy Department in Washington D.C. in 1960, acquiring responsibilities for the development of shipboard radar systems. He managed the development of the phased array radar of the Navy's AEGIS system from the early 1960s through its introduction to the fleet in 1975. Later in his career he directed the development, acquisition and support of all surveillance radars of the surface navy.

He retired from the federal service in 1988, continuing his teaching of radar courses which had begun in 1975. Mr. Hill is a Fellow of the IEEE, an IEEE "distinguished lecturer", a member of its Radar Systems Panel and previously a member of its Aerospace and Electronic Systems Society Board of Governors for many years. He established in 1975 and chaired through 1990 the IEEE's series of international radar conferences and remains on the organizing committee of these, and works with the several other nations cooperating in that series. He has published numerous conference papers, magazine articles and chapters of books, and is the author of the radar, monopulse radar, airborne radar and synthetic aperture radar articles in the McGraw-Hill Encyclopedia of Science and Technology and contributor for radar-related entries of their technical dictionary.

## Course Outline

1. **Introduction and Background.**
   - The nature of radar and the physics involved.
   - Concepts and tools required, briefly reviewed.
   - Directions taken in radar development and the technological advances permitting them.
   - Further concepts and tools, more elaborate.
2. **Advanced Signal Processing.**
   - Review of developments in pulse compression (matched filter theory, modulation techniques, the search for optimality) and in Doppler processing (principles, "coherent" radar, vector processing, digital techniques); establishing resolution in time (range) and in frequency (Doppler).
   - Recent considerations in hybrid coding, shaping the ambiguity function.
   - Target inference. Use of high range and high Doppler resolution: example and experimental results.
3. **Synthetic Aperture Radar (SAR).**
   - Fundamentals reviewed, 2-D and 3-D SAR, example image.
   - Developments in image enhancement. The dangerous point-scatterer assumption. Autofocusing methods in SAR, ISAR imaging. The ground moving target problem.
   - Polarimetry and its application in SAR. Review of polarimetry theory. Polarimetric filtering: the whitening filter, the matched filter. Polarimetric-dependent phase unwrapping in 3D IFSAR.
   - Image interpretation: target recognition processes reviewed.
4. **A "Radar Revolution" - the Phased Array.**
   - The all-important antenna. General antenna theory, quickly reviewed. Sidelobe concerns, suppression techniques. Ultra-low sidelobe design.
   - The phased array. Electronic scanning, methods, typical componentry. Behavior with scanning, the impedance problem and matching methods. The problem of bandwidth; time-delay steering. Adaptive patterns, adaptivity theory and practice. Digital beam forming. The "active" array.
   - Phased array radar, system considerations.
5. **Advanced Data Processing.**
   - Detection in clutter, threshold control schemes, CFAR.
   - Background analysis: clutter statistics, parameter estimation, clutter as a compound process.
   - Association, contacts to tracks.
   - Track estimation, filtering, adaptivity, multiple hypothesis testing.
   - Integration: multi-radar, multi-sensor data fusion, in both detection and tracking, greater use of supplemental data, augmenting the radar processing.
6. **Other Topics.**
   - Bistatics, the resurgent interest. Review of the basics of bistatic radar, challenges, early experiences. New opportunities: space; terrestrial. Achievements reported.
   - Space-Time Adaptive Processing (STAP), airborne radar emphasis.
   - Ultra-wideband short pulse radar, various claims (well-founded and not); an example UWB SAR system for good purpose.
   - Concluding discussion, course review.

# Fundamentals of Radar Technology

**October 26-28, 2005**
Lexington Park, Maryland

**January 24-26, 2006**
Beltsville, Maryland

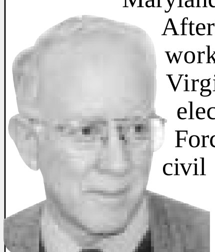
**May 16-18, 2006**
Beltsville, Maryland

$1290 (8:30am - 4:00pm)

## Summary

A three-day course covering the basics of radar, taught in a manner for true understanding of the fundamentals, even for the complete newcomer. Covered are electromagnetic waves, frequency bands, the natural phenomena of scattering and propagation, radar performance calculations and other tools used in radar work, and a "walk through" of the four principal subsystems – the transmitter, the antenna, the receiver and signal processor, and the control and interface apparatus – covering in each the underlying principle and componentry. A few simple exercises reinforce the student's understanding. Both surface-based and airborne radars are addressed.

## Instructor



Mr. Hill received his BS degree in 1957 (Iowa State University) and the MS in 1967 (University of Maryland), both in electrical engineering. After spending a year in microwave work with an electronics firm in Virginia, he was then a ground electronics officer in the U.S. Air Force in the late 1950s and began his civil service career with the U.S. Navy Department in Washington D.C. in 1960, acquiring responsibilities for the development of shipboard radar systems. He managed the development of the phased array radar of the Navy's AEGIS system from the early 1960s through its introduction to the fleet in 1975. Later in his career he directed the development, acquisition and support of all surveillance radars of the surface navy.

He retired from the federal service in 1988, continuing his teaching of radar courses which had begun in 1975 at The George Washington University in its continuing engineering education program and which also included semester teaching with the Virginia Polytechnic Institute in the mid-1980s. The teaching continues now for several interests worldwide. Mr. Hill is a Fellow of the IEEE, an IEEE "distinguished lecturer", a member of its Radar Systems Panel and previously a member of its Aerospace and Electronic Systems Society Board of Governors for many years. He established in 1975 and chaired through 1990 the IEEE's series of international radar conferences and remains on the organizing committee of these, and works with the several other nations cooperating in that series. He has published numerous conference papers, magazine articles and chapters of books, and is the author of the radar, monopulse radar, airborne radar and synthetic aperture radar articles in the McGraw-Hill Encyclopedia of Science and Technology and contributor for radar-related entries of their technical dictionary.

## Course Outline

**First Morning – Introduction**
The basic nature of radar and its applications, military and civil Radiative physics (an exercise); the radar range equation; the statistical nature of detection Electromagnetic waves, constituent fields and vector representation Radar "timing", general nature, block diagrams, typical characteristics,

**First Afternoon – Natural Phenomena: Scattering and Propagation.**
Scattering: Rayleigh point scattering; target fluctuation models; the nature of clutter. Propagation: Earth surface multipath; atmospheric refraction and "ducting"; atmospheric attenuation. Other tools: the decibel, etc. (a dB exercise).

**Second Morning – Workshop**
An example radar and performance calculations, with variations.

**Second Afternoon – Introduction to the Subsystems.**
Overview: the role, general nature and challenges of each. The Transmitter, basics of power conversion: power supplies, modulators, rf devices (tubes, solid state). The Antenna: basic principle; microwave optics and pattern formation, weighting, sidelobe concerns, sum and difference patterns; introduction to phased arrays.

**Third Morning – Subsytems Continued:**
**The Receiver and Signal Processor.**
Receiver: preamplification, conversion, heterodyne operation "image" frequencies and double conversion. Signal processing: pulse compression. Signal processing: Doppler-sensitive processing Airborne radar – the absolute necessity of Doppler processing

**Third Afternoon – Subsystems: Control and Interface Apparatus.**
Automatic detection and constant-false-alarm-rate (CFAR) techniques of threshold control. Automatic tracking: exponential track filters. Multi-radar fusion, briefly Course review, discussion, current topics and community activity.

The course is taught from the student notebook supplied, based heavily on the open literature and with adequate references to the most popular of the many textbooks now available. The student's own note-taking and participation in the exercises will enhance understanding as well.

# Radar Systems Analysis & Design using MATLAB

**November 7-10, 2005**
Beltsville, Maryland

$1595 (8:30am - 4:00pm)

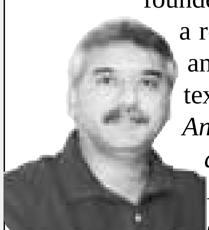


## Summary

This course provides a comprehensive description of radar systems analyses and design. A design case study is introduced and as the material coverage progresses throughout the course, and new theory is presented, requirements for this design case study are changed and / or updated, and the design level of complexity is also increased. This design process is supported with a comprehensive set of MATLAB-7 code developed for this purpose. By the end, a comprehensive design case study is accomplished. This will serve as a valuable tool to radar engineers in helping them understand radar systems design process.

Each student will receive the instructor's textbook *MATLAB Simulations for Radar Systems Design* as well as course notes.

## Instructor



**Dr. Bassem R. Mahafza** is the president and founder of deciBel Research Inc. He is a recognized Subject Matter Expert and is widely known for his three textbooks: *Introduction to Radar Analysis, Radar Systems Analysis and Design Using MATLAB, and MATLAB Simulations for Radar Systems Design*. Dr. Mahafza's background includes extensive work in the areas of Radar Technology, Radar Design and Analysis (including all sensor subcomponents), Radar Simulation and Model Design, Radar Signatures and Radar Algorithm Development (especially in the areas of advanced clutter rejection techniques and countermeasures). Dr. Mahafza has published over 65 papers, and over 100 technical reports.

## What You Will Learn

- How to select different radar parameters to meet specific design requirements.
- Perform detailed trade-off analysis in the context of radar sizing, modes of operations, frequency selection, waveforms and signal processing.
- Establish and develop loss and error budgets associated with the design.
- Generate an indepth understanding of radar operations and design philosophy.
- Several mini design case studies pertinent to different radar topics will enhance understanding of radar design in the context of the material presented.

## Course Outline

1. **Radar Basics:** Radar Classifications; Range; Range Resolution; Doppler Frequency; The Radar Equation; Radar Reference Range; Search (Surveillance); Pulse Integration; Detection Range with Pulse Integration; Radar Losses; Range and Doppler Ambiguities; Resolving Range Ambiguity; Resolving Doppler Ambiguity; "MyRadar" Design Case Study - Visit 1.
2. **Radar Detection:** Detection in the Presence of Noise; Probability of False Alarm; Probability of Detection; Coherent Integration; Non-Coherent Integration; Detection of Fluctuating Targets; Threshold Selection; Probability of Detection Calculation; Detection of Swerling Targets; The Radar Equation Revisited; "MyRadar" Design Case Study - Visit 2.
3. **Radar Waveforms:** Low Pass, Band Pass Signals and Quadrature Components; The Analytic Signal; CW and Pulsed Waveforms; Linear Frequency Modulation Waveforms; High Range Resolution; Stepped Frequency Waveforms; Range Resolution and Range Ambiguity; Effect of Target Velocity; The Matched Filter; Matched Filter Response to LFM Waveforms; Waveform Resolution and Ambiguity; "Myradar" Design Case Study - Visit 3.
4. **The Radar Ambiguity Function:** Examples of the Ambiguity Function; Single Pulse Ambiguity Function; LFM Ambiguity Function; Coherent Pulse Train Ambiguity Function; Ambiguity Diagram Contours; Digital Coded Waveforms; Frequency Coding (Costas Codes); Binary Phase Codes; Pseudo-Random (PRN) Codes; "MyRadar" Design Case Study - Visit 4.
5. **Pulse Compression:** Time-Bandwidth Product; Radar Equation with Pulse Compression; LFM Pulse Compression; Correlation Processor; Stretch Processor; "MyRadar" Design Case Study - Visit 5.
6. **Surface and Volume Clutter:** Clutter Definition; Surface Clutter; Radar Equation for Area Clutter - Airborne Radar; Radar Equation for Area Clutter - Ground Based Radar; Volume Clutter; Radar Equation for Volume Clutter; Clutter Statistical Models; "MyRadar" Design Case Study - Visit 6.
7. **Phased Arrays:** Directivity, Power Gain, and Effective Aperture; Near and Far Fields; General Arrays; Linear Arrays; Array Tapering; Computation of the Radiation Pattern via the DFT; Planar Arrays; Array Scan Loss; "MyRadar" Design Case Study - Visit 7.
8. **Electronic Countermeasures:** Jammers; Self-Screening Jammers (SSJ); Stand-Off Jammers (SOJ); Range Reduction Factor; Chaff.
9. **Radar Cross Section (RCS):** RCS Definition; RCS Prediction Methods; Dependency on Aspect Angle and Frequency; RCS Dependency on Polarization; Polarization; RCS of Simple Objects; Sphere; Ellipsoid; Circular Flat Plate; Truncated Cone (Frustum); Cylinder; Rectangular Flat Plate; Triangular Flat Plate.
10. **Radar Wave Propagation (time permitting):** Earth Atmosphere; Refraction; Stratified Atmospheric Refraction Model; Four-Third Earth Model; Ground Reflection; Smooth Surface Reflection Coefficient; Rough Surface Reflection; Total Reflection Coefficient; The Pattern Propagation Factor; Flat Earth; Spherical Earth.

This course will serve as a valuable source to radar system engineers and will provide a foundation for those working in the field who need to investigate the basic fundamentals in a specific topic. It provides a comprehensive day-to-day radar systems design reference.

DEFENSE

# Radar Tracking, Kalman Filtering and Multi-Sensor Data Fusion

**February 6-8, 2006**
Colorado Springs, Colorado

**March 20-22, 2006**
Beltsville, Maryland

$1290 (8:30am - 4:00pm)

## Summary

The objective of this course is to introduce engineers, scientists, managers, and military operations personnel to the fields of radar tracking, data fusion and to the key technologies which are available today for application to this field. The course is designed to be rigorous where appropriate, while remaining accessible to students without a specific scientific background in this field. The course will start from the fundamentals and move to advanced concepts. This course will identify and characterize the principal components of typical tracking systems. A variety of techniques for addressing different aspects of the tracking data fusion problem will be described. For example, different techniques are required for the assimilation of "time-late" data than those used for "real-time" data. Real world examples of data fusion systems used by both the Navy and the Marines will be presented and discussed. This course will also use specific illustrative examples to show the tradeoffs and systems issues between application of different techniques

## Instructor

**Stan Silberman** is a member of the Corporate Staff of TSC/Washington. He has 31 years of experience in radar systems analysis and design for the Navy, Marine Corps, Air Force, and FAA. In support of Navy programs, he has performed analysis and developed simulations on the AN/SPS-49 and AN/SPY-1 radar, as well as multisensor tracking systems such as AN/SYS-1 and -2. Marine Corps support has included performance assessment of the AN/TPS-59 and AN/TPS-63 radars and simulation and analysis of the multisensor tracker in TAOC. His areas of specialization include automatic detection and tracking systems, sensor data fusion, simulation, and system evaluation.

## Course Outline

1. **Introduction.** Basic concepts & definitions. Target motion models, measurement models, coordinate systems, mathematical review.
2. **Single-Target Single-Sensor Tracking (No False Alarms).** State Estimation – least squares and Kalman filtering. Performance examples. Simplified filters.
3. **Non-linear filtering.** When is it necessary? Extended Kalman Filter. Particle filters. Examples.
4. **Angle-Only Tracking.** Extended Kalman Filter, pseudo-linear filter, modified polar coordinates. Triangulation.
5. **Target maneuvers.** Process noise, correlated noise model. Adaptive noise models. Multiple models including IMM (Interacting Multiple Model).
6. **Single-Target Single-Sensor Tracking (With False Alarms).** Correlation & association. Nearest neighbor, Probabilistic Data Association (PDA).
7. **Track Initiation/Deletion.** Initiation process, m/n and sequential tests for promotion to "firm" track, track deletion.
8. **Single-Sensor, Multiple-Target Tracking.** Expansion of Section 6 to multiple target. Extended nearest neighbor, Joint PDA, Multiple Hypothesis Technique.
9. **Multiple-Sensor, Multiple-Target Tracking.** Fusion architectures. Measurement fusion, track fusion. Similar and dissimilar sensors, co-located and non-co-located.
10. **Sensor alignment.** Types of alignment problems. Impact of uncorrected alignment biases. Alignment techniques.
11. **Attribute fusion.** Bayesian Inference, Dempster-Shafer (Evidential Reasoning), Fuzzy Logic.

## What You Will Learn

- State Estimation Techniques – Kalman Filter, constant-gain filters.
- Non-linear filtering – When is it needed? Extended Kalman Filter.
- Techniques for angle-only tracking.
- Tracking algorithms, their advantages and limitations, including:
  - Nearest Neighbor
  - Probabilistic Data Association
  - Multiple Hypothesis Tracking
  - Interactive Multiple Model (IMM)
- How to handle maneuvering targets.
- Track initiation – recursive and batch approaches.
- Architectures for sensor fusion.
- Sensor alignment – Why do we need it and how do we do it?
- Attribute Fusion, including Bayesian methods, Dempster-Shafer, Fuzzy Logic.

# Synthetic Aperture Radar

DEFENSE

## Fundamentals

**November 14-15, 2005**

Beltsville, Maryland

Instructors: Walt McCandless & Bart Huxtable

$1190** (8:30am - 4:00pm)

$890 without RadarCalc software

## Advanced

**November 16-17, 2005**

Beltsville, Maryland

Instructor: Bart Huxtable

$1190** (8:30am - 4:00pm)

$890 without RadarCalc software

**Includes single user RadarCalc license for Windows PC, for the design of airborne & space-based SAR. Retail price $1000.

### Fundamentals: What You Will Learn

- Basic concepts and principles of SAR.
- What are the key system parameters.
- Performance calculations using RadarCalc.
- Design and implementation tradeoffs.
- Current system performance. Emerging systems.

### Fundamentals: Course Outline

1. **Applications Overview.** A survey of important applications and how they influence the SAR system from sensor through processor. A wide number of SAR designs and modes will be presented from the pioneering classic, single channel, strip mapping systems to more advanced all-polarization, spotlight, and interferometric designs.
2. **Applications and System Design Tradeoffs and Constraints.** System design formulation will begin with a class interactive design workshop using the RadarCalc model designed for the purpose of demonstrating the constraints imposed by range/Doppler ambiguities, minimum antenna area, limitations and related radar physics and engineering constraints. Contemporary pacing technologies in the area of antenna design, on-board data collection and processing and ground system processing and analysis will also be presented along with a projection of SAR technology advancements, in progress, and how they will influence future applications.
3. **Civil Applications.** A review of the current NASA and foreign scientific applications of SAR.
4. **Commercial Applications.** The emerging interest in commercial applications is international and is fueled by programs such as Canada's RadarSat, the European ERS series, the Russian ALMAZ systems and the current NASA/industry LightSAR initiative. The applications (soil moisture, surface mapping, change detection, resource exploration and development, etc.) driving this interest will be presented and analyzed in terms of the sensor and platform space/airborne and associated ground systems design and projected cost.

### Advanced: What You Will Learn

- How to apply SAR to the design of high-resolution systems.
- How to design and build high performance signal processors.
- Design and implementation tradeoffs using RadarCalc.
- SAR activities in DoD, NASA and commercial applications.
- Current state-of-the-art.

### Advanced: Course Outline

1. **SAR Review Origins.** Theory, Design, Engineering, Modes, Applications, System
2. **Processing Basics.** Traditional strip map processing steps, theoretical justification, processing systems designs, typical processing systems.
3. **Advanced SAR Processing.** Processing complexities arising from uncompensated motion and low frequency (e.g., foliage penetrating) SAR processing.
4. **Interferometric SAR.** Description of the state-of-the-art IFSAR processing techniques: complex SAR image registration, interferogram and correlogram generation, phase unwrapping, and digital terrain elevation data (DTED) extraction.
5. **Spotlight Mode SAR.** Theory and implementation of high resolution imaging. Differences from strip map SAR imaging.
6. **Polarimetric SAR.** Description of the image information provided by polarimetry and how this can be exploited for terrain classification, soil moisture, ATR, etc.
7. **High Performance Computing Hardware.** Parallel implementations, supercomputers, compact DSP systems, hybrid opto-electronic system.
8. **Image Phenomenology & Interpretation.** Imagery of moving targets (e.g., train off the track), lay over, shadowing, slant-plane versus ground plane imagery, ocean imagery.
9. **Example Systems and Applications.** SIR-C, ERS-1, AirSAR, Almaz, image artifacts and causes. ATR, coherent change detection, polarimetry, along-track interferometry.

# Antenna and Array Fundamentals

## Basic concepts in antennas, antenna arrays, and antennas systems

NEW!

**September 28-30, 2005**
Beltsville, Maryland

**December 6-8, 2005**
Beltsville, Maryland

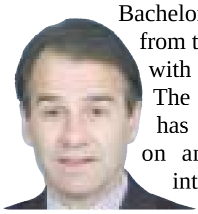
**March 22-24, 2006**
Cleveland, Ohio

$1390 (8:30am – 4:00pm)

### Summary

This three-day course teaches the basics of antenna and antenna array theory. Fundamental concepts such as beam patterns, radiation resistance, polarization, gain/directivity, aperture size, reciprocity, and matching techniques are presented. Different types of antennas such as dipole, loop, patch, horn, dish, and helical antennas are discussed and compared and contrasted from a performance/applications standpoint. The locations of the reactive near-field, radiating near-field (Fresnel region), and far-field (Fraunhofer region) are described and the Friis transmission formula is presented with worked examples. Propagation effects are presented. Antenna arrays are discussed, and array factors for different types of distributions (e.g., uniform, binomial, and Tschebyscheff arrays) are analyzed giving insight to sidelobe levels, null locations, and beam broadening (as the array scans from broadside.) The end-fire condition is discussed. Beam steering is described using phase shifters and true-time delay devices. Problems such as grating lobes, beam squint, quantization errors, and scan blindness are presented. Antenna systems (transmit/receive) with active amplifiers are introduced. Finally, measurement techniques commonly used in anechoic chambers are outlined. The textbook, *Antenna Theory, Analysis & Design*, is included as well as a comprehensive set of course notes.

### Instructor



**Dr. Steven Weiss** is a senior design engineer with the Army Research Lab in Adelphi, MD. He has a Bachelor's degree in Electrical Engineering from the Rochester Institute of Technology with Master's and Doctoral Degrees from The George Washington University. He has numerous publications in the IEEE on antenna theory. He teaches both introductory and advanced, graduate level courses at Johns Hopkins University on antenna systems. He is active in the IEEE and is presently on the steering committee for the Antennas and Propagation Conference for 2005. In his job at the Army Research Lab, he is actively involved with all stages of antenna development from initial design, to first prototype, to measurements. He is a licensed Professional Engineer in both Maryland and Delaware.

### Course Outline

1. **Basic concepts in antenna theory.** Beam patterns, radiation resistance, polarization, gain/directivity, aperture size, reciprocity, and matching techniques.
2. **Locations.** Reactive near-field, radiating near-field (Fresnel region), far-field (Fraunhofer region) and the Friis transmission formula.
3. **Types of antennas.** Dipole, loop, patch, horn, dish, and helical antennas are discussed, compared, and contrasted from a performance/applications standpoint.
4. **Propagation effects.** Direct, sky, and ground waves. Diffraction and scattering.
5. **Antenna arrays and array factors** (e.g., uniform, binomial, and Tschebyscheff arrays).
6. **Scanning from broadside.** Sidelobe levels, null locations, and beam broadening. The end-fire condition. Problems such as grating lobes, beam squint, quantization errors, and scan blindness.
7. **Beam steering.** Phase shifters and true-time delay devices. Some commonly used components and delay devices (e.g., the Rotman lens) are compared.
8. **Measurement techniques used in anechoic chambers.** Pattern measurements, polarization patterns, gain comparison test, spinning dipole (for CP measurements). Items of concern relative to anechoic chambers such as the quality of the absorbent material, quiet zone, and measurement errors. Compact, outdoor, and near-field ranges.
9. **Questions and answers.**

### What You Will Learn

- Basic antenna concepts that pertain to all antennas and antenna arrays.
- The appropriate antenna for your application.
- Factors that affect antenna array designs and antenna systems.
- Measurement techniques commonly used in anechoic chambers.

This course is invaluable to engineers seeking to work with experts in the field and for those desiring a deeper understanding of antenna concepts. At its completion, you will have a solid understanding of the appropriate antenna for your application and the technical difficulties you can expect to encounter as your design is brought from the conceptual stage to a working prototype.

# Implementing TCP/IP and IPv6 Networks

## Migrating Your Internetwork to the Next Generation Internet Protocol

**March 29-30, 2006**

Colorado Springs, Colorado

$990 (8:30am - 4:00pm)

***The growth of the Internet has taxed the capabilities of the current Internet Protocol, IP version 4, requiring enhancements for real-time application support, security, and addressing, that are some of the key enhancements found in IPv6.***

### What You Will Learn

- The architecture of the Internet, and how IP-connected networks interface to that architecture.
- Understand the formats of TCP, IP, UDP and others.
- Study the functions of the supporting protocols, such as ARP, RARP, DNS, BOOTP, RIP and OSPF.
- Discover how applications such as FTP, TELNET, SMTP and HTTP are integrated into a TCP/IP environment.
- Study the various TCP processes, including connections, sequence control, and flow control.
- Understand the operation of SNMP, the Internet standard for network management.
- Understand the limitations of the current IPv4.
- Key features of IPv6: larger addresses and security.
- Analyze the formats of the IPv6 packet header, extension headers, and other constructs.
- Gain insights into how the IPv6 transition will affect other functions at the routers and hosts.
- Explore the affects of IPv6 on other elements of your internet or intranet architecture.
- Learn leading vendors such as Cisco Systems, Sun, IBM, Microsoft and others are implementing IPv6.
- See how the implementation of IPv6 will allow expansion of the global Internet to continue.
- Learn how to strategically plan your transition to IPv6.
- Public domain sources of further information on IPv6.

### Instructor

**Mark A. Miller, P.E.**, has been directly involved with data communication systems and computer networks since 1976. Prior to founding DigiNet® Corporation, he held a number of engineering and management positions within Southwestern Bell; Bell Telephone Laboratories; and AT&T. Mark has lectured extensively on data communication; internetwork design and management; and troubleshooting and analyzing complex internetworks; and has taught at Comdex, Comnet, Networld+Interop, Next Generation Networks, and many other conferences. He is the author of 20 textbooks on internetwork design, analysis and management, published by John Wiley & Sons and McGraw-Hill. Mark holds both BS and MS degrees in Electrical Engineering, and is a Registered Professional Engineer in Colorado, Arizona, Wyoming and Kansas.

### Course Outline

1. **Using TCP/IP and the Internet.** Origin and development of the protocols. The ARPA architecture, and its relationship to the OSI Reference Model. Internet growth and future developments.
2. **Supporting TCP/IP and the Internet Protocols.** The ARPA core protocols. The ARPA address resolution, control and routing protocols. Implementation support within IBM SNA, Windows, Macintosh, and LAN networking environments.
3. **The Network Interface Connection.** Functions of the LAN, MAN and WAN network interfaces. Enabling protocols including Ethernet, FDDI, ISDN, ATM, and Frame Relay. Dialup support using PPP and SLIP.
4. **The Internetwork Connection.** Functions of the Internet Layer. Routing and packet processing algorithms. Functions of the IP header fields. Addressing and subnetwork addressing architectures. Protocols implemented to support the internetwork connection: ARP, RARP, ICMP, BOOTP, RIP, OSPF, EGP, BGP and DNS. Case studies: remote host login sequence, and message fragmentation.
5. **The Host-to-Host Connection.** Functions of the Host-to-Host Layer. Port addresses. Function and operation of the User Datagram Protocol (UDP). Functions and operation of the Transmission Control Protocol (TCP). Case study: establishing and terminating TCP connections.
6. **The Process/Application Connection.** Functions of the Process/Application Layer. Functions and operation of the commonly-used applications: TFTP, FTP, TELNET, SMTP, HTTP and NetBIOS.
7. **Managing the Internet.** The specific management functional areas. Agent/manager model. Structure of Management Information (SMI). Management Information Bases (MIBs). The Simple Network Management Protocol (SNMP), versions 1, 2 and 3, architecture and message formats.
8. **The Need for a New Internet Protocol.** The explosive growth of the Internet. Shortcomings of IP version 4. Technical criteria for IP Next Generation (IPng). The final result: IP Version 6. The 6Bone network.
9. **The IPv6 Specification. IPv6 changes.** IPv6 terminology. The IPv6 header format. Comparing IPv6 with IPv4. Next Header Field Operation. IPv6 packet format. Optional extension headers. Packet size issues. Case Study 1: IPv6 transport over an IPv4 network infrastructure.
10. **IPv6 Addressing Architecture.** The Benchmark - IPv4 Addresses. Classless Interdomain Routing (CIDR). Address options: Unicast, Anycast and Multicast. IPv6 addressing architecture. Unicast addresses: subnet, IEEE 802, hierarchical, provider-based. Transition addresses: IPv4 to/from IPv6. Anycast addresses. Multicast addresses. Case Study 2: addressing operations through an IPv6 network.
11. **Intranetwork Communications.** The Benchmark - ICMP for IPv4. ICMPv6 functions. ICMPv6 message formats. Multicast Listener messages. Neighbor Discovery messages. Path MTU discovery process. Neighbor Unreachability state diagram. Case Study 3: Router Advertisement Messages.
12. **Autoconfiguration and Local Network Issues.** Address autoconfiguration. DHCPv6. IPv6 over local and wide area networks: Ethernet, Token Ring, FDDI, PPP, ATM and Frame Relay. Case Study 4: Neighbor Solicitation/Neighbor Advertisement processes.
13. **Routing Issues.** IPv6 support for RIPng, OSPF and BGP. Case Study 5: RIP operation within IPv6 networks.
14. **Host Issues.** Upper layer checksums. Maximum packet lifetimes. Maximum payload size. Domain Name System (DNS) upgrades. Berkeley UNIX API enhancements. IPv6 security mechanisms. Authentication header format and operation. Encryption header format and operation.
15. **Network Management Issues.** The Agent/Manager paradigm. Structure of Management Information. Management Information Base. IPv6 MIB groups. SNMPv1, v2 and v3 protocol data unit formats.
16. **Transition Strategies - moving from IPv4 to IPv6.** The transition process. Dual IP stack architectures and operation. Packet encapsulation/decapsulation formats. Configured tunneling. Automatic tunneling: host-to-host and router-to-host scenarios. Routing scenarios between IPv4 and IPv6 areas. Implementation roadmap.
17. **Vendor solutions and implementation plans.** IPv6 specifications, vendor implementations, and resources.

# Introduction to EMI

## Summary

This three-day course is designed for technicians, operators, and engineers who need an understanding of Electromagnetic Compatibility (EMC) methodology and concepts. Historically, Radio Frequency Interference (RFI) was first identified as a problem as early as 1925. The growth of the electronics industry, with an attendant growth in systems complexity, led to the expansion of RFI to Electromagnetic Interference (EMI). EMC is the capability for multiple, diverse systems to operate in close proximity without causing or being subject to interference. The course offers a basic working knowledge of the principles of the EMC theory. This course will provide the ability to understand and communicate with communications-electronics (C-E) engineers and project personnel relating to EMC.

## Feb. 28-Mar. 2, 2006

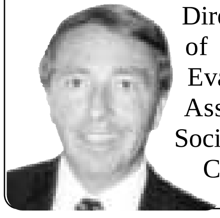
Orlando, Florida

$1,290 (8:30am - 4:30pm)

## Instructor

**Dr. William G. Duff** (Bill) is the President of SEMTAS. Previously, he was the Chief Technology Officer of the Advanced Technology Group of SENTEL. Prior to working for SENTEL, he worked for Atlantic Research and taught courses on electromagnetic interference (EMI) and electromagnetic compatibility (EMC). He is internationally recognized as a leader in the development of engineering technology for achieving EMC in communication and electronic systems. He has 42 years of experience in EMI/EMC analysis, design, test and problem solving for a wide variety of communication and electronic systems. He has extensive experience in assessing EMI at the equipment and/or the system level and applying EMI suppression and control techniques to "fix" problems.

Bill has written more than 40 technical papers and four books on EMC. He also regularly teaches seminar courses on EMC. He is a past president of the IEEE EMC Society. He served a number of terms as a member of the EMC Society Board of Directors and is currently Chairman of the EMC Society Fellow Evaluation Committee and an Associate Editor for the EMC Society Newsletter. He is a NARTE Certified EMC Engineer.



## Course Outline

1. **Examples Of Communications System.** A Discussion Of Case Histories Of Communications System EMI, Definitions Of Systems, Both Military And Industrial, And Typical Modes Of System Interactions Including Antennas, Transmitters And Receivers And Receiver Responses.
2. **Quantification Of Communication System EMI.** A Discussion Of The Elements Of Interference, Including Antennas, Transmitters, Receivers And Propagation.
3. **Electronic Equipment And System EMI Concepts.** A Description Of Examples Of EMI Coupling Modes To Include Equipment Emissions And Susceptibilities.
4. **Common-Mode Coupling.** A Discussion Of Common-Mode Coupling Mechanisms Including Field To Cable, Ground Impedance, Ground Loop And Coupling Reduction Techniques.
5. **Differential-Mode Coupling.** A Discussion Of Differential-Mode Coupling Mechanisms Including Field To Cable, Cable To Cable And Coupling Reduction Techniques.
6. **Other Coupling Mechanisms.** A Discussion Of Power Supplies And Victim Amplifiers.
7. **The Importance Of Grounding For Achieving EMC.** A Discussion Of Grounding, Including The Reasons (I.E., Safety, Lightning Control, EMC, Etc.), Grounding Schemes (Single Point, Multi-Point And Hybrid), Shield Grounding And Bonding.
8. **The Importance Of Shielding.** A Discussion Of Shielding Effectiveness, Including Shielding Considerations (Reflective And Absorptive).
9. **Shielding Design.** A Description Of Shielding Compromises (I.E., Apertures, Gaskets, Waveguide Beyond Cut-Off).
10. **EMI Diagnostics And Fixes.** A Discussion Of Techniques Used In EMI Diagnostics And Fixes.
11. **EMC Specifications, Standards And Measurements.** A Discussion Of The Genesis Of EMC Documentation Including A Historical Summary, The Rationale, And A Review Of MIL-Stds, FCC And CISPR Requirements.

## What You Will Learn

- Examples of Communications Systems EMI.
- Quantification of Systems EMI.
- Equipment and System EMI Concepts.
- Source and Victim Coupling Modes.
- Importance of Grounding.
- Shielding Designs.
- EMI Diagnostics.
- EMC/EMI Specifications and Standards.

# Optimization, Modeling, and Simulation

## Principles of Search, Stochastic Modeling, and Monte Carlo Simulation

NEW!

**February 13-15, 2006**
Beltsville, Maryland

**May 22-25, 2006**
Beltsville, Maryland

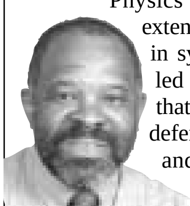
$1390 (8:30am - 4:30pm)


### Summary

This course is an introduction to two closely related areas: (1) stochastic search methods for system optimization and (2) the analysis and construction of Monte Carlo simulations. A few of the many areas where stochastic optimization and simulation-based approaches have emerged as indispensable include decision aiding, prototype development for large-scale control systems, performance analysis of communication networks, control and scheduling of complex manufacturing processes, and computer-based personnel training. The course focuses on core issues in algorithm design and mathematical modeling, together with implications for practical implementation. The course does not dwell on theoretical details related to the methods; attendees are directed to the appropriate literature for such details. Attendees should have a solid working knowledge of probability and statistics at the beginning graduate level and knowledge of multivariate calculus, basic matrix analysis, and linear algebra. To aid understanding, the course will include a brief review of the prerequisite mathematical material. Attendees will receive a copy of the textbook *Introduction to Stochastic Search and Optimization* by J. C. Spall (Wiley, 2003), a comprehensive set of notes, and a CD with Matlab code of the core algorithms. Although not required, attendees are encouraged to bring a laptop with MATLAB installed. The course will include class demonstrations and opportunities to experiment with the algorithms.


### Instructors

**James C. Spall** is a Principal Staff engineer at the Johns Hopkins University, Applied Physics Laboratory and is Chairman of the Applied and Computational Mathematics Program in the Johns Hopkins School of Engineering. Dr. Spall's 20+ years of engineering experience includes work on numerous projects for the U. S. Navy and DARPA. He also has extensive teaching experience, including credit and non-credit courses for working professionals. Dr. Spall has many publications, including two books, one of which is the course text *Introduction to Stochastic Search and Optimization* (Wiley, 2003). He holds two U.S. patents for inventions in control systems. Dr. Spall is a Fellow of IEEE.



**Stacy Hill** joined the Johns Hopkins University Applied Physics Laboratory in 1983. Dr. Hill has extensive theoretical and practical experience in systems modeling and analysis. He has led systems analysis and modeling projects that evaluated the performance of strategic defense systems, and has published papers and given invited talks on stochastic simulation and optimization. He received a Best Paper Award for "Optimization of Discrete Event Dynamic Systems via Simultaneous Perturbation Stochastic Approximation" from the Institute of Industrial Engineers. Dr. Hill teaches in the Johns Hopkins University School of Engineering Program in Applied and Computational Mathematics and serves on its Advisory Board.

### Course Outline

1. **Brief Mathematical Review.** Relevant multivariate analysis, matrix algebra, probability, and statistics.
2. **Background on Search and Optimization.** Basic issues and definitions. Stochastic vs. deterministic methods. No free lunch theorems for optimization. Summary of classical methods of optimization and their limitations.
3. **Direct Search Techniques.** Introduction to direct random search. Monte Carlo methods. Nonlinear simplex (Nelder-Mead) algorithms.
4. **Least-Squares-Type Methods.** Recursive methods for linear systems. Recursive least squares (RLS). Least mean squares (LMS). Connection to Kalman filtering.
5. **Stochastic Approximation for Linear and Nonlinear Systems.** Root-finding and gradient-based stochastic approximation (Robbins-Monro). Gradient-free stochastic approximation: finite-difference (FDSA) and simultaneous perturbation (SPSA) methods.
6. **Search Methods Motivated by Physical Processes.** Simulated annealing and related methods. Evolutionary computation and genetic algorithms.
7. **Model Building.** Issues particular to Monte Carlo simulation models. Bias-variance tradeoff. Selecting "best" model via cross-validation. Fisher information matrix as summary measure.
8. **Simulation-Based Optimization.** Use of Monte Carlo simulations to improve performance of real-world system performance. Gradient-based methods (infinitesimal perturbation analysis and likelihood ratio) and non-gradient-based methods (FDSA, SPSA, etc.). Common random numbers.
9. **Markov Chain Monte Carlo.** Monte Carlo methods for difficult calculations; Metropolis-Hastings and Gibbs sampling. Applications to numerical integration and statistical estimation.
10. **Input Selection and Experimental Design.** Classical vs. optimal design. A practical criterion for optimal design (D-optimality). Input selection in linear and nonlinear models.

### What You Will Learn

- Popular methods for stochastic optimization.
- To recognize when stochastic optimization techniques are necessary or beneficial.
- *Advantages* and *disadvantages* of popular methods for system optimization.
- Essential theoretical principles and assumptions underlying optimization and Monte Carlo simulation and the implications for *practical implementation*.
- Basics of mathematical modeling and the link to Monte Carlo simulation.
- State-of-the-art methods for using Monte Carlo simulations to improve *real system performance*.

# Practical Design of Experiments

## November 15-17, 2005

8:30am - 4:00pm

Beltsville, Maryland

$1290

NEW!

## Summary

This three-day course will enable the participant to plan the most efficient experiment or test which will result in a statistically defensible conclusion of the test objectives. It will show how properly designed tests are easily analyzed and prepared for presentation in a report or paper. Examples and exercises related to various NASA satellite programs will be included.

Many companies are reporting significant savings and increased productivity from their engineering, process control and R&D professionals. These companies apply statistical methods and statistically-designed experiments to their critical manufacturing processes, product designs, and laboratory experiments. Multifactor experimentation will be shown as increasing efficiencies, improving product quality, and decreasing costs. This first course in experimental design will start you into statistical planning before you actually start taking data and will guide you to perform hands-on analysis of your results immediately after completing the last experimental run. You will learn how to design practical full factorial and fractional factorial experiments. You will learn how to systematically manipulate many variables simultaneously to discover the few major factors affecting performance and to develop a mathematical model of the actual instruments. You will perform statistical analysis using the modern statistical software called JMP from SAS Institute. At the end of this course, participants will be able to design experiments and analyze them on their own desktop computers.

## Instructor

**Dr. Manny Uy** is a member of the Principal Professional Staff at The Johns Hopkins University Applied Physics Laboratory (JHU/APL). Previously, he was with General Electric Company, where he practiced Design of Experiments on many manufacturing processes and product development projects. He is currently working on space environmental monitors, reliability and failure analysis, and testing of modern instruments for Homeland Security. He earned a Ph.D. in physical chemistry from Case-Western Reserve University and was a postdoctoral fellow at Rice University and the Free University of Brussels. He has published over 150 papers and holds over 10 patents. At the JHU/APL, he has continued to teach courses in the Design and Analysis of Experiments and in Data Mining and Experimental Analysis using SAS/JMP.

## What You Will Learn

- How to design full and fractional factorial experiments.
- Gather data from hands-on experiments while simultaneously manipulating many variables.
- Analyze statistical significant testing from hands-on exercises.
- Acquire a working knowledge of the statistical software JMP.

## Course Outline

1. **Survey of Statistical Concepts.**
2. **Introduction to Design of Experiments.**
3. **Designing Full and Fractional Factorials.**
4. **Hands-on Exercise:** Statapult Distance Experiment using full factorial.
5. **Data preparation and analysis of Experimental Data.**
6. **Verification of Model:** Collect data, analyze mean and standard deviation.
7. **Hands-on Experiment:** One-Half Fractional Factorial, verify prediction.
8. **Hands-on Experiment:** One-Fourth Fractional Factorial, verify prediction.
9. **Screening Experiments (Trebuchet).**
10. **Advanced designs, Methods of Steepest Ascent, Central Composite Design.**
11. **Some recent uses of DOE.**
12. **Summary.**

## Testimonials ...

*"Would you like many times more information, with much less resources used, and 100% valid and technically defensible results? If so, design your tests using Design of Experiments."*

*Dr. Jackie Telford, Career Enhancement: Statistics, JHU/APL.*

*"We can no longer afford to experiment in a trial-and-error manner, changing one factor at a time, the way Edison did in developing the light bulb. A far better method is to apply a computer-enhanced, systematic approach to experimentation, one that considers all factors simultaneously. That approach is called "Design of Experiments.."*

*Mark Anderson, The Industrial Physicist.*

# Spreadsheet Aided Engineering
## With Visual Basic and Engineering xLToolboxes

**November 14-18, 2005**
Beltsville, Maryland

**January 17-21, 2006**
Lake Tahoe, California

$2495 (8:30am - 4:30pm)


### Summary

This workshop is designed to have an immediate impact on the way that Excel Spreadsheets are used in the engineering process. The underlying key to this change is for the user to gain experience and knowledge on the use of Visual Basic for Applications (VBA) in Excel. Extensive use of VBA is the key to unlocking all the features of Excel, and moving away from attempting to program on worksheets. Those who attend this intensive hands-on workshop experience a dramatic change in their use of Excel and VBA. Benefits include increased productivity, automation of tedious tasks, increased use of XLToolboxes and Add-ins, development of re-usable functions, forms and templates, improved documentation and configuration management, and improved team interaction and parameter sharing.


### Instructor

**Tom R. Mincer**, Ph.D., Founder and President of SpreadsheetWorld, Inc. and Professor of Mechanical Engineering, California State University, Northridge (CSUN). Dr. Mincer is widely recognized as an early pioneer in the extensive use of Excel, VBA and FORTRAN DLLs in engineering. For the past 15 years he has worked extensively in the areas of systems design, simulation and optimization using the Excel Structured Spreadsheet environment.

**David R. McDaniel,** M.S., Vice President, Applications Development, SpreadsheetWorld and Asst. Professor of Aeronautics, U.S. Air Force Academy. David is responsible for managing the development of SpreadsheetWorld's suite of engineering xLToolboxes. He specializes in advanced Excel/VBA techniques including development of User Interfaces, use of class modules, the development of custom dynamic link libraries, and the integration of these capabilities into higher level modeling and analysis projects."

### Course Outline

1. **Overview of Excel™ Environment:** The central role of VBA in Excel & Office, The Excel VBA application object library, Excel menus and toolbar objects, Setting application level preferences, Excel internal function library, Inverting functions— Goal Seeker, Iteration and circular references, Linked worksheets and workbooks, Excel Add-Ins - Solver & Analysis Toolpaks, Forms for simple worksheet user interface, Using the VBA Recorder, xLTManager and xLToolboxes.
2. **Structured Spreadsheets & Documentation:** Structured worksheet layout and design, input-output field structures, Input design parameter field structure, Defined names for input arrays, Output field structures, VBA user defined functions (UDF), Time varying output fields.
3. **Visual Basic for Applications (VBA):** The computational side of VBA, Visual Basic Editor, VBA projects and modules, VBA user defined function procedures, VBA sub procedures, Declaration statements, Debugging VBA code, Data types and naming conventions, Function design for worksheet topology, Naming Excel objects & VBA variables, Vectors, matrices and arrays, VBA logic and control structures.
4. **Building VBA Function Libraries:** Exporting VBA modules to BAS library, Building Excel Add-Ins, Using Add-Ins in Excel, Referencing Add-Ins in VBA, Documentation support.
5. **Object Oriented Programming in Excel:** VBA Object Browser, Object libraries & Excel's object library, Excel object properties & methods, Object collections, Properties that return objects, Range object properties and methods, Object events & VBA event code, Drawing objects with VBA, Animation using VBA.
6. **Userforms & ActiveX for Project Control:** User interface: an overview, Userform driven design, Creating user interfaces, How to design Userforms as GUIs, Designing Userforms with graphics.
7. **Solving System Rules & Optimization:** Formulating system rules, Objective functions, Constraint functions, Design & decision variables, Structured optimization sheets, Using solver for solving rules, Configuration trade-off studies.
8. **Charting and Chart Automation:** Charting VBA object structure, xLTQwikplot & xLTProplot, Using VBA for chart automation.
9. **Data Storage, Retrieval & Analysis:** Importing data into Excel worksheets, Importing data into VBA, Enumeration and lookup functions, Filtering and smoothing data, Interpolation and extrapolation, Linear regression, Linear surface regression, non-linear regression.
10. **Numerical Methods for System Modeling:** Application of xLTNumerical Toolbox, Roots of nonlinear functions, Linear & nonlinear algebraic systems, Numerical integration & differentiation, System sensitivity maps.
11. **Dynamic System Simulation:** Application of xLTSimulation Toolbox, State variable system modeling, State forecasting methods.
12. **Interfacing VBA, FORTRAN & C:** Dynamic Link Libraries (DLLs), Computationally intensive analysis, Converting existing code to DLLs, Interfacing VBA and DLLs, Creating FORTRAN DLLs.
13. **Automation of Applications Using VBA:** Key automation properties & methods, Controlling MATLAB, Controlling Word, PowerPoint, etc.
14. **Developing On-Line Documentation:** HTML help system, Elements of documentation, Linking help to VBA functions.

### Participants in this workshop learn to use Excel and VBA to:

- Create engineering information tables.
- Develop re-useable functional models.
- Monitor the impact of key variables.
- Monitor performance functions.
- Deal with implicit functions.
- Develop and use VBA Add-Ins.
- Use xLToolboxes to support modeling.
- Solve systems of rules.
- Simulate dynamic systems.
- Do system optimization using Solver.
- Monitor System Requirements.
- Setup system sensitivity maps.
- Do system optimization.
- Develop graphic user interfaces.
- Setup system modeling teams.
- Control Fortran modules from VBA.
- Control MATLAB models in Excel.

# Total Systems Engineering Development & Management

## Summary

This four-day course covers four system development fundamentals: (1) a sound engineering management infrastructure within which work may be efficiently accomplished, (2) define the problem to be solved (requirements and specifications), (3) solve the problem (design, integration, and optimization), and (4) prove that the design solves the defined problem (verification). Proven, practical techniques are presented for the key tasks in the development of sound solutions for extremely difficult customer needs.

**September 27-30, 2005**
Beltsville, Maryland

**Nov. 28-Dec. 1, 2005**
Houston, Texas

$1495 (8:00 am - 5:00 pm)

*Call for information about our six-course systems engineering certificate program or for on-site training to prepare for the INCOSE systems engineering exam.*

## Instructor

**Jeffrey O. Grady** is the president of JOG System Engineering, Inc., a system engineering consulting and training company. He has 30 years of industry experience in aerospace companies as a system engineer, engineering manager, field engineer, and project engineer. Jeff has authored five recently published books in the system engineering field and holds a Master of Science in System Management from USC. He teaches system engineering courses nationwide at universities as well as commercially around the country. Jeff is an INCOSE Fellow and Founder.

## What You Will Learn

- How to identify and organize all of the work an enterprise must perform on programs, plan a project, map enterprise work capabilities to the plan, and quality audit work performance against the plan.
- How to accomplish structured analysis using one of several structured analysis models yielding every kind of requirement appropriate for every kind of specification coordinated with specification templates.
- An appreciation for design development through original design, COTS, procured items, and selection of parts, materials, and processes.
- How to develop interfaces under associate contracting relationships using ICWG/TIM meetings and Interface Control Documents.
- How to define verification requirements, map and organize them into verification tasks, plan and proceduralize the verification tasks, capture the verification evidence, and audit the evidence for compliance.

## *WHAT STUDENTS SAY:*

*"This course tied the whole development cycle together for me."*

*"I had mastered some of the details before this course, but did not understand how the pieces fit together. Now I do!"*

*"I really appreciated the practical methods to accomplish this important work."*

## Course Outline

1. **System Management.** Introduction to System Engineering, Development Process Overview, Enterprise Engineering, Program Design, Risk, Configuration Management/Data Management, System Engineering Maturity.
2. **System Requirements.** Introduction and Development Environments, Requirements Elicitation and Mission Analysis, System and Hardware Structured Analysis, Performance Requirements Analysis, Product Architecture Synthesis and Interface Development, Constraints Analysis, Computer Software Structured Analysis, Requirements Management Topics.
3. **System Synthesis.** Introduction, Design, Product Sources, Interface Development, Integration, Risk, Design Reviews.
4. **System Verification.** Introduction to Verification, Item Qualification Requirements Identification, Item Qualification Planning and Documentation, Item Qualification Verification Reporting, Item Qualification Implementation, Management, and Audit, Item Acceptance Overview, System Test and Evaluation Overview, Process Verification.

# Vibration and Shock Measurement & Testing
## for Land, Sea, Air, Space Vehicles & Electronics Manufacture

More dates at our website, www.aticourses.com

### Summary

This three-day course is primarily designed for test personnel who conduct, supervise or "contract out" vibration and shock tests. It also benefits design, quality and reliability specialists who interface with vibration and shock test activities.

Each student receives the instructor's brand new, minimal-mathematics, minimal-theory hardbound text *Random Vibration & Shock Testing, Measurement, Analysis & Calibration.* This 444 page, 4-color book also includes a CD-ROM with video clips and animations.

**October 4-6, 2005**
Longmont, Colorado

**January 24-26, 2006**
Cape Canaveral, Florida

**February 13-15, 2006**
Las Vegas, Nevada

*"Also Available As A Distance Learning Course"*
(Call for Info)

$1995 (8:00am - 4:00pm)

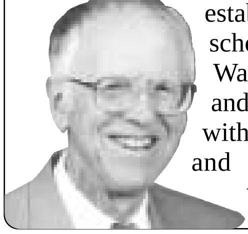
### What You Will Learn

- How to plan, conduct and evaluate vibration and shock tests and screens.
- How to attack vibration and noise problems.
- How to make vibration isolation, damping and absorbers work for vibration and noise control.
- How noise is generated and radiated, and how it can be reduced.

***From this course you will gain the ability to understand and communicate meaningfully with test personnel, perform basic engineering calculations, and evaluate tradeoffs between test equipment and procedures.***

### Instructor

**Wayne Tustin** is President of Equipment Reliability Institute (ERI), a specialized engineering school and consultancy. His BSEE degree is from the University of Washington, Seattle. He is a licensed Professional Engineer - Quality in the State of California. Wayne's first encounter with vibration was at Boeing/Seattle, performing what later came to be called modal tests, on the XB-52 prototype of that highly reliable platform. Subsequently he headed field service and technical training for a manufacturer of electrodynamic shakers, before establishing another specialized school on which he left his name. Wayne has written several books and hundreds of articles dealing with practical aspects of vibration and shock measurement and testing.



### Course Outline

1. **Minimal math review** of basics of vibration, commencing with uniaxial and torsional SDoF systems. Resonance. Vibration control.
2. **Instrumentation.** How to select and correctly use displacement, velocity and especially acceleration and force sensors and microphones. Minimizing mechanical and electrical errors. Sensor and system dynamic calibration.
3. **Extension of SDoF** to understand multi-resonant continuous systems encountered in land, sea, air and space vehicle structures and cargo, as well as in electronic products.
4. **Types of shakers.** Tradeoffs between mechanical, electrohydraulic (servohydraulic), electrodynamic (electromagnetic) and piezoelectric shakers and systems. Limitations. Diagnostics.
5. **Sinusoidal one-frequency-at-a-time vibration testing.** Interpreting sine test standards. Conducting tests.
6. **Random Vibration Testing.** Broad-spectrum all-frequencies-at-once vibration testing. Interpreting random vibration test standards.
7. **Simultaneous multi-axis testing** gradually replacing practice of reorienting device under test (DUT) on single-axis shakers.
8. **Environmental stress screening** (ESS) of electronics production. Extensions to highly accelerated stress screening (HASS) and to highly accelerated life testing (HALT).
9. **Assisting designers** to improve their designs by (a) substituting materials of greater damping or (b) adding damping or (c) avoiding "stacking" of resonances.
10. **Understanding automotive** buzz, squeak and rattle (BSR). Assisting designers to solve BSR problems. Conducting BSR tests.
11. **Intense noise** (acoustic) testing of launch vehicles and spacecraft.
12. **Shock testing.** Transportation testing. Pyroshock testing. Misuse of classical shock pulses on shock test machines and on shakers. More realistic oscillatory shock testing on shakers.
13. **Shock response spectrum** (SRS) for understanding effects of shock on hardware. Use of SRS in evaluating shock test methods, in specifying and in conducting shock tests.
14. **Attaching DUT** via vibration and shock test fixtures. Large DUTs may require head expanders and/or slip plates.
15. **Modal testing.** Assisting designers.

# Wavelets: A Conceptual, Practical Approach

*"This course uses very little math, yet provides an in-depth understanding of the concepts and real-world applications of these powerful tools."*

NEW!

**Nov. 8-10, 2005**
Albuquerque, New Mexico

**Feb. 28-Mar. 2, 2006**
Beltsville, Maryland

$1390 (8:30am - 4:00pm)

## Summary

Fast Fourier Transforms (FFT) are in wide use and work very well if your signal stays at a constant frequency ("stationary"). But if the signal could vary, have pulses, "blips" or any other kind of interesting behavior then you need Wavelets. Wavelets are remarkable tools that can stretch and move like an amoeba to find the hidden "events" and then simultaneously give you their location, frequency, and shape. Wavelet Transforms allow this and many other capabilities not possible with conventional methods like the FFT.

This course is vastly different from traditional math-oriented Wavelet courses or books in that we use examples, figures, and computer demonstrations to show how to understand and work with Wavelets. This is a comprehensive, in-depth. up-to-date treatment of the subject, but from an intuitive, conceptual point of view.

We do look at a few key equations from the traditional literature but only AFTER the concepts are demonstrated and understood. If desired, further study from scholarly texts and papers is then made much easier and more palatable when you already understand the fundamental equations and how they relate to the real world. Students receive a copy of the course slides and a CD containing MATLAB software scripts and demonstrations.

## Instructor

**D. Lee Fugal** is Founder and President of Space & Signals Technologies, LLC. He has over 30 years of industry experience in Digital Signal Processing (including Wavelets) and Satellite Communications. He has been a full-time consultant on numerous assignments since 1991. Recent projects include Excision of Chirp Jammer Signals using Wavelets, design of Space-Based Geolocation Systems (GPS & Non-GPS), and Advanced Pulse Detection using Wavelet Technology. He has taught upper-division University courses in DSP and in Satellites as well as Wavelet short courses and seminars for Practicing Engineers and Management. He holds a Masters in Applied Physics (DSP) from the University of Utah, is a Senior Member of IEEE, and a recipient of the IEEE Third Millennium Medal.

## Course Outline

1. **What is a Wavelet?** Examples and Uses. "Waves" that can start, stop, move and stretch. Real-world applications in many fields: Signal and Image Processing, Internet Traffic, Airport Security, Medicine, JPEG, Finance, Pulse and Target Recognition, Radar, Sonar, etc.
2. **Comparison with traditional methods.** The concept of the FFT, the STFT, and Wavelets as all being various types of comparisons (correlations) with the data. Strengths, weaknesses, optimal choices.
3. **The Continuous Wavelet Transform (CWT).** Stretching and shifting the Wavelet for optimal correlation. Predefined vs. Constructed Wavelets.
4. **The Discrete Wavelet Transform (DWT).** Shrinking the signal by factors of 2 through downsampling. Understanding the DWT in terms of correlations with the data. Relating the DWT to the CWT. Demonstrations and uses.
5. **The Redundant Discrete Wavelet Transform (RDWT)** Stretching the Wavelet by factors of 2 without downsampling. Tradeoffs between the alias-free processing and the extra storage and computational burdens. A hybrid process using both the DWT and the RDWT. Demonstrations and uses.
6. **"Perfect Reconstruction Filters".** How to cancel the effects of aliasing. How to recognize and avoid any traps. A breakthrough method to see the filters as basic Wavelets. The "magic" of alias cancellation demonstrated in both the time and frequency domains.
7. **Highly useful properties of popular Wavelets.** How to choose the best Wavelet for your application. When to create your own and when to stay with proven favorites.
8. **Compression and De-Noising using Wavelets.** How to remove unwanted or non-critical data without throwing away the alias cancellation capability. A new, powerful method to extract signals from large amounts of noise. Demonstrations.
9. **Additional Methods and Applications.** Image Processing. Detecting Discontinuities, Self-Similarities and Transitory Events. Speech Processing. Human Vision. Audio and Video. BPSK/QPSK Signals. Wavelet Packet Analysis. Matched Filtering. How to read and use the various Wavelet Displays. Demonstrations.
10. **Further Resources.** The very best of Wavelet references.

## What You Will Learn

- How to use Wavelets as a "microscope" to analyze data that changes over time or has hidden "events" that would not show up on an FFT.
- How to understand and efficiently use the 3 types of Wavelet Transforms to better analyze and process your data. State-of-the-art methods and applications.
- How to compress and de-noise data using advanced Wavelet techniques. How to avoid potential pitfalls by understanding the concepts. A "safe" method if in doubt.
- How to increase productivity and reduce cost by choosing (or building) a Wavelet that best matches your particular application.

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GPS Technology
Ground System Design & Operation
Hyperspectral & Multispectral Imaging
Introduction To Space
IP Networking Over Satellite
Launch Vehicles & Orbital Mechanics
Launch Vehicle Selection, Performance & Use
Launch Vehicle Systems - Reusable
Orbital & Launch Mechanics
Payload Integration & Processing
Planetary Science for Aero Professionals
Quality Management for Space
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Satellite RF Comm & Onboard Processing
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Total Systems Engineering Development
Wavelets: A Conceptual, Practical Approach

### Sonar & Acoustic Engineering

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Sonar Signal Processing
Structural Acoustics
Submarines & Combat Systems
Underwater Acoustic Modeling
Underwater Acoustic Systems Analysis
Vibration & Noise Control
Vibration & Shock Measurement & Testing

### Radar/Missile/Defense

Advanced Developments in Radar
Advanced Synthetic Aperture Radar
Combat Systems Engineering
C4ISR Requirements & Systems
Electronic Warfare Overview
Fundamentals of Radar
Fundamentals of Rockets & Missiles
GPS Technology
Microwave & RF Circuit Design
Missile Autopilots
Modern Infrared Sensor Technology
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