MONDAY / OCTOBER 5TH / 8:00AM – 11:00AM

MIL-S-901D Cost Avoidance and Clarification Letters-Explained
Mr. Kurt Hartsough & Mr. Domenic Urzillo (NAVSEA Philadelphia) ~ Mr. Hartsough Presenting

In November of 2012, NAVSEA 05P1, the Shock Technical Warrant, issued three MIL-S-901D Cost Avoidance and Clarification letters. The intent of these letters was to clarify areas of MIL-S-901D, reduce the occurrence of repeat testing and normalize the amount of testing required for Lightweight, Medium Weight and Floating Shock Platform testing. This tutorial will provide an opportunity to discuss specific situations related to shock qualification testing with NAVSEA 05P1’s Delegated Approval Authorities for Surface Ships and Submarines. Areas covered include: updated and new definitions, reduce shock test schedules, shock isolation, use of standard and non-standard fixtures, reduced hammer blows, reduced multiple operating mode requirements, reduced retesting, Shock Response Frequency (SRF) and more.

MIL-S-901D Engineering Topics
Mr. Domenic Urzillo (NAVSEA Philadelphia)

MIL-S-901D Engineering topics is a follow-on course to the MIL-S-901D 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-S-901D testing, digital data filtering, shock response frequency, shock test fixture design fundamentals and FSP deck simulation fixtures.

Analysis for Medium Weight Shock
Mr. Josh Gorfain (Applied Physical Sciences) & Mr. Jeff Morris (HI-TEST Laboratories)

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.
MIL-S-901D Shock Qualification Testing
Mr. Kurt Hartsough & Mr. Domenic Urzillo (NAVSEA Philadelphia)

The Naval Surface Warfare Center Carderock Division Philadelphia (NSWCCD-SSES) Code 669 is NAVSEA 05P1’s Delegated Approval Authority (DAA) for MIL-S-901D Surface Ship Shock. As the DAA, Code 669 engineers are responsible for review and approval of all Government Furnished Equipment (GFE) and heavyweight shock tested equipment. NSWCCD Code 669 will be presenting the requirements for shock qualification testing as detailed in MIL-S-901D and interpreted by NAVSEA 05P1. Shock testing theory, MIL-S-901D shock test devices and facilities, detailed specification requirements, cost avoidance and clarification and MIL-S-901D 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.

Understanding Aliasing, FFT, Filtering, SRS/PVSS for FEA/ Test Engineers
Dr. Ted Diehl (Bodie Technology)

This three hour seminar covers, in the language of Mechanical Engineering, Digital Signal Processing (DSP) theory and its application to analyzing challenging transient problems (shock, impact, and other nonlinear, noisy problems). A key focus of the course is obtaining credible correlation and improved interpretation between physical test data and transient simulation data derived from FEA software or similar programs (LS-Dyna, Abaqus/Explicit, Radioss, DOE & DOD codes,...). The presentation explains best practices for working with noisy data and offers many tips to avoid mistakes in data collection and analysis that result in distorted data and incorrect conclusions. One aspect that is often underappreciated is the importance of properly using (DSP) in the collection and processing of BOTH the test and simulation data. Users of explicit dynamics codes compute transient solutions with constantly varying time increments that typically contain significant “solution noise” in addition to the expected “frequency-rich” content created by severe impacts, shocks, failure, etc. This complexity along with other undesirable effects such as aliasing (an often unseen mistake made by the simulation community), numerical stability of DSP algorithms, and filter-induced distortions, can make it very difficult to obtain accurate correlation between simulations and tests. The best approach to achieve success is for both the simulation analyst and the test engineer to understand key concepts of DSP and how to apply them to mechanical engineering problems.

The seminar covers time-domain and frequency domain analysis (DFS, FFT, PSD); data collection (sampling, aliasing, up-sampling, decimation); filtering (lowpass, highpass, IIR, FIR, cascaded vs non-cascaded, numerical stability, and filter-induced distortions), calculating Shock Response Spectrum (SRS and PVSS) from transient data, and numerous unique aspects related to explicit dynamics FEA data (non-constant time increments, massively over-sampled data, short transient signals with non-zero end conditions, ...). Along with a review of the underlying theory, the seminar presents practical applications that demonstrate concepts and also shows how different DSP software products process this class of challenging data.
Introduction to Vibration Testing
Mr. Jon Wilson (Wilson Consulting)

This tutorial introduces the novice to vibration testing and provides a comprehensive review for the experienced practitioner. It concentrates on conceptual understanding and minimizes mathematics. It is recommended for technicians, engineers, program managers, and others who need a basic understanding of the fundamentals of vibration testing.

Topics covered include the definition and nature of vibration; fundamental structural dynamics; sine, complex and random vibration; spectra; vibration measurement and different measurement systems; shakers and shaker system characteristics; and fundamental fixture design and analysis. Student participation and questions are encouraged. Numerous references are cited.

Introduction to Pyroshock Testing
Dr. Vesta Bateman (Mechanical Shock Consulting)

This course discusses the concepts of Near Field, Mid Field Pyroshock and Far Field Pyroshock and their criteria. Instrumentation used for measurement of pyroshock and structural response to pyroshock is described. The development of pyroshock specifications using primarily the Shock Response Spectra is discussed in detail, and various other analysis techniques are presented as well. Simulation techniques for near field, mid field and far field pyroshock are presented and include both pyrotechnic simulations and mechanical simulations. Examples of actual test specifications and the resulting laboratory test configuration and measured results are discussed. In addition, recent problems and issues in the pyroshock community are described and analyzed.
MIL-S-901D Shock Qualification Testing Extensions

Mr. Kurt Hartsough & Mr. Domenic Urzillo (NAVSEA Philadelphia)

The Naval Surface Warfare Center Carderock Division Philadelphia (NSWCCD SSES) Code 669 is NAVSEA 05P1’s Delegated Approval Authority (DAA) for MIL-S-901D Surface Ship Shock. As the DAA, Code 669 engineers are responsible for review and approval of all Government Furnished Equipment (GFE) and heavyweight shock tested equipment. NSWCCD Codes 669 will be presenting the requirements for shock qualification extensions as detailed in MIL-S-901D and interpreted by NAVSEA 05P1. Shock extension specification requirements, MIL-S-901D 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.

Effective Solutions for Shock and Vibration Control

Mr. Alan Klembczyk (Taylor Devices) & Mr. Herb LeKuch (Consultant)

This presentation 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. Protection of COTS electronic equipment and probable damage levels are reviewed for the preparation of design and test specifications. Applications involve shipboard, off-road vehicles and airborne projects. Included also are industrial equipment and seismic control of structures and secondary equipment. Field and test data such as Mil-S-901D barge test measurements are presented. The use of Shock Response Spectra (SRS) for equipment assessment as well as isolator analysis is discussed. Details and examples of shock and vibration analyses are presented including case studies with step by step description of engineering calculations.
Beyond the Shock Response Spectrum  
Mr. David Smallwood (Consultant)

In practice shocks are often quite complicated oscillatory time histories with a large random component. By far the most common method for the characterization of shocks is the shock response spectrum (SRS). The SRS was developed to reduce the complexity to a simple measure, that is, the peak response of a single-degree-of-freedom system to the shock. One of the serious limitations of the SRS is that all temporal information is lost. Several attempts have been make to reduce this limitation by specifying the duration of the shock. However the definition of the “duration” for a complicated shock has not been consistent. Temporal moments provide a consistent framework to define the duration and other moments. Fourier spectra can also be used to characterize shock, but again all temporal information is lost. The most general way to characterize a shock with a large random component is with a time varying spectral density. However, we frequently have insufficient information to estimate this spectrum. Bandlimited temporal moments can help bridge this gap.

The tutorial will introduce the temporal moments and discuss the theoretical implications. The uncertainty theorem will be discussed, and it will be shown how this theorem limits the available information about a shock. Using the product model, a connection between the uncertainty parameter and the variance in the energy estimates will be established. For a shock with a given rms duration, defined by the temporal moments, the uncertainty theorem limits the frequency resolution, as defined by the rms bandwidth. The tutorial will show how the first few bandlimited temporal moments can be used to characterize shock. This information can be used independently of the SRS, or used to supplement the SRS of a shock.

Use of the SEA (Statistical Energy Analysis) Method in the Analysis of Structures' Dynamic Behavior under Random Loads  
Mr. Zeev Sherf (Consultant)

The SEA is a method that analyses the behavior of structures exposed to random loads (acoustic noise, random vibration) in statistical terms using energy flow consideration. The dynamic behavior of a structure is described by a set of equations that relates between an exciting power vector to a response energies vector. The relation is established through a coupling matrix, the elements of each are generated from the modal densities, internal dissipation factors of the structure's subsystems and the coupling loss dissipation factors between the structure's subsystems. First the principles of a system's dynamic behavior description in terms of energy flow are elucidated on two subsystems system. Following methods for identification of modal densities, internal dissipation and coupling loss factor for and between different subsystems by models and by measurements are described. The use of the method in the dynamic behavior description of a structure exposed to an acoustic noise is presented as an example.
MIL-S-901D Subsidiary Component Shock Testing & Alternate Test Vehicles  
Mr. Kurt Hartsough & Mr. Domenic Urzillo (NAVSEA Philadelphia)

The MIL-S-901D Subsidiary Component Shock Testing and Alternate Test Vehicles 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-S-901D Testing and particularly MIL-S-901D Extensions offered by the same instructors (Urzillo and Kurt Hartsough).

Peak Response and First Passage in Random Vibration  
Dr. Thomas Paez (Paez Consulting)

Random vibration tests are performed on structures for several reasons. Among those are (1) exploration of structural characteristics, (2) efforts to understand how structures and their components perform in certain environments, (3) attempts to prove that structures and their components will survive specific environments, etc. The third reason motivates this tutorial. There are two basic causes of structural failure: mechanical fatigue and passage of a measure of response at a location on a structure beyond a critical level. This tutorial develops the formulas for peak response and first passage in stationary random vibration. We start with reviews of probability theory, deterministic structural dynamics, random processes, and stationary random vibration. We then proceed to show how the two problems of first passage and peak response in random vibration are related. We develop general formulas for the probability distribution of peak structural response during a pre-established time period of stationary random vibration. We then use the probability distribution of peak response to obtain the mean and standard deviation of peak response at a sequence of times. The fundamental formulas for the probability distribution of peak response are obtained for narrow-band random vibration. These formulas are generalized to wide-band random vibration during the tutorial. All the topical presentations of this tutorial refer to a numerical example continuously developed throughout the course. MATLAB programs to solve the problems presented in class and for general use are available to class participants. (Note that it is often specified that the peak response of a structure in stationary random vibration is “about three-sigma.” This tutorial shows why that idea is a complete, and usually under-conservative, over-generalization.)
**Shock Response Spectra & Time History Synthesis**  
*Mr. Tom Irvine (Vibrationdata)*

This session covers classical, seismic and pyrotechnic shock. Students will receive basic instruction in calculating shock response spectra for time histories and for synthesizing time histories to meet shock response spectra specifications. The synthesis is performed using wavelets and damped sine functions. Students will receive software programs in both C/C++, Matlab & Python for making these calculations, as well as accompanying pdf files with formulas.

**Airblast and Fragmentation Assessment of Building Infrastructure**  
*Dr. George Lloyd (ACTA Inc.)*

Abstract TBD

**Shock and Vibration Applications using Femap and NX Nastran**  
*Mr. Jonathan Buck (ATA Engineering)*

Femap is an advanced engineering analysis environment used to pre- and post-process finite element models. Paired with the respected structural solver NX Nastran, Femap can be used to predict the behavioral responses of complex structures in static, dynamic, thermal and vibration environments. CAD and solver-neutral technology and cost-effective functionality have enabled Femap to be widely used by the world’s leading engineering organizations. We will begin by introducing Femap and its many uses in shock and vibration environments. We will also demonstrate numerous analyses including transient and frequency responses, normal modes, and the U.S. Navy-developed Dynamic Design Analysis Method (DDAM) using Femap and NX Nastran.
Shock Test Failure Modes
*Mr. Kurt Hartsough & Mr. Domenic Urzillo (NAVSEA Philadelphia)*

This tutorial will cover examples of shock test failures typically experienced by equipment exposed to MIL-S-901D shock levels. MIL-S-901D provides guidance for designers responsible for meeting the requirements of MIL-S-901D. 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.

Fundamentals of Multiple-Input/Multiple-Output Vibration Testing
*Mr. David Smallwood (Consultant)*

The fundamentals of multiple-input/multiple-output (MIMO) vibration random testing will be described. Various forms of the testing will be illustrated including multiple inputs in a single axis into a large test item and multiple inputs in several axes. The basic matrix algebra needed to define the test and the results will be developed. A short discussion of waveform replication and sine testing will be presented. The basic formulation of the control of a MIMO test will be discussed. Random test specifications must now be presented in terms of a spectral density matrix at the control points. The diagonal terms are the auto (power) spectra at the control points. The off diagonal terms are the cross spectra between pairs of control points. The cross spectra are often presented in terms of phase and coherence. The problems in developing specification for these tests will be discussed. Then methods and suggestions for the development of specifications for a MIMO test will be discussed and illustrated.

Design, Analysis & Assessment of Composite Structures
*Dr. E. Thomas Moyer (NAVSEA Carderock) & Mr. Barton McPheeters (AUTODESK Inc.)*

An increasing number of military, civilian and commercial structures are being constructed using Laminated Composite Materials. Designing structures using Laminated Composite Materials involve considerations not traditionally taught in undergraduate engineering curricula. This tutorial will introduce the engineering principles required to understand the mechanical properties and deformation characteristics of Laminated Composite Materials, required design considerations, and design calculation methods. After the introductory material, the complex considerations for the design of joints will be presented. Joints in structures designed using Laminated Composite Materials often comprise a significant number of the Critical Elements for the structure. Criteria to determine required physical testing for structural integrity demonstration will be presented. This tutorial will then focus on the use of the Finite Element Method (FEM) for the structural analysis of composite structures. Available modeling and analysis tools will be discussed highlighting their proper usage and limitations. This tutorial will include the required theoretical foundations required for the design and analysis of structures constructed using Laminated Composite Materials, however, the focus will be on practical design and analysis methodologies of use by practicing engineers.
The Measurement & Utilization of Valid Shock and Vibration Data

Dr. Patrick Walter (TCU / PCB Piezotronics)

Significant focus is often provided to applying sophisticated analysis techniques to data resulting from shock and vibration tests. However, inadequate focus is often provided to assuring that valid shock and vibration data are acquired in the first place. This tutorial attempts to correct this deficiency. For the instrumentation novice it will provide an introduction to shock and vibration measurements, the physics of piezoelectric and silicon based accelerometers, and motion characterization. For the experienced test technician or engineer it will provide additional insight into topics such as optimized measurement system design, accelerometer and measurement system calibration, accelerometer mounting effects, analog filtering, data validation, data utilization, and more. For the analyst or designer it will provide a series of simple observations and back of the envelope calculations that he/she can make on data to validate its credibility before using it in product design.