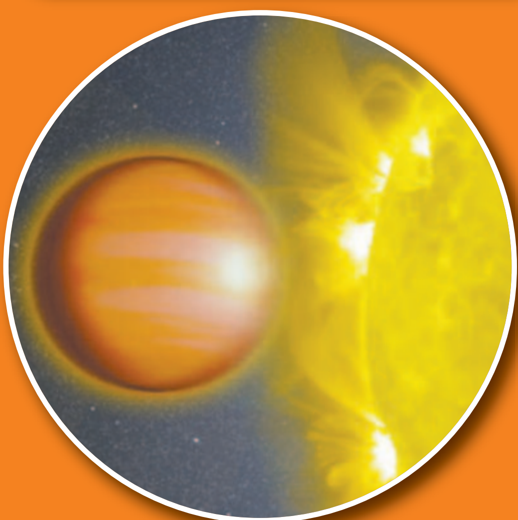
# ATI COURSES

Volume 134
Valid through December 2021

## Applied Technology Institute, LLC

**Training Rocket Scientists Since 1984**

Satellites & Space-Related Systems
Defense: Radar, Missiles & Electronic Warfare
Engineering and Signal Processing
Acoustics, Underwater Sound & Sonar
Systems Engineering & Project Management

*www.ATIcourses.com*

Technical and Training Professionals:

For over 35 years, the **Applied Technology Institute** has earned the trust of and provided solutions to technical professionals and training departments.

**We are slowly getting back to "normal"** but we welcome comments on your preferences and your company's policies regarding training classes. For the foreseeable future our open enrollment courses will be delivered virtually. On a case-by-case basis, we may be able to deliver our courses to your on-site group in person. Regardless, ATI is here for your technical training needs.

**NEW** are our **One-Hour Free Sessions** in which the instructor delivers a topic from a full length course that will be offered soon or is brand new! The current **FREE** courses can be found on **Page 4** of this catalog!

Also new are more **Pre-Recorded / Always Available** courses. See **Page 18**, for now.

**Please visit** our website for courses available for on-site deliveries, **FREE SESSIONs**, or other possible open enrollment dates on our schedule.

**ATI's courses and instructors** are specialized in the following subject matters:

- ***Satellites, Satellite Communications, and Space-Related Systems***
- ***Defense: Radar, Missiles, Electronic Warfare, and SDR***
- ***Engineering and Signal Processing***
- ***Acoustics, Underwater Sound & Sonar***
- ***Systems Engineering***

**Register 3 or more of your team members** for most open enrollment courses and save $100 for each registration.

**On-Sites can save your team a significant amount** especially as your number of attendees increase. In addition, we can generally tailor the content to your specific requirements and schedule the course at a time convenient to your group. We offer various virtual platforms for on-sites.

## What recent patrons are saying about ATI's courses:

***Astropolitics***

*"This was one of the most interesting courses, and easily one of the best taught in my near-decade working in the building. The instructor was engaging and I think the next iteration of the class will be even better as our in-course discussions probably hinted at our priorities."*

***Deep Learning Architectures***

*"Strength would be the depth. I was surprised how thoroughly the instructor described some of the systems."*

*"The content was engaging and presented in a way that demonstrated its relevance to the state of the art and my own applications. engaging, informative, up-to-date, relevant"*

***Multi-Target Tracking & Multi-Sensor Data Fusion***

*"Communicated very clearly. Provided good notes that summarized the main points and presented the information in a way that was interesting and easy to understand."*

*"The instructor explained complex information extremely well. I could follow his explanations most of the time, despite my lack of background in the subject. He clearly knew exactly what he was talking about. He was extremely prompt, timely, etc. I could not believe his perseverance in being able to excitedly talk through slides for 3 days straight."*

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**Applied Technology Institute, LLC**

Regards,

***Please Connect with Jim Jenkins on LinkedIn.***

# Table of Contents

# ATI's FREE One-Hour Sessions

**All course are held from 12:30 – 1:30pm ET**
**Including Q&A with the Instructor**

## Acoustic Fundamentals & Measurements with Underwater Applications

**July 19, 2021** Live Virtual
**FREE** **(1 Hour / 12:30pm - 1:30pm)**

### Summary

This free short session will be an overview of the August 16-19, 2021 *Acoustics Fundamentals, Measurements with Underwater Applications* course (See Page 43). Please visit the link above for more details.

### Instructor

**Dr. Alan D. Stuart**, Associate Professor Emeritus of Acoustics, Penn State, has over forty years experience in the field of sound and vibration. He has degrees in mechanical engineering, electrical engineering, and engineering acoustics. For over thirty years he has taught courses on the Fundamentals of Acoustics, Structural Acoustics, Applied Acoustics, Noise Control Engineering, and Sonar Engineering on both the graduate and undergraduate levels as well as at government and industrial organizations throughout the country.

## Multi-Target Tracking & Multi-Sensor Data Fusion

**August 2, 2021** Live Virtual
**FREE** **(1 Hour / 12:30pm - 1:30pm)**

### Summary

This free short session will be an overview of the August 17-19, 2021 *Multi-Target Tracking & Multi-Sensor Data Fusion* course (See Page 12) . Please visit the link above for more details.

### Instructor

**Stan Silberman**, is a member of the Senior Technical Staff at the Johns Hopkins Univeristy Applied Physics Laboratory. He has over 30 years of experience in tracking, sensor fusion, and radar systems analysis and design for the Navy,Marine Corps, Air Force, and FAA. Recent work has included the integration of a new radar into an existing multisensor system and in the integration, using a multiple hypothesis approach, of shipboard radar and ESM sensors. Previous experience has included analysis and design of multiradar fusion systems, integration of shipboard sensors including radar, IR and ESM, integration of radar, IFF, and time-difference-of-arrival sensors with GPS data sources.

## CSEP Preparation

**September 10, 2021** Live Virtual
**FREE** **(1 Hour / 12:30pm - 1:30pm)**

### Summary

This CSEP Preparation hour will cover key takeaways on applying for the certification, SE processes, SE handbook logic, and specific exam tips from the September 28-30, 2021 three-day Certified Systems Engineering Professional course. The free webinar takeaways include:

• How to efficiently and effectively apply. • How the SE processes are structured and interrelated. • The SE Handbook chapters' logic.• How best to study including 5 test taking rules?

### Instructor

**Mr. William "Bill" Fournier**, , ESEP is Senior Software Systems Engineering with 38 years of experience. Mr. Fournier taught DoD Systems Engineering full time at SMC/DAU as a Professor of Engineering Management. Mr. Fournier has taught Systems Engineering at least part time for more than the last 25 years. Mr. Fournier holds a MBS and a BS Industrial Engineering / Operations Research and is DOORS trained. Bill is a CSEP and passed acquisition extension. He is a contributor to DAU / DSMC, Major Defense Contractor internal Systems Engineering Courses and Process, and INCOSE publications. Bill is a Verification SME. Over 100 of Bill's Students have passed the CSEP exam.

## Wireless Communications & Spread Spectrum Design

**November 5, 2021** Live Virtual
**FREE** **(1 Hour / 12:30pm - 1:30pm)**

### Summary

This free short session will be an overview of the November 16-18, 2021 *Wireless Communications and Spread Spectrum Design course*. Please visit the link above for more details.

### Instructor

**Scott R. Bullock**, P.E., MSEE, specializes in Wireless Communications including Spread Spectrum Systems and Broadband Communication Systems, Networking, Software Defined Radios and Cognitive Radios and Systems for both government and commercial uses. He holds 18 patents and 22 trade secrets in communications and has published several articles in various trade magazines. He was active in establishing the data link standard for GPS SCAT-I landing systems, the first handheld spread spectrum PCS cell phone, and developed spread spectrum landing systems for the government. He is the author of two books, Transceiver and System Design for Digital Communications & Broadband Communications and Home Networking, Scitech Publishing, www.scitechpub.com. He has taught seminars for several years to all the major communication companies, an adjunct professor at two colleges, and was a guest lecturer for Polytechnic University on "Direct Sequence Spread Spectrum and Multiple Access Technologies." He has held several high level engineering positions including VP, Senior Director, Director of R&D, Engineering Fellow, and Consulting Engineer.

# 21st Century Electronic Warfare

**July 20-22, 2021**

Live Virtual

**$2090** (8:30am - 4:30pm)

**Register 3 or More & Receive $100$^{00}$ Each Off The Course Tuition.**

## Summary

This three-day course is oriented to those that have some technical background and minimal knowledge of EW. The targeted audience includes line engineers, program managers, and marketing staff who have some involvement in electronic warfare.

## Instructor

**Dr. Clayton Stewart**-Biosketch

- **Currently:** Visiting Professor Electronic & Electrical Engineering Department, University College London; consultant DARPA, NSF, JHU/APL, & others; Teach short courses in EW, radar, and C4ISR for ATI, UCL, Defence IQ in the US and in Europe.
- **2007-2013**: Technical Director Office of Naval Research Global.
- **1994-2007:** Corporate VP/GM of Reconnaissance and Surveillance Operation, SAIC; managed 500 person, $125 M/year organization.
- **1990-1994:** Associate Prof Electrical & Computer Engineering and Associate Director of Center of Excellence in Command, Control, Communications, and Intelligence, George Mason University; lead for Sensing and Fusion Group.
- **1987-1990:** Program Manager Artificial Ionospheric Mirror (AIM) over-the-horizon radar system, ARCO Power Technologies Inc.
- **1984-1987:** Principal Investigator Signal Processing, Sperry Corporate Technology Center involved in R&D of sensor systems, sensor fusion, EW.
- **1982-1984:** Deputy Director Tactical Systems Division, Air Force Studies and Analyses, the Pentagon; performed and directed operational analyses of C4ISR and EW systems.
- **1978-1982:** Associate Professor Electrical Engineering, US Air Force Academy; Director of Faculty Research; taught courses in radar systems, communications, and EW.
- **1974-1978:** Graduate student Air Force Institute of Technology, earned MSEE and PhDEE
- **1964-1974:** USAF officer, Navigator / Electronic Warfare Officer, flew EB-57, EB-66, and MC-130CT aircraft. Combat tour in SEA. Awarded DFC.

## Course Outline

**1. Introduction to Electronic Combat.** This section will include an introduction to the EW taxonomy: Electronic Attack, Electronic Support, and Electronic Protection. We will discuss the both the old and new terminology. We will also discuss the electromagnetic spectrum and electromagnetic waves.

**2. Modern Threat Weapons and Sensors.** We will discuss various air defense weapons systems including airborne intercept, surface to air missile systems, and anti-aircraft artillery, including both land based and maritime. We will also consider integrated air defense systems. Specific examples will be illustrated. We will also discuss different types of radar systems including surveillance, target acquisition, and fire control as well as electro-optic and infra-red sensor systems. Examples will be illustrated. Russian and Chinese systems will be described, and their geographic employment will be shown.

**3. Vulnerability of Radar Modes.** We will discuss various radar modes such as non-coherent pulsed, coherent pulsed, pulse doppler, FM-CW, pulse compression, and monopulse. For each type we will discuss their vulnerability to EA and their resistance to countermeasures.

**4. Vulnerability/Susceptibility of Weapon Systems.** We will consider effective countermeasures techniques to be applied to airborne interceptors, surface to air missile systems, and anti-aircraft artillery. We will also discuss radar cross section and stealth.

**5. ESM (ES).** For electronic support, we will consider the various types of receivers that are employed, as well as the direction finding systems and analysis systems. Specific ES and SIGINT platforms will be described.

**6. ECM Techniques (EA).** The various approaches to EA will be discussed including noise jamming, spot, swept, and barrage, as well as deception jamming. We will also consider various expendables, including chaff, flares, anti-radiation missiles, and decoys.

**7. ECCM (EP).** For electronic protection we will look at pulse compression techniques, sidelobe blankers, low probability of intercept techniques.

**8. EW Systems.** We will explore the various EW systems employed by the US and some foreign countries. This will include jammers, chaff dispensers, anti-radiation missiles, and decoys and how they are employed. We will include airborne and shipboard systems.

**9. EW Technology.** We will discuss various EW technologies such as antennas, receivers, transmitters, solid state amplifier technology, matched filters, and digital processing technolog.

# AESA Radar & Its Applications

**July 20-22, 2021**
Live Virtual

**$2090** **(8:30am - 4:30pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**


## Summary

While offering performance that is inherently superior to conventional systems, AESA radar is technologically and architecturally more complex. In this three-day course, participants will learn why the AESA radar has become the system of choice on modern platforms by understanding its capabilities and constraints, and how these capabilities and constraints come about as a result of the AESA approach. This course will then proceed to describe in detail several key surface and airborne radar applications that have been used in traditional radar systems, in which performance is enhanced by the AESA class of radar. Essential support technologies such as antenna auto calibration, antenna auto compensation, and radar modeling and simulation will also be covered.


## Instructor

**Dr. Menchem Levitas** has forty four years of experience in science and engineering, thirty six of which have consisted of direct radar and weapon systems analysis, design, and development. Throughout his tenure he has provided technical support for many shipboard and airborne radar programs in many different areas including system concept definition, electronic protection, active arrays, signal and data processing, requirement analyses, and radar phenomenology. He is a recipient of the AEGIS Excellence Award for the development of a novel radar cross-band calibration technique in support of wide-band operations for high range resolution. He has developed innovative techniques in many areas e.g., active array self-calibration and failure-compensation, array multi-beam-forming, electronic protection, synthetic wide-band, knowledge-based adaptive processing, waveforms and waveform processing, and high fidelity, real-time, littoral propagation modeling. He has supported many AESA programs including the Air Force's Ultra Reliable Radar (URR), the Atmospheric Surveillance Technology (AST), the USMC's Ground/Air Task Oriented Radar (G/ATOR), the 3D Long Range Expeditionary Radar (3DLRR), and others. Prior to his retirement in 2013 he had been the chief scientist of Technology Service Corporation's Washington Operations.

## What You Will Learn

- The evolution of radar systems from mechanical rotators to ESA and AESA.
- Fundamental principles and concepts of ESA and AESA.
- Major advantages and challenges of AESA radar systems.
- Required support technologies of AESA arrays.
- Key applications of AESA radar in surface and airborne platforms.
- State-of-the-art advances in related radar technologies – i.e., radar waveforms.

## Course Outline

1. **Introduction.** The evolution of radar from mechanical rotators through ESA to AESA. The driving elements, the benefits, and the challenges. Applications that benefit from the new technology.

2. **Radar Subsystems.** Transmitter, antenna, receiver and signal processor ( Pulse Compression and Doppler filtering principles, automatic detection with adaptive detection threshold, the CFAR mechanism, sidelobe blanking angle estimation), the radar control program and data processor.

3. **Electronically Scanned Antenna (ESA).** Fundamental concepts, directivity and gain, elements and arrays, near and far field radiation, element factor and array factor, illumination function and Fourier transform relations, beamwidth approximations, array tapers and sidelobes, electrical dimension and errors, array bandwidth, steering mechanisms, grating lobes, phase monopulse, beam broadening, examples.

4. **Solid State Active Phased Arrays (AESA).** What is AESA, Technology and architecture. Analysis of AESA advantages and penalties. Emerging requirements that call for AESA, Issues at T/R module, array, and system levels. Emerging technologies. Examples.

5. **Module Failure and Array Auto-compensation.** The 'bathtub' profile of module failure rates and its three regions, burn-in and accelerated stress tests, module packaging and periodic replacements, cooling alternatives, effects of module failure on array pattern. Array failure-compensation techniques.

6. **Auto-calibration of Active Phased Arrays.** Driving issues, types of calibration, auto-calibration via elements mutual coupling, principal issues with calibration via mutual-coupling, some properties of the different calibration techniques.

7. **Multiple Simultaneous Beams.** Why multiple beams, independently steered beams vs. clustered beams, alternative organization of clustered beams and their implications, quantization lobes in clustered beams arrangements and design options to mitigate them. Relation to AESA.

8. **Surface Radar.** Principal functions and characteristics, nearness and extent of clutter, anomalous propagation, dynamic range, signal stability, time, and coverage requirements, transportation requirements and their implications, bird/angel clutter and its effects on radar design. The role of AESA.

9. **Airborne Radar.** Principal functions and characteristics, Radar bands, platform velocity, pulse repetition frequency (PRF) categories and their properties, clutter spectrum, dynamic range, sidelobe blanking, mainbeam clutter, clutter filtering, blindness and ambiguity resolution post detection STC. The role of AESA.

10. **Modern Advances in Waveforms.** Traditional Pulse Compression: time-bandwidth and range resolution fundamentals, figures of merit, existing codes description. New emerging requirements, arbitrary WFG with state of the art optimal codes and filters in response. MIMO radar. MIMO waveform techniques and properties, relation to antenna architecture, and the role of AESA in the implementation of the above.

11. **Synthetic Aperture Radar.** Real vs. synthetic aperture, real beam limitations, derivations of focused array resolution, unfocused arrays, motion compensation, range-gate drifting, synthetic aperture modes, waveform restrictions, processing throughputs, synthetic aperture 'monopulse' concepts.. MIMO SAR and the role of AESA.

12. **High Range Resolution via Synthetic Wideband.** Principle of high range resolution - instantaneous and synthetic, synthetic wideband generation, grating lobes and instantaneous band overlap, cross-band dispersion, cross-band calibration, examples.

13. **Adaptive Cancellation and STAP.** Adaptive cancellation overview, broad vs. directive auxiliary patterns, sidelobe vs. mainbeam cancellation, bandwidth and arrival angle dependence, tap delay lines, space sampling, and digital arrays, range Doppler response example, space-time adaptive processing (STAP), system and array requirements, STAP processing alternatives. Digital arrays and the role of AESA.

14. **Radar Modeling and Simulation Fundamentals.** Radar development and testing issues that drive the increasing reliance on M&S, purpose, types of simulations - power domain, signal domain, H/W in the loop, modern simulation framework tools, examples: power domain modeling, signal domain modeling, antenna array modeling, fire finding modeling.

15. **Radar Tracking.** Functional block diagram, what is radar tracking, firm track initiation and range, track update, track maintenance, algorithmic alternatives (association via single or multiple hypotheses, tracking filters options), role of electronically steered arrays in radar tracking.

16. **Key Radar Challenges and Advances.** Key radar challenges, key advances (transmitter, antenna, signal stability, digitization and digital processing, waveforms, algorithms).

# Counter UAS Technology and Techniques

**November 9-10, 2021**

Live Virtual

**$1590** (8:30am - 4:30pm)

**Register 3 or More & Receive $100.00 Each Off The Course Tuition.**


## Summary

This two-day course delivers a thorough overview promoting an understanding and building a successful Counter Unmanned Aerial System (UAS) architecture. The threat posed by small UAS operated by criminals or terrorists has become more prevalent in recent years. Overall mission effectiveness in countering these systems depends upon appropriate systems and technology. This course presents a comprehensive view of the threat, counter UAS systems, the associated architectures, and organizations that promote and coordinate these activities. It begins with fundamental scientific principles, shows how those principles are exploited in various technologies, describes current systems that take the technology into practice.


## Instructor

**Dr. Clayton Stewart** has over 30 years of experience performing across the spectrum of research direction, line management, program management, system engineering, engineering education, flight operations, and research and development. He has had extensive involvement at all levels as Technical Director, Principal Investigator, Operations Manager, Director of Research, Program Manager, Associate Professor, Chief Scientist, Systems Analyst, Member of the Technical Staff, and Aircrew Member.

## Course Outline

**1.** The threat posed by criminals and terrorists exploiting small UAS in disruptive activities at airports and other critical infrastructure. Small commercial UAS that are available and typically employed.

**2.** Recent events in which criminals or terrorists have threatened critical infrastructure such as airports, in the US and abroad, employing small UAS.

**3.** Sensor systems that are used to detect, identify, and track small UAS. These include radar, radio frequency sensing, electro-optical, infrared, and acoustic sensors. The characteristics, strengths, and weakness of each type of sensor type is discussed.

**4.** The small UAS engagement systems are discussed. These include the use of high-power lasers, jamming, communications capture, and attack drones. The advantages and disadvantages of each of these is discussed.

**5.** Organization, both government and commercial, that promote and coordinate counter UAS activities. These include organizations of the US and other countries.

## What You Will Learn

- The small UAS threat to critical infrastructure.
- Theory and operations of counter UAS sensor systems.
- Counter UAS engagement systems and effectiveness.
- Organizations that promote and coordinate counter UAS activities.

# Interface Control Officer (ICO) Crash Course

**October 18-22, 2021**
Live Virtual
**$2000** **(8:30am - 4:30pm)**

**Register 3 or More & Receive $100^{00} <u>Each</u> Off The Course Tuition.**


## Summary

This five-day Interface Control Officer (ICO) Crash Course is designed to equip students with the knowledge and skills necessary to effectively supervise the planning, design, operation, and management of complex Link 16 and multi-TDL operations and exercises.

All students receive one-year of instructor support which entitles them to contact their instructor with course related questions for one-year.


## Instructor

**Patrick Pierson** a retired U.S. Navy (USN) Joint Interface Control Officer (JICO), is the Managing Director of NCS. Patrick has more than 30 years of operational Tactical Data Link (TDL) experience, and has developed more than 75 TDL training courses which have been delivered to thousands of students around the globe. He is also responsible for the design of the Multi-TDL Planning System, OPTASK Link Generator, Network Design Tool, INDE Processing Program, Improved TSDF Calculator, JFAR, JCM, JAR Generator, and the Link 16 Pulse Planning System. Prior to his retirement, Patrick served as the Theatre JICO for the Commander US Naval Forces Europe and Commander US Naval Forces Sixth Fleet, and was part of the JICO teams for Operation Iraqi Freedom, Operation Allied Force, and dozens of Joint and Coalition exercises.

## Who Should Attend

This course is suitable for personnel that require an understanding of Tactical Data Links, Network Planning, Network Design, Network Management, OPTASK Link, and/or Spectrum Management. The course is suitable for qualified Interface Control Officer's needing a review of current tactics, techniques, and procedures, and for government or industry personnel that need an understanding of the duties, responsibilities, and complexities associated with planning, designing, and managing Link 16 and multi-TDL networks and architectures.

## Course Outline

**1. Tactical Data Link Capabilities and Interoperability.**
- Link 11A/B
- Link 16
- Link 22
- Variable Message F•rmat (VMF)
- Joint Range Extension Applications Protocol (JREAP)
- Tactical Data Link Operations
- Data Forwarding
- TDL Interoperability
- International TDL Interoperability Issues

**2. Multi-TDL Network Planning.**
- Platform Capabilities and Limitations
- Information Exchange Requirements
- Network Architecture Planning
- Roles / Responsibilities
- Primary / Alternate Configuration
- Cryptonet Management

**3. Link 16 Network Design.**
- Network Design Goals
- Network Design Steps
- Participation Group Communities
- Track Capacity Calculations
- NPG Capacity Calculations
- NETMAN T/1 (INDE Files)

**4. Link 16 Operational Network Management.**
- Data Registration
- Dual Tracks / Resolution
- ID / IFF / SIF Conflicts
- Information Management
- Network Integrity
- Network Participation Status
- Entering / Exiting the Network
- Network Monitoring and Management

**5. OPTASK Link o Message Text Composition.**
- Message Text Structure
- Message Formats
- OPTASK Link Message Drafting

**6. Link 16 Spectrum Management o Multi-National Working Group.**
- Frequency Clearance Agreements
- TSDF Calculation
- TSDF Calculation Hands-On Exercises
- Cross-Border Coordination
- Spectrum Coordination Messages

# Link 16 Intermediate with Network Enabled Weapons


**August 9-11, 2021**

Live Virtual

**$2090** (8:30am - 4:30pm)

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary


The Link 16 Intermediate Course covers the most important topics effecting Link 16. The course includes 21 instructional modules and is one of our most popular courses. The Link 16 Network Enabled Weapons course not only explains this new capability in great detail, it offers insight into where it may lead when coupled with Link 16 Enhanced Throughput, Concurrent Multi-Netting, and Concurrent Contention Receive. The course contains hundreds of graphics and animations designed specifically to help the student visualize how the capability is delivered in the joint battlespace.


## Instructor

**Patrick Pierson** a retired U.S. Navy (USN) Joint Interface Control Officer (JICO), is the Managing Director of NCS. Patrick has more than 30 years of operational Tactical Data Link (TDL) experience, and has developed more than 75 TDL training courses which have been delivered to thousands of students around the globe. He is also responsible for the design of the Multi-TDL Planning System, OPTASK Link Generator, Network Design Tool, INDE Processing Program, Improved TSDF Calculator, JFAR, JCM, JAR Generator, and the Link 16 Pulse Planning System. Prior to his retirement, Patrick served as the Theatre JICO for the Commander US Naval Forces Europe and Commander US Naval Forces Sixth Fleet, and was part of the JICO teams for Operation Iraqi Freedom, Operation Allied Force, and dozens of Joint and Coalition exercises.

## Course Outline

- Introduction to Link 16
- Link 16 Documentation
- System Characteristics
- Time Division Multiple Access
- Network Participation Groups
- J-Series Messages
- Waveform Generation
- Time Slot Components
- Message Packing and Pulses
- Link 16 Networks / Nets
- Network Access Modes
- Terminal Synchronization
- Link 16 Network Time
- Network Roles
- Terminal Navigation
- Network Relays
- Network Communications Security
- Link 16 Pulse Deconfliction
- Terminal RF Modes
- Time Slot Duty Factor
- Link 16 Terminals
- Introduction to Link 16 NEW
- NEW Message to NPG Mapping
- J11 Messages (Background Data)
- J11.0 Weapon Response / Status Message
- J11.1 Weapon Directive Message
- J11.2 Weapon Coordination Message
- J11.X Message Acknowledgement
- Weapon In-Flight Track Query / Response / Report
- Bomb-Hit Indication Report
- Target Updates / Retargeting / Mission Supplement
- J11.X Loiter / Abort Messages
- Weapon Handoff
- Contact Reports
- J11.X Ping / EMCON / 3rd Party Communications

## Applicability

This course is suitable for personnel with little or no experience and is designed to take the student to a very high level of comprehension in a short period of time.

## Instructor

**Patrick Pierson** is a retired U.S. Navy (USN) Joint Interface Control Officer (JICO) and the Managing Director of NCS. Patrick has more than 30 years of operational Tactical Data Link (TDL) experience, and has developed more than 75 TDL training courses which have been delivered to thousands of students around the globe. He is also responsible for the design of the Multi-TDL Planning System, OPTASK Link Generator, Network Design Tool, INDE Processing Program, Improved TSDF Calculator, JFAR, JCM, JAR Generator, and the Link 16 Pulse Planning System. Prior to his retirement, Patrick served as the Theatre JICO for the Commander US Naval Forces Europe and Commander US Naval Forces Sixth Fleet, and was part of the JICO teams for Operation Iraqi Freedom, Operation Allied Force, and dozens of Joint and Coalition exercises.

**Attend One Or More Or All!**

# MIDS Baseline Upgrade-2 Introduction

**August 16, 2021** Live Virtual
**$500** **(5 Hours / 8:30am - 1:30pm)**

## Summary

The Introduction to BU2 "Crash-Course" describes the new MIDS capabilities that greatly increase the capability, capacity, flexibility, and security of MIDS terminals into the future.

## Outline

Link 16 Enhanced Throughput (LET). J-Messages over Enhanced Throughput (JET). Double-Bus Activation. Frequency Remapping. Crypto Modernization.

# Link 16 with Network Enabled Weapons - Introduction

**August 17, 2021** Live Virtual
**$750** **(8 Hours / 8:30am – 4:30 pm)**

## Summary

This course provides a one-day comprehensive review of Link 16 Network Enabled Weapons, messages, and data exchange protocols that enable this game-changing combat capability.

## Outline

Intro to Network Enabled Weapons. NEW Message to NPG Mapping. J11.0 Message Overview. J11.0 Weapon Response/Status. J11.1 Weapon Directive Messages. J11.2 Weapon Coordination Message. J11.X Message Acknowledgement. Weapon In-Flight Track. Bomb-Hit Indication Report. In-Flight Target Updates / Retargeting. NEW Related Records.

# Understanding Link 16: Enhanced Throughput

**August 18, 2021** Live Virtual
**$600** **(6 Hours / 8:30am – 2:30pm)**

## Summary

Link 16 Enhanced Throughput increases time slot capacity from 12-words (107,520 bps) to 123-words (1,102,080 bps). Understanding the complex processes associated with LET is critical to being able to realize its potential benefits in the battlespace.

## Outline

Link 16 Enhanced Throughput Background. Host Interfaces. J-Messages over ET (JET). Link 16 Enhanced Throughput (LET). Link 16 Enhanced Throughput Error Detection and Correction. Convolution Encoding. LET Message Structure. Link 16 Enhanced Throughput Message Body.

# Joint Range Extension Applications Protocol

**August 19, 2021** Live Virtual
**$750** **(8 Hours / 8:30am – 4:30pm)**

## Summary

JREAP is the primary mechanism for Link 16 Beyond Line-of-Sight (BLOS) communications. The JREAP "Crash Course" provides an in-depth description of the most important JREAP features to create a comprehensive understanding of the topic.

## Outline

JREAP Introduction. How JREAP is used in the Field. JRE Interface Types. JREAP Documentation. MIL-STD 3011 Appendix-A. MIL-STD 3011 Appendix-B. MIL-STD 3011 Appendix-C. JREAP Header Basics.

# Network Planning and Design - Intro

**August 20, 2021** Live Virtual
**$750** **(8 Hours / 8:30am – 4:30 pm)**

## Summary

This course is a one-day comprehensive summary of the processes and procedures required to successfully plan and design complex coalition networks that support the Information Exchange Requirements of the Operational Commander.

## Outline

Network Planning Introduction. Initial Planning Process Summary. Information Exchange Requirements. Connectivity Analysis. Network Design Requirements Specification. Network Design Introduction. Network Design Steps. Global Settings / Tasks. Participation Group Communities.

# Military Standard 810

## Understanding, Planning and Performing Climatic and Dynamic Tests

**August 16-19, 2021**
Santa Clarita, California
**August 23-26, 2021**
Boxborough, Massachusetts
**October 18-21, 2021**
Orlando, Florida
**$3900** (8:00am - 4:00pm)

**Register 3 or More & Receive $100^00 Each Off The Course Tuition.**


## Summary

This four-day class provides understanding of the purpose of each test, the equipment required to perform each test, and the methodology to correctly apply the specified test environments. Vibration and Shock methods will be covered together with instrumentation, equipment, control systems and fixture design. Climatic tests will be discussed individually: requirements, origination, equipment required, test methodology, understanding of results.

The course emphasizes topics you will use immediately. Suppliers to the military services protectively install commercial-off-the-shelf (COTS) equipment in our flight and land vehicles and in shipboard locations where vibration and shock can be severe. We laboratory test the protected equipment (1) to assure twenty years equipment survival and possible combat, also (2) to meet commercial test standards, IEC documents, military standards such as STANAG or MIL-STD-810H, etc. Few, if any, engineering schools cover the essentials about such protection or such testing.

## Instructor

**Steve Brenner** has worked in environmental simulation and reliability testing for over 30 years, always involved with the latest techniques for verifying equipment integrity through testing. He has independently consulted in reliability testing since 1996. His client base includes American and European companies with mechanical and electronic products in almost every industry. Steve's experience includes the entire range of climatic and dynamic testing, including ESS, HALT, HASS and long term reliability testing.

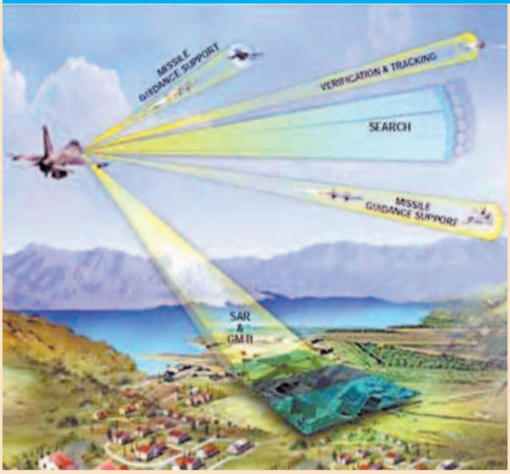
## What You Will Learn

When you visit an environmental test laboratory, perhaps to witness a test, or plan or review a test program, you will have a good understanding of the requirements and execution of the 810G dynamics and climatics tests. You will be able to ask meaningful questions and understand the responses of test laboratory personnel.

## Course Outline

1. **Introduction to Military Standard testing - Dynamics.**
   - Introduction to classical sinusoidal vibration.
   - Resonance effects.
   - Acceleration and force measurement.
   - Electrohydraulic shaker systems.
   - Electrodynamic shaker systems.
   - Sine vibration testing.
   - Random vibration testing.
   - Attaching test articles to shakers (fixture design, fabrication and usage).
   - Shock testing.
2. **Climatics.**
   - Temperature testing.
   - Temperature shock.
   - Humidity.
   - Altitude.
   - Rapid decompression/explosives.
   - Combined environments.
   - Solar radiation.
   - Salt fog.
   - Sand & Dust.
   - Rain.
   - Immersion.
   - Explosive atmosphere.
   - Icing.
   - Fungus.
   - Acceleration.
   - Freeze/thaw (new in 810G).
3. **Climatics and Dynamics Labs demonstrations.**
4. **Reporting On And Certifying Test Results.**

# Multi-Target Tracking and Multi-Sensor Data Fusion




**August 17-19, 2021**

Live Virtual

**$2090** (8:30am - 4:30pm)

**Register 3 or More & Receive $100$^{00}$ Each Off The Course Tuition.**

## Summary

The objective of this three-day course is to introduce engineers, scientists, managers and military operations personnel to the fields of target tracking and 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 more advanced concepts. This course will identify and characterize the principle components of typical tracking systems. A variety of techniques for addressing different aspects of the data fusion problem will be described. Real world examples will be used to emphasize the applicability of some of the algorithms. Specific illustrative examples will be used to show the tradeoffs and systems issues between the application of different techniques.

## Instructor

**Stan Silberman** is a member of the Senior Technical Staff at the Johns Hopkins Univeristy Applied Physics Laboratory. He has over 30 years of experience in tracking, sensor fusion, and radar systems analysis and design for the Navy,Marine Corps, Air Force, and FAA. Recent work has included the integration of a new radar into an existing multisensor system and in the integration, using a multiple hypothesis approach, of shipboard radar and ESM sensors. Previous experience has included analysis and design of multiradar fusion systems, integration of shipboard sensors including radar, IR and ESM, integration of radar, IFF, and time-difference-of-arrival sensors with GPS data sources.

## Course Outline

1. **Introduction.**
2. **The Kalman Filter.**
3. **Other Linear Filters.**
4. **Non-Linear Filters.**
5. **Angle-Only Tracking.**
6. **Maneuvering Targets:** Adaptive Techniques.
7. **Maneuvering Targets:** Multiple Model Approaches.
8. **Single Target Correlation & Association.**
9. **Track Initiation, Confirmation & Deletion.**
10. **Using Measured Range Rate (Doppler).**
11. **Multitarget Correlation & Association.**
12. **Probabilistic Data Association.**
13. **Multiple Hypothesis Approaches.**
14. **Coordinate Conversions.**
15. **Multiple Sensors.**
16. **Data Fusion Architectures.**
17. **Fusion of Data From Multiple Radars.**
18. **Fusion of Data From Multiple Angle-Only Sensors.**
19. **Fusion of Data From Radar and Angle-Only Sensor.**
20. **Sensor Alignment.**
21. **Fusion of Target Type and Attribute Data.**
22. **Performance Metrics.**

## 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.

# Pyrotechnic Shock Testing, Measurement, Analysis and Calibration


## Summary

This is a three- day introduction course to the theoretical and practical aspects of high frequency shock testing, commonly called “pyroshock” or “pyrotechnic shock” testing.

The basic physics involved in pyroshock, including meaningful measurement and analysis of the environment, will be presented and discussed. The presentation encourages attendees (having varied structural dynamic backgrounds and experience) to contribute their personal experiences and observations, and thus to collaborate with the teaching staff and their fellow attendees. Their experience, if any, might range from the quantification of the flight environment to test simulation and/or qualification and flight acceptance of flight articles.

Test simulation and methodologies will be presented and demonstrated in the laboratory. Relevant sections from Wayne Tustin’s text will be reviewed and will be extended into applicable current technical papers and guidelines. This material will be supplemented by the instructor’s pyro-shock measurement, SRS analysis, calibration and pyro-shock testing techniques handouts.


## Instructor

**Vladimir Valentekovich** teaches about pyrotechnic and other forms of shock testing, measurement, analysis and calibration and consults in these fields. He is a graduate of UCLA with his Bachelor and Masters of Science in Mechanical Engineering. He worked as a Senior Test Engineer in Structural Dynamics, specializing in pyrotechnic shock, at Wyle Laboratories, El Segundo.

Vladimir was responsible for quantifying and publishing the high velocity, short duration stress wave resultant in near-field pyroshock, as referenced in the IES Recommended Practice 012.1 Handbook for Dynamic Data Acquisition and Analysis, Appendix A, Pyroshock and the 5th ed. Harris and Piersol Shock and Vibration Handbook, Chapter 26 Part II. Vladimir received the SAVIAC 64th Symposium Henry Pusey Award for this work in 1994.

Wyle Laboratories then was the first independent contractor to do pyroshock qualification testing using the Tomahawk Cruise Missile U/RGM-109D flight structure: from instrumentation, specifying the data acquisition system, placing the charge, to acquiring and analyzing the resultant data.

Valentekovich developed many pyrotechnic shock test methods still used at Wyle. He continues to develop alternate pyro shock methods and test equipment including mechanical impact and ballistic shock simulations.

Vladimir currently consults for aerospace and defense firms who seek to design, perform and complete meaningful dynamics test programs.

## Who Should Attend

This short course is intended for a wide range of technical people, ranging from test technicians to test engineers to design engineers to senior scientists, who need to understand and conduct tests utilizing (or at least simulating) explosions. They also need to measure, record and analyze what happens to test hardware during and immediately after those brief events. Real world pyro shocks occur during explosions and explosive discharges, such as rocket engine ignition, stage separation, etc.

## What You Will Learn

The objective of this course is to introduce the designer, technician and/or engineer to the phenomena of high intensity, short duration field and test laboratory transients and the possible deleterious effects on equipment.

**August 17-19, 2021**

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Course Outline

**1. Definition of Pyro Shock Sources.**
- High Order Explosives (PETN, RDX, Detonation, etc.)
- Low Order Explosives (Gas Generators, Pressure Generators, Deflagration etc.)

**2. Physics.**
- Stress Wave Propagation
- Structural Response.

**3. Data Acquisition System.**
- Source
- Instrumentation
  - Accelerometer – Various Types
  - Signal Conditioning
  - Filtering, High Pass and Low Pass
  - Data Storage
    - Analog (Recall Honeywell RTR Recorders – Long Extinct)
    - Digital
      - Analog to Digital Conversion
      - Sigma Delta Converters
      - Low Pass Filtering Requirements
    - Calibration Of Data Acquisition System
  - Data Integrity – Verification And Analysis
    - Time History Examination
    - Frequency Domain
      - FFT
      - Shock Response Spectrum

**4. Ordnance Testing Methodologies.**
- Gathering And Storing Flight Data
- Full Scale Structure Simulation
- Sub Scale Structure Simulation
- Surrogate Structure Simulation
- Testing Real Hardware That Is Later To Fly

**5. Simulation Testing Methodologies.**
- Electrodynamic Shaker
- Enhanced Electrodynamic Shaker
- Resonant Fixturing
- Mechanical Impact
- Gravity Driven Impact
- Testing Hardware That Is Later To Fly

**6. Testing Examples.**
- Ordnance Pyroshock Test Demonstration By Nts
- Electrodynamic Shaker Pyroshock Simulation Test Demonstration By Nts
- Mechanical Impact Pyroshock Simulation Test Demonstration By Nt

# Radar 101 / 201

## RADAR 101

### Fundamentals of Radar

**August 3, 2021**

Live Virtual

**$850** (8:30am - 4:00pm)

**"Register 3 or More & Receive $50⁰⁰ each Off The Course Tuition."**

## RADAR 201

### Advances in Modern Radar

**August 4, 2021**

Live Virtual

**$850** (8:30am - 4:00pm)

**"Register 3 or More & Receive $50⁰⁰ each Off The Course Tuition."**

**Dr. Menchem Levitas** has forty four years of experience in science and engineering, thirty six of which have consisted of direct radar and weapon systems analysis, design, and development. Throughout his tenure he has provided technical support for many shipboard and airborne radar programs in many different areas including system concept definition, electronic protection, active arrays, signal and data processing, requirement analyses, and radar phenomenology. He is a recipient of the AEGIS Excellence Award for the development of a novel radar cross-band calibration technique in support of wide-band operations for high range resolution. He has developed innovative techniques in many areas e.g., active array self-calibration and failure-compensation, array multi-beam-forming, electronic protection, synthetic wide-band, knowledge-based adaptive processing, waveforms and waveform processing, and high fidelity, real-time, littoral propagation modeling. He has supported many AESA programs including the Air Force's Ultra Reliable Radar (URR), the Atmospheric Surveillance Technology (AST), the USMC's Ground/Air Task Oriented Radar (G/ATOR), the 3D Long Range Expeditionary Radar (3DLRR), and others. Prior to his retirement in 2013 he had been the chief scientist of Technology Service Corporation's Washington Operations.

***ATTEND EITHER OR BOTH RADAR COURSES!***

## Summary

This concise one-day course is intended for those with only modest or no radar experience. It provides an overview with understanding of the physics behind radar, tools used in describing radar, the technology of radar at the subsystem level and concludes with a brief survey of recent accomplish-ments in various applications.

## Course Outline

1. **Introduction.** The general nature of radar: composition, block diagrams, photos, types and functions of radar, typical characteristics.

2. **The Physics of Radar.** Electromagnetic waves and their vector representation. The spectrum bands used in radar. Radar waveforms. Scattering. Target and clutter behavior representations. Propagation: refractivity, attenuation, and the effects of the Earth surface.

3. **The Radar Range Equation.** Development from basic principles. The concepts of peak and average power, signal and noise bandwidth and the matched filter concept, antenna aperture and gain, system noise temperature, and signal detectability.

4. **Thermal Noise and Detection in Thermal Noise.** Formation of thermal noise in a receiver. System noise temperature (Ts) and noise figure (NF). The role of a low-noise amplifier (LNA). Signal and noise statistics. False alarm probability. Detection thresholds. Detection probability. Coherent and non-coherent multi-pulse integration.

5. **The sub-systems of Radar.** Transmitter (pulse oscillator vs. MOPA, tube vs. solid state, bottled vs. distributed architecture), antenna (pattern, gain, sidelobes, bandwidth), receiver (homodyne vs. super heterodyne), signal processor (functions, front and back-end), and system controller/tracker. Types, issues, architectures, tradeoff considerations.

5. **Current Accomplishments and Concluding Discussion.**

## Summary

This one-day course is a supplement to the basic course Radar 101, and probes deliberately deeper into selected topics, notably in signal processing to achieve (generally) finer and finer resolution (in several dimensions, imaging included) and in antennas wherein the versatility of the phased array has made such an impact. Finally, advances in radar's own data processing - auto-detection, more refined association processes, and improved auto-tracking - and system wide fusion processes are briefly discussed.

## Course Outline

1. **Introduction.** Radar's development, the metamorphosis of the last few decades: analog and digital technology evolution, theory and algorithms, increased digitization: multi-functionality, adaptivity to the environment, higher detection sensitivity, higher resolution, increased performance in clutter.

2. **Modern Signal Processing.** Clutter and the Doppler principle. MTI and Pulse Doppler filtering. Adaptive cancellation and STAP. Pulse editing. Pulse Compression processing. Adaptive thresholding and detection. Ambiguity resolution. Measurement and reporting.

3. **Electronic Steering Arrays (ESA): Principles of Operation.** Advantages and cost elements. Behavior with scan angle. Phase shifters, true time delays (TTL) and array bandwidth. Other issues.

4. **Solid State Active Array (SSAA) Antennas (AESA).** Architecture. Technology. Motivation. Advantages. Increased array digitization and compatibility with adaptive pattern applications. Need for in-place auto-calibration and compensation.

5. **Modern Advances in Waveforms.** Pulse compression principles. Performance measures. Some legacy codes. State-of-the-art optimal codes. Spectral compliance. Temporal controls. Orthogonal codes. Multiple-input Multiple-output (MIMO) radar.

6. **Data Processing Functions.** The conventional functions of report to track correlation, track initiation, update, and maintenance. The new added responsibilities of managing a multi-function array: prioritization, timing, resource management. The Multiple Hypothesis tracker.

7. **Concluding Discussion.** Today's concern of mission and theatre uncertainties. Increasing requirements at constrained size, weight, and cost. Needs for growth potential. System of systems with data fusion and multiple communication links.

# Radar Systems Design & Engineering

## Radar Performance Calculations

**July 26-29, 2021**

Live Virtua

**$2290** **(8:30am - 4:30pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary

This four-day course covers radar functionality, architecture, and performance. Fundamental radar issues such as transmitter stability, antenna pattern, clutter, jamming, propagation, target cross section, dynamic range, receiver noise, receiver architecture, waveforms, processing, and target detection are treated in detail within the unifying context of the radar range equation, and examined within the contexts of surface and airborne radar platforms and their respective applications. Advanced topics such as pulse compression, electronically steered arrays, and active phased arrays are covered, together with the related issues of failure compensation and auto-calibration. The fundamentals of multi-target tracking principles are covered, and detailed examples of surface and airborne radars are presented. This course is designed for engineers and engineering managers who wish to understand how surface and airborne radar systems work, and to familiarize themselves with pertinent design issues and the current technological frontiers.

## Instructors

**Dr. Menachem Levitas** has 36 years of experience in radar and weapon systems analysis, design, and development. Throughout his tenure he has provided technical support for shipboard and airborne radar programs in many different areas including system concept definition, electronic protection, active arrays, signal and data processing, requirement analyses, and radar phenomenology. He is a recipient of the AEGIS Excellence Award. He has supported many radar programs including the Air Force's Ultra Reliable Radar (URR), the Atmospheric Surveillance Technology (AST), the USMC's Ground/Air Task Oriented Radar (G/ATOR), the 3D Long Range Expeditionary Radar (3DLRR), and others. He was the chief scientist of Technology Service Corporation's Washington Operations.

**Stan Silberman** is a member of the Senior Technical Staff of the Applied Physics Laboratory. He has over 30 years of experience in tracking, sensor fusion, and radar systems analysis and design for the Navy, Marine Corps, Air Force, and FAA. Recent work has included the integration of a new radar into an existing multisensor system and in the integration, using a multiple hypothesis approach, of shipboard radar and ESM sensors. Previous experience has included analysis and design of multiradar fusion systems, integration of shipboard sensors including radar, IR and ESM, integration of radar, IFF, and time-difference-of-arrival sensors with GPS data sources, and integration of multiple sonar systems on underwater platforms.

## What You Will Learn

- What are radar subsystems.
- How to calculate radar performance.
- Key functions, issues, and requirements.
- How different requirements make radars different.
- Operating in different modes & environments.
- ESA and AESA radars: what are these technologies, how they work, what drives them, and what new issues they bring.
- Issues unique to multifunction, phased array, radars.
- State-of-the-art waveforms and waveform processing.
- How airborne radars differ from surface radars.
- Today's requirements, technologies & designs.

## Course Outline

**1. Introduction.** Radar systems examples. Radar ranging principles, frequencies, architecture, measurements, displays, and parameters. Radar range equation; radar waveforms; antenna patterns, types, and parameters.

**2. Noise in Receiving Systems and Detection Principles.** Noise sources; statistical properties. Radar range equation; false alarm and detection probability; and pulse integration schemes. Radar cross section; stealth; fluctuating targets; stochastic models; detection of fluctuating targets.

**3. CW Radar, Doppler, and Receiver Architecture.** Basic properties; CW and high PRF relationships; dynamic range, stability; isolation requirements, techniques, and devices; superheterodyne receivers; in-phase and quadrature receivers; signal spectrum; spectral broadening; matched filtering; Doppler filtering; Spectral modulation; CW ranging; and measurement accuracy.

**4. Radio Waves Propagation.** The pattern propagation factor; interference (multipath,) and diffraction; refraction; standard refractivity; the 4/3 Earth approximation; sub-refractivity; super refractivity; trapping; propagation ducts; littoral propagation; propagation modeling; attenuation.

**5. Radar Clutter and Detection in Clutter.** Volume, surface, and discrete clutter, deleterious clutter effects on radar performance, clutter characteristics, effects of platform velocity, distributed sea clutter and sea spikes, terrain clutter, grazing angle vs. depression angle characterization, volume clutter, birds, Constant False Alarm Rate (CFAR) thresholding, editing CFAR, and Clutter Maps.

**6. Clutter Filtering Principles.** Signal-to-clutter ratio; signal and clutter separation techniques; range and Doppler techniques; principles of filtering; transmitter stability and filtering; pulse Doppler and MTI; MTD; blind speeds and blind ranges; staggered MTI; analog and digital filtering; notch shaping; gains and losses. Performance measures: clutter attenuation, improvement factor, subclutter visibility, and cancellation ratio. Improvement factor limitation sources; stability noise sources; composite errors; types of MTI.

**7. Radar Waveforms.** The time-bandwidth concept. Pulse compression; Performance measures; Code families; Matched and mismatched filters. Optimal codes and code families: multiple constraints. Performance in the time and frequency domains; Mismatched filters and their applications; Orthogonal and quasi-orthogonal codes; Multiple-Input-Multiple-Output (MIMO) radar; MIMO waveforms and MIMO antenna patterns.

**8. Electronically Scanned Radar Systems.** Fundamental concepts, directivity and gain, elements and arrays, near and far field radiation, element factor and array factor, illumination function and Fourier transform relations, beamwidth approximations, array tapers and sidelobes, electrical dimension and errors, array bandwidth, steering mechanisms, grating lobes, phase monopulse, beam broadening, examples.

**9. Active Phased Array Radar Systems.** What are solid state active arrays (SSAA), what advantages do they provide, emerging requirements that call for SSAA (or AESA), SSAA issues at T/R module, array, and system levels, digital arrays, future direction.

**10. Multiple Simultaneous Beams.** Why multiple beams, independently steered beams vs. clustered beams, alternative organization of clustered beams and their implications, quantization lobes in clustered beams arrangements and design options to mitigate them.

**11. Auto-Calibration Techniques in Active Phased Array Radars:** Motivation; the mutual coupling in a phased array radar; external calibration reference approach; the mutual coupling approach; architectural.

**12. Module Failure and Array Auto-compensation:** The 'bathtub' profile of module failure rates and its three regions, burn-in and accelerated stress tests, module packaging and periodic replacements, cooling alternatives, effects of module failure on array pattern, array auto-compensation techniques to extend time between replacements, need for recalibration after module replacement.

**13. Surface Radar.** Principal functions and characteristics, nearness and extent of clutter, effects of anomalous propagation, the stressing factors of dynamic range, signal stability, time, and coverage requirements, transportation requirements and their implications, sensitivity time control in classical radar, the increasing role of bird/angel clutter and its effects on radar design, firm track initiation and the scan-back mechanism, antenna pattern techniques used to obtain partial relief.

**14. Airborne Radar.** Frequency selection; Platform motion effects; iso-ranges and iso-Dopplers; antenna pattern effects; clutter; reflection point; altitude line. The role of medium and high PRF's in lookdown modes; the three PRF regimes; range and Doppler ambiguities; velocity search modes, TACCAR and DPCA.)

**15. Synthetic Aperture Radar.** Principles of high resolution, radar vs. optical imaging, real vs. synthetic aperture, real beam limitations, simultaneous vs. sequential operation, derivations of focused array resolution, unfocused arrays, motion compensation, range-gate drifting, synthetic aperture modes: real-beam mapping, strip mapping, and spotlighting, waveform restrictions, processing throughputs, synthetic aperture 'monopulse' concepts.

**16. Multiple Target Tracking.** Definition of Basic terms. Track Initiation: Methodology for initiating new tracks; Recursive and batch algorithms; Sizing of gates for track initiation. M out of N processing. State Estimation & Filtering: Basic filtering theory. Least-squares filter and Kalman filter. Adaptive filtering and multiple model methods. Use of suboptimal filters such as table look-up and constant gain. Correlation & Association: Correlation tests and gates; Association algorithms; Probabilistic data association and multiple hypothesis algorithms.

# Rockets & Launch Vehicles: Selection & Design

## September 21-24, 2021

Live Virtual

**$2290** (8:30am - 4:00pm)

**"Register 3 or More & Receive $100⁰⁰ each Off The Course Tuition."**


## Summary

This four-day course provides an overview of rockets and missiles, including a fourth day covering advanced selection and design processes. The course provides a wide practical knowledge in rocket and missile issues and technologies. The seminar is designed for engineers, supporting disciplines, decision makers and managers of current and future projects needing a more complete understanding of the complex issues of rocket and missile technology. The seminar provides a foundation for understanding the issues that must be decided in the design, use, regulation, selection 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 both 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 in the multi-discipline world of rockets and missiles. The class provides what you need to know about how rockets and missiles work, why they are build the way they are, what they are used for and how they differ from use to use. You will learn how rockets and missiles differ when used as weapons, as launch vehicles, and in spacecraft or satellites. The objective is to give the decision maker all the tools needed to understand the available choices, and to manage or work with other technical experts of different specialized disciplines.


## Instructor

**Daniel J. Moser** has been an engineer, innovator, and entrepreneur in the aerospace industry for over 35 years. He has extensive experience in designing and developing launch vehicles, liquid rocket propulsion systems, ablatively-cooled thrust chambers / nozzles, filament-wound composite vessels (liquid propellant tanks, high-pressure gas storage vessels, solid rocket motorcases, and crash-worthy external aircraft fuel tanks), wings, control surfaces, fuselages, radomes, spars, missile tail fins, bulkheads, reentry heat shields, and landing gear. Mr. Moser has a B.S. in Physics, and M.E. in Mechanical Engineering, University of Utah.

## What You Will Learn

- Fundamentals of rocket and missile systems, functions and disciplines.
- The full spectrum of rocket systems, uses and technologies.
- Optimum Selection and Design strategies.
- Fundamentals and uses of solid, liquid and hybrid rocket systems.
- Differences between weapons systems and those built for commerce.

## Course Outline

1. **Introduction to Rockets and Missiles.** The student is introduced to the historic and practical uses of rocket systems.

2. **Classifications of Rockets and Missiles.** The classifications and terminology of all types of rocket systems are defined.

3. **Rocket Propulsion made Simple.** The chemistry and physics of all rockets and rocket nozzles operate to achieve thrust is explained. Rocket performance modeling is introduced.

4. **Rocket Flight Environments.** The flight environments of rockets, such as acceleration, heating, shock, and vibration, are explored.

5. **Aerodynamics and Winds.** The effect of winds, atmospheric density and velocity on lift, drag, and dynamic pressure is explained. Rocket shape, stability and venting are discussed.

6. **Performance Analysis and Staging.** The use of performance modeling and loss factors, are defined. Staging theory for multi-stage rockets are explained.

7. **Mass Properties and Propellant Selection.** The relative importance of specific impulse, bulk density, bulk temperature, storability, ignition properties, stability, toxicity, operability, material compatibility, and ullege. Monopropellant and cold gas propellants are introduced.

8. **Introduction to Solid Rocket Motors.** The historical and technological aspects of Solid Rocket Motors. Solid rocket materials, propellants, thrust-profiles, construction, cost advantages and special applications.

9. **Fundamentals of Hybrid Rockets.** The technology and Problems of hybrid.

10. **Liquid Rocket Engines.** Pressure and pump-fed liquid rocket engines are explained, including injectors, cooling, chamber construction, pump cycles, ignition and thrust vector control.

11. **Introducing the Liquid Rocket Stage.** Liquid rocket stages are introduced, including tank systems, pressurization, cryogenics, and other structures.

12. **Thrust Vector Control.** Thrust Vector control hardware and alternatives are explained.

13. **Basic Rocket Avionics.** Flight electronics elements of Guidance, Navigation, Control, Communications, Telemetry, Range Safety and Payloads are defined.

14. **Modern Expendable Launch Vehicles.** Good launch vehicle design.

15. **Rockets in Spacecraft Propulsion.** The differences between systems on spacecraft, satellites and transfer stages, operating in microgravity.

16. **Launch Sites and Operations.** The role and purpose of launch sites, and the choices available for a launch operations infrastructure.

17. **Useful Orbits & Trajectories Made Simple.** A simplified presentation of orbital mechanics, for the understanding rocket propulsion in orbital trajectories and maneuvers.

18. **Safety of Rocket Systems.** The hazards and mitigations of rocket operations.

19. **Reliability of Rocket Systems.** Reliability, and strategies to improve reliability, are discussed, including random and systematic failures, reliability environments, quality, robustness, and redundancy.

20. **Reusable Launch Vehicle Theory.** Why Reusable Launch Vehicles have had difficulty replacing expendable launch vehicles.

21. **Rocket Cost Principals and Cases.** Cost estimation methods modeling systems as a science, including why costs are so high. Strategies from the Soyuz Case illustrate alternatives and to cost reduction. Integrated modeling and incentives are introduced.

22. **Chemical Rocket Propulsion Alternatives.** Alternatives to chemical rocket propulsion includes air breathing, nuclear, thermal, cannons, and tethers.

23. **Proliferation of Missile Technology.** Foreign Rocket threats.

24. **The Future of Rockets and Missiles.** The direction of rocket technology, science, usage and regulations is conducted.

25. **Opportunities to Select and/or Design Optimum Launch Vehicles.** This fourth day will help you understand optimization processes for both the design and selection of Launch Vehicles.

26. **Selection.** Time and circumstances of optimum selection and the reasons.

27. **Optimizing the Selection Trade Study Process.** Standard vs. optimum processes are explained.

28. **Integrating Available Information on Alternatives.** All Launch Vehicle characteristics must be accurately determined.

29. **The Goals and Incentives of Launch Vehicle Design.** Setting goals and incentives for a success project. Goals and incentives of the past explain future successes and failures.

30. **Optimum Launch Vehicle Design Strategies.** Optimum design strategies are explained to the extent that the student will understand what works and what fails. These strategies are barley understood throughout the Aerospace community, leading to many bad assumptions.

31. **Understanding Why Good Designs Succeed.** The strategies from Soyuz, Delta, Space-X, and beyond, are wrapped.

# Rockets & Missiles

## Fundamentals

**November 16-18, 2021**

Live Virtual

**$2090** (8:30am - 4:00pm)

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary


This 3-day course provides an overview of rockets and missiles for government and industry officials, even those with limited technical experience in rockets and missiles. It provides a practical knowledge in rocket and missile issues and technologies. The seminar provides a foundation for understanding the issues that must be decided 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 both 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 in the multi-discipline world of rockets and missiles. You will learn what you need to know about how rockets and missiles work, why they are build the way they are, what they are used for and how they differ from use to use; how rockets and missiles differ when used as weapons, as launch vehicles, and in spacecraft or satellites. The objective is to give the decision maker all the tools needed to understand the available choices, and to manage or work with other technical experts of different specialized disciplines.


## Instructor

**Daniel J. Moser** has been an engineer, innovator, and entrepreneur in the aerospace industry for over 35 years. He has extensive experience in designing and developing launch vehicles, liquid rocket propulsion systems, ablatively-cooled thrust chambers / nozzles, filament-wound composite vessels (liquid propellant tanks, high-pressure gas storage vessels, solid rocket motorcases, and crash-worthy external aircraft fuel tanks), wings, control surfaces, fuselages, radomes, spars, missile tail fins, bulkheads, reentry heat shields, and landing gear. Mr. Moser has a B.S. in Physics, and M.E. in Mechanical Engineering, University of Utah.

## What You Will Learn

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

## Who Should Attend

- Aerospace Industry Managers.
- Government Regulators, Administrators and sponsors of rocket or missile projects.
- Engineers of all disciplines supporting rocket and missile projects.
- Contractors or investors involved in missile development.

## Course Outline

1. **Fundamentals of Rockets and Missiles:** The historic and practical uses of rocket systems.

2. **Classifications of Rockets and Missiles:** The classifications and terminology of all types of rocket and missile systems are defined.

3. **Rocket Propulsion made Simple:** The chemistry and physics defining how all rockets and rocket nozzles operate to achieve thrust is explained. Rocket performance modeling and efficiencies are introduced.

4. **Rocket Flight Environments:** The flight environments of rockets, acceleration, propellant consumption, heating, shock, vibration, ascent profile and plume phenomenology are explored.

5. **Aerodynamics and Winds:** The effect of winds, atmospheric density, pressure and rocket velocity on lift, drag, and dynamic pressure is explained. Rocket shape, stability and venting requirements are discussed.

6. **Performance Analysis and Staging:** The use of low and high fidelity performance modeling, including performance loss factors, are defined. Staging theory, performance and practices for multi-stage rockets are explained.

7. **Mass Properties and Propellant Selection:** No aspect is more important, or more often mismanaged, that optimum propellant selection. The relative importance of specific impulse, bulk density, bulk temperature, storability, ignition properties, stability, toxicity, operability, compatibility with materials, ullege requirements, and special mixtures are defined. Monopropellant and cold gas propellants are introduced.

8. **Introduction to Solid Rocket Motors:** The historical and technological aspects of Solid Rocket Motors is explored to understand the applications, advantages, disadvantages and tradeoffs over other forms of rockets. Solid rocket materials, propellants, thrust-profiles, construction, cost advantages and special applications are explained.

9. **Fundamentals of Hybrid Rockets:** The operation, safety, technology and Problems associated with hybrid rockets is discussed.

10. **Liquid Rocket Engines:** Issues of pressure and pump-fed liquid rocket engines are explained, including injectors, cooling, chamber construction, pump cycles, ignition and thrust vector control.

11. **Introducing the Liquid Rocket Stage:** The elements of liquid rocket stages are introduced, including propellant tank systems, pressurization, cryogenics, and other structures.

12. **Thrust Vector Control (TVC):** TVC hardware and alternatives are explained.

13. **Basic Rocket Avionics:** Flight electronics elements of Guidance, Navigation, Control, Communications, Telemetry, Range Safety and Payloads are defined.

14. **Modern Expendable Launch Vehicles:** The essence of good launch vehicle design is explored and defined, with examples of the American Delta-II and Russian strategy as an alternative.

15. **Rockets in Spacecraft Propulsion:** The differences in systems found on spacecraft, operating in microgravity, are examined.

16. **Launch Sites and Operations:** Understanding of the role and purpose of launch sites, and the choices available for a launch operations infrastructure.

17. **Useful Orbits & Trajectories Made Simple:** A simplified presentation of orbital mechanics, appropriate for the understanding of the role of rocket propulsion in orbital trajectories and maneuvers, is provided to the student.

18. **Safety of Rocket Systems:** The hazards and mitigations of inherently hazardous rocket operations are examined.

19. **Reliability of Rocket Systems:** Reliability issues for rocket systems, with strategies to improve reliability are explored and explained.

20. **Reusable Launch Vehicle Theory:** The student is provided with an appreciation of why Reusable Launch Vehicles have failed economically.

21. **Rocket Cost Principals and Cases:** The student is introduced to cost estimation methods and cost model systems as a science. An understanding of why costs are so high is provided, with alternative strategies from the Soyuz Case to illustrate alternatives to cost reduction.

22. **Chemical Rocket Propulsion Alternatives:** Alternatives to chemical rockets like jets, nuclear or thermal engines, cannons, tethers and laser weapons.

23. **Proliferation of Missile Technology:** International Trafficking in Arms issues.

24. **The Future of Rockets and Missiles:** A final open discussion regarding the direction of rocket technology, science, usage and regulations of rockets. missiles is conducted to close out the class.

# Always Available – Pre-recorded Coures

## Concurrent Multi-Netting / Concurrent Contention Receive

### Summary

The CMN-4 program greatly increases the amount of tactical information that can be exchanged network-wide, while simultaneously increasing the potential probability of reception, if configured correctly. When coupled with Enhanced Throughput, it is an information exchange game-changer in the future battlespace.

### Outline

- CMN-4 Program Summary
- Multi-Netting Refresh and Review
- Concurrent Multi-Netting (the basics)
- Contention Access Rh and Review
- Concurrent Contention Receive (the basics)
- CMN-4 Technical Enablers (comprehensive explanation

**Pre-Recorded** – Always Available
**$300**
**Attend one or more or all!**

## Network Enabled Weapons

### Summary

Link 16 Network Enabled Weapons (NEW) fuse the proven networking technology of Link 16 with enhanced Precision Guided Munitions to deliver a game-changing capability to the warfighter. Weapons controlled via Link 16 improves accuracy, supports target adjustments, retargeting, BDA, and weapon abort. The course contains hundreds of graphics and animations designed to help the student visualize how the capability is delivered in the joint battlespace.

### Outline

- Intro to Network Enabled Weapons
- J11.0 Message Overview
- J11.0 Weapon Response/Status
- J11.1 Weapon Directive Messages • J11.2 Weapon Coordination Message
- J11.X Message Acknowledgement
- Weapon In-Flight Track • Bomb-Hit Indication Report
- In-Flight Target Updates / Retargeting

**Pre-Recorded** – Always Available
**$600**
**Attend One or More or All!**

## Understanding Link 16: Enhanced Throughput

### Summary

Link 16 Enhanced Throughput increases time slot capacity from 12-words (107,520 bps) to 123-words (1,102,080 bps). Understanding the complex processes associated with LET is critical to being able to realize its potential benefits in the battlespace.

### Outline

- Link 16 Enhanced Throughput Background
- Host Interfaces
- Link 16 Enhanced Throughput (LET)
- Link 16 Enhanced Throughput Error Detection and Correction
- Convolution Encoding
- LET Message Structure
- Link 16 Enhanced Throughput Message Body

**Pre-Recorded** – Always Available
**$600**
**Attend One or More or All!**

## INCOSE CSEP / ASEP Self-Paced

### Summary

This on-line course consisting of 7 modules with over 20 hours of teaching, available on-line delivered by a live instructor or a recorded on-line version that you can take at own pace (with replays) your own most convenient times. The course covers the entire INCOSE SE Handbook Version 4.0. Includes study guides, a comprehensive Process Flow diagram, practice quizzes and exams.

**See Page 26 for more details.**

**Pre-Recorded** – Always Available
**$650**
**Attend One or More or All!**

# Antenna and Array Fundamentals

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

**October 12-14, 2021**

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**


## 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. A comprehensive set of course notes is included.


## Instructor

**Dr. Steven Weiss** is a senior design engineer with the Army Research Lab. 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. 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. **RF Field 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. **Software Simulation Concepts.** Discussion and distinction between: Finite Difference Time Domain (FDTD), the method of moments (MoM), and the Finite Element Method (FEM.) Some commercial codes that use these techniques.

10. **Throughput And Data Rates.** Various antennas are examined to quantify suitability for data transmission.

11. **Special Topics.** The class can be tailored to meet the desired needs of the students.

12. **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.***

# Composite Materials for Aerospace

## Composite Materials, Processing, Fabrication, Design, Analysis and Applications:


## Summary

This three-day course will be of use to design engineers, structural engineers, and materials engineers in the selection of composite materials, design, analysis, processing and fabrication of composite structures. Will include worked numerical examples, physical material samples for classroom examination and references for later application.


## Instructors

**Dr. Jack Roberts** ASME Fellow, specializes in structural analysis & design, composite materials, biomedical & biomechanics and proposal writing. Dr Roberts is a previous member of the Principal Professional Staff at the Johns Hopkins University Applied Physics Laboratory, where he has performed hand structural analysis and finite element modeling on composite structures for Aerospace, Naval, Space and biomedical applications. Dr. Roberts has a Ph.D. in mechanical Engineering from Rensselaer Polytechnic institute and has his own consulting business. Dr. Roberts has over 120 publications, presentations and proceedings, 16 patents, 3 book chapters and numerous

**Mr. Paul Biermann** is a materials and process engineer and a member of the Principal Professional Staff at the Johns Hopkins Applied Physics Laboratory, with over 36 years experience in design, manufacturing and characterization of composite materials and engineering polymers. His has worked on composite components for spacecraft, biomedical applications and for undersea deployment. He has an extensive background in composite cure and assembly techniques, polymer molding and casting, tooling and mold fabrication, adhesive bonding, and test equipment and methods. He holds the degree of BS in Materials Engineering from Rensselaer Polytechnic Institute. Mr. Biermann has 37 published papers and two book chapters. He also holds 17 US patents.

## What You Will Learn

- What are composite materials?
- How to process composite materials and how that affects your design.
- What are anisotropic materials?
- What is laminate analysis?
- What are the failure theories used for composites?
- What is a laminate code and what does it do?
- How is a laminate code used to design a composite structure?
- What is an orthotropic material?
- How to break a structure down into simple plates and shells for preliminary analysis.
- What design equations can be used for orthotropic materials?
- What are the applications of these equations to plates and shells under in-plane or out-of-plane loads?

From this course you will obtain the knowledge and ability to perform basic composite materials selection, separate structures into basic plates and shells for initial preliminary design, perform design and analysis with composite materials, identify tradeoffs, understand the use of special equations for orthotropic materials under in-plane and out-of-plane loads for plates and shells, interact meaningfully with colleagues, and understand the literature.

## August 10-12, 2021

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**"Register 3 or More & Receive $100^{00}$ each Off The Course Tuition."**

## Course Outline

**Day 1 – Composites:** *What are they and how do you use them?*

1. **Composite Materials.** What are they? Why use them?
2. **Past Examples of Composite Applications.** From ancient building materials to aerospace structural solutions.
3. **Reinforcement Materials.** Glass, Carbon, Ceramics and Metals. Fibers and other forms.
4. **Matrix Materials.** Resin systems including thermosetting and thermoplastic. Safety issues. Materials sources, storage and handling requirements.
5. **Processing.** Methods available and why processing and design cannot be treated separately. Tooling design, materials and repair. New developments.
6. **Quality Assurance.** Physiochemical testing. Mechanical testing. Non-destructive testing.

**Day 2 – How to design and analyze composite material structures.**

7. **Laminate Analysis.** Nomenclature, anisotropic and orthotropic equations, material properties, failure theories.
8. **Use of "The Laminator".** Material properties, strengths, ply angles, ply thicknesses, mechanical loads (forces and moments), thermal loads, moisture loads.
9. **Preliminary Design and Analysis.** For preliminary analysis many structures can be broken-down into series of flat rectangular plates or shells.
10. **Composite Orthotropic Plate Bending and Buckling.** Closed-form and approximate equations for bending and buckling of flat rectangular orthotropic plates due to uniform out-of-plane pressure or in-plane compressive loads.
11. **Sandwich Plate Bending and Buckling.** Equations for honeycomb core sandwich plates using composite face sheets.
12. **Cylindrical Shell Bending and Buckling.** Equations for torsion, bending, buckling, or internal/external pressurization of composite cylindrical shells. Shells under multiple loads.

**Day 3- Applications.**

13. **Buckling and Bending of Orthotropic Plates.**
14. **EMI Shielding of Composites.**
15. **Design Techniques for Electronic Enclosures.**
16. **Composite Electronic Enclosure Optimization.**
17. **Composite Bone Implant Design and analysis.**
18. **Re-Design of an Aluminum Electro-Optical Shroud in Composites.**

# Deep Learning Architectures for Defense and Security

## Summary

This 3-day course provides a broad introduction to classical neural networks (NN) and its current evolution to deep learning (DL) technology. This course introduces the well-known deep learning architectures and their applications in defense and security for object detection, identification, verification, action recognition, scene understanding and biometrics using a single modality or multimodality sensor information. This course will describe the history of neural networks and its progress to current deep learning technology. It covers several DL architectures such the classical multi-layer feed forward neural networks, convolutional neural networks (CNN), generative adversarial networks (GAN), restricted Boltzmann machines (RBM), auto-encoders and recurrent neural networks such as long term short memory (LSTM).

Use of deep learning architectures for feature extraction and classification will be described and demonstrated. Examples of popular CNN-baased architectures such as AlexNet, VGGNet, GooGleNet (inception modules), ResNet, DeepFace, Highway Networks, FractalNet and their applications to defense and security will be discussed. Advanced architectures such as Siamese deep networks, coupled neural networks, conditional adversarial generative networks, fusion of multiple CNNs and their applications to object verification and classification will also be covered. The course is for scientists, engineers, technicians, or managers who wish to learn more about deep learning architectures and their applications in defense and security.

## Instructor

**Dr. Nasser M. Nasrabadi**, is a professor in the Lane Computer Science and Electrical Engineering Department at West Virginia University. He was senior research scientist (ST) at US Army Research Laboratory (ARL). He is actively engaged in research in deep learning, image processing, automatic target recognition and hyperspectral imaging for defense and security. He has published over 300 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing, IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.

## What You Will Learn

- Fundamental concepts of neural networks and deep learning.
- Differences between neural network and current deep learning architectures.
- Stochastic gradient descent algorithm to train deep learning networks.
- The popular CNN-based architectures (i.e., LeNet, AlexNet, VGGNet, GooGleNet, ResNet).
- Relative merits of various deep learning architectures, MLP, CNN, GAN, RBM and LSTM.
- Auto-encoders for feature extraction. Generative adversarial networks for object synthesis.
- Deep learning framework for object, pedestrian detection, face, iris, fingerprint identification.
- Siamese and coupled deep learning architectures for cross-modal object verification & identification.
- Deep learning architectures for multi-v.

**October 5-7, 2021**

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**"Register 3 or More & Receive $100⁰⁰ each Off The Course Tuition."**

## Course Outline

1. **History of Neural Networks.** Origin of the artificial neural networks (ANN) and its relationship with artificial intelligence & expert systems. Artificial neuron models vs biological neurons. Characteristics of receptive fields of neurons in visual cortex. Binary and continues perceptrons.

2. **Multi-layer Perceptrons.** Concept of layering, basics of gradient descent and backpropagation learning algorithm for network training.

3. **Activation Functions.** Non-linearity functions in neural networks, Hard limiting, Sigmoid, Tanh and ReLU functions.

4. **Overfitting and Generalization.** The concept of overfitting and generalization in deep learning, sparsity-based regularization, L1 sparsity, L2 sparsity and groups sparsity, concept of dropout as regularization.

5. **Auto-encoders.** Denoising autoencoders, hetero-associative auto-encoders, sparse autoencoders, convolutional autoencoders, learning manifold and dimensionality reduction.

6. **Restricted Boltzmann Machines.** Idea behind the classical RBM and deep belief nets.

7. **Convolutional Neural Network Architectures.** Concept of convolution neural network architectures and the functions of its layers. Use of different kernel sizes, average pooling, max pooling and concept of using overlapping and non-overlapping strides.

8. **Modern Convolutional Neural Network architectures.** LeNet, AlexNet, VGGNet, GoogleNet, ResNet, DeepFace, Highway Networks and FractalNet.

9. **Generative Adversarial Networks (GAN).** Concept of GAN and conditional GAN for cross-modality synthesis, image restoration and distortion removal.

10. **Coupled & Siamese Deep Neural Networks.** Cross-modal face and object classification, image search and retrieval, Cross-modal deep hashing, Siamese networks for distance metric learning.

11. **Multisensory Fusion Architectures.** Deep fusion architectures, deep learning architectures for multimodality and Multiview.

12. **Applications of Deep Neural Networks.** CNN-based object recognition and detection, deep automatic target recognition, deep biometrics (face, iris, fingerprint, voice), cross-spectral classification, scene-to-text generation, sketch-to-photo synthesis, object pedestrian detection from surveillance cameras or moving platforms.

# EMC PCB Design & Integration

**October 12-14, 2021**

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**"Register 3 or More & Receive $100<sup>00</sup> each Off The Course Tuition."**

## Summary

If you are a design or compliance engineer, it pays for you to know how and why EMI testing is conducted, as well as the typical causes of failure. This 3-day course offers all of the EMI information you'll need to design compliant Printed Circuit Boards (PCBs)—including design considerations at CAE and CAD levels—for you to provide a compliant radiation / susceptibility product. You'll examine ways to prevent common EMI/EMC problems regarding power supplies, cables, connectors, slots, discontinuity of ground planes and more. This three-day class will focus on EMI and RFI issues regarding PCBs, computers, analog designs and systems, along with relevant EMI regulations in the U.S., the European Union and Asia. Highlights include PCB radiation basics, radiation and bypass on PCBs, PCB radiation suppression techniques, grounding designs / filtering, crosstalk / termination, power and ground planes, antenna loops, spread spectrum clocking, and differential-mode and common-mode radiation. Enclosure and supplemental control techniques are presented as a part of design where the PCB control measures are restricted.

## Instructor

**Robert Hanson, MSEE**, has unmatched experience in teaching and knowledge of electronics. As a Testability Overseer for Boeing Commercial Airline products, Mr. Hanson has worked with non-EEs and EE's. His over 40 years of work experience in the design manufacturing and testing areas have enabled him to consult and train both nationally and internationally. As a digital design engineer at The Boeing Company, Rockwell, Honeywell, and Loral, Mr. Hanson designed and provided prototype operational analysis on many high-speed designs, including PCBs for AWACs, B1-B, 747-400, missiles, and ground support test equipment. He has played a very active role in automating the line, implementing robotics and participating in producibility studies, and working in the CAE/Cad/CAT, JIT, simulation and automatic assembly environments. He also has performed studies and headed research projects in the computer-integrated manufacturing environment. Mr. Hanson has extensive experience in the testing disciplines (both factory and field, commercial and military). His teaching experience include electronic conventions, over 100 private companies on site, and universities. Boeing Company awarded him Aerospace Man of the Year for saving $6,000,000 for inventing a new testing technique for the Boeing B-1 bomber electronics.

## What You Will Learn

This course will provide you with the knowledge to design a compliant EMC system right the first time. It provides a set of rules for both PCBs and enclosures to identify and correct EMI design deficiencies. It provides you with tips & techniques to successfully conduct compliance testing at the FCC, MIL-STD or EU testing facilities.

## Course Outline

1. **Fundamentals.** Frequency, time, and distance; lumped versus distributed systems, four kinds of reactance, ordinary and mutual capacitance and inductance.

2. **EMI Concerns.** EMI, source, path and receptor; threats, EMI issus, EMI regulations.

3. **Conducting a Compliance Test With Emphhasis on the PCB and Enclosure.** Conducted emissions, radiated emissions, RF immunity, conducted RF immunity, ESD, lightening, electrical fast transient, shock and EMP.

4. **EMI Design Requirements for PCBs.** Interference coupling mechanism, CM radiation, antenna loops, basics of PCB radiation, PCB suppression techniques, design for immunity, switching mode power supplies (SMPS).

5. **Design Considerations for EMI Compatibility.** Crosstalk – inductive/capacitive, forward/backward – how does it occur? Why does it cause radiation how is it minimized? Picket fences, Cu fills, spread spectrum clocking, bypass and radiation on PCBs, Near/Far field, differential/common coupling modes and resonance, analog circuitry.

6. **Power Distribution and Grounding.** Power/ground planes why do they cause radiation and how is it minimized? Splits, slots, moats, floats, drawbridge, how to design for minimizing emissions from power/ground planes. How to design for digital/analog (multibias) and single bias PCBs. Ideal stackups to be EMC.

7. **Cables/Connectors and PCB, Concerns of PCBs Interfacing with Filtering and Shielding.** Capacitive and magnetic shielding, slots in PCBs, shield grounding, cable radiation, shielding types, transfer impedance, shielding connection.

8. **Enclosures, Motherboards, Backplanes and Blades.** Loss of PCB ground plane in cables, how to design a PCB land trace to a connector pin to eliminate reflections, cables configuration, antenna loops with cable connections, high-speed connectors.

9. **Filtering and Shielding.** Shielding versus filtering, using ferrites, filtering mains supply, using transients suppressors on mains and I/O lines, radiation through shields.

10. **Backplane Layout Concerns.** Effects of source and load impedance and why mismatches cause radiation, the capacitive load: Zo and propagation delay and radiation effects, 90o, 45o bends, guard traces, interplane capacitance, via discontinuity and vias resonance concerns, backdrilling vias.

11. **Busses and Differentials.** Multidrop systems, drivers, transceivers, and designing a high-speed bus, attributes/drawbacks of loosely/tightly couple differential pairs, differential impedance, advantages and disadvantages of edge (side by side), broadside (dual), asymmetric, and microstrip differentials; reflections and crosstalk in differentials, matching electrical lengths.

12. **High Speed Clocking.** Clock, skew and jitter, the effects of ISI, skin, and dielectric losses; the effect of various base materials of long-haul transmission, a real-world example of compensation techniques.

13. **Apertures, Wave Lengths, Absorption Materials and Heat Sinking.** The major concern today is the aperture openings versus the frequency of signals versus the higher density packaging, i.e. ICs are running hotter and the ever increasing signal edge rate. This leads to more radiation through the apertures, i.e. lamda is shorter, but more heat is generated because Power = C times F times V2. What's new in enclosure absorption materials and what are their capabilities for minimizing radiation? What's new in heat sink materials (backplanes, blades, servers) which in turn alleviate the need for heat conduction through the apertures? These current issues will also be covered in the course.

# EMI / EMC in Military Systems

**Includes Mil Std-461/464 & Troubleshooting Addendums**

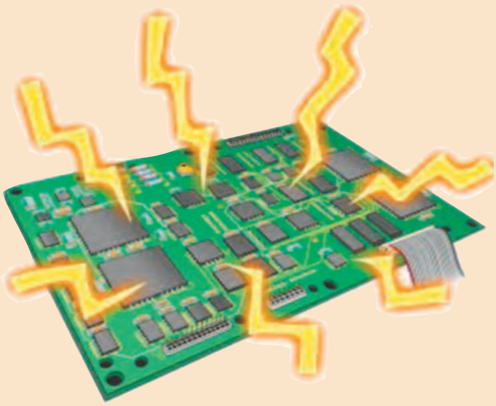
**June 22-24, 2021**

Live Virtual

(4 Half Days)

**$2090** **(10:00am - 3:00pm)**

**Register 3 or More & Receive $100[00] Each Off The Course Tuition.**



## Summary

Systems EMC (Electromagnetic Compatibility) involves the control of EMI (Electromagnetic Interference) at the systems, facility, and platform levels (e.g. outside the box.) This four half-days course provides a comprehensive treatment of EMI/EMC problems in military systems. These include both the box level requirements of MIL-STD-461 and the systems level requirements of MIL-STD-464. The emphasis is on prevention through good EMI/EMC design techniques - grounding, shielding, cable management, and power interface design. Troubleshooting techniques are also addressed in an addendum. Please note - this class does NOT address circuit boards issues. Each student will receive a copy of the *EDN Magazine Designer's Guide to EMC* by Daryl Gerke and William Kimmel, along with a complete set of lecture notes.

## Instructor

**Daryl Gerke**, PE, has worked in the electronics field for over 40 years. He received his BSEE from the University of Nebraska. His experience ranges includes design and systems engineering with industry leaders like Collins Radio, Sperry Defense Systems, Tektronix, and Intel. Since 1987, he has been involved exclusively with EMI/EMC as a founding partner of Kimmel Gerke Associates, Ltd. Daryl has qualified numerous systems to industrial, commercial, military, medical, vehicular, and related EMI/EMC requirements.

## What You Will Learn

- How to identify, prevent, and fix common EMI/EMC problems in military systems.
- Simple models and "rules of thumb" and to help you arrive at quick design decisions (NO heavy math).
- EMI/EMC troubleshooting tips and techniques.
- Design impact (by requirement) of military EMC specifications (MIL-STD-461 and MIL-STD-464)
- EMI/EMC documentation requirements (Control Plans, Test Plans, and Test Reports).

## Course Outline

1. **Introduction.** Interference sources, paths, and receptors. Identifying key EMI threats - power disturbances, radio frequency interference, electrostatic discharge, self-compatibility. Key EMI concepts - Frequency and impedance, Frequency and time, Frequency and dimensions. Unintentional antennas related to dimensions.

2. **Grounding - A Safety Interface.** Grounds defined. Ground loops and single point grounds. Multipoint grounds and hybrid grounds. Ground bond corrosion. Lightning induced ground bounce. Ground currents through chassis. Unsafe grounding practice.

3. **Power - An Energy Interface.** Types of power disturbances. Common impedance coupling in shared ground and voltage supply. Transient protection. EMI power line filters. Isolation transformers. Regulators and UPS. Power harmonics and magnetic fields.

4. **Cables and Connectors - A Signal Interface.** Cable coupling paths. Cable shield grounding and termination. Cable shield materials. Cable and connector ferrites. Cable crosstalk. Classify cables and connectors.

5. **Shielding - An Electromagnetic Field Interface.** Shielding principles. Shielding failures. Shielding materials. EMI gaskets for seams. Handling large openings. Cable terminations and penetrations.

6. **Systems Solutions.** Power disturbances. Radio frequency interference. Electrostatic discharge. Electromagnetic emissions.

7. **MIL-STD-461 & MIL-STD-464 Addendum.** Background on MIL-STD-461 and MIL-STD-464. Design/proposal impact of individual requirements (emphasis on design, NOT testing.) Documentation requirements - Control Plans, Test Plans, Test Reports.

8. **EMC Troubleshooting Addemdum.** Trouble shooting vs Design & Test. Using the "Differential Diagnosis" Methodology Diagnostic and Isolation Techniques - RFI, power, ESD, emissions.

# MIL-STD-461F(G) Test Methods & Compliance

**August 2-5, 2021**
Live Virtual
(Online Only)
**$1340** **(9:00am - 4:30pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary

Military and Aerospace Systems must comply with Electromagnetic Compatibility (EMC) requirements. MIL-STD-461G is applied to Department of Defense (DoD) procurements for equipment and subsystems and RTCA DO-160G is the EMC certification standard for commercial aviation. The EMC test and evaluation requirements have a lot of similarity and this course takes advantage of that similarity through instruction that combines the two standards.

MIL-STD-461G test and evaluation methods will be presented, including system requirements, general requirements, test article configurations, and documentation. This course offers critical information for military compliance professionals, testing industry professionals, and developers involved with electronics systems development. Instruction for each of the MIL-STD-461 test and measurement methods along with analysis of the test results will be covered.

DO-160G methods are integrated into the course by looking at the differences for requirements that are fundamentally alike during that method's discussion, along with supplementing the course material with DO-160G test methods that are not part of MIL-STD-461G.

This 5-day (approximately 7-hours/day) course provides detailed focus on performing the testing, reducing and understanding the data and managing test problems. It features practical methods to address the complexity of the standard configuration along with concepts to manage the unusual product types. The attendees are part of the laboratory tests where they participate in accomplishing the test to enhance retention of the material presented in the course.

## Instructor

**Steven G. Ferguson** is the owner of Compliance Direction, LLC and has been working in the compliance test arena for over 40 years at test laboratories and manufacturing companies designing products, developing procedures and performing tests. He presents various courses on EMI/EMC compliance including EMC for Nuclear Power Facilities, architectural Shielding and this course on MIL-STD-461 & DO-160 testing at customer facilities on-site for multiple government and industrial clients. He holds an iNARTE EMC engineer certification.

## Course Outline

- **Basic Concepts of Electromagnetic Effects**
- **Terms and Definitions**
- **EMI – The Problem**
- **Measurement Units (The Decibel)**
- **Electromagnetic Environment**
- **Standards: MIL-STD-464C, MIL-STD-461G, DO160G**
- **Data Item Descriptions (Control Plans, Test Procedures, Test Reports)**
- **Managing your EMI/EMC test program**
- **Emissions and Susceptibility, General concepts**
- **Interface Requirements / Facility requirements**
- **Configuring the test article**
- **Instrumentation**
- **Test Methods (MIL-STD-461G)**
- **Conducted Emissions**
- CE101, CE102*, CE106
- Section 21
- Conducted Susceptibility
- CS101*, CS103, CS104, CS105, CS109, CS114*, CS115, CS116*, CS117, CS118
- Sections 17, 18, 19, 20, 22, 23, 25
- **Radiated Emissions**
- RE101, RE102*, RE103
- Sections 15, 21
- **Radiated Susceptibility**
- RS101, RS103, RS105
- Section 20
- **Power Quality**
- Section 16
- **Summary and Review**

*** Test Methods Planned For Laboratory Sessions**

## What You Will Learn

- Details on test methods, purpose, test execution, data reduction and analysis.
- How to prepare for the test and configuration management.
- Tailoring the test approach to meet unique product evaluation needs.
- How to assess operation of automated test equipment for proper operation.
- How to develop alternative approaches to overcome technical obstacles.
- How to obtain data to guide design changes to resolve compliance issues.

## Who Should Attend

- EMC Test Engineers and Technicians.
- Program/project managers responsible for EMC evaluation oversight.
- Anyone who interprets EMC data or troubleshoots EMC issues.
- Design engineers responsible for EMC.

# MIL-STD-461G / RTCA DO-160G EMC
## Methods & Compliance (Online only)

**September 27-October 1, 2021**

Live Virtual

(4 Half Days)

**$1650** **(10:00am - 5:00pm)**

**Register 3 or More & Receive $100[00] Each Off The Course Tuition.**

## Summary

Military and Aerospace Systems must comply with Electromagnetic Compatibility (EMC) requirements. MIL-STD-461G is applied to Department of Defense (DoD) procurements for equipment and subsystems and RTCA DO-160G is the EMC certification standard for commercial aviation. The EMC test and evaluation requirements have a lot of similarity and this course takes advantage of that similarity through instruction that combines the two standards.

MIL-STD-461G test and evaluation methods will be presented, including system requirements, general requirements, test article configurations, and documentation. This course offers critical information for military compliance professionals, testing industry professionals, and developers involved with electronics systems development. Instruction for each of the MIL-STD-461 test and measurement methods along with analysis of the test results will be covered.

DO-160G methods are integrated into the course by looking at the differences for requirements that are fundamentally alike during that method's discussion, along with supplementing the course material with DO-160G test methods that are not part of MIL-STD-461G.

This five-day (approximately 6-hours/day) course provides detailed focus on performing the testing, reducing and understanding the data and managing test problems. It features practical methods to address the complexity of the standard configuration along with concepts to manage the unusual product types. Military and Aerospace Systems must comply with Electromagnetic Compatibility (EMC) requirements.

This is an iNARTE approved training course and qualifies for CPD credits required for continuing certification. If you are not iNARTE certified, Compliance Direction can provide guidance on obtaining your certification.

## Instructor

**Steven G. Ferguson**, has been working in the compliance test arena for over 40 years at test laboratories and manufacturing companies designing products, developing procedures and performing tests. He presents various courses on EMI/EMC compliance including EMC for Nuclear Power Facilities, Architectural Shielding, Electromagnetic Environmental Effects (EEE) and this course on MIL-STD-461 testing at customer facilities on-site for multiple government and industrial clients. He holds an iNARTE EMC engineer certification.

## Course Outline

- Basic Concepts of Electromagnetic Effects
- Terms and Definitions
- EMI – The Problem
- Measurement Units (The Decibel)
- Electromagnetic Environment
- Standards: MIL-STD-464C, MIL-STD-461G, DO160G
- Data Item Descriptions (Control Plans, Test Procedures, Test Reports)
- Managing your EMI/EMC test program
- Emissions and Susceptibility, General concepts
- Interface Requirements / Facility requirements
- Configuring the test article
- Instrumentation
- Test Methods (MIL-STD-461G)
- Conducted Emissions
- CE101, CE102, CE106

**DO-160: Section 21**

- Conducted Susceptibility

**CS101, CS103, CS104, CS105, CS109, CS114, CS115, CS116*, CS117, CS118**

**DO-160: Sections 17, 18, 19, 20, 22, 23, 25**

- Radiated Emissions

**RE101, RE102, RE103**

**DO-160: Sections 15, 21**

- Radiated Susceptibility

**RS101, RS103, RS105**

**DO-160: Section 20**

- Power Quality

**DO-160: Section 16**

- Summary and Review

## What You Will Learn

- EMC Test Engineers and Technicians.
- Program/project managers responsible for EMC evaluation oversight.
- Anyone who interprets EMC data or troubleshoots EMC issues.
- Design engineers responsible for EMC.

# Random Vibration & Shock Testing - Fundamentals

for Land, Sea, Air, Space Vehicles & Electronics Manufacture

**November 9-11, 2021**

San Diego, California

**$3200** **(8:00am - 4:00pm)**

**Register 3 or More & Receive $100[00] Each Off The Course Tuition.**

## 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, 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.

## Instructor

**Steve Brenner** has been working in the field of environmental simulation and reliability testing for over 30 years.

Beginning in the late sixties with reliability and design verification testing on the Lunar Module, the Space Shuttle in the eighties, to semiconductor manufacturing equipment in the nineties, Mr. Brenner has always been involved with the latest techniques for verifying equipment integrity through testing.

Mr. Brenner began his career as an Environmental test engineer with Grumman Aerospace Corporation in New York, worked as design verification and reliability engineer for the Air Force, an Environmental Test Engineer for Lockheed Missiles and Space company, and spent 18 years with Kaiser Electronics in San Jose, where he managed the Environmental Test Lab and was involved with the design of hardware intended for severe environments.

## 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.***

## 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.

# Wireless Communications & Spread Spectrum Design

## Summary

This three-day course is designed for wireless communication engineers involved with spread spectrum systems, and managers who wish to enhance their understanding of the wireless techniques that are being used in all types of communication systems and products. It provides an overall look at many types and advantages of spread spectrum systems that are designed in wireless systems today. Cognitive adaptive systems are discussed. This course covers an intuitive approach that provides a real feel for the technology, with applications that apply to both the government and commercial sectors.


## Instructor

**Scott R. Bullock,** P.E., MSEE, specializes in Wireless Communications including Spread Spectrum Systems and Broadband Communication Systems, Networking, Software Defined Radios and Cognitive Radios and Systems for both government and commercial uses. He holds 18 patents and 22 trade secrets in communications and has published several articles in various trade magazines. He was active in establishing the data link standard for GPS SCAT-I landing systems, the first handheld spread spectrum PCS cell phone, and developed spread spectrum landing systems for the government. He is the author of two books, Transceiver and System Design for Digital Communications & Broadband Communications and Home Networking, Scitech Publishing, www.scitechpub.com. He has taught seminars for several years to all the major communication companies, an adjunct professor at two colleges, and was a guest lecturer for Polytechnic University on "Direct Sequence Spread Spectrum and Multiple Access Technologies." He has held several high level engineering positions including VP, Senior Director, Director of R&D, Engineering Fellow, and Consulting Engineer.

## What You Will Learn

- How to perform link budgets for types of spread spectrum communications?
- How to evaluate different digital modulation/demodulation techniques?
- What additional techniques are used to enhance digital Comm links including; multiple access, OFDM, error detection/correction, FEC, Turbo codes?
- What is multipath and how to reduce multipath and jammers including adaptive processes?
- What types of satellite communications and satellites are being used and design techniques?
- What types of networks & Comms are being used for commercial/military; ad hoc, mesh, WiFi, WiMAX, 3&4G, JTRS, SCA, SDR, Link 16, cognitive radios & networks?
- What is a Global Positioning System?
- How to solve a 3 dimension Direction Finding?

***From this course you will obtain the knowledge and ability to evaluate and develop the system design for wireless communication digital transceivers including spread spectrum systems.***

## November 16-18, 2021

Live Virtual

**$2090** (8:30am - 4:30pm)

**"Register 3 or More & Receive $100⁰⁰ each Off The Course Tuition."**

## Course Outline

1. **Transceiver Design.** dB power, link budgets, system design tradeoffs, S/N, Eb/No, Pe, BER, link margin, tracking noise, process gain, effects and advantages of using spread spectrum techniques.

2. **Transmitter Design.** Spread spectrum transmitters, PSK, MSK, QAM, CP-PSK, FH, OFDM, PN-codes, TDMA/CDMA/FDMA, antennas, T/R, LOs, upconverters, sideband elimination, PAs, VSWR.

3. **Receiver Design.** Dynamic range, image rejection, limiters, MDS, superheterodyne receivers, importance of LNAs, 3rd order intercept, intermods, spurious signals, two tone dynamic range, TSS, phase noise, mixers, filters, A/D converters, aliasing anti-aliasing filters, digital signal processors DSPs.

4. **Automatic Gain Control Design & Phase Lock Loop Comparison.** AGCs, linearizer, detector, loop filter, integrator, using control theory and feedback systems to analyze AGCs, PLL and AGC comparison.

5. **Demodulation.** Demodulation and despreading techniques for spread spectrum systems, pulsed matched filters, sliding correlators, pulse position modulation, CDMA, coherent demod, despreading, carrier recovery, squaring loops, Costas and modified Costas loops, symbol synch, eye pattern, inter-symbol interference, phase detection, Shannon's limit.

6. **Basic Probability and Pulse Theory.** Simple approach to probability, gaussian process, quantization error, Pe, BER, probability of detection vs probability of false alarm, error detection CRC, error correction, FEC, RS & Turbo codes, LDPC, Interleaving, Viterbi, multi-h, PPM, m-sequence codes.

7. **Cognitive adaptive systems.** Dynamic spectrum access, adaptive power gain control using closed loop feedback systems, integrated solutions of Navigational data and closed loop RSSI measurements, adaptive modulation, digital adaptive filters, adaptive cosite filters, use of AESAs for beamsteering, nullstearing, beam spoiling, sidelobe detection, communications using multipath, MIMO, and a combined cognitive system approach.

8. **Improving the System Against Jammers.** Burst jammers, digital filters, GSOs, adaptive filters, ALEs, quadrature method to eliminate unwanted sidebands, orthogonal methods to reduce jammers, types of intercept receivers.

9. **Global Navigation Satellite Systems.** Basic understanding of GPS, spread spectrum BPSK modulated signal from space, satellite transmission, signal structure, receiver, errors, narrow correlator, selective availability SA, carrier smoothed code, Differential DGPS, Relative GPS, widelane/narrowlane, carrier phase tracking KCPT, double difference.

10. **Satellite Communications.** ADPCM, FSS, geosynchronous / geostationary orbits, types of antennas, equivalent temperature analysis, G/T multiple access, propagation delay, types of satellites.

11. **Broadband Communications and Networking.** Home distribution methods, Bluetooth, OFDM, WiFi, WiMax, LTE, 3&4G cellular, QoS, military radios, JTRS, software defined radios, SCA, gateways, Link 16, TDMA, adaptive networks, mesh, ad hoc, on-the-move, MANETs, D-MANETs, cognitive radios and networks.

12. **DF & Interferometer Analysis.** Positioning and direction finding using interferometers, direction cosines, three dimensional approach, antenna position matrix, coordinate conversion for moving.

# INCOSE CSEP / ASEP Self-Paced Pre-recorded

## Self-Paced on YOUR Schedule

Virtual **$650**

**Register 3 or More & Receive $50⁰⁰ Each Off The Course Tuition.**

## Course Outline

**Each module has a Pre-Class Quiz and After-Class Quiz**

**Pre-class Module: Understanding the INCOSE Certification Process**

- **Module 1: Introduction to Systems Engineering and the Life Cycle Model**
- **Module 2: Approaches to Systems Engineering**
- **Module 3: Project Planning From a SE Point Of View**
- **Module 4: SE and Technical Management Processes**
- **Module 5: Requirements**
- **Module 6: Design Considerations**
- **Module 7: Tech Processes**

**After class: 120 Question Practice Exam**

## Summary

An online course consisting of 7 modules with over 20 hours of teaching. Once registered you'll be provided admittance to the class web portal, which you will have access to 24/7. This online class can be taken at your own pace (with unlimited replays) and at your own most convenient times. The course covers the entire INCOSE SE Handbook Version 4.0. Includes study guides, a comprehensive Process Flow diagram, practice quizzes and exams.

Take control of your career and get your INCOSE Systems Engineer Professional (SEP) certification now! This class provides 16 Professional Development Units (PDUs) and 24 PDU if you complete quizzes and the 120 Question Practice Exam. The quizzes prepare you to take INCOSE SEP exam. We are confident that our testing materials will prepare you to pass the INCOSE SEP exam the first time

## Instructor

**Paul Martin, ESEP, CTT+**, is a practicing Systems Engineer with over 35 years of experience. He has been everything from a Product Engineer for General Electric Products Division to a Software Systems Engineer for a multi-million dollar Navy program. He developed the INCOSE SEP Exam Preparation Course back in 2009 and has taught the material to several hundred students. For the course Paul developed a unique comprehensive Process Flow diagram that contextualize all 31 Organizational, Project and Technical processes that are outlined in the INCOSE SE Handbook. Many of Paul's students have commented on the effectiveness of the diagram. Paul has a unique and passionate style that keeps students interest at a high level.

## Testimonials ...

*"I took a CSEP prep course from Paul last May and, after putting it off, finally took the exam in December and passed. Just wanted to let you know. Your prep course and materials were very helpful. I felt well-prepared for the exam, but it was still harder than expected. I felt that the wording on some of the questions was confusing. But I passed, and that's what matters"*

*"This course takes a very complex topic and gives it structure and cohesion in order to impart knowledge as well as suggest best practices: two thumbs up!*

*I found the tests particularly useful in pinpointing my areas of deficiency. In my prep for the CSEP test, I studied and took the test iteratively, gradually cementing my command of the subject."*

*"Course content was very well organized and had complete coverage of required material."*

*"He obviously has had a long working career in SE and knows the material. Kept the focus on what is needed to pass the CSEP exam."*

*"Just wanted to let you know I successfully passed the CSEP exam today. Thanks again for your help. You are an excellent instructor, and I appreciate your examples and explanations.*

*I found the tests particularly useful in pinpointing my areas of deficiency. In my prep for the CSEP test, I studied and took the test iteratively, gradually cementing my command of the subject."*

*"Course content was very well organized and had complete coverage of required material."*

*"He obviously has had a long working career in SE and knows the material. Kept the focus on what is needed to pass the CSEP exam."*

*"Just wanted to let you know I successfully passed the CSEP exam today. Thanks again for your help. You are an excellent instructor, and I appreciate your examples and explanations."*

# Certified Systems Engineering Professional - CSEP Preparation

**Guaranteed Training to Pass the CSEP Certification Exam**

## September 28-30, 2021

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary


This three-day course walks through the CSEP requirements and the INCOSE Handbook Version 4 to cover all topics on the CSEP exam. Interactive work, study plans, and sample examination questions help you to prepare effectively for the exam. Participants will leave the course with solid knowledge and three sample examinations.

Attend the CSEP course to learn what you need. Follow the study plan to seal in the knowledge. Use the sample exam to test yourself and check your readiness. Contact our instructor for questions if needed. Then take the exam. If you do not pass, you can retake the course at no cost.

We recommend you already have the *INCOSE Handbook Ver 4.0* in either digital (free) or hardcopy form.


## Instructor

**Mr. William "Bill" Fournier**, ESEP-Acq is Principal Acquisition Systems Engineering with over 35 years experience. Mr. Fournier taught DoD Systems Engineering full time for over three years at DSMC/DAU as a Professor of Engineering Management. Mr. Fournier has taught Systems Engineering at least part time for more than 30 years. Mr. Fournier holds an MBA and BS Industrial Engineering / Operations Research and is DOORS trained. Mr. Fournier was verification lead for Ground-Based Missile Defense for 8 years. Also, he served as Assessment and Verification team lead. Bill has also Lead IV&V for a number of systems intensive Agile systems.

## What You Will Learn

- How to pass the CSEP examination!
- Details of the INCOSE Handbook, the source for the exam.
- Your own strengths and weaknesses, to target your study.
- The key processes and definitions in the INCOSE language of the exam.
- How to tailor the INCOSE processes.
- Five rules for test-taking.

## Course Outline

1. **Introduction.** What is the CSEP and what are the requirements to obtain it? Terms and definitions. Basis of the examination. Study plans and sample examination questions and how to use them. Plan for the course. Introduction to the INCOSE Handbook. Self-assessment quiz. Filling out the CSEP application.

2. **Systems Engineering and Life Cycles.** Definitions and origins of systems engineering, including the latest concepts of "systems of systems." Hierarchy of system terms. Value of systems engineering. Life cycle characteristics and stages, and the relationship of systems engineering to life cycles. Development approaches. The INCOSE Handbook system development examples.

3. **Technical Processes.** The processes that take a system from concept in the eye to operation, maintenance and disposal. Stakeholder requirements and technical requirements, including concept of operations, requirements analysis, requirements definition, requirements management. Architectural design, including functional analysis and allocation, system architecture synthesis. Implementation, integration, verification, transition, validation, operation, maintenance and disposal of a system.

4. **Project Processes.** Technical management and the role of systems engineering in guiding a project. Project planning, including the Systems Engineering Plan (SEP), Integrated Product and Process Development (IPPD), Integrated Product Teams (IPT), and tailoring methods. Project assessment, including Technical Performance Measurement (TPM). Project control. Decision-making and trade-offs. Risk and opportunity management, configuration management, information management.

5. **Enterprise & Agreement Processes.** How to define the need for a system, from the viewpoint of stakeholders and the enterprise. Acquisition and supply processes, including defining the need. Managing the environment, investment, and resources. Enterprise environment management. Investment management including life cycle cost analysis. Life cycle processes management standard processes, and process improvement. Resource management and quality management.

6. **Specialty Engineering Activities.** Unique technical disciplines used in the systems engineering processes: integrated logistics support, electromagnetic and environmental analysis, human systems integration, mass properties, modeling & simulation including the system modeling language (SysML), safety & hazards analysis, sustainment and training needs.

7. **After-Class Plan.** Study plans and methods. Using the self-assessment to personalize your study plan. Five rules for test-taking. How to use the sample examinations. How to reach us after class, and what to do when you succeed.

***The INCOSE Certified Systems Engineering Professional (CSEP) rating is a coveted milestone in the career of a systems engineer, demonstrating knowledge, education and experience that are of high value to systems organizations. This two-day course provides you with the detailed knowledge and practice that you need to pass the CSEP examination.***

# Model Based Systems Engineering

## Creating and Using Models for More Effective Systems Engineering

**December 13-16, 2021**
Live Virtual
**$2290** (8:30am - 4:30pm)

**"Register 3 or More & Receive $100^00 each Off The Course Tuition."**


## Summary

This 4-day course provides an introduction to Model-Based Systems Engineering (MBSE): the practice of using a system model to streamline the process of requirements analysis, architecture, and design. Lectures on proven, state-of-the-art techniques will be reinforced with lessons learned and case studies from the instructor's own experiences applying MBSE of major DoD acquisition programs, along with in-class, live demonstrations using a popular system modeling tool (Cameo Systems Modeler™ by No Magic, Inc.) to create an example model. Students will be provided with a temporary, fully-functional tool license with which they can get hands-on experience working tutorial exercises that reinforce the lecture material.

The course is valuable to systems engineers, program managers, and anyone else interested in understanding what is required to create a system model, how to use it to support systems engineering activities on a program, and the benefits that can be realized.


## Instructor

**Sean McGervey**, is a Systems Engineer at the Johns Hopkins University Applied Physics Laboratory, where he has been the Architecture Lead on a Major Defense Acquisition Program (ACAT-1) for the US Navy and most recently is leading several efforts within the Systems Engineering Transformation initiative of the US Navy's Strategic Systems Programs. Sean founded the JHU/APL MBSE Community of Practice to foster MBSE collaboration and innovation, and currently teaches three courses in MBSE at the laboratory. Prior to joining APL, Sean worked in the Systems Engineering Department at Northrop Grumman Mission Systems in Baltimore, Maryland for 15 years. While there, Sean applied MBSE on multiple ACAT-1 programs and founded the Northrop Grumman Corporate Model-Based Engineering (MBE) Community of Practice. Sean is an OMG Certified Systems Modeling Professional at the Model Builder: Advanced level and has been active in INCOSE's MBSE Initiative.

## Course Outline

1. **MBSE Overview.** What MBSE is and isn't, practical benefits of MBSE.
2. **Introduction to the Systems Modeling Language (SysML).** Language notation and diagrams, element types and relationships.
3. **Tool Introduction and Methodology Introduction.** How to use a typical modeling tool, methodology for developing a model.
4. **Organizing Your Model.** Best practices for model organization, packages, model libraries.
5. **Stakeholder Needs Analysis.** Operational architecture, capabilities, measures of effectiveness, mission use cases.
6. **Systems Context Definition.** Systems of systems architectures, black-box system specification.
7. **System Requirements Elicitation.** System use cases, functional requirements derivation.
8. **Functional Analysis.** Use case scenarios, Functional decomposition.
9. **Logical and Physical Architecture.** Allocation of functions to logical elements, allocation of logical to physical elements.
10. **Parametric Analysis.** Analysis contexts, Linking technical measures and system attributes, executing the analysis.
11. **Reviewing and Assessing the Design.** Model verification, executing a design review.
12. **Advanced Topics in MBSE.** Creating extensions to SysML, domain-specific modeling, model validation.

## What You Will Learn

- Practical, proven techniques for creating models using industry standard SysML, and how to use those models to support systems engineering.
- How to use one of the most popular system modeling tools to create, verify, and validate system models.
- Preparing for a formal design review using the model as its centerpiece.
- Linking the SysML model to external analytical models.

# Requirements Development & Management

## Building Requirements that Effectively Communicate and Guide

**July 27-29, 2021**

Live Virtual

**$2090** (8:30am - 4:30pm)

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**


## Summary

One of the most significant impacts a systems engineer can have on a project is to ensure the successful identification, analysis, allocation, management, and use of requirements. This course provides both lecture and practical work on the creation and use of requirements in a system development from concept to verification

The three-day course begins with an overview of the purpose and use of requirements. We identify the possible sources of requirements, and how to define and validate requirements from each type of source. We teach how to write requirements, with practical hands-on practice on each type of requirement. We also focus on the entire set of requirements, with methods to graphically analyze the requirements to ensure completeness, correctness, and cohesion. We teach requirements allocation, how to decompose high-level requirements into lower-level requirements that create meaningful practical specifications for the system components. We show how to use requirements to guide system verification. Finally, we look at the structure and tools for requirements management, to ensure that all requirements are met and that non-required features are not created. From beginning to verification, good systems engineers use requirements as the primary definition for the system and its elements, to help the product system.


## Instructor

**Mr. William "Bill" Fournier,** ESEP-Acq is Principal Acquisition Systems Engineering with over 35 years experience. Mr. Fournier taught DoD Systems Engineering full time for over three years at DSMC/DAU as a Professor of Engineering Management. Mr. Fournier has taught Systems Engineering at least part time for more than 30 years. Mr. Fournier holds an MBA and BS Industrial Engineering / Operations Research and is DOORS trained. Mr. Fournier was verification lead for Ground-Based Missile Defense for 8 years. Also, he served as Assessment and Verification team lead. Bill has also Lead IV&V for a number of systems intensive Agile systems.

## What You Will Learn

- All the methods in collaborative work.
- Define and quantify the operation need.
- Write requirements.
- Graphical Requirements analysis.
- Allocate the requirements into an architecture.
- Plan verification.

## Course Outline

1. **Requirements Overview.**

• What are requirements and how do they fit in to system development?

• Context of system development models.

• Role of requirements.

• Importance of requirements.

• Requirements cycles for contracted, R&D, and commercial development.

2. **Stakeholder Requirements.** Defining the system at its highest level, in terms of the stakeholder needs. The basic steps in understanding a new system.

• Problem definition with the stakeholders.

• System boundaries and life cycle.

• System environment.

• Define the need in operational terms.

• What to do with the operational descriptions.

• Quantify the need to allow effective trade offs.

• Application of SysML diagrams for operational definition.

3. **Defining Requirements.** How to convert operational descriptions into technical requirements.

• Five types of requirements and the characteristics of each type: functional, performance, interface, constraint, and verification requirements.

• Create functional and performance requirements using mission analysis as an engineering technique.

• Interface requirements as a definition of system boundaries; how to create them.

• Constraint requirements on the system, its environment, and its development.

• Verification requirements as the basis for system proof, including the Requirements Verification Matrix (RVM).

• Requirements document types – specifications, use cases, agile, SCRUM.

• Formal requirements writing rules from the INCOSE Requirements Writing Guide.

4. **Requirements Analysis.** Methods to validate requirements to ensure that systems requirements are complete, coherent, and cohesive.

• Working with requirements interactions.

• Diagramming techniques to evaluate sets of requirements.

• Useful SysML diagrams: use case, activity, state machine diagrams. Strengths and weakness of each diagram.

5. **Requirements Allocation.** Requirements as engineering tools during the system architecting and design phases.

• Overview of system architecture and how requirements are used to define components.

• Allocation methods with examples – direct allocation, apportionment, derivation.

• Application of allocation methods to different types of high-level requirements.

• Architectural design using requirements.

6. **Requirements Management.** Using a requirements database to allow requirements to guide the design.

• Requirements management methods; when to do what tasks.

• Feedback to the system development so that requirements act as the guide.

• Ensuring the system meets all requirements and does not add unnecessary functions.

• How to use managed requirements to plan and perform system verification.

• Attributes of requirements management databases.

• Survey of requirements management tools.

• Simple management in Excel.

7. **Case Study.** Small-group study of a virtual development project in five segments to apply the learned methods.

• Defining the need.

• Converting stakeholder requirements to technical requirements

• Writing good requirements.

• Requirements analysis.

• Requirements allocation.

# Systems of Systems

## Sound Collaborative Engineering to Ensure Architectural Integrity

**November 2-3, 2021**

Live Virtual

**$1590** **(8:30am - 4:30pm)**

**"Register 3 or More & Receive $100.00 each Off The Course Tuition."**

## Summary

Today's operational environments are dominated by complex Systems of Systems. We now create unprecedented scope and complexity. Extended life cycles, legacy systems and ongoing re-architecting add to the difficulty. Success requires sound methods to manage complexity while maintaining the integrity of the design and supporting shifting operational priorities.

When you think your systems should be working better than they are, this two-day workshop presents detailed, useful techniques to develop effective systems of systems and to manage the engineering activities associated with them. The course is designed for program managers, project managers, systems engineers, technical team leaders, logistic support leaders, and others who take part in developing today's complex systems.

## Instructor

**Mr. William "Bill" Fournier**, ESEP-Acq is Principal Acquisition Systems Engineering with over 35 years experience. Mr. Fournier taught DoD Systems Engineering full time for over three years at DSMC/DAU as a Professor of Engineering Management. Mr. Fournier has taught Systems Engineering at least part time for more than 30 years. Mr. Fournier holds an MBA and BS Industrial Engineering / Operations Research and is DOORS trained. Mr. Fournier was verification lead for Ground-Based Missile Defense for 8 years. Also, he served as Assessment and Verification team lead. Bill has also Lead IV&V for a number of systems intensive Agile systems.

## Course Outline

1. **Systems of Systems (SoS) Concepts.** What SoS can achieve. Capabilities engineering vs. requirements engineering. Operational issues: geographic distribution, concurrent operations. Development issues: evolutionary, large scale, distributed. Roles of a project leader in relation to integration and scope control.

2. **Complexity Concepts.** Complexity and chaos; scale-free networks; complex adaptive systems; small worlds; synchronization; strange attractors; emergent behaviors. Introduction to the theories and how to work with them in a practical world.

3. **Architecture.** Design strategies for large scale architectures. Architectural Frameworks including the DOD Architectural Framework (DODAF), TOGAF, Zachman Framework, and FEAF. How to use design patterns, constitutions, synergy. Re-Architecting in an evolutionary environment. Working with legacy systems. Robustness and graceful degradation at the design limits. Optimization and measurement of quality.

4. **Integration.** Integration strategies for SoS with systems that originated outside the immediate control of the project staff, the difficulty of shifting SoS priorities over the operating life of the systems. Loose coupling integration strategies, the design of open systems, integration planning and implementation, interface design, use of legacy systems and COTS.

5. **Collaboration.** The SoS environment and its special demands on systems engineering. Collaborative efforts that extend over long periods of time and require effort across organizations. Collaboration occurring explicitly or implicitly, at the same time or at disjoint times, even over decades. Responsibilities from the SoS side and from the component systems side, strategies for managing collaboration, concurrent and disjoint systems engineering; building on the past to meet the future. Strategies for maintaining integrity of systems engineering efforts over long periods of time when working in independent organizations.

6. **Testing and Evaluation.** Testing and evaluation in the SoS environment with unique challenges in the evolutionary development. Multiple levels of T&E, why the usual success criteria no longer suffice. Why interface testing is necessary but isn't enough. Operational definitions for evaluation. Testing for chaotic behavior and emergent behavior. Testing responsibilities in the SoS environment.

## What You Will Learn

- Capabilities engineering methods.
- Architecture frameworks.
- Practical uses of complexity theory.
- Integration strategies to achieve higher-level capabilities.
- Effective collaboration methods.
- T&E for large-scale architectures.

# Design and Analysis of Bolted Joints

## For Aerospace Engineers

## Summary

Just about everyone involved in developing hardware for space missions (or any other purpose, for that matter) has been affected by problems with joints using threaded fasteners. Common problems include rupture, fatigue, detrimental yielding or joint slip, galling, inadequate preload, loss of preload, low or nonlinear stiffness, excess weight, procurement cost and lead time, incompatibility with the space environment, and time-consuming assembly. The main objective of this three-day course is to build understanding of how bolted joints behave, how they fail, and how to design them to be dependable and cost effective.

Participants need calculators to work class problems.

### Recent attendee comments ...

*"It was a fantastic course, one of the most useful short courses I have ever taken." "Interaction between instructor and experienced designers (in the class) was priceless."*

*"(The) examples (and) stories from industry were invaluable." "Everyone at NASA should take this course!"*

*"(What I found most useful:) strong emphasis on understanding physical principles vs. blindly applying textbook formulas."*

*(What you would tell others) "Take it!" "You need to take it." "Take it. Tell everyone you know to take it."*

*"Excellent instructor. Great lessons learned on failure modes shown from testing."*

*"A must course for structural/mechanical engineers and anyone who has ever questioned the assumptions in bolt analysis"*

*"Well-researched, well-designed course." "Kudos to you for spreading knowledge!"*

## Instructor

**Tom Sarafin** Tom Sarafin is the President and Chief Engineer of Instar Engineering and Consulting, Inc. He has worked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. Since founding Instar in 1993, he's consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Millennium Space Systems, Space Systems/LoraL, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of Spacecraft Structures and Mechanisms: From Concept to Launch and is a contributing author to Space Mission Analysis and Design. He's also the principal author of a series of papers titled "Vibration Testing of Small Satellites." Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

## September 14-16, 2021

Live Virtual

**$2200** (8:30am - 5:00pm)

**"Register 3 or More & Receive $100<sup>00</sup> each Off The Course Tuition."**

## Course Outline

1. **Overview.** Common problems with bolted joints. A process for designing a bolted joint. General design guidelines. The importance of preload. Introduction to NASA-STD-5020 and 5020A. Key definitions. High-level requirements from NASA-STD-5020A. Margin of safety. Establishing internal standards and criteria.

2. **Screw Threads: Evolution and Important Characteristics.** Brief history of screw threads and thread forms. Rolled vs. cut threads. Thread-form features and compatibility. Tensile stress area. Fine threads vs. coarse threads.

3. **Developing a Concept for the Joint.** General types of joints and fasteners. Configuring the joint. Designing a stiff joint. Shear clips and tension clips. Avoiding problems with fixed fasteners.

4. **Calculating Bolt Loads When Ignoring Preload.** How a preloaded joint carries load. Temporarily ignoring preload. What about friction as a load path? Common assumptions and their limitations. An effective process for calculating bolt loads in a compact joint. Examples.

5. **Failure Modes and Assessment Methods.** Understanding stress analysis from the engineer's perspective. An effective process for strength analysis. Bolt tension and shear. Tension joints. Shear joints. Class exercise: identifying potential failure modes. Bolted joints with composite materials.

6. **Thread Stripping and Pull-out Strength.** How threads fail. Computing theoretical shear engagement areas. Including a knock- down factor. Test results.

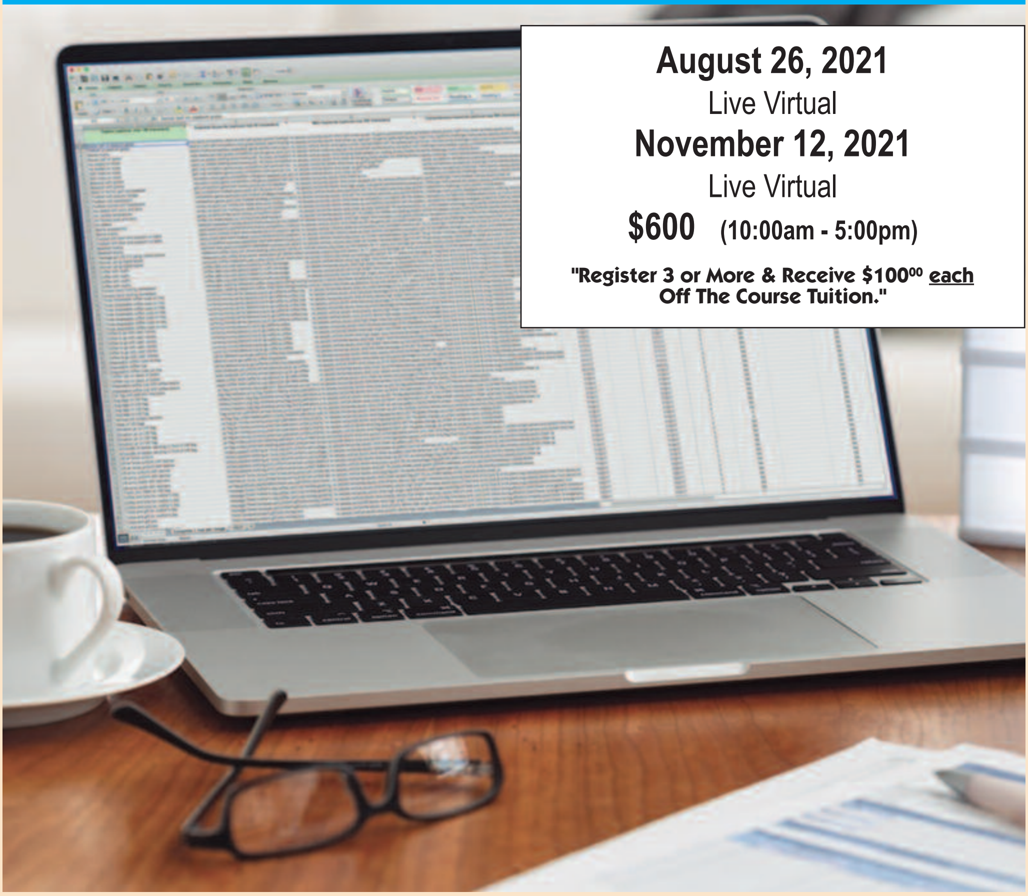
7. **Selecting Hardware and Detailing the Design.** Selecting compatible materials. Nuts and threaded inserts. Use of washers. Bolt features and geometry. Selecting fastener length and grip. Recommended fastener hole sizes. Guidelines for simplifying assembly. Establishing preload. Torque-preload relationship. Locking features and NASA- STD-5020A. Maintaining preload.

8. **Mechanics of a Preloaded Joint.** Mechanics of a preloaded joint under applied tensile load. Estimating bolt stiffness and clamp stiffness. Understanding the load-introduction factor. Worst case for steel bolts and aluminum fittings. Key conclusions regarding load sharing. Effects of bolt ductility. How temperature change affects preload.

9. **Fastening System Analysis per NASA-STD-5020A.** Objectives and summary. Calculating maximum and minimum preloads. Tensile loading: ultimate-strength analysis. Separation analysis. Tensile loading: yield-strength analysis. Shear loading. Interaction of tension, shear, and bending. Joint-slip analysis. Fatigue. Justification for low likelihood of fatigue failure.

10. **Special Topics.** Finite element modeling of bolted joints. Design tables: preliminary bolt sizing, based on NASA-STD-5020A analysis criteria.

# Notching and Force Limiting Workshop



**August 26, 2021**
Live Virtual
**November 12, 2021**
Live Virtual
**$600** (10:00am - 5:00pm)

**"Register 3 or More & Receive $100^{00} each Off The Course Tuition."**

## Summary


NFLW is a one-day computer workshop that is available only as an optional follow-on to **STDI (Structural Test Design and Iterpretation)** or **VTSS (Vibration Testing of Small Satellites)** course.

Several Microsoft Excel spreadsheets will be provided to be used in class. The instructor will guide the class into completing the first spreadsheet by filling in the applicable equations, as covered in **STDI** and **VTSS**.


## Prerequisite

Completion of one of either **STDI** or **VTSS** within 12 months of NFLW (preferably immediately before NFLW) or the instructor's permission in advance. Each participant must have his or her own laptop computer loaded with Microsoft Excel.

Please contact us for that permission.

## What You Will Learn

The objectives of this course are for you to "learn by doing". The goal is for you to be able to design technically justifiable force limits, manual notches, and response limits for future tests.

## Instructor

**Tom Sarafin** is President and Chief Engineer of a consulting firm. He has worked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. He has consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Space Systems/Loral, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of *Spacecraft Structures and Mechanisms: From Concept to Launch* and is a contributing author to *Space Mission Analysis and Design*. He's also the principal author of a series of papers titled "Vibration Testing of Small Satellites." Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

# Satellite Communications: Introduction

**August 10-12, 2021**

Live Virtuall

**$2090** (8:30am - 4:30pm)

**"Register 3 or More & Receive $100⁰⁰ each Off The Course Tuition."**

## Summary


This three-day introductory course reviews the essential elements of all satellite communications systems, with an emphasis on system design and performance. The objective is to inform new engineers and other professionals as well as those knowledgeable in specific technical and business areas by covering the technical characteristics of each aspect of the space and ground system, and show how they relate to each other. The fundamental connection is the radio link between satellite and earth station, which is covered in detail. Basic design of the satellite and earth station are covered to identify primary elements of each and to compare alternatives which have been and continue to be employed in real systems. These include geostationary satellites and non-geostationary constellations that are currently in development.


## Instructor

**Bruce R. Elbert**, (MSEE, MBA) is president of an independent satellite communications consulting firm. He is a recognized satellite communications expert and has been involved in the satellite and telecommunications industries for over 40 years. He founded ATSI to assist major private and public sector organizations that develop and operate digital video and broadband networks using satellite technologies and interactive services. During 25 years with Hughes Electronics, he directed the design of several major satellite projects, including Palapa A, Indonesia's original satellite system; the Galaxy follow-on system; and the development of the first GEO mobile satellite system capable of serving handheld user terminals. Mr. Elbert was also ground segment manager for the Hughes system, which included eight teleports and 3 VSAT hubs. He served in the US Army Signal Corps as a radio communications officer and instructor. By considering the technical, business, and operational aspects of satellite systems, Mr. Elbert has contributed to the operational and economic success of leading organizations in the field. He has written seven books on telecommunications and IT, including *Introduction to Satellite Communication, Third Edition* (Artech House, 2008). *The Satellite Communication Applications Handbook, Second Edition* (Artech House, 2004); *The Satellite Communication Ground Segment and Earth Station Handbook* (Artech House, 2001), the course text.

## Course Outline

**1. Satellite Systems, Services, and Regulation.** Introduction and historical background. The place of satellites in telecommunications. Satellite service definitions: broadcasting BSS, fixed-satellite FSS, and mobile satellite MSS. Major suppliers and operators of satellites. Satellite regulation: role of the ITU, FCC, and regulatory bodies of the various countries where services are provided. Satellite system design overview. Satellite real-world demands: security, control of accidental and intentional interference, resolving RFI.

**2. Technical Fundamentals.** Satellite orbit alternatives and their characteristics: geostationary and non-geostationary. Basic definitions: channels, circuits, transponders, decibels. Satellite frequency bands – L, S, C, X, Ku, Ka, etc.: properties of waves, free space loss, polarization, bandwidth. Propagation through the atmosphere: air and clouds, rain, the ionosphere. Carrying information on radio waves: coding, modulation, multiplexing, DVB-S2 standard and extensions. Digital communications demands: bit error rate and availability.

**3. The Space Segment.** The space environment: gravity, radiation and space debris. Orbits: geostationary orbits; non-geostationary orbits. Orbital slots, footprints, and coverage; satellite spacing; eclipses and sun interference. Basic design of a satellite: structure and spacecraft subsystems (bus), antennas and repeaters (payload).

**4. The Ground Segment.** Earth stations: types – VSATs and hubs, RF equipment (amplifiers and frequency converters), antenna configurations (reflector designs, phased arrays), mounting and pointing (fixed and mobile installations). Antenna properties: gain; directionality; sidelobes and legal limits on sidelobe gain. Electronics, EIRP, and G/T: LNA and LNB, SSPA; signal flow through an earth station.

**5. The Satellite Earth Link.** Atmospheric effects on signals: rain effects and rain climate models; rain fade margins. Link budgets, C/N and Eb/No. Multiple access techniques: FDMA, TDMA and ALOHA, CDMA; Paired Carrier Multiple Access, demand assignment; on-board processing. Signal security issues. Internet Protocol networks and adaptation to the satellite link.

**6. Conclusion.** Industry issues and trends: non-geostationary constellations for broadband, small sats, high altitude platforms, and challenges in the future.

## What You Will Learn

- How satellite communications relates to other forms of wireless systems that are used to provide one-way broadcasting and two-way interactive services, especially those delivered through the global Internet.
- The framework that defines the properties of the satellite itself as part of the system and as governed by international rules and regulations, and as offered by commercial operators around the world.
- The types of earth stations used to employ space resources, particularly very small aperture terminals (VSATs) to fixed and mobile users, and larger stations used as hubs and gateways.
- The basic principles of radio-wave propagation and the link budget, which establish whether the connection between user and satellite will work as required.
- The tradeoffs among the various orbits, frequency bands, and modulation and coding technologies needed to realize the required services via the satellite link.
- The evolution of this technology in a changing world.

# Satellite Communications Design & Engineering

**A comprehensive, quantitative tutorial designed for satellite professionals**

## November 9-11, 2021

Live Virtual

**$2090** (8:30am - 4:30pm)

**"Register 3 or More & Receive $100<sup></sup>00 each Off The Course Tuition."**

## Summary

This three-day course is designed as a practical course for practicing engineers, and is intended for communications engineers, spacecraft engineers, managers and technical professionals who want both the "big picture" and a fundamental understanding of satellite communications. The course is technically oriented and includes examples from real-world satellite communications systems. It will enable participants to understand the key drivers in satellite link design and to perform their own satellite link budget calculations. The course will especially appeal to those whose objective is to develop quantitative computational skills in addition to obtaining a qualitative familiarity with the basic concepts.

## Instructors

**Robert Summers** has been developing space communication systems for more than 30 years, ranging from store-and-forward messaging by low Earth orbit satellites, to audio and video broadcasting from geosynchronous orbit, and voice and data communication constellations in between. He has been at the Johns Hopkins University Applied Physics Laboratory for the last 12 years, where he has been involved in numerous space system engineering activities. He has lectured in the JHU Whiting School of Engineering on system engineering topics, including telemetry, tracking and control (TT&C) subsystem communications that links the satellites to the ground systems. He has a BSEE from Stanford University and two MS degrees from Johns Hopkins, in computer science and technical management.

**Chris DeBoy** leads the RF Engineering Group in the Space department at the Johns Hopkins University Applied Physics Laboratory, and is a member of APL's Principal Professional Staff. He has over 25 years of experience in satellite communications, from systems engineering (he is the lead RF communications engineer for the New Horizons Mission to Pluto) to flight hardware design for both low- Earth orbit and deep-space missions. He holds a BSEE from Virginia Tech, a Master's degree in Electrical Engineering from Johns Hopkins, and teaches the satellite communications course for the Johns Hopkins University.

## What You Will Learn

- A comprehensive understanding of satellite communication.
- An understanding of basic vocabulary.
- A quantitative knowledge of basic relationships.
- Ability to perform and verify link budget calculations.
- Ability to interact meaningfully with colleagues and independently evaluate system designs.
- A background to read the literature.

## Course Outline

1. **Mission Analysis.** Kepler's laws. Circular and elliptical satellite orbits. Period of revolution. LEO, MEO, HEO, and Geostationary Orbits. Orbital elements. Azimuth and Elevation, slant range, coverage angle and ground trace.

2. **The RF Link – The Signal.** Antenna gain, effective isotropic radiated power, receive flux density and receive power, Friis link equation and variants. Review of deciBels (dB's).

3. **The RF Link – Noise.** Antenna gain, effective isotropic radiated power, receive flux density and receive power, Friis link equation and variants. Review of deciBels (dB's).

4. **The RF Link – Putting It Together.** Receive system G/T, received CNR, SNR. Bent-pipe and regenerative transponders, multiple carrier operation, noise power robbing and back-off.

5. **Signals and Spectra.** Properties of a sinusoidal wave. Synthesis and analysis of an arbitrary waveform. Fourier Principle. Harmonics. Fourier series and Fourier transform. Frequency spectrum.

6. **Methods of Modulation.** Overview of modulation, frequency translation, sidebands, analog AM/FM modulation.

7. **Digital Modulation.** Nyquist sampling, analog-to-digital conversion, ISI, Nyquist pulse shaping, raised cosine filtering, BPSK, QPSK, MSK, 8PSK, QAM, GMSK, higher order modulation, bandwidth, power spectral density, constellation diagrams.

8. **Demodulation and Bit Error Rate.** Coherent detection and carrier recovery, phase-locked loops, bit synchronizers, bit error probability, Eb/No, BPSK, QPSK detection, digital modulation performance.

9. **Coding.** Information theory basics, Shannon's theorem, code rate, coding gain, Hamming, BCH, and Reed-Solomon block codes, convolutional codes, Viterbi decoding, hard and soft decision, concatenated coding, Trellis coding, Turbo codes, LDPC codes.

10. **Bandwidth.** Equivalent (noise) bandwidth. Occupied bandwidth. Allocated bandwidth. Relationship between bandwidth and data rate. Dependence of bandwidth on methods of modulation and coding. Tradeoff between bandwidth and power. Emerging trends for bandwidth efficient modulation.

11. **Antennas.** Directivity and gain, reciprocity, antenna patterns, beam solid angle, half-power beamwidth, nulls and sidelobes, efficiency, large apertures, antenna examples, shaped reflectors, phased-arrays.

12. **Antenna Noise Temperature.** Brightness temperature, antenna noise temperature calculation and estimates, examples.

13. **Polarization.** Linear, circular, elliptical polarization, axial ratio, handedness, interoperability, polarization mismatch loss.

14. **Propagation.** Earth's atmosphere, atmospheric attenuation, rain attenuation, rain models and variation with frequency, impact on G/T, system examples.

15. **Earth Stations.** Antenna types, facilities, RF components, operations center.

16. **Satellite Transponders.** Satellite communications payload architecture, frequency plan, transponder gain, TWTA and SSPA, amplifier characteristics, intermodulation products.

17. **Multiple Access Techniques.** Frequency division multiple access (FDMA). Time division multiple access (TDMA). Code division multiple access (CDMA) or spread spectrum. Capacity estimates.

18. **Link Budgets.** Communications link calculations, uplink, downlink, and composite performance, link budgets for single carrier and multiple carrier operation. Detailed worked examples.

19. **Diversity.** Site, phase, frequency, time, polarization diversity techniques and system examples.

20. **Navigation.** Range and range-rate (Doppler) tracking, GPS.

21. **VSATs.** Applications, access techniques, typical implementations.

22. **Commercial and Military Satcomm.** System examples, GEO platforms, high throughput satellites, Iridium, Globalstar, Orbcomm, O3B, MILSATCOM, etc.

23. **The Electromagnetic Spectrum.** Frequency bands used for satellite communication. ITU regulations. Fixed Satellite Service. Direct Broadcast Service. Digital Audio Radio Service. Mobile Satellite Service.

# Satellite Link Budget Training on the Personal Computer

## GEO & non-GEO, L Through Q/V Bands

**August 31-Sepember 2, 2021**

Live Virtual

**$2090** **(8:30am - 4:30pm)**

**"Register 3 or More & Receive $100⁰⁰ each Off The Course Tuition."**

## Summary


Exciting new material on non-GEO and Q/V bands. Link budgets are the standard tool for designing and assessing satellite communications transmissions, considering radio-wave propagation, satellite performance, terminal equipment, radio frequency interference (RFI), and other physical layer aspects of fixed and mobile satellite systems. The format and content of the link budget must be understood by many engineers and managers with design and operation responsibilities. SatMaster is a highly-recognized yet low-cost PC-based software tool offered through the web by Arrowe Technical Services of the UK. This three-day course reviews the principles and use of the link budget along with hands-on training in SatMaster 10, the latest version, for one- and two-way transmission of digital television; two-way interactive services using very small aperture terminals (VSATs); point-to-point transmission at a wide range of data rates; and interactive communications with mobile terminals. Services at UHF, L, S, C, X Ku, Ka, Q, and V bands to fixed and mobile terminals are considered. The course includes several computer workshop examples to enhance participants' confidence in using SatMaster and to improve their understanding of the link budgeting process. Participants should gain confidence in their ability to prepare link budgets and their facility with SatMaster. Examples from the class are employed as time allows. The course notes are provided.

You will need a Windows OS laptop to class with SatMaster software. It can be purchased directly from www.satmaster.com (a discount is available to registered attendees).

Previously titled Satellite Link Budget Training using SatMaster Software.


## Instructor

**Bruce R. Elbert**, MSEE, MBA, adjunct professor (retired), College of Engineering, University of Wisconsin, Madison. Mr. Elbert is a recognized satellite communications expert and has been involved in the satellite and telecommunications industries for over 40 years. He founded Application Technology Strategy, L.L.C., to assist major private and public sector organizations that develop and operate cutting-edge networks using satellite and other wireless technologies and services. During 25 years with Hughes Space and Communications (now Boeing Satellite Systems), he directed communications engineering of several major satellite projects. Mr. Elbert has written seven books on satellite communications, including *The Satellite Communication Applications Handbook*, Second Edition (Artech House, 2004); *The Satellite Communication Ground Segment and Earth Station Handbook* (Artech House, 2001); and *Introduction to Satellite Communication, Third Edition* (Artech House, 2008).

## Course Outline

### Day 1

(**Principles of Satellite Links and Applicability of SatMaster**)

- Standard ground rules for satellite link budgets.
- Frequency band selection, UHF, L, S, C, X, Ku, Ka, Q, and V bands.
- Satellite footprints (EIRP, G/T, and SFD) and transponder plans; application of on-board processors.
- Propagation considerations: the isotropic source, line of sight, antenna principles.
- Atmospheric effects: troposphere (clear air and rain) and ionosphere (Faraday and scintillation).
- Rain effects and rainfall regions; use of the built-in ITU-DAH and Crane rain models.
- Modulation systems (QPSK, OQPSK, MSK, GMSK, 8PSK, 16 QAM, and 32 APSK and higher).
- Forward error correction techniques (Viterbi, Reed-Solomon, BCH, Turbo, and LDPC codes, Turbo and concatenated codes).
- Transmission equation and its relationship to the link budget.
- Introduction to the user interface of SatMaster.
- Differences between SatMaster 9, the current version, and previous versions.
- File formats: antenna pointing, database, digital link budget, non-GEO, and digital processing/regenerative repeater link budget.
- Built-in reference data and calculators.
- Example of a digital GEO one-way link budget (DVB-S2) using equations and SatMaster.

### Day 2

(**Detailed Link Design in Practice: Computer Workshop**)

- Earth station block diagram and characteristics.
- Antenna characteristics (main beam, sidelobe, X-pol considerations, mobile antennas).
- HPA characteristics, intermodulation and sizing , uplink power control.
- Link budget workshop example using SatMaster: GEO Single Channel Per Carrier (SCPC) with multi-carrier backoff.
- Transponder loading and optimum multi-carrier backoff; power equivalent bandwidth.
- Review of link budget optimization techniques using the program's built-in features.
- Computing the uplink EIRP and transmit power; uplink power control (UPC).
- Interference sources (X-pol, adjacent satellite interference, adjacent channel interference).
- Earth station power flux density limits and the use of spread spectrum for disadvantaged antennas co-channel interference from other beams.

### Day 3

(**Consideration of Interference and Workshop in Digital Link Budgets**)

- C/I estimation and trade studies.
- Performance estimation for carrier-in-carrier (Paired Carrier Multiple Access) transmission.
- Example: digital VSAT, multi-carrier operation.
- Use of batch location files to prepare link budgets for a large table of locations.
- Non-GEO systems and how SatMaster can be used for “snapshot” analysis.
- Example: LEO link budget based on OneWeb system. Use of batch location files to prepare link budgets for a large table of locations.
- Case study from the class using the above elements and SatMaster.

# Space Mission Structures
## From Concept to Launch

**October 5-7, 2021**

Live Virtual

**$2200** (8:30am - 5:00pm)

**"Register 3 or More & Receive $100^00 each Off The Course Tuition."**

*"This course is a 'must take' for every engineer involved with space hardware/systems."*

*"Excellent presentation—a reminder of how much fun engineering can be."*

*"I wish I had taken this class 20 years ago. Possibly the best course I've ever taken."*


## Summary

This 3-day course presents the structure for a space or launch vehicle as a system. Originally based on the instructor's book, *Spacecraft Structures and Mechanisms: From Concept to Launch*, this course has evolved and been improved continuously since 1995.

If you are an engineer involved in any aspect of spacecraft or launch-vehicle structures, regardless of your level of experience, you will benefit from this course. Subjects include functions, requirements, environments, stress analysis, fatigue fracture mechanics, finite element analysis, configuration development, preliminary design, designing to avoid problems with dynamic loads, improving the loads-cycle process, verification planning, quality assurance, testing, and risk assessment.

Includes a color course book containing presentation materials and a copy of the instructor's 850-page reference book, *Spacecraft Structures and Mechanisms: From Concept to Launch (1995)*.


## Instructor

**Tom Sarafin**, is President and Chief Engineer of Instar Engineering and Consulting, Inc. He has worked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. Since founding Instar in 1993, he's consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Space Systems/Loral, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of *Spacecraft Structures and Mechanisms: From Concept to Launch* and is a contributing author to *Space Mission Analysis and Design*. He's also the principal author of a series of papers titled *"Vibration Testing of Small Satellites."* Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

## What You Will Learn

The objectives are to impart a systems perspective of space-mission structures and improve your understanding of:

- Structural functions, requirements, and environments.
- How structures behave and how they fail.
- How to develop structures that are cost-effective and dependable for space missions.

## Course Outline

**1. Overview of Space Mission Structures.** Structural functions and requirements. Effects of the space environment. How launch affects things structurally. Dispelling some myths. Top-level criteria for strength analysis. Understanding verification. Relating verification to requirements.

**2. Launch Environments and How Structures Respond.** Overview of the mechanics of vibration. Breaking down the launch environment. Quasi-static loads Transient loads and coupled loads analysis. Sinusoidal vibration. Acoustics. Random vibration. Mass/acceleration curves. Shock.

**3. Assessing Structural Integrity: Stress Analysis.** What it means to assess structural integrity. Stress and strain. Accounting for strength variation. Government standards for test options and factors of safety. Understanding stress analysis from the engineer's perspective. Common pitfalls and case histories. An effective process for strength analysis. Fatigue ad fracture mechanics. Fracture control. Structural design criteria.

**4. Overview of Finite Element Analysis.** Idealizing structures. Introduction to FEA and stiffness matrices, Effective use of FEA. Quality assurance for FEA.

**5. Configuration Development and Preliminary Structural Design.** A process for preliminary design. Configuring a spacecraft. FireSat example. Types of structures and forms of construction. Materials. Methods of attachment. Reducing cost by reducing the number of parts. Designing an adaptable structure. Designing for manufacturing. Using analysis to dessign efficient structures. Providing direct load paths. Estimating weight and managing weight growth.

**6. Improving the Loads-Cycle Process.** The traditional loads-cycle process with coupled loads analysis (CLA). Ideas for improving the loads-cycle process. Managing payload math models. Integrating stress analysis with CLA. Potentially eliminating the need for mission-specific CLA for launch of small spacecraft. Sensitivity analysis for large spacecraft.

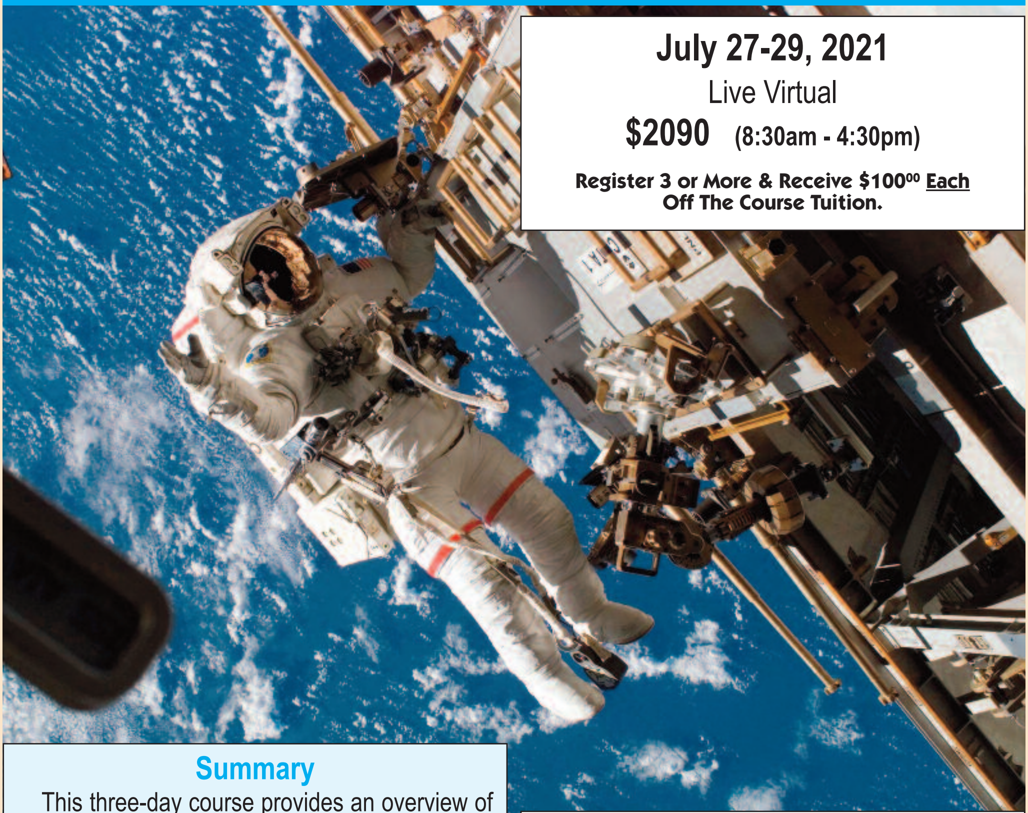
**7. Verification and Quality Assurance.** Whose job is this? Attending to details. Controlling the configuration. Proactive verification. Verification methods and logic. Philosophies for product inspection. Establishing a test program. Designing a test. Documenting and presenting verification.

**8. Final Verification and Risk Assessment.** Overview of final verification. Addressing late-arising loads problems. What does it mean to "understand" a risk? Hypothetical example: Negative margin of safety. Making the launch decision.

## Who Should Attend

Structural and mechanical design engineers, stress and dynamics analysts, systems engineers, and others interested in the topic.

# Space Missions Fundamentals



**July 27-29, 2021**

Live Virtual

**$2090** (8:30am - 4:30pm)

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary

This three-day course provides an overview of the fundamental concepts and technologies of modern space mission systems. Space missions and satellite systems combine science, engineering, and external phenomena. The course will concentrate on scientific and engineering foundations of space missions, spacecraft systems, and interactions among various subsystems.

## Instructor

**Dr. Mike Gruntman** is Professor of Astronautics at the University of Southern California. He is a specialist in astronautics, space technology, space sensors and instrumentation, and space physics. Gruntman participates in several theoretical and experimental programs in space science and space technology, including space missions. He authored and co-authored more 200 publications (including two books) in various areas of astronautics, space technology, space physics, scientific instrumentation, space and rocket history, and space education.

## Who Should Attend

Engineers and managers in the aerospace/defense industry, FFRDCs and government R&D laboratories and centers who are involved in planning, designing, building, launching and operating space systems and spacecraft subsystems and components.

## Course Outline

The fundamentals of space environment, orbital mechanics, propulsion, and subsystem technologies provide an indispensable basis for system engineering. The introduced basic nomenclature, vocabulary, and concepts will make it possible to converse with understanding with mission planners, designers, operators, and subsystem specialists.

The extensive set of course notes provide a concise reference for understanding, planning, and designing space missions and operating modern spacecraft.

Topics Covered include:

- Common space mission and spacecraft bus configurations, requirements, and constraints.
- Fundamentals of space environment and its effects on space systems.
- Common orbits and velocity increments and propellant amounts for typical maneuvers.
- Fundamentals of spacecraft subsystems and their interactions.
- Elements of space mission system engineering.

# Structural Design and Analysis for Aerospace Engineers

**December 7-9, 2021**

Live Virtual

**$2200** **(10:00am - 6:00pm Eastern)**

**Register 3 or More & Receive $100$^{00}$ Each Off The Course Tuition.**


## Summary

This new 3-day course is a companion course to Instar's flagship course, "Space Mission Structures: From Concept to Launch" (SMS). SMS gives the big picture of spaceflight structures development, while SDA goes into much more detail on design and analysis of aerospace structures and is not specific to spacecraft; most of the course applies to aircraft as well. Although we recommend people start with SMS and follow with SDA, SMS is not a prerequisite.

Subjects include statics and mechanics of materials (with emphasis on practical applications), strength and fatigue analysis (with emphasis on empirical and semi-empirical methods rather than on sole reliance on finite element analysis), and structural design (philosophy, material selection, types of structures and their considerations, methods of attachment, and guidelines).

Participants should be prepared to work class problems.

Prior acquisition of the instructor's 850-page reference book, *Spacecraft Structures and Mechanisms: From Concept to Launch* [1995], is recommended but not required.


## Instructor

**Tom Sarafin** is President, Chief Engineer, and founder of Instar Engineering and Consulting, Inc. and has worked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. Since founding Instar in 1993, he's consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Space Systems/Loral, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of *Spacecraft Structures and Mechanisms: From Concept to Launch* and is a contributing author to *Space Mission Analysis and Design*. He's also the principal author of a series of papers titled *"Vibration Testing of Small Satellites."* Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

Prior acquisition of the instructor's 850-page reference book, *Spacecraft Structures and Mechanisms: From Concept to Launch* [1995], is recommended but not required.

## Who Should Attend

Structural and mechanical design engineers, stress analysts, and others interested in the topic.

## Course Outline

**1. Structural Requirements and Design Criteria.** Structural requirements: what they are and what they are not. Typical structural functions and constraints. How flight loading environments affect the structure. Standards and criteria. Top-level criteria for strength. Other commonly used structural design criteria.

**2. Review of Statics and Free-Body Diagrams.** Static equilibrium and free-body diagrams. Benefits of a statically determinate interface. Examples and class problems. Relationship between load and displacement.

**3. Mechanics of Materials.** Stress and strain. Combined state of stress. Beams and bending stress. Unsymmetrical bending. Torsion and the effects of warping constraint. Thermal effects.

**4. Strength Analysis.** Accounting for variation in material strength: allowable stresses. Revisiting the margin of safety. Interaction of stresses; failure theories. Failure in practice. The benefits of ductility. Understanding stress analysis from the engineer's perspective. Common pitfalls and case histories. An effective process for strength analysis. Failure modes for fastened joints. Exercise: identifying potential failure modes. Forms of buckling. Elastic buckling of columns. Inelastic buckling and eccentric loading. Buckling of plates and shells.

**5. Fatigue of Metals.** What is fatigue? Brief history of fatigue failures and ensuing research.

What causes fatigue? Crack initation and growth. Stress concentration factors. Terms defining a loading cycle. Presentation of fatigue data. High-cycle (stress-life) vs. low-cycle (strain-life) fatigue. Palmgren-Miner rule. The Goodman method and equivalent alternating stress. Linear-elastic fracture mechanics. Fracture control. Generating a loading spectrum. Designing to avoid fatigue failure.

**6. Structural Design.** Opening thoughts on structural design. Material selection. Types of structures and important things to understand when designing them: Beams. Trusses and frames. Forms of lightweight panels and shells. Monocoque and semi-monocoque cylinders. Skin-stringer and panel-frame structures. Methods of attachment. Reducing cost by reducing the number of parts. Designing an adaptable structure. Summary of Sec. 6: Structural design guidelines.

**Appendix:.** Tips on finite element modeling.

# Structural Test Design & Interpretation for Aerospace


## Summary

This 3-day course provides a rigorous look at structural testing and its roles in product development and verification for aerospace programs. The course starts with a broad view of structural verification throughout product development and the roles of testing. The course then covers planning, designing, performing, interpreting, and documenting a test.

The course emphasizes static loads testing and vibration testing on a shaker. Several case studies are presented after first breaking the class into teams and tasking them with brainstorming how they would design effective tests.

An optional 4th day is available with a computer workshop on Notching and Force Limiting for an additional $600. Please see Page 29 for more information.


## Recent attendee comments ...

- *"Great course. I wish I had more people from my team with me."*
- *"The review of the entire topic is great. Typically don't get a chance to look at big picture."*
- *"I think this course should be a 'must take' for stress engineers in charge of designing and conducting standard tests."*
- *"I liked the case histories and examples. It is always good to see how theory is applied."*

## Instructor

**Tom Sarafin** is President and Chief Engineer of Instar Engineering and Consulting, Inc. He hasworked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. Since founding Instar in 1993, he's consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Space Systems/Loral, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, "Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of Spacecraft Structures and Mechanisms: From Concept to Launch and is a contributing author to Space Mission Analysis and Design. He's also the principal author of a series of papers titled "Vibration Testing of Small Satellites." Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

## Who Should Attend

All engineers involved in ensuring that flight vehicles and their payloads are structurally safe to fly. This course is intended to be an effective follow-up the instructor's course "Space-Mission Structures (SMS): From Concept to Launch", although that course is not a prerequisite.

## What You Will Learn

***The objectives of this course are to improve your understanding of how to:***

- Identify and clearly state test objectives.
- Design (or recognize) a test that satisfies the identified objectives while minimizing risk.
- Establish pass / fail criteria.
- Design the instrumentation.
- Interpret test data.
- Write a good test plan and a good test report.

## November 9-11, 2021

Live Virtual

**$2200** **(8:30am - 5:00pm)**

**"Register 3 or More & Receive $100⁰⁰ each Off The Course Tuition."**

## Course Outline

**1. Overview of Structural Testing.** Why do a structural test? Structural requirements. The building-blocks verification process. Verification logic flows. Qualification, acceptance, and protoflight testing. Selecting the right type of test. Two things all tests need. Test management: documents, reviews, and controls.

**2. Designing and Documenting a Test.** Designing a test. Suggested contents of a test plan. Test-article configuration. Boundary conditions. Ensuring adequacy of a strength test. A key difference between a qualification test and a proof test. Effective instrumentation, preparing to interpret test data. Documenting with a test report.

**3. Loads Testing of Small Specimens.** Applications and objectives. Common loading systems. Test standards. Case history: designing a test to substantiate NASA criteria for bolt analysis.

**4. Static Loads Testing of Large Assemblies.** Introduction to static loads testing. Special considerations. Introducing and controlling loads. Developing the load cases. Be sure to design the right test.

**5. Testing on an Electrodynamic Shaker.** Test configuration. Limitations of testing on a shaker. Fixture design. Deriving loads from measured accelerations. Sine-sweep testing. Sine- burst testing. Understanding random vibration. Random vibration testing.

**6. Notching and Force Limiting.** Understanding notching and why we do it. Case history: STEP-4 mission. Methods of notching. Force limiting. Designing a force-limiting fixture. NASA's semi-empirical method of force limiting; examples. Modification of force limits during test. Response limiting. Manual notching.

**7. Overview of Other Types of Structural Test.** Centrifuge testing. Modal survey testing and math-model correlation. Acoustic testing. Shock testing.

**8. Case History: Vibration Testing of a Spacecraft Telescope.** Overview. Initially planned structural test program. Problem statement. Revised approach. Testing at the telescope level of assembly. Test anomalies. Lessons learned and conclusions.

# Vibration Testing of Small Satellites


## Summary

This new two-day course provides a tutorial, practical guidance, examples, and recommendations for testing a small satellite on an electrodynamic shaker. Addressed are sine-burst testing, random vibration testing, and low-level diagnostic sine sweeps. Notching, response limiting, and force limiting are addressed in detail, with examples. The course is primarily aimed at satellites in the 50 – 500 lb (23 – 230 kg) range, but it also applies to CubeSats. Most of the guidance applies to larger satellites as well if they will be tested on a shaker. This course is designed for engineers and managers involved in ensuring small spacecraft can withstand launch environments.


## Instructor

**Tom Sarafin** is President and Chief Engineer of an engineering company. He has worked full time in the space industry since 1979 as a structural engineer, a mechanical systems engineer, a project manager, and a consultant. Since founding Instar in 1993, he's consulted for NASA, DARPA, the DOD Space Test Program, Lockheed Martin, DigitalGlobe, Space Systems/Loral, Spaceflight Industries, and other organizations. He was a key member of the team that developed NASA-STD-5020, Requirements for Threaded Fastening Systems in Spaceflight Hardware" (March 2012). He is the editor and principal author of *Spacecraft Structures and Mechanisms: From Concept to Launch* and is a contributing author to *Space Mission Analysis and Design.* He's also the principal author of a series of papers titled *"Vibration Testing of Small Satellites."* Since 1995, he has taught over 250 courses to more than 5000 engineers and managers in the aerospace industry.

## What You Will Learn

***The objectives of this course are to improve your understanding of how to:***

- Establish an effective vibration test program.
- Identify and clearly state test objectives.
- Design (or recognize) a test that satisfies the identified objectives while minimizing risk of an over test.
- Establish pass/fail criteria and interpret test data.
- Write effective test plans and reports.

## Recent attendee comments ...

*"Anyone involved with the mechanical structure of a spacecraft or test engineering of ensuring a spacecraft survives launch should take this course – very well taught!"*

*"Great job teaching the why and how of vibration testing of small sats."*

## August 24-25, 2021

Live Virtual

**$1650** (8:30am - 4:30pm)

**"Register 3 or More & Receive $100.00 each Off The Course Tuition."**

***"April 23, 2020: Optional one-day computer workshop on notching and force limiting, available only to participants of the Vibration Testing course. $600. Participants must bring a computer loaded with Microsoft Excel."***

## Course Outline

**1. Overview.** Shaker basics. Test Objectives. Review: Mechanics of Vibration; transmissibility. Common types of vibration tests. Pass/fail criteria. Limitations of testing on a shaker. Dry running the test.

**2. Test Configuration, Fixtures, and Instrumentation.** Test article configuration. Test fixture design. Providing a flight-like interface. Mass simulator design. Accelerometers. Strategies for determining base force and moment.

**3. Low-level Sine Sweep Testing.** Objectives and test parameters. Examples of response data. Deriving damping from test data. Criteria for pre- and post-test comparisons. Common reasons for differences between pre and post-test data. Limitations of sine-sweep comparisons in detecting failure.

**4. Sine Burst Testing.** Introduction and objectives. Applicable standards. Limitations of sine-burst test effectiveness. Pass/fail criteria. Designing the sine-burst test environment. Establishing the test axes and deriving the target accelerations. Selecting the sine-burst frequency. Potential problem and recommendations.

**5. Random Vibration Testing.** Introduction and objectives. Acceleration (or power) spectral density: understanding $g^2$/Hz. Root-mean-square acceleration. Peak acceleration for random vibration. Decibels. How test environments are derived. Government standards. Use of GEVS environments and a related common problem. Data resolution. Interpreting test data.

**6. Notching and Force Limiting.** What is notching, and why do we do it? Methods of notching: force limiting, response limiting, and manual notching. Case history: how notching without technical rationale led to mission failure. Using force gages to measure base force. Force limiting: references, the semi-empirical method of deriving force limits, examples modification during test. Response limiting. Manual notching.

**7. Test Documentation and Reviews.** Managing the process. Test plans and procedures. Getting buy-in before the test. Test-readiness review. Pre-teardown review. Flash report. Test report.

# Acoustic Fundamentals & Measurements with Underwater Applications

**August 16-18, 2021**

Live Virtual

**$2090** **(10:30am - 4:00pm)**

**Register 3 or More & Receive $100⁰⁰ Each Off The Course Tuition.**

## Summary

This four-day course is intended for engineers and other technical personnel and managers who have a work-related need to understand basic acoustics concepts and how to measure and analyze sound. This is an introductory course and participants need not have any prior knowledge of sound or vibration. Each topic is illustrated by relevant applications, in-class demonstrations, and worked-out numerical examples. Since the practical uses of acoustics principles are vast and diverse, participants are encouraged to confer with the instructor (before, during, and after the course) regarding any work-related concerns. On-site courses are fully customized to the customer's applications.

## Instructor

**Dr. Alan D. Stuart**, Associate Professor Emeritus of Acoustics, Penn State, has over forty years experience in the field of sound and vibration. He has degrees in mechanical engineering, electrical engineering, and engineering acoustics. For over thirty years he has taught courses on the Fundamentals of Acoustics, Structural Acoustics, Applied Acoustics, Noise Control Engineering, and Sonar Engineering on both the graduate and undergraduate levels as well as at government and industrial organizations throughout the country.

## What You Will Learn

- How underwater sensors work.
- How to make proper sound level measurements.
- How to analyze and report acoustic data.
- The basis of decibel (dB) scale used in underwater acoustics.
- How to use third-octave band analyzers and narrow-band spectrum analyzers.
- How acoustic arrays are used to improve target detection.
- How to measure sound propagation loss including surface scatter and bottom penetration.
- How to detect a passive target in a background of ambient and self-noise.
- How to detect an active sonar ping in a background of reverberation noise.

Recent attendee comments ...

*"Great instructor made the course interesting and informative. Helped clear-up many misconceptions I had about sound and its measurement."*

*"Enjoyed the in-class demonstrations; they help explain the concepts. Instructor helped me with a problem I was having at work, worth the price of the course!"*

## Course Outline

**1. Introductory Concepts.** Sound in fluids and solids. Sound as particle vibrations. Waveforms and frequency. Sound energy and power consideration.

**2. Acoustic Waves in Water.** Plane and spherical acoustic waves. Spreading loss and plane wave equivalent. Sound pressure, intensity, and power. Decibel (dB) scales used in underwater acoustics. Sound reflection, transmission, and refraction (Snell's law). Mechanisms of underwater sound absorption.

**3. Underwater Acoustic Transducers.** Hydrophone and active transducer element designs and response characteristics. Underwater intensity and vector probe designs and operational limitations. Accelerometer designs and frequency response.

**4. Sound Measurements.** Underwater sound level scales. Octave band analyzers. Narrow band and FFT spectrum analyzers. Detecting tones in noise. Hydrophone calibration techniques.

**5. Sound Sources and Arrays.** Active sonar design and response characteristics. Directivity patterns of simple and multi-pole sources: monopole, dipole and quadri-pole sources. Acoustic arrays and beamforming. Sound radiation from vibrating machines and structures. Radiation efficiency.

**6. Underwater Acoustics.** Sound refraction due to temperature, depth, and salinity. Ambient and self-noise consideration. Passive and active sonar equation. Passive and active target detection, tracking, and localization. Reverberation noise: volume, surface, and bottom. Topics of interest to the course participants.

# Passive & Active Sonar - Fundamentals

**August 31-September 3, 2021**

Live Virtual

**$2290** (8:30am - 4:30pm)

**Register 3 or More & Receive $100.00 Each Off The Course Tuition.**


## Summary

This four-day course is designed for SONAR systems engineers, combat systems engineers, undersea warfare professionals, and managers who wish to enhance their understanding of passive and active SONAR or become familiar with the "big picture" if they work outside of either discipline. Each topic is presented by instructors with substantial experience at sea. Presentations are illustrated by worked numerical examples using simulated or experimental data describing actual undersea acoustic situations and geometries. Visualization of transmitted waveforms, target interactions, and detector responses is emphasized.


## Instructor

**Dr. Harold "Bud" Vincent**, Research Associate Professor of Ocean Engineering at the University of Rhode Island is a U.S. Naval officer qualified in submarine warfare and salvage diving. He has over twenty years of undersea systems experience working in industry, academia, and government (military and civilian). He served on active duty on fast attack and ballistic missile submarines, worked at the Naval Undersea Warfare Center, and conducted advanced R&D in the defense industry. Dr. Vincent received the M.S. and Ph.D. in Ocean Engineering (Underwater Acoustics) from the University of Rhode Island. His teaching and research encompass underwater acoustic systems, communications, signal processing, ocean instrumentation, and navigation. He has been awarded four patents for undersea systems and algorithms.

## What You Will Learn

- The differences between various types of SONAR used on Naval platforms today.
- The fundamental principles governing these systems' operation.
- How these systems' data are used to conduct passive and active operations.
- Signal acquisition and target motion analysis for passive systems.
- Waveform and receiver design for active systems.
- How to avoid significant mistakes revealed by experience at sea.
- The major cost drivers for undersea acoustic systems.

## Course Outline

1. **Sound and the Ocean Environment:** Conductivity, temperature, depth (CTD), sound velocity profiles, refraction, decibels, transmission loss, and attenuation. Source reference levels in air and water.

2. **SONAR System Fundamentals.** Major system components in a SONAR system (transducers, signal conditioning, digitization, signal processing, displays and controls). Various SONAR systems (hull, towed, side scan, multibeam, communications, navigation, etc.). Calculation of source level (dB) as a function of acoustic power output (watts) and source directivity index. Measurement of target strength at sea, echo energy splitting.

3. **Array Gain and Beampatterns.** Calculation of beam patterns for line arrays, directional steering, shading for sidelobe control. Directivity index of an array and array grating lobes.

4. **SONAR Equations.** Passive and active SONAR equations. Probabilities of detection and false alarm. Relationship between energy, intensity, and spectrum height. Alternative active SONAR equations when working against noise or reverberation. Limitations of these equations in deep and shallow water.

5. **Target Motion Analysis (TMA).** What it is, why it is done, how SONAR is used to support it, what other sensors are required to determine the motion of passive targets.

6. **Time-Bearing Analysis.** How relative target motion affects bearing rate, ship maneuvers to compute passive range estimates (Ekelund Range). Use of time-bearing information to assess passive target motion.

7. **Waveform and Receiver Design.** Traditional and novel waveform alternatives. Replica correlation and convolution. Discrete Fourier transform. Narrowband and wideband ambiguity functions. Accounting for real medium effects.

# Sonar & Target Motion Analysis

## Summary

This three-day course is designed for SONAR systems engineers, combat systems engineers, undersea warfare professionals, and managers who wish to enhance their understanding of this discipline or become familiar with the "big picture" if they work outside of the discipline. Each topic is illustrated by worked numerical examples, using simulated or experimental data for actual undersea acoustic situations and geometries.

## Instructor

**Dr. Harold "Bud" Vincent** Research Associate Professor of Ocean Engineering at the University of Rhode Island and President of DBV Technology, LLC is a U.S. Naval Officer qualified in submarine warfare and salvage diving. He has over twenty years of undersea systems experience working in industry, academia, and government (military and civilian). He served on active duty on fast attack and ballistic missile submarines, worked at the Naval Undersea Warfare Center, and conducted advanced R&D in the defense industry. Dr. Vincent received the M.S. and Ph.D. in Ocean Engineering (Underwater Acoustics) from the University of Rhode Island. His teaching and research encompasses underwater acoustic systems, communications, signal processing, ocean instrumentation, and navigation. He has been awarded four patents for undersea systems and algorithms.

## What You Will Learn

- What are of the various types of SONAR systems in use on Naval platforms today.
- What are the major principles governing their design and operation.
- How is the data produced by these systems used operationally to conduct Target Motion Analysis and USW.
- What are the typical commercial and scientific uses of SONAR and how do these relate to military use.
- What are the other military uses of SONAR systems (i.e. those NOT used to support Target Motion Analysis).
- What are the major cost drivers for undersea acoustic systems.

**October 19-21, 2021**

Live Virtual

**$2090** (8:30am - 4:30pm)

**"Register 3 or More & Receive $100^{00} each Off The Course Tuition."**

## Course Outline

1. **Sound and the Ocean Environment.** Conductivity, Temperature, Depth (CTD). Sound Velocity Profiles.Refraction, Transmission Loss, Attenuation.

2. **SONAR Equations.** Review of Active and Passive SONAR Equations, Decibels, Source Level, Sound Pressure Level, Intensity Level, Spectrum Level.

3. **Signal Detection.** Signals and Noise, Array Gain, Beamforming, BroadBand, NarrowBand.

4. **SONAR System Fundamentals.** Review of major system components in a SONAR system (transducers, signal conditioning, digitization, signal processing, displays and controls). Review of various SONAR systems (Hull, Towed, SideScan, MultiBeam, Communications, Navigation, etc.).

5. **SONAR Employment, Data and Information.** Hull arrays, Towed Arrays. Their utilization to support Target Motion Analysis.

6. **Target Motion Analysis (TMA).** What it is, why it is done, how is SONAR used to support it, what other sensors are required to conduct it.

7. **Time-Bearing Analysis.** How relative target motion affects bearing rate, ship maneuvers to compute passive range estimates (Ekelund Range). Use of Time-Bearing information to assess target motion.

8. **Time Frequency Analysis.** Doppler shift, Received Frequency, Base Frequency, Corrected Frequency. Use of Time-Frequency information to assess target motion.

9. **Geographic Analysis.** Use of Time-Bearing and Geographic information to analyze contact motion.

10. **Multi-sensor Data Fusion.** SONAR, RADAR, ESM, Visual.

11. **Relative Motion Analysis and Display:** Single steady contact, Single Maneuvering contact, Multiple contacts, Acoustics Interference.

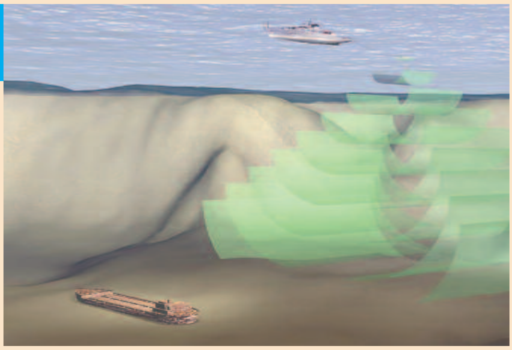
# Sonar Signal Processing

**September 28-30, 2021**

Live Virtual

**$2090** **(8:30am - 4:00pm)**

**Register 3 or More & Receive $100[00] Each Off The Course Tuition.**



## Summary


This three-day short course provides an overview of sonar signal processing. Processing techniques applicable to bottom-mounted, hull-mounted, towed and sonobuoy systems will be discussed. Spectrum analysis, detection, classification, and tracking algorithms for passive and active systems will be examined and related to design factors. Advanced techniques such as high-resolution array-processing and matched field array processing, advanced signal processing techniques, and sonar automation will be covered.

The course is valuable for engineers and scientists engaged in the design, testing, or evaluation of sonars. Physical insight and realistic performance expectations will be stressed. A comprehensive set of notes will be supplied to all attendees.


## Instructors

**James W. Jenkins** joined the Johns Hopkins University Applied Physics Laboratory in 1970 and has worked in ASW and sonar systems analysis. He has worked with system studies and at-sea testing with passive and active systems. He was a senior physicist investigating improved signal processing systems, APB, onship monitoring, and SSBN sonar.

**Dr. Bruce Newhall** has over 40 years of experience in underwater acoustics, sonar, and signal processing. He was chief scientist for several large scale Navy experiments, and the supervisor of the Acoustic and Electromagnetics Group at the Johns Hopkins Applied Physics Lab. He has served as Associate Editor for the IEEE Journal of Oceanic Engineering. In recognition of his innovative work, he is a fellow of the Acoustic Society, received the bronze medal from the NDIA and is the 2017 recipient of the Donald W. Tufts award in underwater acoustic signal processing from the IEEE.

## Course Outline

**1. Introduction to Sonar Signal Processing**. Introduction to sonar detection systems and types of signal processing performed in sonar. Correlation processing, Fournier analysis, windowing, and ambiguity functions. Evaluation of probability of detection and false alarm rate for FFT and broadband signal processors.

**2. Beamforming and Array Processing.** Beam patterns for sonar arrays, shading techniques for sidelobe control, beamformer implementation. Calculation of DI and array gain in directional noise fields.

**3. Passive Sonar Signal Processing.** Review of signal characteristics, ambient noise, and platform noise. Passive system configurations and implementations. Spectral analysis and integration.

**4. Active Sonar Signal Processing.** Waveform selection and ambiguity functions. Projector configurations. Reverberation and multipath effects. Receiver design.

**5. Passive and Active Designs and Implementations.** Design specifications and trade-off examples will be worked, and actual sonar system implementations will be examined.

**6. Advanced Signal Processing Techniques.** Advanced techniques for beamforming, detection, estimation, and classification will be explored. Optimal array processing. Data adaptive methods, super resolution spectral techniques, time-frequency representations and active/passive automated classification are among the advanced techniques that will be covered.

## What You Will Learn

- Fundamental algorithms for signal processing.
- Techniques for beam forming.
- Trade-offs among active waveform designs.
- Ocean medium effects.
- Optimal and adaptive processing.

# TOPICS for ON-SITE Courses

## ATI offers these courses AT YOUR LOCATION...customized for you!

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C4ISR Requirements, Principles, and Systems
Combat Systems Engineering
Concurrent Multi-Netting / Concurrent Contention Receive - Always Available
Counter UAS Technology and Techniques
Electronic Packaging - Introduction
Electronic Protection and Electronic Attack
Electronic Warfare - Advanced
Electronic Warfare - Overview of Tech & Ops
Electronic Warfare 101
Electronic Warfare Against the New Threat Environment
Electronic Warfare ELINT Receivers w /DSP
Electronic Warfare Tactical Battlefield Communications
EW / ELINT Receivers with Digital Signal Processing Techniques
Examining Network Centric Warfare
Explosives Technology & Modeling
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Link 16 / JTIDS / MIDS
Link 16 Advanced with Network Enabled Weapons (Virtual)
Link 16 Network Enabled Weapons Planning & Design -Intro - Always Available
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MIDS Baseline Upgrade-2 - Introduction
MIDS Baseline Upgrade-2 and JTRS Training (Virtual)
MIDS Baseline Upgrade-2 Introduction
MIDS JTRS and Baseline Upgrade-2 Capabilities
Military Standard 810
Missile Defense: Making Decisions
Missile Design, Development & Engineering
Multi-Target Tracking & Multi-Sensor Data Fusion
Naval Weapons Principles
Network Planning and Design - Intro
Propagation Effects for Radar & Communication Systems
Pyrotechnic Shock Testing, Measurement, Analysis and Calibration
Radar 101
Radar 201 - Advances in Modern Radar
Radar Principles
Radar Systems Design & Engineering
Radar Systems Fundamentals
Rockets & Launch Vehicles - Selection & Design
Rockets & Missiles Fundamentals
Software Defined Radio Development - Practical
Synthetic Aperture Radar
Tactical & Strategic Missile Guidance
Tactical & Strategic Missile Guidance
Understanding Link 16: Enhanced Throughput
Unmanned Air Vehicle Design
Unmanned Aircraft System Fundamentals
Wireless Sensor Networking Solutions for Tactical ISR (T-ISR)

### Engineering & Signal Processing

Advanced Topics in Digital Signal Processing
Antenna & Array Fundamentals
Applied Measurement Engineering
Composite Materials for Aerospace
Computational Electromagnetics
Data: Visualization
Deep Learning Architectures for Defense & Security
Design for EMC & Troubleshooting -3 days
Digital Signal Processing - Tips & Tricks
Digital Signal Processing System Design
Digital Technology - Essentials
Electromagentic Compatibility Design & Signal Itegrity
Electromagnetic Environmental Effects (E3) for Space Systems
Electronic Technology - Essentials
EMC PCB Design and Integration Course
EMI / EMC in Systems & Facilities
EMI/EMC in Military Systems
Evolutionary Optimization Algorithms: Fundamentals
Fiber Optics Fundamentals and Applications
Fiber Optics Technology & Applications
High-Speed Digital Design & PCB Layout
High-Speed Digital Design & PCB Layout / Internet of Things / 5G Transmission
Internet of Things - Hands-On Development
Introduction to Electromagnetic Compatibility/Interference (EMC/EMI) in Communications Systems
Kalman Filtering Fundamentals
MIL-STD 461F (G) Test Methods & Compliance
MIL-STD_461G Test Methods and Compliance (Online Only)
MIL-STD-461G / RTCA DO-160G EMC Methods & Compliance (Online only)
Optical Communications Systems
Radio Frequency Interference (RFI) in Wireless Communications
Random Vibration & Shock Testing - Fundamentals
Remote Sensing For Earth Science Applications
RF Engineering - Fundamentals
RF Engineering with MATLAB
Statistics with Excel Examples - Fundamentals
Telecommunications - Fundamentals
Wireless Communications & Spread Spectrum Design

### Satellite Communications, Space & Aerospace

Aircraft Conceptual Design
Aircraft Design: Configuration Layout, Loft, & CAD
Astropolitics
Avionics & Weapons Systems Flight Test
Communications Payload Design and Satellite System Architecture
Design & Analysis of Bolted Joints
Directions in Space Remote Sensing
Earth Station & Terminal Design
EMI / EMC in Communications Systems
Ground Systems Design & Operations
Ground Systems Design & Operations
Launch Vehicle Design - Advanced Topics
Launch Vehicle Design, Selection, Performance, & Use
Launch Vehicle Systems - Reusable
Liquid Rocket Engines for Spacecraft
New Directions for Space Remote Sensing
Notching and Force Limiting Workshop (NFLW)
Optical & Remote Sensing
Project Management for Space Systems
Remote Sensing Information Extraction
SATCOM Technology and Networks
Satellite Communications - Introduction
Satellite Communications - State of the Art
Satellite Communications Design and Engineering
Satellite Communications Systems - Advanced
Satellite Laser Communications
Satellite Link Budget Training on the Personal Computer
Satellite Liquid Propulsion Systems
Solid Rocket Motor Design & Applications
Space Environment Implications for Spacecraft Design
Space Mission Analysis and Design
Space Mission Structures
Space Missions Fundamentals
Space Systems Fundamentals
Space-Based Laser Systems
Spacecraft Configuration Development & Structural Design (SCD)
Spacecraft Structures: Design, Analysis and Test
Spacecraft Systems Integration & Test
Spacecraft Thermal Control
Structural Design & Analysis for Aerospace Engineers (SDA)
Structural Test Design and Interpretation for Aerospace Programs
Understanding Structural Verification: For Space-Mission Hardware
Vibration Testing of Small Satellites

### Sonar Engineering & Acoustics

Acoustics Fundamentals, Measurements with Underwater Applications
Acoustics Fundamentals, Measurements, and Applications
Acoustics Fundamentals: Airborne Noise Monitoring
Advanced Topics In Underwater Acoustics
Advanced Topics In Underwater Acoustics 3 days
Applied Physical Oceanography and Acoustics
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Ocean Optics: Fundamentals & Naval Applications
Passive and Active Sonar
Sonar & Target Motion Analysis
Sonar 101
Sonar Principles & ASW Analysis
Sonar Signal Processing
Sonar Transducer Design
Submarines & Submariners
Undersea Warfare - Advanced
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