TUTORIAL DESCRIPTIONS—SUNDAY

NON-LINEAR FE ANALYSIS FOR SHOCK AND VIBRATION - MR. TONY ABBEY

The course is aimed at engineers who are just starting to use nonlinear FE dynamic analysis with impacting surfaces to investigate shock and vibration, or existing users who need some guidance as to practical usage. The examples use NEiNastran, but the technique and ideas presented are generic. No background in dynamic analysis is required as the basics of modal analysis and non-linear transient analysis will be covered. Any theory will be based on a practical engineering approach. The course will look at the background to dynamic analysis using modal methods, linear transient and nonlinear transient analysis. Finally the use of contact surfaces to model accurate impulsive loads is covered. The theoretical basis of the method will be covered from a practical engineering perspective with the use of simple examples to illustrate the various stages. Practical guidelines on carrying out a prior modal survey, estimating time step size and impact duration prior to the transient analysis will be shown. Several example nonlinear analysis will be carried out using NEiNastran to illustrate the process. Full interpretation of the results will be given with attention paid to understanding what are the design drivers in each case and what engineering judgments can be made from the data. Typical problems with nonlinear analysis will be shown, traps to avoid and best practice. Finally a strategy for dealing with large models is presented. Model size and solution times are becoming ever larger, and the importance of reducing analysis and data extraction to practical limits is explored. Attendees will be given a full set of notes including background modal analysis techniques.

INTRODUCTION TO VIBRATION TESTING - MR. JON WILSON

Introduction to Vibration Testing 3-hour Tutorial for 77th Shock & Vibration Symposium October 29 – November 3, 2006 Presented by Jon Wilson, Principal Consultant, Jon S. Wilson Consulting, LLC. 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.

BEYOND THE SHOCK RESPONSE SPECTRUM (SRS) - MR. DAVID SMALLWOOD

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 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.

Wavelet transforms can also be used to characterize shocks. These techniques will be introduced as a method to decompose a transient into component parts that are approximately bandlimited. The product of the bandwidth and duration is held approximately constant for each component. The temporal moments of the components are then used to characterize the shock.

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.

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.

It will be shown how the product model can be used to synthesize realizations of a shock, which match the temporal moments. Examples will be shown that suggest, that if the bandlimited temporal moments are matched, the SRS will also be matched. The realizations can be used for some tests (for example, shaker shock) or can be used as inputs to analytical models to estimate response.

Several examples using real data will be used to illustrate the moments and the application.

The harmonic wavelet transform will be briefly introduced and its use in characterizing transients will be illustrated.

UNDEX ANALYSIS OF FLOATING STRUCTURES - DR. RAY DADDAZIO AND MR. FRED COSTANZO

This tutorial starts off with an introduction of why the analysis of floating structures to underwater explosions (UNDEX) loadings is of interest. This is followed by a brief discussion of free-field UNDEX phenomena, followed a more detailed description of physics-based UNDEX simulation. Both coupled and decoupled fluid-structure interaction (FSI) problems will be discussed. Next, a discussion of strategies employed in simulating structural responses to UNDEX will be presented, starting with simple analytical tools, and progressing to more detailed finite element analysis strategies. Issues associated with energy dissipation, frequency ranges of interest, and validation through comparison with existing test data will be addressed. Finally, the highlights of this tutorial will be summarized, and where appropriate throughout each of the sections, example problems and lessons learned will be presented.

TUTORIAL DESCRIPTIONS—SUNDAY (CONT)

SHOCK POLICY (9072.1A) - MR. KURT HARTSOUGH & MR. DOMENIC URZILLO

The Naval Surface Warfare Center Carderock Division Philadelphia (NSWCCD SSES) Code 623 is NAVSEA 05P3's Delegated Approval Authority (DAA) for MIL-S-901D Surface Ship Shock. As the DAA, Code 623 is responsible for review and approval of all Government Furnished Equipment and all Heavyweight tested equipment. In addition, NSWCCD SSES Code 6202 is the NAVSEA 05P3 DAA for all analysis and DDAM approvals. NSWCCD SSES Codes 623 and 6202 will be presenting the Navy's Shock Qualification Process as detailed in NAVSEAINST 9072.1A. This course will cover in detail the responsibilities of all Navy organization. It will cover in detail the documentation requirements for a successful shock qualification program. This includes technical policy requirements, the requirements for waivers, deviations and deficiencies and a detailed explanation of the shock qualification approval process. Who should attend? 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 and maintenance of shock hardened Navy ships and shock qualification test facilities.

COMPOSITE MECHANICS - DR. TOM MOYER

Composite Laminates - Materials & Configurations / Laminate Stiffness & Strength / Laminate Theory - Stiffness & Analysis / Laminate Behavior - Failure Modes & Strength / Laminate Joints & Design / Dynamic Considerations For Composite Laminates

This course will provide an overview and introduction to the analysis and design of structures using laminated composite materials. Emphasis will be on practical understanding of the basic mechanics of laminated composites and their application. Examples will be drawn from real design applications of existing structures as well as simple illustrative problems. Combinations of analytical and numerical results will be employed in the examples typical of design application. The intended audience is engineers with a typical understanding of undergraduate mechanics (Statics/ Dynamics/strength of Materials) and some practical experience in mechanical design.

VALIDATION AND EDITING OF SHOCK AND VIBRATION DATA - MR. ALLAN PIERSOL

This short course surveys the most common errors that occur during the acquisition of shock and vibration data, including signal clipping, transducer and/or amplifier saturation, excessive background noise, intermittent noise spikes and wild points, power line pickup, spurious trends and signal dropouts. Practical procedures to detect such errors and wild points, power line pickup, spurious trends and signal dropouts. Practical procedures to detect such errors by visual inspections of the data signals and/or simple analysis of the signals are detailed. For those cases where the resulting anomalies can be removed from the data, appropriate data editing techniques are discussed. Emphasis is given to pyroshock data, which is particularly vulnerable to data acquisition errors. The presentation concentrates on graphical illustrations of the detection and editing procedures rather than an analytical treatment of the problem. This short course is intended for all engineers and scientists that are engaged in the acquisition and analysis of all types of analog data. The material is presented at a level appropriate for entry level engineers and technicians, but should also be beneficial to more experienced laboratory engineers and managers of data acquisition and analysis facilities.

MULTI-DIMENSION MOTION CONTROL (MIMO) - MR. RUSS AYRES

Multi-dimension motion control more closely simulates the actual product vibration environment than single axis motion. This class will give a basic understanding of motion in multi-dimensions, including why your test lab should contain many small actuators controlling one large structure. Specific items covered are: good fixture design, uses of Spectral Density Matrices, Singularities in your lab equipment, using Input/Output Transformations to create (or suppress) rotation or bending and non-Positive Definite conditions.

MIL-S-901D SHOCK QUALIFICATION TESTING - MR. KURT HARTSOUGH & MR. DOMENIC URZILLO

The Naval Surface Warfare Center Carderock Division Philadelphia (NSWCCD SSES) Code 623 is NAVSEA 05P3's Delegated Approval Authority (DAA) for MIL-S-901D Surface Ship Shock. As the DAA, Code 623 is responsible for review and approval of all Government Furnished Equipment and all Heavyweight tested equipment. In addition, NSWCCD SSES Code 6202 is the NAVSEA 05P3 DAA for all analysis and DDAM approvals. NSWCCD Codes 623 and 6202 will be presenting the requirements for Shock Qualification Testing and Analysis as detailed in NAVSEAINST 9072.1A, MIL-S-901D and NAVSEA 0908-LP-000-3010 Rev 1. This course will concentrate on MIL-S-901D test requirements and how the DDAM requirements in NAVSEA 0908-LP-000-3010 fit into the shock qualification process of equipment. This course will include a detailed explanation of the test requirements as stated in MIL-S-901D and as interpreted by NAVSEA 05P3. Shock qualification testing of principal units, shock qualification by extension of principal units and shock testing of subsidiary components will be covered. Who should attend? 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.

TUTORIAL DESCRIPTIONS—SUNDAY (CONT)

BASIS OF ELEMENTARY SHOCK ISOLATION SYSTEM DESIGN - DR. CHRISTOPHER MERRILL

Shock isolation system design is sometimes performed by persons that have not had the opportunity to design shock isolation systems for the various types of shock tests and inputs encountered in current DOD environments. This short course is intended to provide a framework that the designer can use to direct a shock isolation design with minimum false starts. Explanations are provided for the basic engineering issues and terminology encountered in shock isolation system design problems. Possible selection criteria that the designer may encounter during design of a shock isolation system are identified. Two design examples are provided that demonstrate incompatibilities sometimes encountered. Finally, the basic steps of the design process algorithm are reviewed. This course is directed at the design or analytical professional that has limited experience with shock isolation system design or the design professional with major expertise in a specialized area of shock isolation that wants to investigate more global excitations (i.e. vehicular shock expert that is interested in parallels with marine or seismic shock).

SHOCK RESPONSE SPECTRUM - USES AND ABUSES - MR. TIMOTHY EDWARDS

The shock response spectrum (SRS) is by far the most widely used tool for analyzing shock data. Although quite useful, the SRS does have limitations. This tutorial will illustrate both the proper use and exploitation of the SRS. Both analysts and testers will find this tutorial useful. Topics will include: Definition of the shock response spectrum; Common SRS ordinates; SRS computation including the use of digital filters for SRS computation (the Smallwood algorithm); Specifying shock tests including the SRS envelopes and notches and Specifying levels of conservatism; Examples of un-conservative SRS test specifications including failure mechanisms in mechanical systems and misapplication of SRS to MDOF systems; SRS cheating including different waveform types used to achieve a specified SRS; the abuse of haversines; and using the SRS to inflate testing capability; and Alternative descriptions of shock.

SHOCK AND VIBRATION USING MATLAB - PROF. KJELL AHLIN

In recent years, systems for multi-channel data acquisition of shock and vibration signals have become available at much lower cost than before. In the meantime, Matlab has become a leading software for engineering computations at universities as well as in industry. Matlab can be used as a very cost effective solution for the engineer who needs powerful software for analyzing shock and vibration data. The tutorial will give an overview of how Matlab can be used to analyze data from typical applications.

UNDEX ANALYSIS USING ABAQUS/EXPLICIT AND ABAQUS/CAE - DR. JEFFREY CIPOLLA

This tutorial describes the use of ABAQUS to solve problems in underwater explosive effects on structures. ABAQUS/CAE's graphical user interface is a very powerful and convenient tool for the construction of UNDEX structural and fluid models, definition of loads, and visualization of results. Version 6.6 includes significantly enhanced support for UNDEX-related features in ABAQUS. Because of the nature of the loading, ABAQUS/Explicit, which uses explicit time integration, is the preferred solution method, although ABAQUS/Standard's implicit algorithms may also be applied. Modeling methods and techniques as well as software usage will be discussed.

THE MEASUREMENT OF DYNAMIC PRESSURE IN AIR BLAST, ORDNANCE, UNDERWATER EXPLOSIONS, AND OTHER CHALLENGING ENVIRONMENTS - DR. PATRICK WALTER

This tutorial focuses on the successful measurement of dynamic pressure data. Pressure types are first explained and guidance is provided for selection of the proper sensor technology for a given application. Techniques to assure successful measurements in the harsh environments of air blast, underwater explosions, and ordnance testing are covered extensively. Attention is devoted to transducer design and construction methods, transducer mounting considerations, transducer signal conditioning, understanding and minimizing external noise sources that corrupt the pressure signal, and considerations to minimize signal distortion attributable to the transducer cable. Last, transducer and measurement system calibration techniques are presented.

TUTORIAL DESCRIPTIONS—MONDAY

THEORETICAL BACKGROUND AND BEST PRACTICE USING DDAM - MR.TONY ABBEY

The course is aimed at engineers who are just starting to use the DDAM method, or existing users who need some guidance as to practical usage. The examples use NEiNastran, but the technique and ideas presented are generic. No background in dynamic analysis is required as the basics of modal analysis will be covered. Any theory will be based on a practical engineering approach. The course will look at the background to the DDAM method, considering the evolution of the technique and the current specification. The theoretical basis of the method will be covered from a practical engineering perspective with the use of simple examples to illustrate the various stages. Several example DDAM analysis will be carried out using NEiNastran DDAM solution to illustrate the process. Full interpretation of the results will be given with attention paid to understanding what are the design drivers in each case and what engineering judgments can be made from the data. Typical problems with DDAM analysis will be shown, traps to avoid and best practice. Finally a strategy for dealing with large models is presented. The need to reach a target Modal Effective mass and the potential for many hundreds of modes being required is critical issue in the Industry and is fully addressed. Attendees will be given a full set of notes including background modal analysis techniques.

INTRODUCTION TO HAZARD-BASED RELIABILITY ANALYSIS - DR. GEORGE LLOYD

It is increasingly important to quantify the expected reliability of long-lived complex systems which are subjected to very non-stationary environments, arising for example from system relocations to disparate environments and the consequent exposure to shock and vibration. Quantifying reliability and the uncertainty of its estimate under these scenarios is difficult using classical empirically-based approaches or strictly computational damage-based modeling schemes. In this tutorial we seek to introduce attendees to the basics of a hazard-based technique which provides a framework for advanced methodologies for accomplishing reliability estimates with quantified uncertainty. The ultimate goal of the method is to leverage existing empirical data to construct surrogate populations and hazard estimates along desired covariate trajectories for reliability analysis.

The scope of the tutorial will be confined to an overview of several topics which lie at the core of this ultimate strategy. The topics consist of the selection of reliability variables and a survey of empirical reliability estimators for censored reliability data, selection of covariates (factors which influence reliability) and quantification of continuous and intermittent covariates as stochastic processes, and descriptions of the empirical hazard associated with observed covariate histories in a parametric reliability framework suitable for more advanced work.

PRIMER ON BLAST EFFECTS IN AIR, SOIL, AND WATER - DR. BOB WELCH

The effects of detonations from high explosives have unfortunately become a challenge for the civilian as well as the military community. This tutorial provides basic information about explosions for the practicing engineer. Blast effects phenomena associated with explosions in air, water, and geologic media are described. Hopkinson scaling relations are discussed that dictate how explosion effects scale with charge size and distance. Simple equations are given that predict blast field parameters in water, air, and soil as a function of charge weight and range. Explosion-induced cratering phenomena in soil and rock are described and predictive graphs provided. Airblast reflection phenomena at rigid interfaces are covered and relationships that quantify the reflected waves as a function of incident pressure and incident angle are given. Airblast inside tunnels from high explosive detonations is discussed. The tutorial material is taken from unclassified Corps of Engineers technical manuals, classical literature and papers on the subject, and the author's research experience.

DATA ACQUISITION FOR SHOCK AND VIBRATION APPLICATIONS - MR. STRETHER SMITH

This seminar will provide participants with the knowledge required to specify, evaluate, and use digital data acquisition systems in shock- and vibration-measurement applications. Principles of sampling and digitizing theory are presented and reinforced with practical examples from everyday testing operations. Aliasing-error-protection strategies and the resulting data distortion are discussed at length. System hardware components are described and their interaction and the effects of component-type selection on overall performance discussed. Special emphasis will be placed on the effects of out-of-band energy in shock measurements.

A set of simple tests for evaluation of acquisition systems, using hardware found in most laboratories, will be described. Post-test analysis techniques to compensate for data distortions and interpolate sparse data sets will be described and demonstrated.
The course is intended for people with all levels of expertise. Beginners will find that the course builds from basics and that they will come away with the tools needed to acquire accurate data. Experienced participants will discover powerful new ways to view the process that will result in more accurate and repeatable results from their experiments.

NAVAL SHOCK ANALYSIS AND DESIGN - DR. RUDY SCAVUZZO

First an overview of content of SVM-17, Naval Shock Analysis and Design, by Rudy Scavuzzo and Henry Pusey will be presented. The monograph briefly covers naval shock testing machines and vehicles, a detailed treatment of normal mode theory and its relationship to the Dynamic Design Analysis Method (DDAM); special considerations of DDAM including allowable stresses are covered in Chapter 3. Whole ship shock analyses including fluid-structure interaction and shock analyses in the plastic regime are presented in Chapters 4 and 5, respectively. Emphasis in the tutorial will be made on Chapter 5, shock analyses in the plastic regime. Energy in the modes of vibration can be directly related to the shock spectrum. This concept is very important because it means the energy in a system is bounded. Thus, plastic deformation or plastic work from shock in an equipment structure is also bounded. After considering the energy in shock, plastic analyses in piping and foundations from shock inputs will be presented. Analytical results will be compared to test data.

TUTORIAL DESCRIPTIONS—MONDAY (CONT)

REVIEW OF STRUCTURAL DYNAMICS - DR. JOSHUA GORDIS

This tutorial will review the fundamental concepts in vibration and structural dynamics. Starting from single degree-of-freedom systems, we will review the concepts of free and forced response and the role of damping in both. Impulse and frequency response will be discussed. Multi-degree of freedom system will be discussed, and the significance of natural frequencies and modes shapes in both free and forced response will be reviewed. The treatment of damping (proportional and non-proportional) will be A qualitative review of finite element analysis (FEA) will be presented and computational procedures associated with FEA in structural dynamics will be discussed. These will include modal vs. direct integration, model reduction, substructuring. Experimental modal analysis (modal testing) will be introduced.

The intended audience includes anyone who needs a refresher on the fundamentals of vibration and structural dynamics, or those people who need familiarity with the concepts but have never had formal education in this area.

MIL-S-901D SHOCK QUALIFICATION TESTING EXTENSIONS - MR. KURT HARTSOUGH & MR. DOMENIC URZILLO

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THE MEASUREMENT AND UTILIZATION OF VALID SHOCK AND VIBRATION DATA - DR. PATRICK WALTER

Significant focus is often provided to applying sophisticated analysis techniques to the 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.

OVERVIEW OF UNDERWATER SHOCK AND DDAM - PROF. YOUNG SHIN

The three hour short course on naval ship shock analysis and design will be presented by Dr. Young Shin, Professor of Mechanical Engineering at the Naval Postgraduate School. It will provide engineers, scientists, and naval architects a general overview of underwater explosion phenomena, bodily structural response analysis, fluid-structure interaction, shock spectrum and the Dynamic Design Analysis Method for shock qualification of shipboard equipment. It will also cover Hopkinson's scaling problem.

PYROSHOCK TESTING - DR. VESTA BATEMAN

This course discusses the concepts of Near-Field 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 various analysis techniques is discussed. Simulation techniques for near-field and far-field pyroshocks 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. References and a bibliography of more detailed information are provided. Test Engineers, managers and practitioners who are responsible for pyroshock testing will benefit from this course and its broad overview of pyroshock test technology and methods.

APPLICATION OF THE USA CODE TO UNDERWATER SHOCK PROBLEMS - DR. JOHN DERUNTZ

The purpose of this course is to provide engineers, scientists, and naval architects a working knowledge of the theoretical foundations and practical details of the USA (Underwater Shock Analysis) code for usage in design and analysis problems of submerged and semi-submerged structures in an explosive environment.

TUTORIAL DESCRIPTIONS—MONDAY (CONT)

VIBRATION AND SHOCK TEST FIXTURE DESIGN - MR. WAYNE TUSTIN

Usually fabricated from magnesium or aluminum for lightness with rigidity, a fixture adapts the mounting provisions of a device under test (DUT) to the armature of a shaker (for vibration testing) or to the table or anvil of a shock test machine (for shock testing). In a sense, the DUT side of the fixture attempts to "represent" the hardware to which the DUT will attach in service. This tutorial will examine that goal and various design and fabrication approaches to achieving that goal. Prior to first use, a new fixture should be evaluated experimentally. During use, DUT-fixture and fixture-shaker or fixture-shock test machine bolting is critical. Between tests, the fixture should be stored properly.

DDAM ANALYSIS USING DDAM-FOR-ABAQUS - DR. DAVID WINKLER & MR. DAVID WOYAK

An effective approach to performing DDAM analysis is available using Version 6.5 of the ABAQUS linear and nonlinear FEA program. Developed as a free product called DDAM for ABAQUS, it allows DDAM-specific input through graphical and non-graphical user interfaces. Emphasis has been made on providing the Navy with ease-of-use, standardization of output results, and a high degree of automation. Many features have been incorporated to help enhance the productivity of any DDAM practitioner. For example, a closely spaced modes method has been included as an optional analysis procedure. As an add-on module that is separate from the core ABAQUS program, the application can be rapidly enhanced to meet special needs of the shock community. This tutorial will teach the proper usage of DDAM for ABAQUS and will highlight particular features and advantages of the capability as illustrated by examples. The material is suitable for both managers and analysts.

MIL-S-901D SUBSIDIARY COMPONENT SHOCK TESTING AND ALTERNATE TEST VEHICLES - MR. KURT HARTSOUGH & MR. DOMENIC URZILLO

The MIL-S-901D Subsidiary Component Shock Testing and Alternate Test Vehicles course will cover the following areas; NAVSEA 05P3'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 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 (Domenic Urzillo and Kurt Hartsough).