94TH SHOCK AND VIBRATION SYMPOSIUM

TUTORIAL GUIDE

NOVEMBER 3 - 7, 2024 | DALLAS

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SUNDAY, NOVEMBER 3
EXTENDED TUTORIAL SESSION I (9AM - 4PM)

MIL-DTL-901E SHOCK QUALIFICATIONS & SHOCK EXTENSIONS
Kurt Hartsough (901 E&T)

MIL-DTL-901E SHOCK QUALIFICATIONS
Instructors will be presenting the requirements for shock qualification testing as detailed in MIL-DTL-901E and interpreted by NAVSEA 05P1. Shock testing theory, MIL-DTL-901E shock test devices and facilities, detailed specification requirements, cost avoidance and clarification and MIL-DTL-901E IC#2 will be covered. Attendees should include anyone involved in the acquisition, specification, review and approval of Navy shipboard equipment including PARMs and LCMs and contracting officers, contractors having to deal with the Navy and wishing to supply shock qualified equipment to the Navy, Ship Program Managers and Ship Logistic Managers responsible for the acquisition & maintenance of shock hardened Navy ships and shock qualification test facilities.

MIL-DTL-901E SHOCK EXTENSIONS
Instructors will also be presenting the requirements for shock qualification extensions as detailed in MIL-DTL-901E and interpreted by NAVSEA 05P1. Shock extension specification requirements, MIL-DTL-901E design guidelines and shock design lessons learned will be covered. Attendees should include anyone involved in the acquisition, specification, review and approval of Navy shipboard equipment including PARMs and LCMs and contracting officers, contractors having to deal with the Navy and wishing to supply shock qualified equipment to the Navy, Ship Program Managers and Ship Logistic Managers responsible for the acquisition & maintenance of shock hardened Navy ships and shock qualification test facilities.

**If you enroll in this six-hour course, the two separate courses of similar names on Monday will be duplicate material.*

MONDAY, NOVEMBER 4
TUTORIAL SESSION I (8AM - 11AM)

MIL-DTL-901E SHOCK QUALIFICATION TESTING
Kurt Hartsough (901 E&T)

Instructors will be presenting the requirements for shock qualification testing as detailed in MIL-DTL-901E and interpreted by NAVSEA 05P1. Shock testing theory, MIL-DTL-901E shock test devices and facilities, detailed specification requirements, cost avoidance and clarification and MIL-DTL-901E IC#2 will be covered. Attendees should include anyone involved in the acquisition, specification, review and approval of Navy shipboard equipment including PARMs and LCMs and contracting officers, contractors having to deal with the Navy and wishing to supply shock qualified equipment to the Navy, Ship Program Managers and Ship Logistic Managers responsible for the acquisition & maintenance of shock hardened Navy ships and shock qualification test facilities.

PLANNING LIFE CYCLE DESIGN, ANALYSIS, AND SHOCK AND VIBE QUALIFICATION OF NAVY EQUIPMENT
Dr. Christopher Merrill (CM&A Engineering)

This tutorial provides general simple techniques for use in parallel with long term Classical and Numerical Dynamic Analysis of Systems subjected to US Navy shock and vibration requirements over Navy equipment life cycles to maximize accuracy and minimize errors in Dynamic Analysis and Qualification of electronic and mechanical systems. The interaction of the US Navy shock and vibration requirements is a major driver of the efficacy of long-term Dynamic Analysis from the start. Apart from major issues that occur on any major long-term developmental programs, simple, seemingly minor, errors present in the analysis from the beginning can lead to huge cost and schedule impacts generally at the worst time for the program (FAT). Fortunately, there are procedural long-term Dynamic Analysis Quality Control techniques that can be used from the beginning and in parallel during the long-term dynamic analysis to mitigate the risk of such errors. This tutorial will provide examples of types and genesis of such errors, as well as, a process to perform at the beginning and in parallel with the long-term dynamic analysis in order to perform quality control comparisons to mitigate these errors. Finally, the importance of comparison of FAT dynamic test results to dynamic analysis including failure and use of prototyping will be included. The tutorial will end with an exercise where the trainer will attempt to stump the trainee with balky computer model results. The trainee will leave the tutorial with a list of types and genesis of discrete and basic errors, a process chart and algorithm for applying these Quality Control Techniques at the start and in parallel with the long-term dynamic analysis, and insight on improving techniques for planning Life Cycle Design, Analysis, and Shock and Vibe Qualification of Navy Equipment.

FUNDAMENTALS OF SINE AND RANDOM SHAKER TESTING
Chris Sensor (Siemens)

This tutorial will cover the fundamental concepts of shaker Sine and Random vibration testing. Swept Sine, Sine Dwell, Random, Sine-on-Random, Random-on-Random and Time Waveform Replication test modes will be covered. Additional topics such as response limiting, control channel averaging, kurtosis, and practical shaker considerations will also be discussed. Subjects will be accompanied by live demos of shaker tests, with opportunities for hands on participation by attendees.

MIMO VIBRATION TESTING AND ANALYSIS USING OPEN-SOURCE SOFTWARE

Daniel Rohe (Sandia National Laboratories)

Open-Source Tools have become widespread in several scientific disciplines. The free and open-source Python programming language has become a serious competitor to Matlab as a scripting language for performing scientific analyses. There are now several major Structural Dynamics Python packages that are in development or have been released, such as PyFBS, Rattlesnake Vibration Controller, SDynPy, and SDyPy. It is now possible to perform the entire Structural Dynamics workflow using only free and open-source software. Moving Structural Dynamics into open source provides numerous benefits: students can examine code to learn exactly how various algorithms work, researchers can tinker with the code to explore new solutions without having to write everything from scratch, and practitioners can execute their tests or analyses in software that isn't simply a "black box."

This tutorial will introduce and demonstrate two software tools developed at Sandia National Laboratories that have been released open source. SDynPy is a Python package for performing structural dynamics analyses. It provides many common structural dynamics and signal processing operations as built-in functions and provides numerous tools to visualize data. Rattlesnake is a Multiple-Input, Multiple-Output (MIMO) vibration controller that can perform Random and Transient vibration control, as well as modal testing, using various hardware devices.

First, the SDynPy Python package will be used to perform pre-test analysis: a finite element model of the test article will be loaded and analyzed to select optimal instrumentation and shaker locations. Then Rattlesnake will be used to perform Modal, MIMO Random, and MIMO Transient testing. SDynPy will then be used to analyze the results of the tests and compare back to the model.

ANALYSIS FOR A MEDIUM WEIGHT SHOCK TEST

Josh Gorfain (Quartus Engineering)

While a shock test is essentially the bottom line for a shock qualification, a lot of analysis often goes into the mix before the test. The reasons for this are many: The equipment manufacturer wants his equipment to pass and will often commission some kind of pre-test prediction to maximize the likelihood of success or to high-light design problems. Since the weight and frequency of the tested equipment can affect the response of the test significantly, the system may need to be examined to assure that the tested environment is correct. This tutorial will first review the Medium Weight Shock Machine (MWSM) and its use in shock qualification testing, followed by presentation of the test environment. Next, the types of analysis that can be performed to estimate the test environment experienced by a given piece of equipment will be described. The intention of these analyses is to provide an assessment of equipment response subject to a MWSM test in an effort to assure a successful test. Additionally, the merits and limits of these methods are discussed so the most appropriate method may be rationally selected for a given application. Examples will be presented that illustrate the different types of analyses and how they may be applied.

MONDAY, NOVEMBER 4
TUTORIAL SESSION II (NOON - 3:00PM)

MIL-DTL-901E SHOCK QUALIFICATION TESTING EXTENSIONS
Kurt Hartsough (901 E&T)

Instructor will be presenting the requirements for shock qualification extensions as detailed in MIL-DTL-901E and interpreted by NAVSEA 05P1. Shock extension specification requirements, MIL-DTL-901E design guidelines and shock design lessons learned will be covered. Attendees should include anyone involved in the acquisition, specification, review and approval of Navy shipboard equipment including PARMs and LCMs and contracting officers, contractors having to deal with the Navy and wishing to supply shock qualified equipment to the Navy, Ship Program Managers and Ship Logistic Managers responsible for the acquisition & maintenance of shock hardened Navy ships and shock qualification test facilities.

DATA INTEGRITY
John Hiatt (DEWESoft)

The data integrity training is designed as an overview of the data acquisition process and how each step in the measurement chain can affect your measured data. Primary focus of this session is on the data acquisition system (DAS). We will learn what happens in each step of the process and how to mitigate common measurement errors. The idea is to get the best possible data first time. Its hard to make good decisions with bad data. We also cover DAS specifications so users can be better prepared to compare system specifications.

FUNDAMENTALS OF CLASSIC SHOCK AND SRS SHAKER TESTING
Chris Sensor (Siemens)
Bob Metz (PCB Piezotronics)

This tutorial will cover the fundamental concepts of shaker shock testing, from field data acquisition to Classic Shock and Shock Response Spectrum (SRS) wavelet synthesis in a vibration controller. The tutorial will cover shock data acquisition and analysis, classic shock pulses, SRS concepts, SRS and Pseudo Velocity Shock Spectrum (PVSS) data analysis, a review of Classic Shock and SRS test methods in MIL-STD-810H (including the “new” method of Te and TE), shock test tailoring and SRS wavelet synthesis for shaker SRS testing. A segment covering specialty shock sensors and instrumentation will also be presented. Subjects will be accompanied by live demos of data acquisition and shaker tests, with opportunities for hands on participation by attendees.

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EFFECTIVE SOLUTIONS FOR SHOCK AND VIBRATION CONTROL

Alan Klembczyk (Taylor Devices) & Ken Lussky (BAE Systems)

Part 1 of this Tutorial provides an outline of various applications and methods for implementing isolation control of dynamic loads and damping within a wide array of dynamic systems and structures. Photos, videos, and graphical results are presented of solutions that have been proven effective and reliable in the past. Design examples are given and typical applications are reviewed. Additionally, key definitions and useful formulae are presented that will provide the analyst or systems engineer with the methods for solving isolation problems within the commercial, military, and aerospace sectors. A wide range of isolation mounts and systems are covered including liquid dampers, elastomer and wire rope isolators, tuned mass dampers, and engineered enclosures. Engineering guidelines are presented for the selection and evaluation of isolation control products.

Part 2 of this Tutorial addresses characterization of shock and vibration environments and finite element analysis (FEA) of shock and vibration isolation performance. Methods used to characterize shock and vibration responses and their application are defined. For shock these include spectral definitions (SRS shock response spectrum and PVSS pseudo velocity shock spectrum) and time-history definitions (peak velocity, peak acceleration, average acceleration and displacement). These are discussed with respect to their application to shock input severity, and equipment fragility and damage potential. Shock test qualification methods, their input definitions, and how they are represented in FEA are discussed. Also addressed are the value of damping in shock isolation and how shock and vibration isolation systems are represented in FEA. For vibration the spectral definition of Acceleration Spectral Density (ASD) is discussed. Other topics addressed are the application of UERD Tools for shock characterization, and when to engage with the appropriate shock and vibration Technical Warrant Holders (TWH).

AN INTRODUCTION TO ALIASING, FFT, FILTERING, SRS & MORE FOR FEA USERS AND TEST ENGINEERS

Dr. Ted Diehl (Bodie Technology)

Working with either physical test data and/or numerical simulations related to severe mechanical shock, impact, failure, etc. is challenging. Some of the biggest challenges in this type of work are 1) properly collecting the initial raw data while avoiding aliasing, 2) utilizing robust methods to identify and separate the “noise & distortions” from the “true” frequency-rich content in the data, and 3) determining what portion of the “true” frequency-rich content is meaningful and what does it tell you. For a given problem, the initial appearance of raw time-domain data in this class of work may be vastly different between physical testing and data derived from transient simulation codes (LS-Dyna, Abaqus/Explicit, RADIOSS…). While the data might look different, the rules of DSP (Digital Signal Processing) are the same. Most importantly, understand and utilizing DSP properly is a critical requirement to success in BOTH types of approaches, especially to obtain correlation between physical tests and simulation of the same specific problem.

The tutorial provides guidance to simulation analysts and test engineers on how to properly collect and process such data; ultimately uncovering significantly improved results. The course covers highlights of DSP theory in the language of Mechanical Engineering pertinent to simulation analysts and test engineers. This tutorial introduces key aspects of working with transient data – specifically, explaining time-domain and frequency domain analysis (DFS, FFT, PSD); data collection (sampling, up-sampling, decimation, and aliasing); filtering (lowpass, highpass, IIR, and FIR), how to avoid aliasing, calculating Shock Response Spectrum (Accel SRS & PVSS) from transient data, and unique aspects related to explicit dynamics FEA data (non-constant time increments, massively over-sampled data, short transient signals with non-zero end conditions, and more). Simplified demonstrations are presented to solidify key DSP aspects, along with many relevant real-world examples. Both FEA users and experimentalists will benefit from this training.

MONDAY, NOVEMBER 4
TUTORIAL SESSION II (CONTINUED)

INTRODUCTION TO MIL-STD-461 ELECTROMAGNETIC INTERFERENCE TESTING

Jeff Viel (Element US Space & Defense)

This 3 hour tutorial provides a detailed technical overview of MIL-STD-461G addressing the electromagnetic interference (EMI) emission and susceptibility test methods and control requirements for subsystems and equipment and subsystems designed or procured for the Department of Defense (DoD). This tutorial starts from the very beginning discussing the basis for EMI control testing, including a historical case study, to the progressive development of test methods and requirements adapted to modern day technologies and electromagnetic environments. While the standard is broadly designed to address all DOD platforms, this tutorial is focused to specifically address shipboard and submarine application requirements.

MONDAY, NOVEMBER 4
TUTORIAL SESSION III (3:30PM - 6:30PM)

MIL-DTL-901E SUBSIDIARY COMPONENT SHOCK TESTING & ALTERNATIVE TEST VEHICLES
Kurt Hartsough (901 E&T)

The course will cover the following areas: NAVSEA 05P1's current policy for testing subsidiary components, description of test environment requirements, examples of recent successful test programs, alternate test vehicle descriptions, alternate test vehicle limitations, discussions on shock spectra, Multi-Variable Data Reduction (MDR) and various shock isolation systems. This course is intended to give the necessary information to equipment designers and program managers who intend to shock qualify COTS equipment that will require frequent upgrades due to obsolescence, equipment upgrades, change in mission, etc. Although not required, it is recommended that those attending this course also attend courses on Shock Policy, MIL-DTL-901E testing and particularly MIL-DTL-901E extensions offered by the same instructors (Urzillo and Kurt Hartsough).

DDAM 101
George D. (Jerry) Hill (SERCO)

The U.S. Navy Dynamic Design Analysis Method (DDAM) has been in general use since the early 1960s. It is a method of estimating peak shock response of equipment and outfitting on naval combatants using normal mode theory, originally extended from earthquake analysis methods. The DDAM requires linearelastic model behavior and employs a statistical method of modal superposition yet has persisted to today as the U.S. Navy required method for shock qualification by analysis. This, in spite of the rapid advancement of dynamic transient simulation technology and techniques for representing nonlinearities including material plasticity and contact behavior. The tutorial will address: how the method works, how the shock spectral input values are presented in DDS-072-1, what is the role of modal weights and participation factors, why has the method persisted including what are its strengths and also what are its weaknesses. The tutorial will provide a basic understanding of the method, requirements, and procedures to those who expect to be involved in shock analysis and will demystify the procedure for many who are current users.

AIR BLAST AND CRATERING: AN INTRODUCTION TO THE ABC'S OF EXPLOSION EFFECTS IN AIR AND ON LAND
Denis Rickman (USACE ERDC)

This three-hour course introduces the effects of explosions in air and on land. Topics covered include airblast, soil/rock/pavement cratering, and ground shock phenomena produced by explosive detonations. There is a little math, but for the most part, the focus is on aspects and principles that are of practical use to those conducting (and utilizing) blast-related research. Most researchers in the blast arena have some grasp of explosion effects fundamentals, but very few have a good, broad-based understanding of how it all works. The goal is to provide the participants with enough of an understanding that they can appreciate the various explosion phenomena and those parameters that affect blast propagation and blast loading of objects in a terrestrial setting.

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MONDAY, NOVEMBER 4
TUTORIAL SESSION III (CONTINUED)

ACOUSTIC ENVIRONMENT ORIGINIS, EFFECTS, AND SIMULATION
Zeev Sherf

In this tutorial an overview of the acoustic noise environment will be presented. In this environment, the hardware that is used to fulfill different functions, is exposed to changing level and spectral content pressure fluctuations. They are three aspects on which the presentation will focus: the generation of acoustic noise, its effects and its simulation.

DIGITAL SIGNAL PROCESSING - FILTERING AND THE FOURIER TRANSFORM (GOING FROM TIME TO FREQUENCY DOMAIN)
John Hiatt (DEWESoft)

Two of the most common Digital Signal Processing (DSP) techniques are filtering and transforming data from the time domain to the frequency domain with the Fourier transform (FFT). Both mathematical processes can create unwanted effects on the data. This session will examine these effects on your data and how they can be mitigated. For the Fourier transform, we will also discuss the assumptions, inputs to the FFT and possible reasons FFT's calculated with two different software packages do not match. This training is designed to help new users understand how these processes and how they work to help prevent data processing mistakes.

INTRODUCTION TO DESIGNING SHOCK MOUNTED SYSTEMS USING SHOCK ISOLATION MOUNT PREDICTION & LOADING ESTIMATES (SIMPLE) SOFTWARE
Dave Callahan (HII Newport News Shipbuilding)

This course will introduce a process for designing and assessing shock isolation systems with special emphasis on applications related to the design of shipboard equipment for shock loads produced by underwater explosions utilizing the analytical software tool "Shock Isolation Mount Prediction & Loading Estimates" (SIMPLE). This process is split into two parts: 1) initial analysis using classic Shock Response Spectrum (SRS) and 2) assessment, confirmation, iteration or comparison of isolation system designs using SIMPLE simulation methods. Attendees will learn how to build six Degree of Freedom (DOF) SIMPLE models of isolated systems, select shock mounts and modify mount properties, select shock inputs, evaluate the isolation system performance and iterate designs rapidly. This course is intended for anyone that desires validation and assurance that shock and vibration mounts are properly selected for equipment racks, consoles, cabinets, and other structures using SIMPLE software. Examples of SIMPLE users are: engineers, program & project managers, equipment integrators, shock and vibration analysts, mount vendors, and shock qualification reviewers/approvers.

TUESDAY, NOVEMBER 5
TUTORIAL SESSION IV (8:00AM - 11:00AM)

OVERVIEW OF UNDERWATER EXPLOSION PHENOMENOLOGY AND BULK CHARGE WEAPON EFFECTS

NOTE: LIMITED DISTRIBUTION D (SECURITY PAPERWORK REQUIRED)

Greg Harris (Consultant)

This tutorial will provide an overview of underwater explosion (UNDEX) phenomenology relevant to bulk charge underwater warheads. The phenomenology discussion includes UNDEX shock wave propagation, bulk cavitation effects, and UNDEX bubble dynamics. UNDEX testing and analysis procedures for characterizing the shock wave and bubble performance of explosive compositions will be described. Finally, a brief discussion of the damage mechanisms used by bulk charge underwater weapons such as mines and torpedoes will be given using illustrative examples from UNDEX testing programs and recent naval encounters.

This talk contains Controlled Unclassified Information (CUI) / Distribution Statement D: Distribution authorized to DOD agencies and US DOD contractors.

BLAST PRESSURE MEASUREMENT

Dr. Troy Skinner (NASA), Bob Metz (PCB Piezotronics), Denis Rickman (USACE ERDC)

When researchers collect poor blast pressure data, they often conclude "it must be the gauge!" Truth be known, sensors rarely insert themselves into a blast test. Instead, they bravely go into whatever location the test engineer commands, often producing poor data or worse, experiencing an untimely death. These brave, and costly, soldiers deserve better!

To make matters more complicated, there are two sensing technologies to choose from. Quartz piezoelectric and silicon MEMS piezoresistive transducers are both successfully used for air-blast pressure measurements. This tutorial will objectively compare strengths and weaknesses of MEMS piezoresistive and ICP piezoelectric pressure transducers focused only on their applicability to the air-blast environment. The analysis considers measurement errors found in air blast, which include thermal transients, acceleration/strain, and cable length effects. Transducer performance parameters of dynamic range, ruggedness/survivability, and frequency response will be compared.

MIL-DTL-901E ENGINEERING TOPICS

Domenic Urzillo (NSWC Carderock)

MIL-DTL-901E Engineering topics is a follow-on course to the MIL-DTL-901E Test and Extension training courses and is aimed at providing the NAVSEA acquisition and engineering communities with a more in-depth review of engineering mathematics routinely used in equipment shock qualification. Topics covered include shock spectrum as it relates to MIL-DTL-901E testing, digital data filtering, shock response frequency, shock test fixture design fundamentals and FSP deck simulation fixtures.

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TWO APPROACHES TO RANDOM VIBRATION ANALYSIS

Dr. Thomas Paez (Thomas Paez Consulting)

Two fundamental approaches exist for analysis of random vibration. The approach used most commonly is based on knowledge of the spectral densities of forces and motions. In practice, an experimentalist measures a physical environment applied to a structure. A data analyst uses the measured data to estimate the spectral density of the environment. That spectral density is used either by a model developer (e.g., a finite element modeler) to compute the response spectral density of a critical structure, or by a laboratory experimentalist to control the input to a critical structure whose responses are measured, then used to estimate response spectral densities. The procedure can be extended in many ways to establish important features of the critical structure and its response. The spectral density was formally defined in 1930.

The other approach to random vibration analysis has its roots in the work of Albert Einstein. This latter approach is known as the diffusion approach to random vibration analysis; it was suggested in a paper written in 1905 by Einstein. His intent was to investigate the motion of very small particles suspended in a liquid, i.e. Brownian motion, and draw inferences about the dimension of the molecules of the liquid. Einstein did not say it in his paper, but the problem he solved was the random vibration of a rigid mass attached to ground by a dashpot, and excited by a white noise input. Later, he and others solved for the random vibration of a mass attached to ground by both a spring and a dashpot.

One year following the publication of Einstein's paper, a completely different approach was specified by Smoluchowski. He analyzed a discrete time/discrete space problem that came to be known as the "drunkard's walk." A particle starts at the origin and during the first time interval, moves one step to the right with probability p or one step to the left with probability q=1-p. Motion proceeds at each time/space step in the same manner. Following n steps, the probability distribution of particle location can be developed. When the limit is taken appropriately as time step duration and spatial step length approach zero, the governing equation and solution approach those implied by Einstein.

This presentation develops both approaches to random vibration analysis. Some MATLAB code and a PDF of the color slides are distributed electronically.

REMOVING THE BOUNDARY CONDITION HOBGOBLINS IN VIBRATION QUALIFICATION TESTING WITH MODAL TECHNIQUES

Troy Skousen (Sandia National Laboratories) & Randy Mayes (Consultant)

How a modal technique provides a simple modification to the base input mitigating the field-to-laboratory impedance mismatch for high confidence component qualification

Random vibration laboratory testing is used to qualify components to survive in-service responses to system environments. Using realistic research hardware and an analytical rocket system, we show that traditional single degree of freedom (SDOF) shaker test specifications guarantees large response uncertainties when compared with the field environment responses due to the difference in laboratory boundary conditions. A brief review is provided showing how fixed-base mode shapes are derived from test data. A model utilizing fixed-base and rigid body modes of the component on its vibration test fixture is used to decompose the component field motion into a few intuitive responses. This model demonstrates why 6DOF laboratory control can eliminate large uncertainties in traditional SDOF testing with a corresponding boost in qualification confidence. In fact, the model leads to modified base inputs for a greatly improved SDOF or 3DOF test.

TUESDAY, NOVEMBER 5
TUTORIAL SESSION IV (CONTINUED)

COMMON ROADBLOCKS AND LESSONS LEARNED FROM SHOCK QUALIFICATION; PRACTICAL GUIDANCE AND CASE STUDIES

Lisa McGrath (HII Newport News Shipbuilding)

This course will focus on errors and missteps common to the shock qualification process and how they can be avoided by walking attendees through qualification efforts for several real-life examples. The instructor will provide details on the issues which were faced, the utilized testing/analysis methodologies, related 901 requirements, and lessons learned. The end-goal of the training is to provide attendees with a better practical understanding of shock qualification by test and extension.This course is aimed at those who are or will be responsible for shock qualifying naval equipment per 901 requirements. This course assumes the attendees have at least a base understanding of 901 methodologies and requirements. Therefore it is recommended (but not required) that attendees have sat through previous 901 trainings or at least have a base understanding of 901 requirements.There will also be a portion of the tutorial set aside for specific attendee questions and hypothetical scenarios.

WEDNESDAY, NOVEMBER 6
TUTORIAL SESSION IV (3:30PM - 6:30PM)

SHOCK TEST FAILURE MODES
Kurt Hartsough (901 E&T)

This tutorial will cover examples of shock test failures typically experienced by equipment exposed to MIL-DTL-901E shock levels. MIL-DTL-901E provides guidance for designers responsible for meeting the requirements of MIL-DTL-901E. This tutorial will show how and why equipment failures occur and show how minor design changes can prevent shock failures. Hands on demonstrations, real time high speed video and analysis will be used to demonstrate both failures and corrective actions.

QUANTITATIVE METHODS FOR SURVIVABLE ELECTRONICS PACKAGING FOR COMBINED LOADING OF THERMAL AND HIGH AMPLITUDE MECHANICAL SHOCK
NOTE: LIMITED DISTRIBUTION D (SECURITY PAPERWORK REQUIRED)
Dr. Adriane Moura (ARA) & Dr. Matthew Neidigk (AFRL)

Fuze electronics intended for hard target defeat must survive both MIL-STD thermal cycle environments and extreme mechanical shock. Fuzes are often potted to prevent printed circuit board (PCB) flexure associated with component failure during impact. Potting techniques, or packaging strategies, may vary significantly by vendor and are often developed through trial and error. In many cases they are proprietary. Some packaging strategies include the application of elastomeric coatings to PCBs and components, or the use of epoxy underfills beneath components. Because most packaging materials are polymers, the disparity in thermal expansion between them and other fuze materials leads to a whole new series of problems during thermal cycling. As such, the DoD and the DOE have devoted considerable effort in the areas of material characterization, model development, and experimental validation, all with the goal of identifying survivable packaging strategies for use in both conventional and nuclear weapon stockpiles. Upon completion of this course, the user should have a basic understanding of the properties of common packaging materials, modeling and simulation tips and tricks, and latest developments in the design and evaluation of survivable packaging strategies for high-g electronics.

INTRODUCTION TO WEAPONS EFFECTS AND SHIP COMBAT SURVIVABILITY ANALYSIS
Jan Czaban (Zenginworks Limited)

This short course provides a practical understanding of naval ship combat survivability and methods to assess the effects of various weapons. The introduction will review terminology, concepts and current practice involved in setting, achieving and verifying survivability requirements. Naval threats and weapon types will be reviewed and methods for predicting their resultant loads and damage mechanisms explained. Primary weapons effects will include attacks from underwater explosions, above water explosions, internal blast, fragments and ballistic projectiles. Sample problems will be provided to demonstrate how to estimate the extent of damage sustained by ship structures and how to apply and interpret damage using standard terms of capability degradation. Methods for hardening ship systems and structures will be reviewed with an introduction provided to explain dynamic load effects tolerance, armour systems and simplified pass/fail global design assessment techniques. The course material will be entirely based on public domain sources and includes a comprehensive list of references and applicable military standards.

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WEDNESDAY, NOVEMBER 6
TUTORIAL SESSION IV (CONTINUED)

MISSION SYNTHESIS FROM FIELD DATA TO SHAKER REFERENCE PROFILES

Umberto Musella (Siemens)

Vibration control tests are performed to verify that an aerospace system and all its sub-components can withstand the vibration environment during the operational life. These tests aim to accurately replicate the in-service environment that a Device Under Test (DUT) will experience in-service via controlled shaker excitation. For aerospace systems and subsystems, random and/or sine vibration tests are required for all the main mechanical and electrical components. These types of tests are performed to replicate in the laboratory the response of the DUT to the broadband random inputs (e.g. transportation or in-flight environments) or responses to sweeping tonal phenomena. Many manufacturers rely upon ASTM, IEEE, MIL or ISO standard to define the vibration profiles. These profiles are typically the results of enveloping a very large set of possible in-service events and also include conservative safety margins. Some events used for standard profiles may not be representative for a specific DUT and yet drive the design leading to potentially unacceptable and costly overdesign. More dangerously, events that may be critical for a specific DUT may not be well-captured by the legacy standardized profiles. This could lead to product field failures, consumer dissatisfaction and warranty/recall costs. In this tutorial we describe a robust methodology to derive shaker test specification directly from field data: Mission Synthesis.

SEVERAL ISSUES IN THE ANALYSIS, GENERATION, AND SIMULATION OF SHOCK

Zeev Sherf

Given a shock spectrum, many shock time histories can be generated from it, although from one time history only one shock spectrum can be generated. This is a well known fact. And also a limiting one, in the use of the shock spectrum as a measured shock's, descriptive tool. The presentation starts by demonstrating, how from one shock spectrum, several different shock time histories can be generated. They differ not only in shape and duration but also in several characteristic parametersthat can be given numerical values. As such are the vibro-acoustic indexes, the energy of the shock and the damage induced by it. The work starts by the description of the shock time history generation process from a given shock spectrum. From the same shock spectrum several shock time histories are generated. Characteristic shock descriptive parameters can be evaluated: the energy, the induced damage and the vibro acoustic indexes. In the present paper the energy is used.

A PRIMER ON VIBRATION TESTING AND DATA ANALYSIS

Dr. Luke Martin (NSWC Dahlgren)

This tutorial will give an introduction to vibration testing and will be concept focused. The tutorial will begin with an understanding of a typical laboratory vibration test setup, followed by a deeper dive of the fundamental components. Specifically, a typical single degree of freedom vibration test will be decomposed into its pieces: amplifier, shaker, slip table, test item, vibration controller, and reference profiles. Once the components of the control loop are understood, the tutorial will focus on data analysis required by both the vibration controller to conduct a test and by a user who wishes to use measured field data to develop a tailored vibration test profile.