

96TH SHOCK & VIBRATION SYMPOSIUM



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ORLANDO

SEPTEMBER 20-24, 2026

INSIDE COVER - PURPOSEFULLY LEFT BLANK



Welcome

TO ORLANDO AND THE
96TH SHOCK AND VIBRATION SYMPOSIUM!

Since the first meeting in 1947, the Shock and Vibration Symposium has become the oldest continual forum focused on the response of structures and materials to vibration and shock. The symposium was created as a mechanism for the exchange of information among government agencies concerned with design, analysis, and testing. It now provides a valuable opportunity for the technical community in government, private industry, and academia to meet to discuss research, practices, developments, and issues of mutual interest.

The symposium is presented by the
SHOCK AND VIBRATION EXCHANGE.

Thank You

**WE WOULD LIKE TO RECOGNIZE OUR TECHNICAL ADVISORY GROUP (TAG) MEMBERS
WHO PARTICIPATED ON THE 96TH SHOCK AND VIBRATION SYMPOSIUM
SUMMER PLANNING COMMITTEE AND/OR AWARD REVIEW COMMITTEE:**

Dr. Joseph Ambrico, NUWC Newport*
Thomas Brodrick, NAVSEA*
Dr. Robert Browning, Battelle**
Justin Caruana, Cardinal Engineering*
Paul Crvelin, Taylor Devices*
Shawn Czerniak, Hutchinson*
Matt Forman, NSWC Dahlgren*
Sean Frye, Taylor Devices*
Dr. Michael Hale, Trideum**
Adam Hapij, Thornton Tomasetti*
Greg Harris, ATR**
Kurt Hartsough, 901E&T*
John Hiatt, DEWESoft*
Roger Ilamni, NSWC Indian Head*
Dr. Jim Lightstone, DOT&E*
Luke Martin, NSWC Dahlgren*

Timothy McGee, NSWC Carderock*
Bart McPheeters, Leidos*/**
Bob Metz, PCP Piezotronics**
Calvin Milam, Element US Space & Defense*
Nick Misselbrook, Thornton Tomasetti*
Michael Olsen, HII-NNS*
Joshua Payne, USACE ERDC*
Drew Perkins, SAVE/HI-TEST*
John Przybysz, IDA*
Jeff Rybak, PCB Piezotronics*
Ashley Shumaker, SAVE/HI-TEST*
Troy Skousen, Sandia National Laboratories*
George Vankirk, USACE ERDC*
Mackenzie Wilson, HII-NNS*
Lauren Yancey, HI-TEST Laboratories**
Bill Yancey, HI-TEST Laboratories**

**TAG members in attendance at summer meeting for 96TH S&V program review.*

***TAG members who peer-reviewed award nomination packages*

THANK YOU

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SCHEDULE AT A GLANCE

(WITH DAILY OUTLINE AND HOURS)

DAY/DATE	PROGRAM FEATURE TYPE	TIME	PAGE
SUNDAY (09/20)	REGISTRATION (SALON 13)	7:00AM - 5:00PM	
	TUTORIALS	8:00AM - 4:00PM	PG. 7
MONDAY (09/21)	REGISTRATION (SALON 13)	7:00AM - 6:00PM	
	TUTORIALS	8:00AM - 6:30PM	PG. 8-13
	EXHIBIT HALL SETUP (EXECUTIVE BALLROOM)	NOON - 6:00PM	
	WELCOME RECEPTION (EXECUTIVE BALLROOM)	6:30PM - 8:00PM	PG. 14
TUESDAY (09/22)	REGISTRATION (SALON 13)	7:00AM - 6:00PM	
	EXHIBIT HALL OPEN (EXECUTIVE BALLROOM)	7:00AM - 5:00PM	
	TUTORIALS	8:00AM - 11:00AM	PG. 16-18
	GENERAL SESSION I & EXHIBITORS LUNCHEON	11:00AM - 1:00PM	PG. 20-21
	TECHNICAL PAPER SESSIONS & TRAINING	1:00PM - 6:10PM	PG. 22-25
WEDNESDAY (09/23)	REGISTRATION (SALON 13)	7:00AM - 6:00PM	
	TECHNICAL PAPER SESSIONS & TRAININGS	8:00AM - NOON	PG. 26-29
	EXHIBIT HALL OPEN (EXECUTIVE BALLROOM)	9:00AM - 4:00PM	
	GENERAL SESSION II & AWARDS LUNCHEON	NOON - 1:30PM	PG. 30-31
	TECHNICAL PAPER SESSIONS & TRAININGS	1:30PM - 3:05PM	PG. 32-33
	TUTORIALS	3:30PM - 6:30PM	PG. 34-36
	EXHIBIT HALL DISMANTLE	4:15PM - 6:00PM	
THURSDAY (09/24)	COMMERCIALLY SPONSORED SOCIAL EVENT	7:00PM - 10:00PM	PG. 38-39
	REGISTRATION (SALON 13)	7:00AM - NOON	
	TECHNICAL PAPER SESSIONS & TRAININGS	8:00AM - NOON	PG. 40-43
	S&V TAG COMMITTEE MEETING (MTG ROOM)	1:00PM - 2:00PM	PG. 43
	EXHIBIT HALL LAYOUT & VENDOR DESCRIPTIONS		PG. 44-51
	HOTEL MEETING SPACE FLOOR PLANS		PG. 52-54
	CORPORATE ADS		PG. 55+

Food & Beverage Events



(ALL SYMPOSIUM ATTENDEES ARE WELCOME TO ATTEND EVENTS LISTED BELOW)

MONDAY (09/21)	WELCOME RECEPTION (EXECUTIVE BALLROOM / EXHIBIT HALL) <i>BEVERAGES & HEAVY HORS D'OEUVRES</i> SPONSORED BY HI-TEST LABORATORIES & SHOCK TECH <i>*GUESTS OF SYMPOSIUM ATTENDEES ARE WELCOME.</i>	6:30PM - 8:00PM
TUESDAY (09/22)	BREAKFAST & NETWORKING (EXECUTIVE BALLROOM / EXHIBIT HALL)	7:00AM - 8:00AM
	GENERAL SESSION 1: KEYNOTE ADDRESS & EXHIBITORS LUNCHEON (EXECUTIVE BALLROOM / EXHIBIT HALL)	11:00AM - 1:00PM
	ICE CREAM SOCIAL (EXECUTIVE BALLROOM / EXHIBIT HALL)	3:00PM - 3:40PM
WEDNESDAY (09/23)	BREAKFAST & NETWORKING (EXECUTIVE BALLROOM / EXHIBIT HALL)	7:00AM - 8:00AM
	GENERAL SESSION 2: AWARDS PRESENTATION AND LUNCHEON (EXECUTIVE BALLROOM / EXHIBIT HALL)	NOON - 1:30PM
	AFTERNOON DESSERT BREAK & PASSPORT PROGRAM DRAWING (EXECUTIVE BALLROOM / EXHIBIT HALL)	3:05PM - 3:40PM
	SYMPOSIUM SOCIAL/DINNER SPORTS & SOCIAL @ THE POINTE COMMERCIALY SPONSORED BY HI-TEST LABORATORIES <i>*GUESTS OF SYMPOSIUM ATTENDEES ARE WELCOME.</i>	7:30PM - 9:30PM
THURSDAY (09/24)	BREAKFAST & NETWORKING (EXECUTIVE BALLROOM / EXHIBIT HALL)	7:00AM - 8:00AM

**PLEASE NOTE THAT ALL MEALS ARE COMMERCIALY SPONSORED THROUGH EXHIBITOR AND CORPORATE SUPPORTER REVENUES. NO COSTS FOR MEALS ARE DIRECTLY INCLUDED IN INDIVIDUAL ATTENDANCE FEES.*



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TUTORIAL SESSION I

8:00 - 11:00AM

OPTIONAL THREE HOUR COURSES. ATTENDEES WILL RECEIVE A CERTIFICATE OF COMPLETION AND MAY RECEIVE CEUs/PDHs (VARIES BY STATE). ADDITIONAL FEES APPLY TO ATTEND.

MIL-DTL-901E SHOCK QUALIFICATION POLICY & TESTING

Kurt Hartsough (901 E&T)

SIGNATURE 1

Instructor 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.

TUTORIAL SESSION II

1:00 - 4:00PM

MIL-DTL-901E SHOCK QUALIFICATION TESTING EXTENSIONS

Kurt Hartsough (901 E&T)

SIGNATURE 1

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.



OPTIONAL THREE HOUR COURSES. ATTENDEES WILL RECEIVE A CERTIFICATE OF COMPLETION AND MAY RECEIVE CEUs/PDHs (VARIES BY STATE). ADDITIONAL FEES APPLY TO ATTEND.

MIL-DTL-901E SUBSIDIARY COMPONENT SHOCK TESTING & ALTERNATIVE TEST VEHICLES

Kurt Hartsough (901 E&T)

SIGNATURE 1

The MIL-DTL-901E 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-DTL-901E testing and particularly MIL-DTL-901E extensions offered by the same instructor (Hartsough).

FUNDAMENTALS OF SINE AND RANDOM SHAKER TESTING

Chris Sensor (Siemens)

SALON 3

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.

ANALYSIS FOR A MEDIUM WEIGHT SHOCK TEST

Josh Gorfain (Quartus Engineering)

SALON 4

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.

TUTORIAL SESSION III
8:00 - 11:00AM
(CONTINUED)

MONDAY
SEPTEMBER 21

**PLANNING LIFE CYCLE DESIGN, ANALYSIS, AND SHOCK AND VIBE QUALIFICATION
OF NAVY EQUIPMENT**

SALON 5/6

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.



OPTIONAL THREE HOUR COURSES. ATTENDEES WILL RECEIVE A CERTIFICATE OF COMPLETION AND MAY RECEIVE CEUs/PDHs (VARIES BY STATE). ADDITIONAL FEES APPLY TO ATTEND.

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

Dr. Ted Diehl (Bodie Technology)

SIGNATURE 1

Working with either physical test data and/or numerical simulations related to severe mechanical shock, impact, failure, etc. is extremely challenging. Some of the biggest challenges in this type of work are 1) properly collecting the initial raw data while avoiding aliasing [especially from numerical simulations], 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 3-hour seminar provides guidance to both 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 seminar introduces key aspects of working with transient data – specifically, clearly 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 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, 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.

DATA INTEGRITY

John Hiatt (DEWESoft)

SALON 5/6

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)
Melissa Maze (PCB Piezotronics)

SALON 3

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.

TUTORIAL SESSION IV NOON - 3:00PM (CONTINUED)

MONDAY

SEPTEMBER 21

THE HISTORY OF RANDOM VIBRATION

Dr. Tom Paez (Consultant)

SALON 1/2

Random vibration is the study of the responses excited in structures by stationary (steady-state) and nonstationary stochastic inputs. A necessity for the implementation of random vibration analyses is random signal analysis; it is used to specify the functions that underly random input and response models. Random vibrations are ubiquitous in practice; hence, the theories of random vibration and random signal analysis are used frequently. This presentation defines the terminology and quantities used in random processes and random vibration, and it describes the fundamental operations that can be performed. It also shows how random signal analyses are used in connection with random vibration. The development of the theory of random vibration from the foundational paper written by Einstein (1905) to the present era are described. Course participants are provided with a link to a site with a color copy of the presentation slides as well as MATLAB functions that reproduce many of the examples in the presentation.

HELLO FORTRAN: A MODERN FORTRAN PRIMER FOR ENGINEERS AND SCIENTISTS

Dr. Robert S. Browning (Battelle)

SALON 7/8

Fortran continues to be a powerful language for numerical computing and is widely used in high-performance computing and data analysis. It also supports many popular legacy libraries, as well as both research and production software. Despite this, universities have largely stopped teaching Fortran, which is unfortunate given how much the engineering and scientific communities rely on Fortran (whether they realize it or not). This course seeks to help fill the gap by introducing engineers and scientists to modern Fortran. The primary focus will be on the essential elements of the language and best practices for developing maintainable applications. The intended audience is engineers and scientists who already have some familiarity with basic programming concepts. While this is not a replacement for a more thorough course, it is expected that, by the end of the course, participants will have a greater appreciation of Fortran as a modern language and will have the necessary tools to begin using Fortran for real-world applications. The course will also point participants to additional resources for further study with the goal of fostering a stronger Fortran community.

INTRODUCTION TO DESIGNING SHOCK MOUNTED SYSTEMS USING SHOCK ISOLATION MOUNT PREDICTION & LOADING ESTIMATES (SIMPLE) SOFTWARE

Dave Callahan (HII Newport News Shipbuilding)

SALON 4

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.



DDAM 101

George D. (Jerry) Hill (SERCO)

SALON 3

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.

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

John Hiatt (DEWESoft)

SALON 5/6

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.

SOLVING SHOCK AND VIBRATION PROBLEMS: ISOLATION SYSTEMS

Shawn Czerniak (Hutchinson)

SIGNATURE 1

This tutorial will be structured in three parts to provide the attendee with: 1) Shock and Vibration fundamentals (Spring-Mass-Damper system, Linear vs Non-Linear, Material selection & Material influence) 2) Various examples of commercially available isolation solutions (Elastomeric, Metallic, Friction Damped, Air Damped, Application examples) , and 3) Real world examples of isolation systems at work (System parameters, Isolation system requirements, Analytical predictions & Shock test videos). The attendee will leave the tutorial with an enhanced understanding of how an isolator designer uses their expertise and available tools to craft a compliant isolation system that meets the needs of their customer.

TUTORIAL SESSION V
3:30 - 6:30PM
(CONTINUED)

MONDAY
SEPTEMBER 21

**AIR BLAST AND CRATERING: AN INTRODUCTION TO THE ABC'S OF EXPLOSION EFFECTS
IN AIR AND ON LAND**

SALON 1/2

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.

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

SALON 4

David Callahan (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.



MONDAY
SEPTEMBER 21



Welcome Reception

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**ALL SYMPOSIUM ATTENDEES AND GUESTS
ARE INVITED TO ATTEND.**

6:30 - 8:00PM

**HEAVY HORS D'OEUVRES & DRINKS
EXECUTIVE BALLROOM (EXHIBIT HALL)**

SAVE Awards & Nomination Instructions

Henry C. Pusey Best Paper Award

KEEP A LOOKOUT IN THE PROGRAM FOR THIS QR CODE!
SCAN TO NOMINATE ANY PRESENTATION DESERVING OF
OUR ANNUAL **HENRY C. PUSEY BEST PAPER AWARD**.
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Lifetime Achievement Award

THE LIFETIME ACHIEVEMENT AWARD IS BESTOWED TO A MEMBER OF THE SHOCK AND VIBRATION COMMUNITY WHO HAS MADE SIGNIFICANT TECHNICAL CONTRIBUTIONS TO THE FIELD WITH A LIFETIME OF CAREER DEDICATION.

REACH OUT TO DREW PERKINS OR ASHLEY SHUMAKER FOR ADDITIONAL AWARD CRITERIA AND/OR A NOMINATION PACKAGE FOR THIS PRESTIGIOUS AWARD.



TUTORIAL SESSION VI

8:00 - 11:00AM

OPTIONAL THREE HOUR COURSES. ATTENDEES WILL RECEIVE A CERTIFICATE OF COMPLETION AND MAY RECEIVE CEUs/PDHs (VARIES BY STATE). ADDITIONAL FEES APPLY TO ATTEND.

OVERVIEW OF UNDERWATER EXPLOSION PHENOMENOLOGY & BULK CHARGE WEAPON EFFECTS

SALON 7/8

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.

FUNDAMENTALS OF MODAL ANALYSIS

SIGNATURE 1

Steff Nelson (Siemens)

The class will focus on hands-on demos related to tap testing modal analysis. It will begin with simple concepts such as what is a mode, what is damping, what is a natural frequency. It will build to more advanced concepts like modal curve fitting and best practices for taking data and setting up a test. Participants will be encouraged to bring a laptop to follow along, with some others being encouraged to participate in the modal hits. Also covered will be frequency response functions and coherence.

INTRODUCTION TO MIL-STD-461 ELECTROMAGNETIC INTERFERENCE QUALIFICATION REQUIREMENTS FOR SHIPBOARD & SUBMARINE ELECTRONICS EQUIPMENT

SALON 4

Jeffrey Viel (Element US Space & Defense))

This 3 hour tutorial provides a comprehensive overview of the Electromagnetic Interference (EMI) requirements and verification criteria for airborne, sea, space, and ground systems and platforms as defined in the most current version of MIL-STD-461G, the Electromagnetic Interference and Control Requirements for electrical and electronic subsystems. This course explains the basic cause and effects of EMI/E³ within platform installations as well as their operating environments and how equipment and subsystems and platform systems are evaluated against these threats.

This course covers many common issues encountered during MIL-STD-461G/H compliance testing, including lessons learned and comparisons to previous versions of the standard to highlight important changes to these requirements overtime. Essential guidance on test/evaluation planning and formal test procedure development will be provided along with a detailed technical overview of the test & assessment methods defined in the standard.



7:00 - 8:00AM | EXHIBIT HALL

AFTER BREAKFAST, ENJOY THE OPPORTUNITY TO NETWORK
WITH OTHER ATTENDEES AND INTERACT WITH EXHIBITORS.

TUESDAY
SEPTEMBER 22

TUTORIAL SESSION VI

8:00 - 11:00AM (CONTINUED)

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

SALON 1/2

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.

RESONANT PLATE SHOCK TESTING FOR PYROSHOCK SIMULATION

SALON 3

Dr. Carl Sisemore (ShockMec Engineering)

Pyroshock is traditionally defined as a decaying, oscillatory structural response to a high-amplitude, high-frequency mechanical excitation. The other distinctive characteristic is the near zero momentum transfer from the shock event. The aerospace industry has long recognized the potentially destructive effect of pyroshock on sensitive electronics and electro-mechanical devices. The aerospace industry frequently utilizes the firing of explosive bolts, nuts, pins, cutters, and other similar pyrotechnic devices to perform operations in their systems due to the simplicity of operation and the high reliability of those mechanisms. Additionally, other non-explosive environments such as the sudden release of strain energy or metal-to-metal impacts can produce effects similar to pyroshock. Resonant plate shock testing is a common technique for simulating pyroshock events in the laboratory. Resonant plate testing can produce a very similar, high-amplitude, high-frequency oscillatory shock response in a test article. The concept is relatively simple, but the application of the test method is an art. There are many variables to consider when designing a resonant plate test: plate size and materials, boundary conditions and damping configuration, impacting mass, impact velocity and interface stiffness. All these variables interplay to create a pyroshock simulation in the test laboratory. This tutorial will provide an overview of resonant plate theory and the practical implementation of resonant plate shock testing. How should resonant plate shock environments and test specifications be defined. How to design resonant plates for frequency and performance. How to select impact hammers and test configurations for successful shock testing. Examples from actual resonant plate shock tests will also be used to demonstrate the theoretical results seen in practice.





TUTORIAL SESSION VI

8:00 - 11:00AM (CONTINUED)

PRIMER ON NONLINEAR SOLID MECHANICS AND ALGORITHMS FOR MODELING OF EXTREME EVENTS

SALON 5/6

Dr. Kent T. Danielson (US Army ERDC)

Dr. Robert S. Browning (Battelle Memorial Institute)

The purpose of this course is to introduce nonlinear solid/structural mechanics and associated numerical methods for practical high-fidelity modeling and simulation involving severe loadings, such as high-speed impact/penetration and response to explosive detonations. The intent is to foster better usage of such software, particularly as an initial primer for those more familiar with linear mechanics and static or slower implicit dynamic methods that desire the basics of high-rate modeling. More experienced users might also find the discussions useful in going beyond typical default settings and methods found in common software. In this course, the focus will be entirely on lumped-mass explicit approaches that are typically the most appropriate for high-rate solid/structural dynamics. The material will be given in the context of Lagrangian finite element analysis, but much will be common to meshfree, finite volume, and similar methods. Other topics include performance of the nonlinear fundamental equations and their “weak” characteristics, nonlinear stress, strain and rate measures and their interpretations, material frame indifference and traits of constitutive models, causes and treatments (element technologies) of both shear and volumetric locking, artificial bulk viscosity and hourglass control, and explicit mass lumping and the critical time increment. The recommended prerequisites are a fundamental understanding of basic solid/structural mechanics (stress and strain) and the finite element method.

Exhibitor Passport Program



HOW IT WORKS:

- EACH SYMPOSIUM ATTENDEE IS GIVEN A "PASSPORT" WITH A LISTING OF PARTICIPATING EXHIBITORS.
- PARTICIPATING EXHIBITORS ARE PROVIDED A CUSTOM STAMP/STICKER.
- AS THE ATTENDEES VISIT THE PARTICIPATING EXHIBITORS, EXHIBITORS "STAMP" THE PASSPORT OF THE ATTENDEE.
- ATTENDEES WHO COLLECT THE STAMP OF AT LEAST 20 PARTICIPATING VENDORS ARE ENTERED INTO THE DRAWING.
- PRIZES RANGE FROM GIFT CARDS TO GADGETS TO NEW EXHIBITOR PRODUCTS!
- DRAWING TO BE HELD DURING THE WEDNESDAY AFTERNOON BREAK (3:05 - 3:40PM).

THANK YOU TO THE EXHIBITORS PARTICIPATING IN THE PASSPORT PROGRAM:



TUESDAY
SEPTEMBER 22

**EXHIBITORS LUNCHEON
(GENERAL SESSION I)
WITH KEYNOTE ADDRESS
11:00AM - 1:00PM**

11:00AM—11:10AM

CALL TO ORDER

Drew Perkins, SAVE / HI-TEST Laboratories

EXECUTIVE BALLROOM

11:10AM—11:15AM

KEYNOTE INTRODUCTION

Dr. Kent Danielson, USACE ERDC

11:15AM—NOON

KEYNOTE ADDRESS:

SIZE SCALING IN IMPACT CRATERING AND THE DART IMPACT

Dr. James D. Walker, Southwest Research Institute

NOON—1:00PM

LUNCH

FOLLOWED BY EXHIBITOR MEET & GREET

Exhibitor Meet & Greet

Enjoy time to peruse the exhibit hall and meet the vendors.

.....

**DON'T FORGET TO GET STARTED ON YOUR PASSPORT PROGRAM ENTRY FORM!
DRAWING TO BE HELD DURING WEDNESDAY'S AFTERNOON BREAK IN THE EXHIBIT HALL.
PRIZES TO INCLUDE:**

SAVE PROGRAM PRIZES

**\$250 AMAZON GIFT CARD
APPLE IPAD
APPLE WATCH
APPLE AIRTAGS
RING VIDEO DOORBELL
BEATS HEADPHONES**

VENDOR DONATED PRIZES

**YETI MERCHANDISE
VARIOUS GIFT CARDS
MISC. ELECTRONICS
EXHIBITOR APPAREL & SWAG**



**EXHIBITORS LUNCHEON
(GENERAL SESSION I)
WITH KEYNOTE ADDRESS
11:00AM - 1:00PM**

**TUESDAY
SEPTEMBER 22**

Meet the Speaker

.....

DR. JAMES D. WALKER **DIRECTOR & ACTING INSTITUTE SCIENTIST**



Dr. James D. Walker is Director of the Engineering Dynamics Department and an acting Institute Scientist at Southwest Research Institute, where he oversees a multi-disciplinary effort investigating the dynamic response of materials and structures and where he has worked for 38 years. His work includes and combines large scale numerical simulations, analytical techniques, and experiments. Among his recognitions is a Best Paper Award at the 2012 Hypervelocity Impact Symposium for a paper studying the size-scaling behavior of momentum enhancement in impact cratering. He is author of the text *Modern Impact and Penetration Mechanics*, published by Cambridge University Press in 2021. Dr. Walker is the recipient of three NASA Group Achievement Awards. In 2004 he was included in *Popular Science's* third annual list of "Brilliant 10" scientists. He was awarded the 2005 ASME Holley Medal for his work in the Space Shuttle Columbia accident investigation and the 2014 TAMEST O'Donnell Award in Technology Innovation. He is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineers (ASME), a Ballistics Science Fellow of the International Ballistics Society (IBS), and a recipient of the Distinguished Scientist Award from the Hypervelocity Impact Society (HVIS). He is a former president of both HVIS and IBS and served on the board of directors of AIAA. Dr. Walker was a member of the DART Investigation Team. He resides with his wife and daughters in San Antonio, Texas.

KEYNOTE ADDRESS: SIZE SCALING IN IMPACT CRATERING AND THE DART IMPACT

On Monday, September 26, 2022, at 6:14 p.m. Central Daylight Time, the Double Asteroid Redirection Test (DART) spacecraft impacted the asteroid moonlet Dimorphos at 6.14 km/s (13,700 miles per hour). This impact altered the orbital speed of the 150-meter-across moonlet about its primary asteroid Didymos by 2.7 mm/s. This impact demonstrated the ability to deflect an asteroid using the planetary defense technology of hypervelocity kinetic impact.

SwRI has studied high speed impacts for many years. When a high speed or hypervelocity impact occurs, a crater is formed. Size scaling of this event is of interest, meaning, for example, how the resulting crater properties change as the initial impactor size increases, so that we can compare impact craters formed in the laboratory vs. large impact craters such as produced by NASA's DART impact. While the crater depth normalized by impactor diameter is fairly insensitive to initial impactor size, there are other aspects of the cratering process where dimensionless results show a strong dependence on the initial size of the impactor. These include (all appropriately normalized) crater diameter, mass of material liberated as ejecta, and momentum of the ejecta material. Examples of experiments (with SwRI's powder and large two-stage light gas guns) and computational results and comparisons are presented, including impacts into metals, concrete, rocks, and rubble piles for impact speeds ranging from 2 to 6 km/s. To reproduce the observed scaling behavior in large scale numerical simulations it is necessary to use target material constitutive models that include finite length scales (nonlocal models).

The ratio of the change in momentum in the target to the initial momentum of the impactor is referred to as β . The preliminary estimate for β from the DART impact is 3.6, meaning that an additional 2.6 times as much momentum was transferred to the asteroid due to the crater ejecta as was brought in by the impacting spacecraft. (A pre-DART-impact experiment into a rubble pile at SwRI gave a β of 3.4.) A final DART β requires a number we do not know today, namely the mass of the impacted body. In 2024, the European Space Agency launched a follow-on mission to the Didymos system to determine the mass of Dimorphos and also to look for an impact crater. The Hera spacecraft arrives at Didymos this December. Both the DART and Hera missions will be discussed in the talk.

	SESSION 1: RAPID AND COST-EFFECTIVE APPROACH FOR NAVAL SHIP SHOCK DESIGN, ANALYSIS, AND EQUIPMENT QUALIFICATION 1:00-3:00PM / UNLIMITED DIST. A CHAIR(S): NICK MISSELBROOK (THORNTON TOMASETTI) HON. NICKOLAS GUERTIN (DAVIE DEFENSE)	SESSION 2: BLAST RESPONSE & MODELING 1:00-3:00PM / UNLIMITED DIST. A CHAIR(S): ANDREW BOWMAN (USACE ERDC) WILLIAM FURR (USACE ERDC)	SESSION 3: DYSMAS I 1:00-3:00PM / LIMITED DIST. D CHAIR(S): ROGER ILAMNI (NSWC INDIAN HEAD) DR. EMILY GUZAS (NUWC NEWPORT)
	SIGNATURE 1	SALON 3	SALON 7/8
((##)) FOLLOWING EACH PAPER TITLE INDICATES ASSOCIATED PAGE NUMBER IN THE ABSTRACT BOOK APPENDIX.			
1:00	EARLY-STAGE SHIP DESIGN, MODELING & TAILORED SPECIFICATIONS FOR EQUIPMENT (1) <i>Roope Kotiranta & Henri Lotvonen (Nesti), Turkka Jappinen (Helsinki Shipyard)</i>	EFFECT OF FINITE ELEMENT MODELING APPROACH ON PREDICTING RESIDUAL STRENGTH OF DAMAGED INFRASTRUCTURE (3) <i>2LT Thomas Vellenga (US Army), Dr. Eric Williamson & LTC Christopher Graves (USMA)</i>	SHOCK WAVE PROPAGATION AND FLOATING SHOCK PLATFORM RESPONSE TO BURIED SEABED UNDEX: TEST SUMMARY 2026 (6) <i>Roger Ilamni (NSWC IHD), Greg Harris, Katherine Knowles, & Tim App (ATR), Swen Metzler & Sven Diedrichsen (WTD-71), Manfred Krüger & Adrian Salah (iABG)</i>
1:25	SHOCK AND WHIPPING ANALYSIS WITH ABAQUS (1) <i>Juha Virtanen (VTT Technical Research Centre of Finland Ltd), Turkka Jappinen (Helsinki Shipyard)</i>	NUMERICAL CHARACTERIZATION OF FAR-FIELD BLAST LOADS RELATED TO MILD TRAUMATIC BRAIN INJURY (4) <i>Dr. Andrew Bowman, Paul Sparks, Dr. Catherine Stephens, Dr. Andreas Frank, & Jason Roth (US Army ERDC)</i>	UNDEX SHOCK WAVE LOADING FOR CHARGES ON THE SEA BOTTOM: QUANTIFYING DIFFERENCES BETWEEN IN-WATER AND IN-SEDIMENT SHOCK WAVE PROPAGATION (6) <i>Greg Harris & Katherine Knowles (ATR), Roger Ilamni (NSWC IHD)</i>
1:50	SHOCK ANALYSIS FOR ELECTRICAL PODDED PROPULSION (2) <i>Toni Partanen (ABB Marine & Ports), Juha Virtanen (VTT Technical Research Centre of Finland Ltd), Turkka Jappinen (Helsinki Shipyard)</i>	NUMERICAL SIMULATION OF THE PABLO-I NEAR-FIELD BLAST EXPERIMENT USING CTH AND VIPER BLAST (4) <i>Dr. Peter McDonald, Dr. James Wurster, & Andrew Nicholson (Viper Applied Science), Dr. Photios Papados (US Army ERDC)</i>	ESTIMATING SEABED EOS PARAMETER VALUES FROM OBSERVATIONAL DATA FOR UNDEX SIMULATIONS (7) <i>Dr. Eugenia Stanisauskis Weiss (Applied Physical Sciences), Dr. Emily Guzas, Dr. Peter Miklavcic, & Dr. Joe Ambrico (NUWC Newport)</i>
2:15	EQUIPMENT SHOCK QUALIFICATION USING HYBRID METHOD (COMBINED CALCULATION AND RESIDUAL SHOCK TESTING) (2) <i>Henri Lotvonen (Nesti), Turkka Jappinen (Helsinki Shipyard)</i>	INTERESTING INSTRUMENTATION READINGS AND APPROACHES RELATED TO ARENA BLAST TESTING (5) <i>Dr. Jason Florek, David Holgado, Justin Huang, & Dr. Rodrigo Mourao (Stone Security Engineering)</i>	UPDATES ON SIMULATING NEAR-FIELD UNDEX AGAINST SUBMERGED CONCRETE STRUCTURES (7) <i>Dr. Joe Ambrico, Dr. Emily Guzas, & Dr. Ryan Chamberlin (NUWC Newport), Dr. Jay Ehrgott & Joshua Payne (US Army ERDC), Roger Ilamni (NSWC Indian Head)</i>
2:40	CASE STUDY EXAMPLES OF EQUIPMENT QUALIFICATION PROCESS - HYBRID METHOD IN PRACTICE (2) <i>Aki Kinnunen & Kalle Vehvilainen (Vibrol), Arto Laine (Marioff)</i>	HIGHER-ORDER HYPOELASTIC-PLASTIC BEAM ELEMENTS IN THREE-DIMENSIONS FOR EXPLICIT DYNAMICS (5) <i>William Furr & Dr. Kent Danielson (US Army ERDC), Dr. Arun Srinivasa & Dr. J.N. Reddy (Texas A&M University)</i>	PREDICTING WEAPON EFFECTS ON CRITICAL UNDERWATER INFRASTRUCTURE: DATA GAPS AND FUTURE NEED (8) <i>Joshua E. Payne, Jeffrey R. Holmes, & Dr. John Q. Ehrgott (ERDC), Dr. Emily Guzas (NUWC NPT), Roger Ilamni (NSWC IHD)</i>

3:00

-

3:40



Ice Cream Social
EXECUTIVE BALLROOM (EXHIBIT HALL)



SESSION 4: ELECTRONICS EVALUATION AND SENSING FOR HIGH-G ENVIRONMENTS 1:00-3:00PM / LIMITED DIST. D CHAIR(S): DR. ADRIANA MOURA (ARA) DR. MATTHEW NEIDIGK (SANDIA NATL LABS)	VENDOR SESSION A: EXHIBITOR PRESENTATIONS INCLUDING CASE STUDIES, NEW DEVELOPMENTS, TESTING & PRODUCTS 1:00-2:35PM / UNLIMITED DIST. A CHAIR(S): DR. TED DIEHL (BODIE TECHNOLOGY)	TRAINING I: ADVANCED MEASUREMENT TECHNIQUES FOR CAPTURING EXCURSION ENVELOPES DURING MIL-DTL-901E SHOCK TESTING 1:00-2:00PM / UNLIMITED DIST. A INTRODUCTION TO MEDIUM WEIGHT SHOCK TESTING 2:00-3:00PM / UNLIMITED DIST. A
SALON 5/6	SALON 4	SALON 1/2
(##) FOLLOWING EACH PAPER TITLE INDICATES ASSOCIATED PAGE NUMBER IN THE ABSTRACT BOOK APPENDIX.		
1:00 DEVELOPMENT OF A NEW EMBEDDED DEVICE ACCELERATION AND PRESSURE TEST (EDAPT) CAPABILITY (8) <i>Dr. Adriane G. Moura, Zach Jowers, Jared Hammerton, & Dustin Landers (ARA), Dr. Matthew Neidigk (Sandia National Labs)</i>	A METHOD TO PREDICT NON-LINEAR PERFORMANCE OF A DAMPED SPRING-MASS SYSTEM (10) <i>Michael Czajka (Taylor Devices)</i>	 ADVANCED MEASUREMENT TECHNIQUES FOR CAPTURING EXCURSION ENVELOPES DURING MIL-DTL-901E SHOCK TESTING (12) <i>Michael Poslusny (Leidos Gibbs & Cox) 1:00-2:00PM</i>
1:25 EVALUATING 6DOF IMPACT DYNAMICS AND DECELERATION IN WATER ENTRY AIR DROP FLIGHT TESTS (9) <i>Zach Jowers, Dr. Adriane G. Moura, Dustin Landers, James Scheppegegrell, & Dr. Alain Beliveau (ARA), Samuel Schemmer (AFRL)</i>	ROBUST SALVAGING OF SHOCK ACCELERATION DATA (10) <i>Dr. Ted Diehl (Bodie Technology, Inc.)</i>	
1:50 DYNAMIC EVALUATION OF EMBEDDED FUZE ENVIRONMENTS ACROSS MIL-STD TEMPERATURES (9) <i>Dustin Landers, Dr. Adriane G. Moura, Zach Jowers, & Dr. Alain Beliveau (ARA), Fahad Abumohaimed (AFRL)</i>	HIGH SPEED IMAGING IN CONFINED AND REMOTE LOCATIONS (11) <i>William Spinelli (Photron)</i>	
2:15 MODELING EMBEDDED FUZE RELIABILITY IN PENETRATING MUNITIONS (9) <i>Dalton Gavin & Dr. Michael Nixon (Torch Technologies), Dr. Matthew Neidigk (Sandia National Labs)</i>	COMPARING TWR AND ITWR FOR HYDRAULIC AND ELECTRODYNAMIC SHAKER CONTROL (11) <i>Dr. Brynna Neff (Crystal Instruments)</i>	 INTRODUCTION TO MEDIUM WEIGHT SHOCK TESTING (12) <i>Jeff Morris (HI-TEST Laboratories) 2:00-3:00PM</i>
2:40 RESIDUAL STRESS ANALYSIS OF SURFACE MOUNT VS. THROUGH-HOLE COMPONENTS (10) <i>Dr. Matthew Neidigk & Joel Limmer (Sandia National Laboratories)</i>		

3:00

3:40



Ice Cream Social
EXECUTIVE BALLROOM (EXHIBIT HALL)



	SESSION 5: SHOCK STANDARDS ACROSS AUKUS 3:45-6:10PM / UNLIMITED DIST. A CHAIR(S): NICOLAS MISSELBROOK (THORNTON TOMASETTI)	SESSION 6: MIMO VIBRATION 3:45-4:55PM / UNLIMITED DIST. A ISOLATION I 5:00-6:10PM / UNLIMITED DIST. A CHAIR(S): TROY SKOUSEN (SANDIA NATIONAL LABS) DR. LUKE MARTIN (NSWC DAHLGREN)	SESSION 7: DYSMAS II 3:45-5:45PM / LIMITED DIST. D CHAIR(S): HORACIO NOCHETTO (NSWC INDIAN HEAD) CAROLINE WILEY (NSWC INDIAN HEAD)
	SIGNATURE 1	SALON 3	SALON 7/8
3:45	DEMYSTIFYING UK MAP01-470 (13) <i>Nicolas Misselbrook, Gavin Colliar, & Alan Ferguson (Thornton Tomasetti), Helen Peterson (UK MOD SDA-NATG-VR)</i>	MULTI-EXCITER TESTING DEVELOPMENTS (15) <i>Norman Trepanier, Eric Brogmus, & Bryan Taylor (Raytheon)</i>	INTERNAL BLAST MODELING OF POST-DETONATION COMBUSTION OF AN ALUMINIZED EXPLOSIVE UTILIZING DYSMAS (18) <i>Colin Burns & Dr. Jeff St. Clair (NSWC Indian Head)</i>
4:10	THE AUSTRALIAN SHOCK STANDARD (13) <i>Ian Leaver (Thornton Tomasetti), Lachlan Maloney & Matt Solon (Directorate of Naval Engineering, Australia)</i>	OPTIMIZING SHAKER PLACEMENTS IN MULTI-EXCITER IMMAT TESTING VIA GENETIC ALGORITHMS (16) <i>Ruben Araújo, Dr. Mattia Dal Borgo, Umberto Musella, Dr. Alberto Garcia de Miguel, & Dr. Bart Forrier (Siemens Digital Industries Software)</i>	DYSMAS SIMULATIONS OF NATURALLY FRAGMENTING MUNITIONS (18) <i>Jim Warner, Brian Howell, & Sean Tidwell (NSWC Indian Head), Tim App (ATR)</i>
4:35	MIL-DTL-901E: THE US SHOCK STANDARD (13) <i>Kurt Hartsough (901E&T)</i>		INTERNAL BLAST TESTING IN SUPPORT OF DYSMAS AFTERBURN MODELING DEVELOPMENT FOR NON-IDEAL EXPLOSIVES (18) <i>Colin Burns & Dr. Jeff St. Clair (NSWC Indian Head)</i>
5:00	UK SHOCK TESTING FACILITIES (14) <i>Gavin Colliar, Nicolas Misselbrook, & Alan Ferguson (Thornton Tomasetti)</i>	PERFORMANCE COMPARISON OF ARCH MOUNTS™ AND WIRE ROPE ISOLATORS (16) <i>Andrew Liberatore, Darko Gjoreski, & Richard Rakowski (Shock Tech, Inc.)</i>	LARGE-SCALE UNDEX PREDICTION OF NOVEL UNDERWATER FORMULATIONS USING EQUATIONS OF STATE CALIBRATED FROM SMALL-SCALE DATA (19) <i>Orlando Andres Mulero Flores & Dr. George McDaniel (NSWC Indian Head)</i>
5:25	AUS SHOCK TESTING FACILITIES (14) <i>Ian Leaver, Gavin Colliar, & Alan Ferguson (Thornton Tomasetti)</i>	AMPLITUDE-SPECIFIC EQUIVALENT DAMPING CHARACTERIZATION OF WIRE ROPE ISOLATORS FOR REDUCED-ORDER SHOCK MODELING (17) <i>Chris Sjoroos (IDC)</i>	MACHINE LEARNING FOR UNDEX SHOCK HOLING RULE (19) <i>Sujan Bashyal (ATR), Horacio Nochetto (NSWC Indian Head)</i>
5:50	COMPARISON OF AUKUS SHOCK QUALIFICATION STANDARDS (15) <i>Nicolas Misselbrook & Ian Leaver (Thornton Tomasetti), Helen Peterson (UK MOD SDA-NATG-VR), Brian Lang (NSWC Carderock)</i>	DYNAMIC SIMULATION OF THE SHOCK RESISTANCE OF RUBBER ISOLATORS (17) <i>Dr. Jun Han (Simu Hub)</i>	

	SESSION 8: STRUCTURAL RESPONSE AND HAZARD EVALUATION 3:45-5:20PM / LIMITED DIST. D TEST FACILITIES & QUALIFICATION SPECS 5:25-6:10PM / LIMITED DIST. D CHAIR(S): JEFFREY HOLMES (US ARMY ERDC) MARCUS BARKSDALE (US ARMY ERDC)	VENDOR SESSION B: EXHIBITOR PRESENTATIONS INCLUDING CASE STUDIES, NEW DEVELOPMENTS, TESTING & PRODUCTS 3:45-6:10PM / UNLIMITED DIST. A CHAIR(S): CORINNE ALONZO (NSWC CARDEROCK) JULIA KOMOROWSKI (NSWC CARDEROCK)	TRAINING II: INTRODUCTION TO UERDTOOLS 3:45-5:45PM / LIMITED DIST. D 
	SALON 5/6	SALON 4	SALON 1/2
3:45	OVERVIEW OF THE MAGAZINE EARTH COVER UPDATE/REASSESSMENT STUDY, EXPERIMENT 10 (MERCURY 10) (20) <i>Jeffrey Holmes, Joshua Payne, Dr. Paul T. Mead, Dr. T. Neil Williams, Dr. John Q. Ehrgott, Jr., & Denis D. Rickman (US Army ERDC)</i>	REAL-TIME RESONANCE COMPENSATION TO IMPROVE THE ACCURACY OF BLAST WAVE PRESSURE MEASUREMENTS (23) <i>Dr. Thomas Gerber, Alan R. Szary, Douglas Firth, & Patrick Rule (Precision Filters, Inc.)</i>	INTRODUCTION TO UERDTOOLS (25) <i>Rachel McIntyre & Ryan Hegarty (NSWC Carderock)</i> 3:45 - 5:45PM 
4:10	EXPERIMENT PLAN TO QUANTIFY HD 1.3 THERMAL HAZARDS IN TEST CUBICLES (20) <i>Adam Mayatt (US Army ERDC)</i>	VALIDATING A WRI SOLUTION THROUGH SIMULATION AND EXPERIMENTAL METHODS (24) <i>Ozzie Irowa (Socitec)</i>	
4:35	SMALL MAGAZINE VOLATILITY TESTING OF HD 1.3 AND 1.4 MATERIALS (20) <i>Jonathan Dahlem & Dr. John Q. Ehrgott, Jr. (US Army ERDC), Jeremy Grey (US Coast Guard FORCECOM)</i>	DEVELOPMENT OF A MIPS RESONANT BEAM SHOCK TEST MACHINE (24) <i>Dr. Carl Sisemore (ShockMec Engineering)</i>	
5:00	WAVE PROPAGATION CHARACTERISTICS THROUGH HOMOGENEOUS AND STRATIFIED MEDIA (21) <i>Dr. Photios Papados & Dr. Kent Danielson (US Army ERDC), Dr. Nicholas Arnold (DTRA)</i>	VIPER BLAST FOR ADVANCED AIRBLAST SIMULATIONS (24) <i>Dr. Peter McDonald (Viper Applied Science)</i>	
5:25	TUBE AND BREECH FATIGUE LAB OVERVIEW (22) <i>Lucas Smith (US Army DEVCOM-AC-WSEC), Scott Lobdell (US ARMY/DEVCOM-AC-WSEC/Benet Labs)</i>	MODERNIZING VIBRATION TEST AUTOMATION VIA REST API AND AI-ASSISTED IMPLEMENTATION (25) <i>Jacob Willett (m+p International)</i>	
5:50	RESTRUCTURING OF UFC 3-340-01 CHAPTER 12 (22) <i>Dr. Eric Kjolsing & Mark Weaver (Karagozian & Case), John Geringer (US Army Corps of Engineers Protective Design Center), Brett Williams (US Army ERDC)</i>	VIBRATION AT CRYOGENIC TEMPERATURES (25) <i>Roger Rutz (Experior Laboratories)</i>	



	SESSION 9: TEST EQUIPMENT MODELING & SIMULATION 8:00-9:35AM / UNLIMITED DIST. A CHAIR(S): CALVIN MILAM (ELEMENT DEFENSE) GREGORY BUDRISS (NSWC PHILADELPHIA)	SESSION 10: EXPERIMENTAL VIBRATION TECHNIQUES 8:00-9:35AM / UNLIMITED DIST. A CHAIR(S): DR. PETER VO (RAYTHEON) JADE VANDE KAMP (VIBRATION RESEARCH)	SESSION 11: SHOCK QUALIFICATION ANALYSIS 8:00-9:35AM / LIMITED DIST. D CHAIR(S): RYAN SHORTS (NSWC CARDEROCK) ISABEL CATUGAS (NSWC CARDEROCK)
	SIGNATURE 1	SALON 3	SALON 7/8
8:00	CAN A THEORY OF WAVE PROPAGATION THROUGH LAYERED MEDIA EXPLAIN HOW RESONANT PLATE ANVIL DESIGN AFFECTS THE SHOCK PULSE ENERGY CONTENT? (26) <i>Dr. Nancy Winfree & Joshua Nowlin (Sandia National Laboratories), Dr. Carl Sisemore (ShockMec Engineering)</i>	SINE-ON-RANDOM TOLERANCES: COMPARING EXPECTED STATISTICAL VARIATION AND MIL-STD COMPLIANCE (28) <i>Jade Vande Kamp (Vibration Research)</i>	EFFECTS OF MESHING PRACTICES ON LINEAR ELASTIC MODAL STRUCTURAL RESPONSE (30) <i>Ian Larson (NSWC Carderock)</i>
8:25	FLUID STRUCTURE INTERACTION DUE TO SEISMIC AIRGUN LOADING (26) <i>Dr. Daniel Clark & Oliver Craggs (Thornton Tomasetti)</i>	CONTROLLING OUT HARMONIC DISTORTION ON A HYDRAULIC SHAKER (28) <i>Raman Sridharan (Data Physics Corporation)</i>	EFFECTS OF MESHING PRACTICES ON ELASTIC PLASTIC STRUCTURAL RESPONSE (30) <i>Katherine Jordan (NSWC Carderock)</i>
8:50	NUMERICAL SIMULATION FOR LIGHTWEIGHT SHOCK TEST (26) <i>Keisuke Terada & Daisuke Morimoto (Japan Marine United Corporation)</i>	TOWARDS AUTOMATED LUMPED PARAMETER MODEL IDENTIFICATION OF ELECTRODYNAMIC SHAKERS (29) <i>Dr. Mattia Dal Borgo & Umberto Musella (Siemens Digital Industries Software), Francesco Bentivoglio & Dr. Emiliano Rustighi (University of Trento)</i>	MASS FEEDBACK EFFECTS ON DECK ENVIRONMENTS (30) <i>Serena Sauers (NSWC Carderock)</i>
9:15	ENHANCED AND ACCURATE UPSAMPLING FOR DERIVATIVE-SENSITIVE SHOCK SIGNALS (27) <i>Dr. Ted Diehl (Bodie Technology, Inc.)</i>	EXPERIMENTAL AND NUMERICAL PACKING OF GLASS MICROBEADS FOR ELECTRONIC ENCAPSULATION (29) <i>Joseph Erwin (Sandia National Laboratories)</i>	STANDARD SHOCK QUALIFICATION OF MAST MOUNTED EQUIPMENT (30) <i>Timothy McGee, Rachel McIntyre, Jake Mason, & Matt Stevens (NSWC Carderock)</i>

9:35

10:00

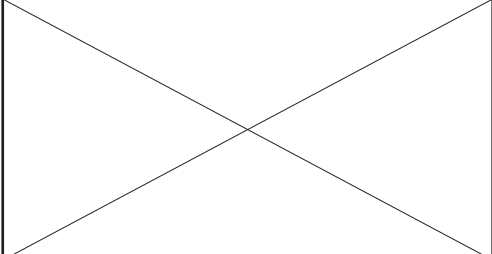


COFFEE BREAK

with the Exhibitors

EXHIBIT HALL / EXECUTIVE BALLROOM



	SESSION 12: BALLISTICS I 8:00-9:10AM / LIMITED DIST. D CHAIR(S): DAVID LICHLYTER (US ARMY ERDC) BRUCE PATTERSON (AFRL)	VENDOR SESSION C: EXHIBITOR PRESENTATIONS INCLUDING CASE STUDIES, NEW DEVELOPMENTS, TESTING & PRODUCTS 8:00-9:35AM / UNLIMITED DIST. A CHAIR(S): CATHERINE STEPHENS (US ARMY ERDC)	TRAINING III: PRELIMINARY DESIGN ASSESSMENT STRATEGIES FOR STRUCTURAL INTEGRITY IN SHOCK & VIBRATION 8:00-8:45AM / UNLIMITED DIST. A 
	SALON 5/6	SALON 4	SALON 1/2
8:00	DEVELOPMENT OF FAST RUNNING DETAILED FINITE ELEMENT PROJECTILE MODELS (30) <i>Logan Rice, Dr. Mark Adley, David Lichlyter, & Dr. Darren Rice (US Army ERDC)</i>	REDUCING SHIPBOARD VIBRATIONS BY APPLICATION OF POLYURETHANE SHOCK MOUNTS IN A DOUBLE RESILIENTLY MOUNTED GENERATOR SET (32) <i>Danny Smit (Vulkan)</i>	PRELIMINARY DESIGN ASSESSMENT STRATEGIES FOR STRUCTURAL INTEGRITY IN SHOCK & VIBRATION (33) <i>Dr. Charles Hull (Lockheed Martin)</i> 8:00-8:45AM 
8:25	INVESTIGATION INTO MOMENTUM TRANSFER FROM BUILDING AND EARTHWORKS COLLATERAL DEBRIS (31) <i>Dr. Zane Roberts (US Army ERDC)</i>	CHAMP – CRITICAL HIGH-VALUE ASSET MONITORING PLATFORM (32) <i>Dylan Pike (enDAQ/Hutchinson)</i>	
8:50	JOINT DTRA/AFLCMC PENETRATION EXPERIMENTS AGAINST PRISTINE AND BLAST-DAMAGED ROCK TARGETS (31) <i>Mark Green (Geomechanics Research & Analysis); Full list of contributing authors provided in Abstract Book</i>	BETTER DATA FROM IMPERFECT FOOTAGE: ADVANCES IN IMAGE MOTION ANALYSIS (33) <i>Daniel Bissell (Image Systems)</i>	
9:15		MIL-DTL-901E: THE GOOD, THE BAD, AND THE MISLEADING (33) <i>Kurt Hartsough (901 Engineering & Training)</i>	

9:35

10:00



COFFEE BREAK

with the Exhibitors

EXHIBIT HALL / EXECUTIVE BALLROOM

	SESSION 13: UNDEX SIMULATION & DOUBLY ASYMPTOTIC APPROXIMATION 10:00-11:10AM / UNLIMITED DIST. A CHAIR(S): DAN PROVENZANO (NSWC PHILADELPHIA) CHRISTINA BACKES (NSWC PHILADELPHIA)	SESSION 14: ANALYSIS TECHNIQUES 10:00-NOON / UNLIMITED DIST. A CHAIR(S): GARRETT WILES (NSWC DAHLGREN) LEEYUNG CHANG (NSWC CARDEROCK)	SESSION 15: DYSMAS III 10:00-11:35AM / LIMITED DIST. D CHAIR(S): DR. JEFF ST. CLAIR (NSWC INDIAN HEAD) TYLER REA (NSWC INDIAN HEAD)
	SALON 3	SALON 4	SALON 7/8
10:00	EFFICIENT SIMULATION OF SUBMARINE UNDERWATER BLAST USING THE DOUBLY ASYMPTOTIC APPROXIMATION (DAA) (33) <i>Jason Krist (Siemens)</i>	A PARAMETERIZED SHOCK WAVEFORM MODEL FOR IMPROVED MECHANICAL SHOCK SYNTHESIS (35) <i>Garrett Wiles (NSWC Dahlgren)</i>	HIGH FIDELITY MODELING OF SHOCK HOLING AGAINST A GENERIC SUBMARINE PRESSURE HULL (38) <i>Rachael Busby & Dr. Jeff St. Clair (NSWC Indian Head)</i>
10:25	UNDERWATER SHOCK AND WHIPPING ANALYSIS OF COMPOSITE NAVAL SHIP STRUCTURE USING TRIDENT DAA SOFTWARE (34) <i>Dr. Sergio G. Arias, Dr. Lei Jiang, Dr. T.S. Koko & Tom MacAdam (Lloyd's Register Advisory)</i>	PARAMETRIC OPTIMIZATION OF BOX AND REMOVAL (BARC) MODELS FOR SHOCK TESTING (35) <i>Jason Krist (Siemens)</i>	SHOCK HOLING TESTING AGAINST A SCALED PRESSURE HULL (39) <i>Rachael Busby & Dr. Jeff St. Clair (NSWC Indian Head), Reece Roehsler & Jason Craft (NSWC Carderock), Katherine Knowles (ATR)</i>
10:50	VALIDATION OF A GEERS-HUNTER UNDEX LOADING MODEL COUPLED WITH OPENRADIOSS USING VIPER CORAL (35) <i>Andrew Nicholson, Dr. Peter McDonald, & James Wurster (Viper Applied Science), Elliott Cucciol (ENSTA University)</i>	AI SURROGATE MODELS FOR SHOCK AND VIBRATION ANALYSIS OF A SHIP STRUCTURE (36) <i>Jason Krist (Siemens)</i>	HIGH SPEED, SCALED WEAPON PENETRATION TESTING AGAINST A POPULATED MARITIME STRUCTURE (39) <i>Andrew Cammenga & David Spencer (NAWC China Lake), Rachael Busby, Horacio Nochetto, & Dr. Jeff St. Clair (NSWC Indian Head)</i>
11:15		FINITE CELL METHOD FOR QUICK-TURN VIBRATION ANALYSIS AND MAC-BASED CORRELATION (37) <i>Jason Krist (Siemens)</i>	DYSMAS SIMULATIONS OF HIGH SPEED WEAPON PENETRATION AGAINST A POPULATED MARITIME STRUCTURE (39) <i>Horacio Nochetto, Rachael Busby, & Dr. Jeff St. Clair (NSWC Indian Head)</i>
11:40		PREDICTION OF NASA SHOCKSAT FRANGIBLE JOINT SHOCK ENVIRONMENTS – DERIVING THE FORCING FUNCTION (38) <i>Joshua Gorfain (Quartus)</i>	



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	SESSION 16: HYDROSTATIC IMPLOSION AND UNDEX 10:00-11:35AM / LIMITED DIST. D CHAIR(S): DR. BEN MEDINA (NSWC CARDEROCK) DR. JOE AMBRICO (NUWC NEWPORT)	TRAINING IV: SHOCK RESPONSE SPECTRUM PRIMER 10:00-11:30AM / UNLIMITED DIST. A 	WORKING GROUP: DYNAMIC ENVIRONMENTS QUALIFICATION WORKING GROUP 10:00-NOON 
	SALON 5/6	SALON 1/2	SIGNATURE 1
10:00	COMPOSITE PRESSURE VESSEL HYDROSTATIC IMPLOSION MODELING AND TESTING PART 1 (40) <i>Dr. Benjamin Medina & Elio Cusi (NSWC Carderock)</i>	SHOCK RESPONSE SPECTRUM PRIMER (41) <i>Dr. Carl Sisemore (ShockMec Engineering)</i> 10:00 - 11:30AM	DYNAMIC ENVIRONMENTS QUALIFICATION WORKING GROUP <i>Troy Skousen & David Soine (Sandia National Laboratories)</i> 10:00AM - NOON <i>The goal of dynamic environments qualification is to demonstrate that designs can withstand vibration inducing in-service loads while performing as required. Qualification evidence is often collected through laboratory testing intended to mimic field environment conditions with some conservatism. The objective of the Dynamic Environments Qualification Working Group is to shepherd the advancement of ideas and methods for shock and vibration environments qualification through test and analysis in the Shock & Vibration Symposium community. It is a forum to bring together the people that will lead the community to advance the state of the art in dynamic environments qualification. Collaborative discussion will include:</i> • Discuss and evaluate effectiveness of sessions, tutorials, trainings, and discussion groups held at the symposium this year. • Identify thoughts, traditions, and standard practices that may be holding us back. • Sharing thoughts on the research needed to advance the state of the art. • What actions should the working group take within and external to the Shock and Vibration Symposium?
10:25	COMPOSITE PRESSURE VESSEL HYDROSTATIC IMPLOSION MODELING AND TESTING PART 2 (40) <i>Elio Cusi & Dr. Benjamin Medina (NSWC Carderock)</i>		
10:50	AUTOMATED HIGH FIDELITY LETHALITY ASSESSMENTS OF SUBVALUE MODEL (40) <i>Gregory Gorman, Nicholas Valm, Christopher Craig, & Adam Hapij (Thornton Tomasetti), Rebecca Dickey & Jonathan Lee (NSWC Carderock)</i>		
11:15	AN APPLICATION OF THE IDU FRAMEWORK TO CREATE ML MODELS FOR HYDROSTATIC IMPLOSION (41) <i>Dr. Abilash Nair, Nicholas Valm, Christopher Craig, & Adam Hapij (Thornton Tomasetti) Dr. Benjamin Medina & Elio Cusi (NSWC Carderock), Dr. Joe Ambrico (NUWC Newport)</i>		
11:40			



**SEE A PRESENTATION WORTHY OF OUR HENRY C. PUSEY AWARD?
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NOON—12:05PM

CALL TO ORDER

Drew Perkins (SAVE / HI-TEST Laboratories)

EXECUTIVE BALLROOM

12:05PM—12:15PM

HENRY PUSEY BEST PAPER AWARD

PRESENTED TO:

Dr. Charles Hull (Lockheed Martin)

12:15PM—12:20PM

AWARD FOR EXCELLENCE IN INSTRUCTION AWARD

PRESENTED TO:

Jeffrey Viel (Element US Space & Defense)

12:20PM—12:30PM

LIFETIME ACHIEVEMENT AWARD

PRESENTED TO:

Denis Rickman (US Army ERDC)

Henry Pusey Best Paper Award

PRESENTED TO:

"Introduction to Genetic Algorithms for Vibration and Shock Design"
Dr. Charles Hull (Lockheed Martin)

Genetic algorithms, a subset of artificial intelligence, are becoming increasingly popular for problem solving in mechanical engineering. This study shows how genetic algorithms can be leveraged for the design of structures subjected to vibration and shock. A simple lumped parameter example is presented whereby a motion objective is optimized through selection of stiffness and damping parameters. The example introduces the framework of genetic based design optimization, providing insights while serving as a launching point for applications in complex structures and systems.

Award for Excellence in Instruction

PRESENTED TO:

Jeffrey Viel (Element US Space & Defense)
for his tutorial "Introduction to MIL-STD-461 Electromagnetic Interference Testing"

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.

**AWARDS LUNCHEON
(GENERAL SESSION II)
NOON - 1:30PM**



Lifetime Achievement Award

PRESENTED TO:

Denis Rickman
US Army ERDC

Mr. Denis Rickman is awarded the Lifetime Achievement Award in Shock and Vibration for his pioneering research in explosion effects, development of revolutionary post-blast forensic methodologies, leadership on internationally significant projects, and tireless dedication to mentoring the next generation of researchers. These efforts have fundamentally advanced the state-of-the-art and practice in the shock and vibration community.

Mr. Rickman had a distinguished 42-year career as a Research Physicist with the U.S. Army Engineer Research and Development Center (ERDC), joining in October 1983. He served as the Team Leader of the Experimental/Numerical Group and a Research Physicist in the Engineering Systems and Materials Division, where he led complex, multi-disciplinary research programs. He established himself as an internationally recognized subject matter expert in explosion effects phenomenology, blast mitigation, forensic analysis, and explosive demolitions, serving as a primary consultant for numerous U.S. and allied government agencies.

Denis Rickman is also the 2025 recipient of the Award for Excellence in Instruction at the 95th Shock and Vibration Symposium, as well as a multi-year recipient of the Henry Pusey Best Paper Award at annual Symposia.



Denis Rickman

**2026 LIFETIME ACHIEVEMENT
AWARD WINNER**

Congratulations to our Award Winners!

	SESSION 17: ELASTOMERIC ISOLATION 1:30-3:05PM / UNLIMITED DIST. A CHAIR(S): DR. PETER VO (RAYTHEON) GRETE BRESSNER (HUTCHINSON)	SESSION 18: VIBRATION DATA ANALYSIS 1:30-2:40PM / UNLIMITED DIST. A CHAIR(S): MATT FORMAN (NSWC DAHLGREN) DR. VASANT JOSHI (NSWC INDIAN HEAD)	SESSION 19: BALLISTICS II 1:30-3:05PM / LIMITED DIST. D CHAIR(S): CHRISTOPHER SHACKELFORD (US ARMY ERDC) GLYNN HARRINGTON (US ARMY ERDC)
	SALON 3	SALON 4	SALON 5/6
1:30	BUSHING DYNAMIC STIFFNESS ESTIMATE FROM RANDOM VIBRATION TESTING (41) <i>Dr. Ricky Stanfield & Dung Chi Pham (Corvid Technologies), Richard Rakowski & Darko Gjoreski (Shock Tech)</i>	POSSIBLE USAGE IF GENERAL SPECTRAL DENSITY THEORY FOR ENVIRONMENTAL SPECIFICATIONS (44) <i>Neil Loychik (LANL)</i>	USING EPIC TO BUILD A MACHINE LEARNING DATABASE FOR STEEL PENETRATION (45) <i>David Lichlyter (US Army ERDC)</i>
1:55	CONSIDERATIONS WHEN DEFINING TEST ENVIRONMENTS TO CHARACTERIZE ISOLATOR PERFORMANCE: HIGHLIGHTED BY A NEWLY DEVELOPED ELASTOMER (42) <i>Grete Bressner (Hutchinson Aerospace & Industry)</i>	USING ADVANCED MATHEMATICS TO ENHANCE VIBRATION TESTING WHILE REDUCING OVERALL COSTS (44) <i>Stewart Slykhous (Spectral Dynamics)</i>	DEVELOPMENT AND IMPLEMENTATION OF MACHINE LEARNING MODELS FOR FRAGMENT TERMINAL PERFORMANCE PREDICTIONS (45) <i>Christopher Shackelford, David Lichlyter, Dr. T. Neil Williams, & Dr. John Q. Ehrgott, Jr. (US Army ERDC)</i>
2:20	DESIGN AND DYNAMIC CHARACTERIZATION OF A STEWART PLATFORM INSPIRED PASSIVE VIBRATION ISOLATOR (42) <i>Dr. Peter Woerner (KDS Dynamics)</i>	FFT SPECTROGRAM FOR DAMPING LOGARITHMIC DECREMENT (44) <i>Dr. Ricky Stanfield (Corvid Technologies)</i>	COMPARATIVE ANALYSIS BETWEEN PREDICTIVE METHODS AND EXPERIMENTAL DATA OF SHAPED CHARGE JET PENETRATION INTO CONCRETE (45) <i>Glynn Harrington (US Army ERDC)</i>
2:45	RESONANT CHARACTERISTICS OF THE PAYNE EFFECT (43) <i>Noah Zimmerman, Dr. Peter Vo, Jay Paz, & Teri Stoner (Raytheon)</i>		EXTENSION OF THE FORERSTAL PENETRATION EQUATIONS TO CONCRETE PERFORATION INCORPORATING VELOCITY-DEPENDENT TARGET RESISTANCE (46) <i>Dr. Kyle Crosby (US Army ERDC)</i>

3:05
-
3:40

Dessert Break & Passport Program Drawing EXECUTIVE BALLROOM/EXHIBIT HALL

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PARTICIPANTS DO NOT NEED TO BE PRESENT TO WIN.

ENIDINE

	<i>TRAINING V:</i> INTRODUCTION TO MULTI SHAKER TESTING 1:30-3:05PM / UNLIMITED DIST. A 	<i>TRAINING VI:</i> INTERPRETING FINITE ELEMENT RESULTS 1:30-2:30PM / UNLIMITED DIST. A 	<i>TRAINING VII:</i> INTRODUCTION TO HEAVYWEIGHT SHOCK TESTING 1:30-3:05PM / UNLIMITED DIST. A 
	SALON 7/8	SALON 1/2	SIGNATURE 1
1:30	INTRODUCTION TO MULTI SHAKER TESTING (46) <i>Raman Sridharan</i> (Data Physics/NVT Group) 1:30 - 3:00PM	INTERPRETING FINITE ELEMENT RESULTS (46) <i>Bart McPheeters</i> (Leidos) 1:30 - 2:30PM	INTRODUCTION TO HEAVYWEIGHT SHOCK TESTING (47) <i>Jeff Morris</i> (HI-TEST Laboratories) 1:30-3:05PM
1:55			
2:20			
2:45			

3:05

-
3:40

Dessert Break & Passport Program Drawing
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OPTIONAL THREE HOUR COURSES. ATTENDEES WILL RECEIVE A CERTIFICATE OF COMPLETION AND MAY RECEIVE CEUs/PDHs (VARIES BY STATE). ADDITIONAL FEES APPLY TO ATTEND.

SHOCK TEST FAILURE MODES

Kurt Hartsough (901 E&T)

SIGNATURE 1

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

SALON 5/6

NOTE: LIMITED DISTRIBUTION D (SECURITY PAPERWORK REQUIRED)

Dr. Matthew Neidigk (Sandia National Laboratories)

Dr. Adriane G. Moura (Applied Research Associates)

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

SALON 3

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.

TUTORIAL SESSION VII

3:30 - 6:30PM

(CONTINUED)

WEDNESDAY

SEPTEMBER 23

REVIEW OF PRACTICAL VIBRATION/SHOCK MITIGATION METHODOLOGIES

SALON 4

Dr. Daryoush Allaei (QRDC)

Prof. Arezoo Emdadi (Missouri Univ. of Science and Technology)

Real-world vibration and shock mitigation strategies fall into three main categories: Source control - reduce vibration or shock load where it originates, Path control - interrupt or attenuate transmission, and Receiver protection - isolate or harden the sensitive system.

Source Mitigation Techniques (Eliminate or Reduce Excitation) is the most effective when feasible. Common Methods include balancing rotating components (reduces centrifugal forces), precision alignment of shafts and couplings, reducing excitation forces (lower speeds, smoother profiles), soft start / ramp control (limits transient shock), process redesign (e.g., replacing impact processes (inducing shock waves) with continuous ones), and eliminating resonance at the source avoids amplification downstream. Even small improvements here often yield large system-wide benefits.

Path Mitigation Techniques (Interrupt Transmission) address or modify how vibration or shock load travels through structures. Some of the well know methods are isolation using elastomer mounts (rubber, neoprene), spring isolators, and air mounts. The main idea is to reduce transmissibility when operating frequency $> \sqrt{2} \times$ natural frequency. Damping treatments is another approach that is most effective near or at resonance frequency. Some of the damping treatments include viscoelastic damping layers, constrained layer damping (CLD), and tuned mass dampers (TMDs). One may modify structure by increasing stiffness (shift natural frequency), adding mass (lower response amplitude at high frequency), and introduce discontinuities (break transmission paths). It is noted that isolation works best for steady-state vibration while damping is critical for transient and resonant conditions.

Receiver Mitigation Techniques (Protect the Payload) is applied when source/path control is limited or impractical. Some of these methods are isolating systems, such as equipment mounts, floating platforms, and shock-mounted enclosures. Shock protection methods include foam packaging (energy absorption), wire rope isolators (high durability), and hydraulic dampers (high-energy shock). Structural hardening includes reinforced components, ruggedized electronics, and potting or encapsulation. It is noted that receiver isolation should consider payload fragility curves (G-level vs duration) while over-isolation can introduce instability or excessive motion.

Practical application of these methodologies will be discussed.

MIL-DTL-901E ENGINEERING TOPICS

SALON 1/2

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.



BLAST PRESSURE MEASUREMENTS

Dr. Troy Skinner

Denis Rickman (US Army ERDC)

Mike Sacramone (PCB Piezotronics)

SALON 7/8

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.

encapsulation. It is noted that receiver isolation should consider payload fragility curves (G-level vs duration) while over-isolation can introduce instability or excessive motion.

Practical application of these methodologies will be discussed.

97th

SHOCK & VIBRATION

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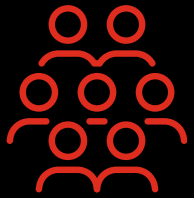




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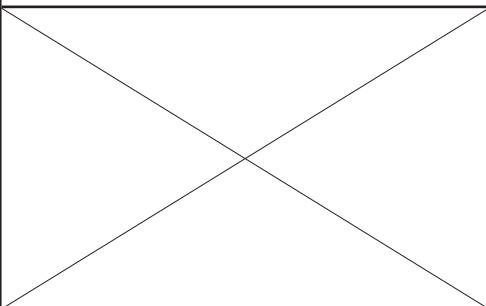
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	SESSION 20: MIL-STD-167 VIBRATION & SHIPBOARD TEST METHODOLOGIES 8:00-8:45AM / UNLIMITED DIST. A CHAIR(S): KAITLYN RIGGS (NSWC PHILADELPHIA) PETER ZAWYCKY (NSWC PHILADELPHIA)	SESSION 21: NEXT GENERATION SHOCK RESPONSE SPECTRUM 8:00-9:10AM / UNLIMITED DIST. A CHAIR(S): DR. EVAN SAUNDERS (SANDIA NATIONAL LABS) RYAN POWERS (NSWC PHILADELPHIA)	SESSION 22: PACKAGING & ISOLATING FOR SHOCK SURVIVABILITY 8:00-8:45AM / LIMITED DIST. D 8:50-9:35AM / UNLIMITED DIST. A CHAIR(S): ANDREW CUNNINGHAM (NSWC CARDEROCK) RICHARD CLAYSON (SANDIA NATIONAL LABS)
	SALON 3	SALON 4	SALON 7/8
8:00	STANDARDS DRIVEN SYNTHESIS AND DELIVERY OF SHAKER TEST PROGRAMMES (47) <i>Neil McRae & Gavin Colliar (Thornton Tomasetti)</i>	SRS-BASED TRANSFER FUNCTIONS: A NUMERICAL STUDY (48) <i>Daniel Blueborn & Dr. Evan Saunders (Sandia National Laboratories)</i>	SHOCK QUALIFIED PAYLOAD STOWAGE SOLUTIONS FOR SUBMARINE APPLICATIONS (49) <i>Teresa Gangi (NUWC Newport)</i>
8:25	UPDATE TO SHIPBOARD VIBRATION TEST METHODOLOGIES (48) <i>Dr. Luke Martin (NSWC Dahlgren), Thomas Borawski (NSWC Philadelphia)</i>	MODAL SHOCK RESPONSE SPECTRUM (48) <i>Dr. Evan Saunders, Troy Skousen, & Dr. Randy Mayes (Sandia National Laboratories)</i>	HIGH ENERGY ROPE MOUNT ISOLATOR RELAXATION (50) <i>Javier Garcia-Rivera (Raytheon)</i>
8:50		SHOCK TIME SERIES SYNTHESIS VIA MULTIPLE WAVELET ENSEMBLE METHOD (49) <i>Syed Raza, Dr. Dustin Harvey, & Adam Watts (Los Alamos National Laboratory)</i>	PREDICTING COMPLEX SHOCK FAILURE MODES OF SPECIALIZED PACKAGING AND HANDLING SYSTEMS USING EXPLICIT NON-LINEAR FEA (50) <i>Aayush Gandhi (Naval PHST Center)</i>
9:15			VALIDATING FEA MODELS FOR WIRE ROPE ISOLATION SYSTEMS AGAINST ANALYTICAL METHODS (50) <i>Justin Lam (Naval PHST Center)</i>
 SESSION BREAK 9:35 - 10:00AM  			



	SESSION 23: BLAST CHARACTERIZATION 8:00-9:35AM / LIMITED DIST. D CHAIR(S): DeBORAH LUCKETT WEATHERSPOON (USACE) ROOSEVELT DAVIS (AFRL)	PANEL: INTEGRATING ARTIFICIAL INTELLIGENCE (AI) INTO ENVIRONMENTAL QUALIFICATION TESTING (EQT) 8:00-9:35AM / UNLIMITED DIST. A 	TRAINING VIII: INTRODUCTION TO LIGHTWEIGHT SHOCK TESTING 8:00-9:00AM / UNLIMITED DIST. A 
	SALON 5/6	SALON 1/2	SIGNATURE 1
8:00	PLASTIC BONDED EXPLOSIVE PERFORMANCE UNDER VACUUM (51) <i>Noah Meisner, Michael Vena, Nicholas Oberts, & Joseph Magallanes (Karagozian & Case, Inc.), Daniel Portillo (Southwest Research Institute)</i>	INTEGRATING ARTIFICIAL INTELLIGENCE (AI) INTO ENVIRONMENTAL QUALIFICATION TESTING (EQT) (54) <i>This panel will examine the opportunities and challenges associated with integrating Artificial Intelligence (AI) into Environmental Qualification Testing (EQT), specifically with shock, vibration, and electromagnetic interference (EMI) applications. See full description in Abstract Book.</i> MODERATORS: <i>Allison Vella Noyes (Leidos Gibbs & Cox) Greg Budriss (NSWC Philadelphia)</i> 8:00-9:35AM 	INTRODUCTION TO LIGHTWEIGHT SHOCK TESTING (55) <i>Jeff Morris (HI-TEST Laboratories) 8:00-9:00AM</i> 
8:25	AUTONOMOUS MOMENTUM GAGE FOR MUTIPHASE FLOW (52) <i>Dr. Paul Cammarata, Damian Camo, Raul Reyes, Grant Spear, & Dr. Sean Cooper (Applied Research Associates), Dr. Robert Abernathy & Kiran Shah (DTRA)</i>		
8:50	EMPIRICAL DATA OF THE BLAST OVERPRESSURE (BOP) ENVIRONMENT INSIDE A DEPARTMENT OF WAR TACTICAL BREACHING TRAINING FACILITY (52) <i>DeBorah Luckett Weatherspoon, Dr. Kellan Sullivan, & Dr. Catherine Stephens (US Army ERDC)</i>		
9:15	BLAST DOSE ACCUMULATION METHODOLOGY (53) <i>Noah Meisner, Joseph Hamilton, Dr. Youcai Wu, Dr. William Chen-Mertens, Jonathan Raygoza, Isabela Cardenas, & Dr. Joseph Magallanes (Karagozian & Case), Dr. Michael Shields (Johns Hopkins Univ), Dr. Allison Nelson & Dr. Pamela VandeVord (Virginia Tech)</i>		
 SESSION BREAK 9:35 - 10:00AM 			

	SESSION 24: INSTRUMENTATION FOR DYNAMIC TESTING 10:00-11:35AM / UNLIMITED DIST. A CHAIR(S): MATT DAVIS (NEWPORT NEWS SHIPBUILDING) DAVIN JAHNKE (NSWC PHILADELPHIA)	SESSION 25: LAB & FLIGHT PYROSHOCK 10:00-11:10AM / UNLIMITED DIST. A COMBINED SHOCK & VIBRATION CHARACTERIZATION & TESTING 11:15-11:35AM / UNLIMITED DIST. A CHAIR(S): PAUL PRETE (NSWC PHILADELPHIA) AUSTIN GLENWRIGHT (NSWC PHILADELPHIA)	SESSION 26: SHOCK TESTING MODELING & METHODS 10:00-10:45AM / LIMITED DIST. D 10:50-NOON / UNLIMITED DIST. A CHAIR(S): PETER ZAWYCKY (NSWC PHILADELPHIA) KEVIN BEHAN (APPLIED PHYSICAL SCIENCES)
	SALON 3	SALON 4	SALON 7/8
10:00	HIGH-G SHOCK ACCELEROMETERS: DAMPED VS. UNDAMPED (55) <i>James Nelson (PCB Piezotronics)</i>	ISOLATION PROPERTIES OF CUBEŠAT MOUNT ASSEMBLY (56) <i>Darko Gjoreski, Richard Rakowski, & Shane Jansen (Shock Tech)</i>	A METHOD FOR RECOVERING STRUCTURAL EFFECTIVE MASS IN A COUPLED ACOUSTIC-STRUCTURAL MODAL ANALYSIS USING THE STRUCTURAL MASS MATRIX (59) <i>Pedro Jimenez (HII Newport News Shipbuilding)</i>
10:25	AN IMPROVED FLASH TEST FOR PRESSURE TRANSDUCER DESIGN (55) <i>John Hilton, Cameron Stekelenburg, Steve Carter, & Joseph VanDeWeert (Kulite)</i>	DAMPING TREATMENTS AND BOUNDARY CONDITIONS IN RESONANT PLATE SHOCK TESTING AND THEIR EFFECT ON THE PLATE'S MODAL RESPONSE (57) <i>Dr. Carl Sisemore (ShockMec Engineering)</i>	IMPROVING SHOCK MODELING AND SIMULATION REQUIREMENTS AND CRITERIA FOR SURFACE COMBATANTS (59) <i>Steve Arturo (HII Newport News Shipbuilding)</i>
10:50	MIL-DTL-901 SUBSIDIARY SHOCK PROGRAM DEVELOPMENT UPDATES – PRINCIPAL UNIT TESTING AND MODEL DEVELOPMENT (56) <i>Matt Forman & Dr. Bryan Joyce (NSWC Dahlgren)</i>	REUSABLE AERIAL DELIVERY EQUIPMENT (57) <i>Dr. Daryoush Allaei & Drew Holsenback (QRDC), Prof. Arezoo Emdadi (Missouri Univ. of Science and Technology)</i>	APPLICATION OF CONTINUOUS HIGH AMPLITUDE BIDIRECTIONAL FORCE SYSTEM (CHABFS) ISOLATION SYSTEMS OF US NAVY SHIPBOARD EQUIPMENT TO MINIMIZE EXCURSIONS OF, AND TRANSMITTED ACCELERATIONS TO, ISOLATED EQUIPMENT (59) <i>Dr. Christopher Merrill (CM&A Engineering)</i>
11:15	HIGH-SPEED IMAGING & PYTHON SCRIPTING FOR VIBRATION EXTRACTION (56) <i>Prof. Kyle Gilroy (Phantom High-Speed Cameras, Vision Research)</i>	COMBINED VIBRATION AND SHOCK TESTING DEVELOPMENT (58) <i>Dr. Jim DeClerck & Dr. Cora Taylor (Michigan Technological University), David Soine & Steve Carter (Sandia National Laboratories)</i>	SUBMARINE UNDERWATER EXPLOSION TESTING (60) <i>Johan Jeppsson (Saab)</i>
11:40			SHOCK QUALIFICATION OF HAZARDOUS EQUIPMENT USING A PORTABLE SHOCK TEST MACHINE (60) <i>Liam Rayner & Gavin Colliar (Thornton Tomasetti)</i>

1:00
-
2:00



SAVE TECHNICAL ADVISORY GROUP (TAG) MEETING

SIGNATURE 1

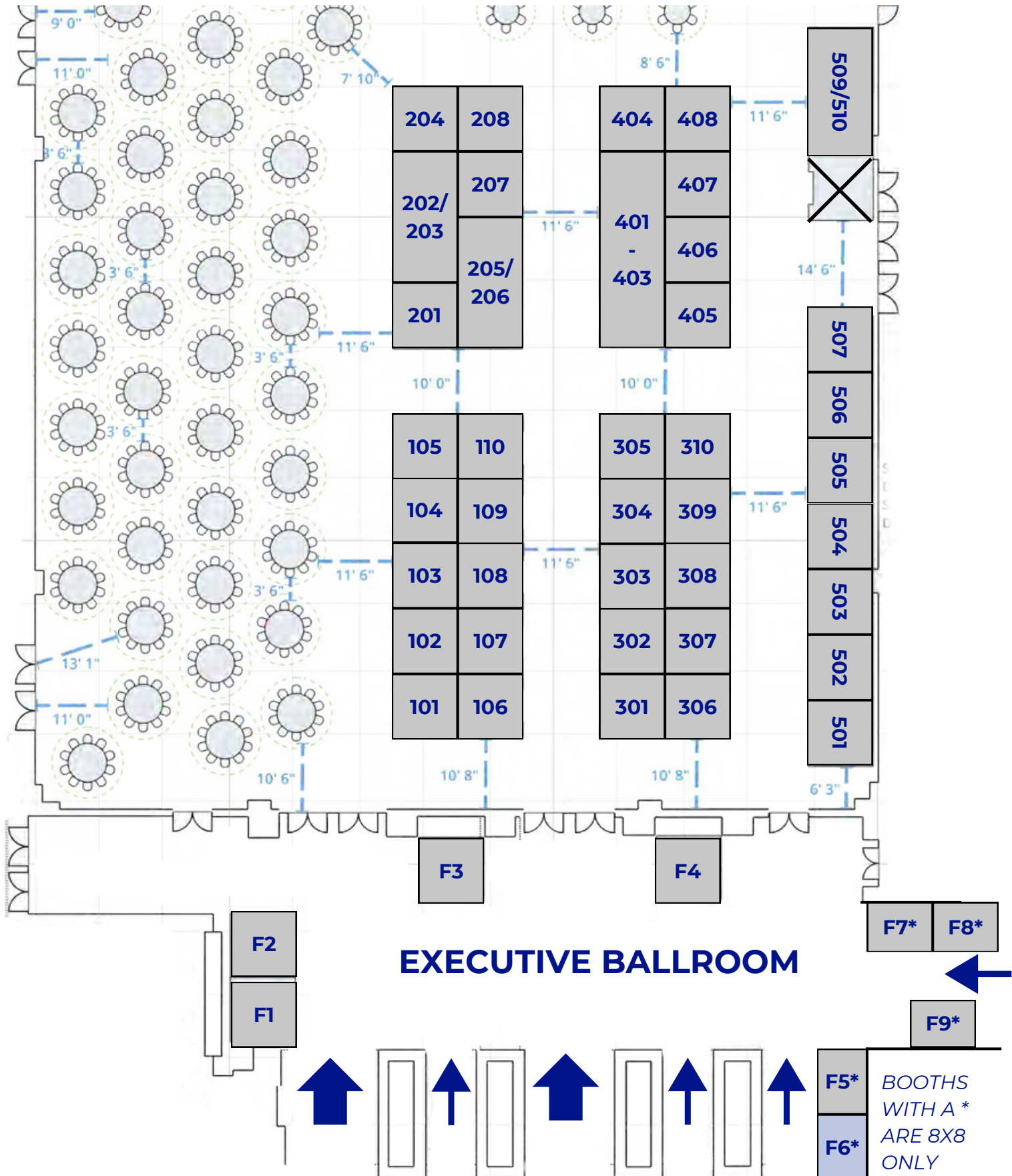
The annual meeting of the members of the SAVE Technical Advisory Group (TAG) will convene to review the 96th Shock & Vibration Symposium and discuss plans for 2027.

	SESSION 27: STRUCTURAL RESPONSE & FRM DEVELOPMENT 10:00-11:35AM / LIMITED DIST. D CHAIR(S): GABRIEL RIVEROS (US ARMY ERDC) ERNESTO CRUZ (US ARMY ERDC)	TRAINING IX: AN INTRODUCTION TO DYNAMIC ANALYSIS 10:00-11:00AM / UNLIMITED DIST. A 	WORKING GROUP: MIL-STD-810J DISCUSSION GROUP 10:00-NOON / UNLIMITED DIST. A 
	SALON 5/6	SALON 1/2	SIGNATURE 1
10:00	BRIDGE AND PIER VULNERABILITY: SUBSCALE DECK BREACHING EXPERIMENTS FOR FAST-RUNNING MODEL ENHANCEMENT (61) <i>Gabriel Riveros (US Army ERDC)</i>	AN INTRODUCTION TO DYNAMIC ANALYSIS (63) <i>Bart McPheeters (Leidos)</i> 10:00 - 11:00AM 	MIL-STD-810J DISCUSSION GROUP PRESENTERS/MODERATORS: <i>William Barber (AI Signal Research)</i> <i>Dr. Michael Hale (Trideum)</i> <i>Randy Patrick (US Army Yuma)</i> <i>Dr. Luke Martin (NSWC Dahlgren)</i> <i>Matthew Lucas (US Army ATEC)</i> <i>Additional Members TBD</i> This group discussion will delve into structural and technical changes to the shock and vibration test methods in MIL-STD-810 that are currently in progress. <i>Contributors will cover all updates, including both Climatic and Dynamic Environmental Test Methods.</i>
10:25	EFFECTS OF VARYING VENT GEOMETRIES ON BLAST INTRUSION OF EXTERNALLY DETONATED BARE CHARGES IN SCALED STRUCTURES (62) <i>Patrick Camacho, Bowen Woodson, Shelby Buckley, & Austin Hopkins (US Army ERDC)</i>		
10:50	EVALUATING EXPEDIENT OVERHEAD COVER SOLUTIONS FOR SURVIVABILITY FROM EMERGING THREATS (62) <i>Marcus Barksdale, Austin Hopkins, & Bowen Woodson (US Army ERDC)</i>		
11:15	A PHYSICS-INFORMED EMPIRICAL MODEL FOR STRUCTURAL BREACHING UNDER CONTACT OR NEAR-FIELD EXPLOSIVE LOADING (63) <i>Ernesto Cruz-Gutierrez (US Army ERDC)</i>		
11:40			
1:00 - 2:00	 SAVE TECHNICAL ADVISORY GROUP (TAG) MEETING <i>The annual meeting of the members of the SAVE Technical Advisory Group (TAG) will convene to review the 96th Shock & Vibration Symposium and discuss plans for 2027.</i> SIGNATURE 1		

Exhibitor List

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F3	EXPERIOR LABORATORIES	303	BOEING/LMTF
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		510	MECALC

Exhibit Hall Layout



Exhibitor Descriptions



ACUTRONIC

901E&T provides an extensive training course on MIL-DTL-901E. Presented by a previous Delegated Approval Authority (DAA) of NAVSEA, the instructor provides a history of the MIL-Spec and delves into the comprehensive arena of shipboard equipment shock qualification. By the end of the course, participants will have the knowledge/strategies to craft a streamlined, cost-effective shock qualification test schedule.

ACUTRONIC USA has a proud history of building technologies and teams that are crucial to the aerospace, defense, and transportation industries. Acutronic's Simulation & Test Division is the global market leader in high-performance motion simulation and test equipment. Acutronic's Aerospace Components Division manufactures specialty components for use on uncrewed aerial vehicles, land defense applications, and missile systems.



ADVANCED TEST EQUIPMENT RENTALS primary focus is providing a complete rental solution of measurement and test equipment to industries such as Aerospace, Defense, Communications, EMC, and more. Our wide inventory, custom solutions, flexible terms, and quality support differentiates us from competitors as a complete solution for all test and measurement needs. Our inventory covers most electronic test applications and we are always expanding to remain the leading rental provider.

VULKAN

AMERICAN VULKAN CORP (AVC) is a member of the multinational VULKAN Group. American VULKAN Corporation's manufacturing and main office is located at our 60,000 sq ft facility in Winter Haven, Florida, with a supporting location in Fort Lauderdale, Florida. AVC is home to three divisions: Marine, Industry and Energy and Refrigeration and A/C. Our portfolio covers high-performance flexible couplings and resilient mounts, engineered to meet the most demanding naval requirements for torque transmission, vibration isolation, shock resistance, and acoustic signature reduction.



ATA ENGINEERING provides analysis- and test-driven design for aerospace, defense, themed entertainment, consumer products, and industrial and mining equipment. We use advanced computer-aided engineering software to solve problems for our customers and to design, analyze, and test complex, highly engineered structures subject to severe dynamic loads.



BODIE TECHNOLOGY provides engineers with excellent software, training, and consulting resources to help analyze complex nonlinear mechanics problems, especially those involving problematic or noisy transient data. Bodie offers guidance on how to tackle a nonlinear mechanics problem, including best practices for utilizing FEA and physical testing methods.



BOEING'S LITTLE MOUNTAIN TEST FACILITY is a state-of-the-art test facility, Air Force Materiel Command laboratory dedicated to simulation testing of nuclear hardness, survivability, reliability and electromagnetic compatibility of defense systems. Center test laboratories simulate environments for nuclear radiation, air blast, shock and vibration, electromagnetic pulse, electromagnetic interference, and compatibility testing.



CIH EQUIPMENT COMPANY specializes in providing calibration and torque solutions for industrial hygiene equipment. Our services ensure that devices like gas meters, airflow meters, and sound level meters are calibrated with precision and repaired as needed to maintain top performance. Our goal is to help you stay compliant with industry standards while ensuring the accuracy and safety of your equipment.



COMPUTER METHODS develops professional firmware, software, services and IOT applications for embedded devices, Windows, Web, Android and iOS platforms. We specialize in medical, business and industrial applications for deployment on target systems or in client/server environments with connectivity to the cloud.



CRYSTAL INSTRUMENTS (CI) is a leading worldwide supplier of vibration controllers, portable dynamic signal analyzers, and dynamic measurement systems for product testing, machine monitoring, and vibration and acoustic analysis. CI's products are used across a wide range of industries, including aerospace, defense, and medical device manufacturing.

Exhibitor Descriptions



DATA PHYSICS has been pioneering high-performance vibration testing and signal analysis in the aerospace, defense and automotive industries since 1984. We design and manufacture a range of air and water-cooled electrodynamic shakers, vibration controllers, and dynamic signal analyzers. Data Physics controllers lead the industry in multi-shaker vibration control, and our MIMO controllers are trusted to control the world's most advanced multi-shaker vibration tables including multi-shaker single axis, 3-DOF, 6-DOF, 6+DOF, over-actuated systems, IMMAT/modal control, and more. Data Physics control and safety technology was critical to the successful pre-launch testing of the James Webb Space Telescope, and Sierra Space Dream Chaser spaceplane.



DAYTON T. BROWN's tenured engineers provide experience in adapting our test equipment to meet the most challenging customer requirements. Our extensive test facility includes several shakers, anechoic EMI/EMC rooms, multiple chambers to perform a myriad of environmental tests and our newly expanded structural testing area with its 40ft ceiling. DTB is an A2LA and NVLAP accredited laboratory in accordance with ISO/IEC 17025 requirements and is ISO 9001:2008 and AS9100C registered.



DEWESOFT, a privately held company, is a World leading provider of data acquisition software and hardware serving all. The DEWESoft software and hardware synchronizes Analog, Digital, Video, GPS, CAN, ARINC 429/1553, PCM and Chapter 10 support. The instruments have wide temperature and shock ranges and are available in many configurations.



DEWETRON offers highly intuitive, end-to-end test and measurement systems designed to enhance predictability, efficiency, and safety across the globe. Our modular systems provide reliable measurement data and flexible, needs-based data acquisition capabilities, catering to the energy, automotive, transportation, and aerospace industries. Our strength lies in delivering customized measurement solutions that are ready-to-use and can be quickly adapted to the evolving needs of test environments and advanced technologies. With over 30 years of experience, innovation, and collaboration, DEWETRON has earned the trust and respect of the global market, with more than 25,000 DEWETRON measurement systems and over 400,000 measurement channels in operation at renowned companies worldwide.



E-LABS is a full-service testing laboratory featuring state of the art facilities, knowledgeable personnel, and simulation services such as test planning and fixture design. We perform climatic and dynamic testing, offer full EMI and EMC testing, and conduct specialized testing such as explosive atmosphere, high pressure, and helium leak detection.



Founded as NTS Technical Systems, today **ELEMENT U.S. SPACE & DEFENSE** brings more than 60 years of experience and expertise being tasked with the most complex projects and programs in the world. From centrifuge testing for the latest Mars rover, vibration testing for the Space Launch System (SLS), or environmental simulations for next-generation missiles, Element U.S. Space & Defense is the pioneering partner for highly custom, end-to-end, testing design and implementation.



ENDEVCO provides a complete range of dynamic test and measurement sensor solutions, including piezoelectric, piezoresistive, MEMS, and variable capacitance accelerometers, as well as angular rate, shock, and 6 DoF sensors, miniature pressure sensors, signal conditioners, cables and accessories. Our brand is recognized for highly reliability products with a wide range of testing applications, including automotive design and crash testing, aircraft and space vehicle testing, weapons and munition testing, and general lab testing. Endevco is an assumed name of PCB Piezotronics of North Carolina, Inc., which is a wholly-owned subsidiary of PCB Piezotronics, Inc. More info www.endevco.com



ETS SOLUTIONS is a world leader in High performance shakers. We are discussing our IPA series amp, designed to never fail a fuse, and our Extreme Acceleration Solid armature Y-connection "EASY" Ring, designed for up to 220 g sine and 180 g RMS Random. ETS Solutions offers affordable, high quality vibration test equipment. Utilizing extensive and innovative technical expertise ETS delivers a reliable long term solution to meet your test requirements. All systems comply with the European CE standards with full testing and certification from TUV-SUD Product Service GmbH.

Exhibitor Descriptions



EXTERIOR LABORATORIES is a test laboratory providing independent design verification and qualification testing services to component and system manufacturers, military contractors, integrators and system providers within the Telecommunication, Military, Aerospace, Space, Industrial, Medical and many other industries. Recognized throughout the industry for superior customer service, consistent on-time delivery, project management by experts and end-to-end accountability, Exterior Labs offers customers cost-effective, highly qualified testing services that add value to any organization, regardless of size.



DYTRAN BY HBK is a leading manufacturer and designer of piezoelectric and DC MEMS sensors. Dytran offers a complete range of impulse hammers, piezoelectric force and pressure sensors, electronics, cables, and accessories for dynamic measurements, with full in-house customization capabilities.



HII is America's largest military shipbuilder. HII specializes in providing shock and vibration qualification and support through recognized expertise in testing and advanced shock analysis. HII is also the creator of the patented Deck Simulating Shock Machine (DSSM), the newest Navy approved test method in MIL-DTL-901E.



HI-TEST LABORATORIES, INC. has been a trusted partner to the U.S. Navy and defense industry for more than 50 years, providing engineering, testing, and evaluation services for mission-critical systems. As the only commercial facility with all NAVSEA-approved MIL-DTL-901E shock test platforms in one location, HI-TEST offers unmatched capability for shock qualification testing. Our services span the entire test lifecycle—from pre-test engineering and fixture design to test execution, data analysis, and final reporting—helping customers execute efficient, successful qualification programs with confidence.



HUTCHINSON Defense and Mobility products have proven performance in all major modern conflicts from the first Gulf War to the Balkans, Iraq, Afghanistan and Syria. Hutchinson is trusted worldwide by soldiers to ensure their mobility and protection in all terrains and combat situations. Hutchinson provides innovative products and proactive support that exceeds customers' expectations and meets the demands of tomorrow's lighter and more survivable vehicles.



IC2 was created in 2001 initially to provide a commercialization path for University of Florida (UF) generated intellectual property (Interdisciplinary Microsystems Group @ UF), specifically in the areas of MEMS-based instrumentation, flow control, acoustics and smart materials. IC2 has since solidified its focus around a core mission of developing precision sensors to advance the measurement of aerodynamic and aeroacoustic quantities.



IMAGE SYSTEMS offers accurate and valuable measuring results – fast. Our software is used in hundreds of different applications where the movement, orientation or shape of an object, shall be measured and analyzed. TrackEye is the market-leading software suite for elite Motion Analysis tests in research and industry. Thanks to its high accuracy, modular structure, calculation speed and intuitive user interface, professional report – TrackEye is used by professionals across the globe in a wide range of applications from critical feature tracking, outline analysis and dynamic movement analysis.



INSTRUMENTED SENSOR TECHNOLOGY (IST) has developed a full line of shock and vibration data recorder products that cover a broad range of testing and monitoring applications. The company was founded to design, develop, and manufacture digital data recording technology for dynamic measurements, such as acceleration data loggers, triaxial accelerometer loggers, and transportation data recorders.



ISOLATED DYNAMICS CORP (IDC) is a leader in the design, engineering, and manufacture of Shock & Vibration Isolation systems for both military and commercial applications. Specializing in rugged, all-metallic wire rope isolators. IDC has amassed an impressive list of shock qualified systems for the US Navy and all branches of the military. IDC's unsurpassed experience and knowledge in the field of shock and vibration isolation, makes it possible for us to engineer a solution from early concept to final product. All of IDC's products are proudly made in the USA using only the highest quality domestic materials.

Exhibitor Descriptions



ITT ENIDINE DEFENSE designs and manufactures energy absorption, vibration isolation and shock systems for defense applications. These engineered products support applications in weapon systems, naval, transportation, and aviation. Products include elastomeric, hydraulic, mechanical shock isolation, as well as standard off the shelf products such as HERMS and Wire Rope Products.



LANSMONT CORPORATION is a global leader in designing and manufacturing shock and vibration measurement systems, monitoring instrumentation, and package-testing equipment. Founded in 1971 and headquartered in Monterey, California, the company helps major manufacturers, government labs, and educational institutions optimize product and package durability.



M+P INTERNATIONAL is a worldwide provider of high-quality test and measurement solutions for vibration control, noise & vibration analysis and general data acquisition. By working closely with our customers, we understand their applications from an engineer's point of view and this is apparent in our products. A policy of continuous research and development, which has led to many pioneering solutions, ensures that our products demonstrate superior performance and quality.



MAX Q DYNAMICS is one of the nation's leading electrodynamic vibration shaker experts. We help to supply the industry's most reliable and accurate machinery and we repair the rest so that it lives up to that standard. Learn more about our team that wants to roll out the red carpet for you.



MECALC TECHNOLOGIES AND COMPUTER METHODS have collaborated to create a new system for Pyroshock data acquisition using the ALI25 module and PhoenixKconnect software. The ALI25 is a high-bandwidth module designed for triggered/burst acquisition of Pyro-Shock and Mechanical Shock data, while PhoenixKconnect is a software application for transient event data acquisition and analysis.



MIDE / ENDAQ is a Hutchinson Company with brands that include: enDAQ shock, vibration & environmental sensors & software; Piezo.com Offering high-value piezoelectric products and expert solutions; and Mide's HydroActive Seal Products. Midé is a leading provider of advanced engineering products and services. Midé is committed to providing customers with high-quality deliverables that are on-time, on budget, and meet their expectations through the use of a quality management system focused on continual improvement. Midé uses industry best practices in both execution and cost effectiveness.



NOVASTARSOLUTIONS delivers cutting-edge technical services and products across multiple industries. Driven by innovation and guided by expertise, we create customized solutions that empower you to move forward with confidence. Now providing Primary Standards and Flow Calibrations! Our Scope of Accreditation to ISO/IEC 17025:2017 and ANSI/NCSL Z540-1-1994 standards provides you the confidence that we deliver exceptional calibration services. Our American Association for Laboratory Accreditation (A2LA) is a proud achievement and provides confidence in our calibration services



PCB manufactures vibration, pressure, force and strain, shock, and acoustic sensors used by design engineers and predictive maintenance professionals worldwide for test, measurement, monitoring, and control requirements. Our sensors support testing in aerospace and defense, automotive, transportation, civil engineering, and general R&D industries. Primary sensing technologies include piezoelectric (ICP®), piezoresistive, and capacitive MEMS. With a worldwide customer support team, 24-hour SensorLine, and a global distribution network, PCB is committed to Total Customer Satisfaction. PCB Piezotronics is a wholly-owned subsidiary of Amphenol Corporation.



PHOTRON has continually expanded their product line to aid in the advancement of photo optics and electronic technologies furthering research and development in the areas of digital imaging and slow motion analysis. Markets include microfluidics, military testing, aerospace engineering, automotive, broadcast, particle image velocimetry (PIV), digital image correlation (DIC), ballistics testing, and more.

Exhibitor Descriptions



POLYTEC has been bringing light into the darkness for more than 50 years. With over 400 employees worldwide we develop, produce and distribute optical measurement technology solutions for research and industry. Our quality innovative products have an excellent reputation internationally among the expert community. We find solutions tailored to our customers' requirements.



PRECISION FILTERS, INC. is a global provider of instrumentation for test measurements. You can rely on a single source for signal conditioning and switching—a complete range of instrumentation—products optimized to work together to provide high performance at reasonable cost. PFI designs and manufactures precision solutions that include a family of analog signal conditioning, filtering and switching systems. The 28000 Signal Conditioning System provides a complete range of transducer conditioning with up to 256 channels per chassis. Precision's solid-state switch provides up to 256x256 cross-point switching and replaces tedious manual patch panels. The PF-1U provides 8 or 16 channels of high performance filter/amplifiers in a compact package with Ethernet control.



QUANTIFI PHOTONICS, a Teradyne company, manufactures optical test instrumentation for Photonic Doppler Velocimetry (PDV) and related research applications. Our scalable PDV test solutions help researchers perform reliable velocity measurements in shock physics, impact testing, dynamic events, and materials science.



SHOCK TECH brings higher value and quality products to meet the most stringent industry standards. We design, manufacture and test shock attenuation and vibration isolation systems for the most demanding environments. We provide solutions for your equipment's dynamic protection problems and are experts at quick-turn, affordable results.



SHOCKMEC ENGINEERING is a small startup research and development company focused on shock testing and analysis. We have designed and produced our own resonant plate shock test system that is sized for convenient installation in almost any laboratory space. Resonant plate shock testing is intended to be representative of pyroshock and other similar high-energy, low-displacement shock events. Our company also performs shock design and analysis work as well as acoustics testing and design.



Simcenter is the **SIEMENS** software brand for addressing Predictive Engineering Analytics. The Simcenter portfolio consists of solutions that span 3D simulation, 1D simulation, and testing solutions. It is comprised of a number of well-known products such as Simcenter Test.Lab, NX Nastran, STAR-CCM+, Simcenter Imagine.Lab and Simcenter 3D. Simcenter Test Solutions specializes in testing for Acoustics, Structural Dynamics, Rotating Machinery, Durability/Fatigue and Vibration Control and are the market leader for high-end data acquisition and test results visualization and post processing.



The **SOCIETY FOR EXPERIMENTAL MECHANICS** is composed of members from academia, government, and industry who are committed to application, research and development, education, and promotion of experimental methods to: (a) increase knowledge of physical phenomena; (b) further understanding of the behavior of materials, structures and systems; and (c) provide the necessary physical basis and verification for analytical and computational approaches to the development of engineering solutions.



SOCITEC US is the leading American manufacturer of shock and vibration control systems. Our solutions protect and extend the life of the equipment and its surrounding. Socitec US leverages its expertise in vibration, shock, and dynamics to develop high performance solutions. These solutions are tested and approved by multiple international companies. The optimal solution requires comprehensive analysis of the dynamic system and a precise understanding of its reactions. Our team adopts a global approach that includes research, analysis, study, and solution design followed by installation and rigorous monitoring.



SPECTRAL DYNAMICS (SD) is a technically innovative company that has served the Shock and Vibration community for 56 years. Whether it's Sine control of challenging tests, innovative MIMO control of multiple shakers, Shock data capture at 5 Msample/s/channel or accurate Phase-locked acquisition of hundreds of channels of data, Spectral Dynamics uses mathematics effectively to reduce the total costs of dynamic testing. Call Spectral Dynamics for a customized solution to your needs in Vibration, Shock or Acoustic Test Control; Multi-Channel Data Acquisition; Modal Analysis or PIND Testing.

Exhibitor Descriptions



TAYLOR DEVICES has provided innovative solutions for shock and vibration control since 1955. Our customers include all branches of the US Military and NASA Space Programs. Products include precise positioning shock isolators, fluid, elastomer and hydropneumatic spring-dampers, high capacity fluid dampers, and modular machined springs. Made 100% in the USA.



TEAM CORPORATION continues to define the future of advanced, high-performance vibration test systems and solutions that advance the aerospace, defense and automotive industries. Pioneering the world of multi-axis test systems has led to the introduction of many state-of-the-art high frequency hydraulic and electrodynamic multi-axis test solutions, such as the CUBE and Tensor test systems. Utilizing advanced hydrostatic bearing technology that has been refined over the past 65 years, Team Corporation implements leading hydraulics engineering to solve unique problems that others cannot. Team has designed and engineered many ground-breaking test systems, some noteworthy examples are active within NASA's Space Environments Complex (SEC). This includes the most powerful spacecraft Reverberant Acoustic Test Facility (RATF), and the world's highest capacity and most powerful spacecraft shaker system – the Mechanical Vibration Facility (MVF)—where test programs for Orion/Artemis, and the Sierra Space Dream Chaser spaceplane were completed.



THORNTON TOMASETTI provides engineering design, investigation and analysis services to clients worldwide on projects of every size and complexity. We have 70 years of experience in research, testing and software development for the U.S. Navy and Department of Defense in the fields of blast, underwater shock, impact and vibration effects.



VIBRATION RESEARCH (VR) has been the innovator in vibration control, data acquisition, and dynamic signal analysis since 1995. VR builds reliable and user-friendly software and hardware at its headquarters in Michigan, USA. It is attentive to emerging technologies and changes to the industries it serves. With every software release, the customer can expect new and relevant features meticulously tested before they reach them. Testing labs worldwide trust VR for the industry's best testing systems and support that delivers unrivaled value. Visit the VR booth to discuss your testing and analysis requirements with industry experts.



VIPER APPLIED SCIENCE has over three decades of experience between them in the fields of Blast, Shock & Vibration, Structural Dynamics, Computational Physics & Numerical Methods. All our team have a background in Engineering Consultancy, and the software we write and services we offer our clients reflect this. We pride ourselves in developing practical, usable, real world solutions that don't cost the earth.



VISION RESEARCH designs and manufactures high-speed digital imaging systems that are used in military, industrial, academic, machine vision, and entertainment sectors. Phantom cameras allow you to analyze physical phenomena when it's too fast to see, and too important not to TM. Vision Research prides itself in the high resolution of its images, the power of its software, the reliability of its products and its high level of attentiveness and dedication to its customers. The company's innovative approach to high speed electronic "digital" imaging was recognized by the US Patent Office and was granted US Patent #5,625,412.



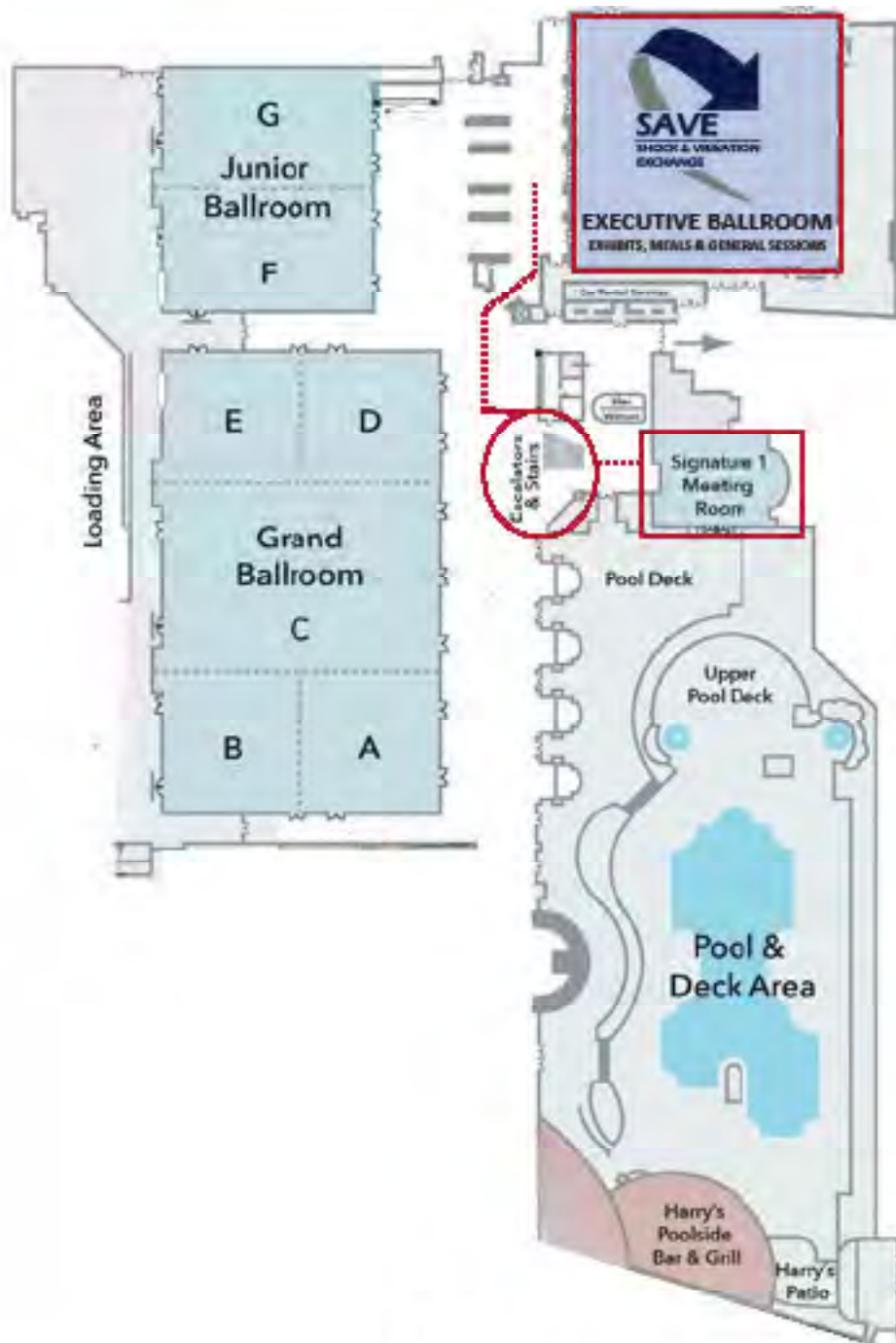
EUROFINS MET LABS is the global service leader for product safety approvals and regulatory certification of electrical products — With facilities, accreditations, and 60 years of experience to get your products approved and to market faster. We are qualified to NRTL certify products in over 200 UL Standard categories and can test up to an additional 230+ standards for the U.S. market. For Canada, we maintain a wide scope of SCC accreditations and also offer expert third-party testing to almost any product safety standard for the European Union or Asia Pacific.

Rosen Centre Meeting Space Layout

MAIN FLOOR (FLOOR 1)

EXECUTIVE BALLROOM & FOYER:
SIGNATURE 1 MEETING ROOM:

EXHIBITS/GENERAL SESSION/MEALS
TECHNICAL SESSIONS/TRAININGS

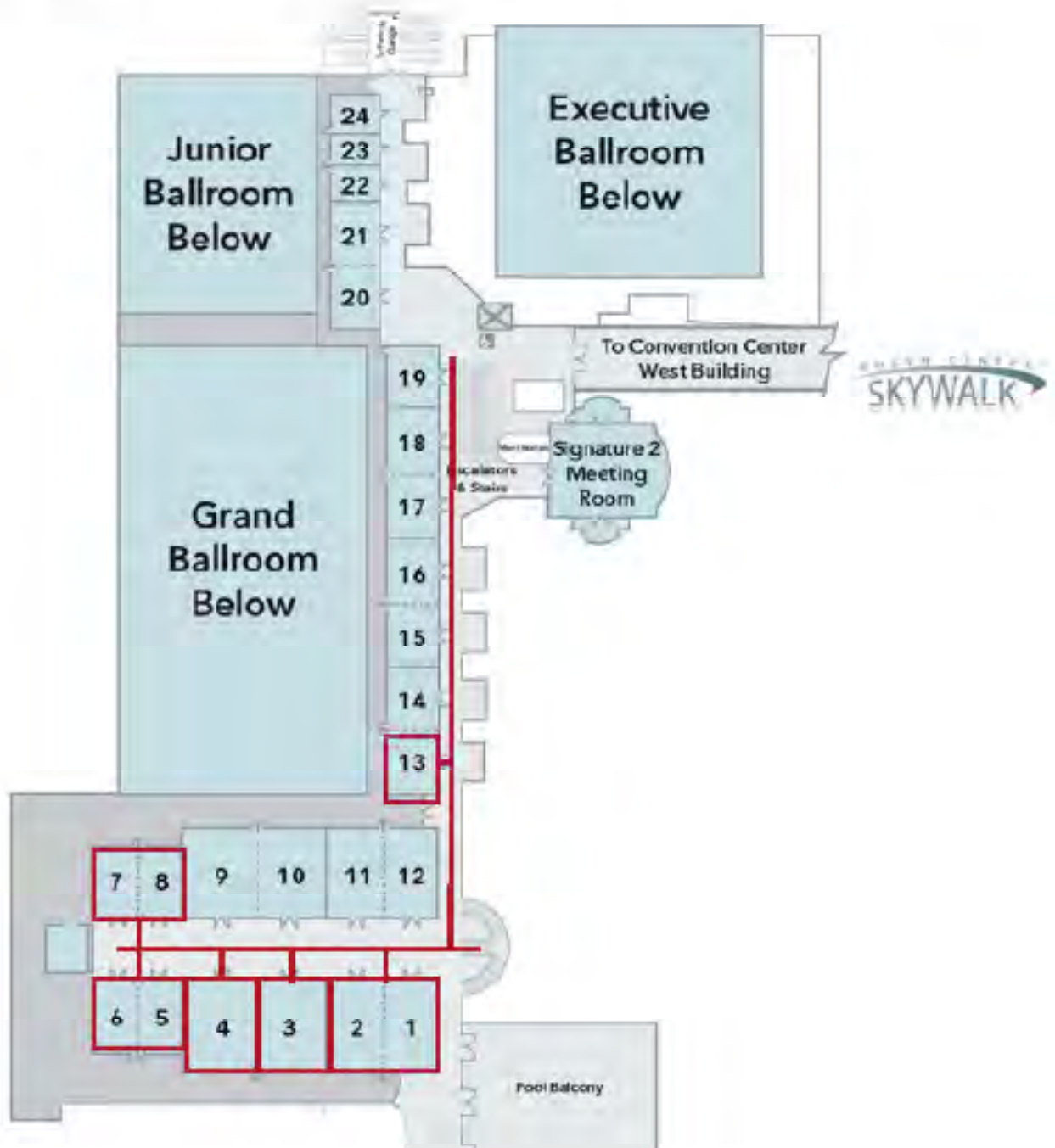


Rosen Centre Meeting Space Layout

MEZZANINE LEVEL (FLOOR 2)

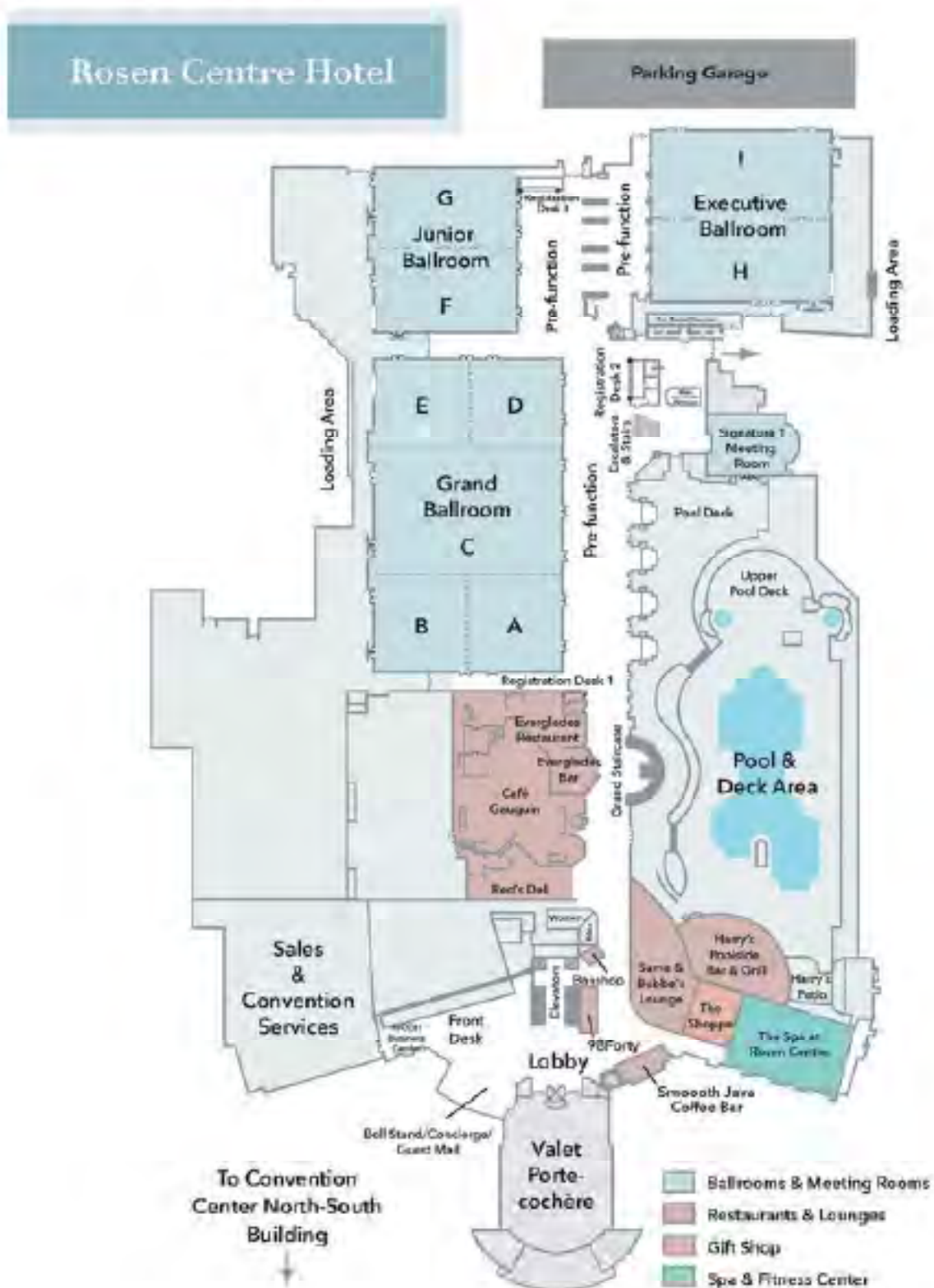
SALONS 1-8: TECHNICAL SESSIONS/TRAININGS

SALON 13: REGISTRATION/SYMPOSIUM OPERATIONS



Rosen Centre Meeting Space Layout

HOTEL OVERVIEW

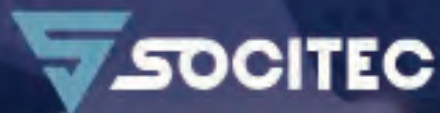


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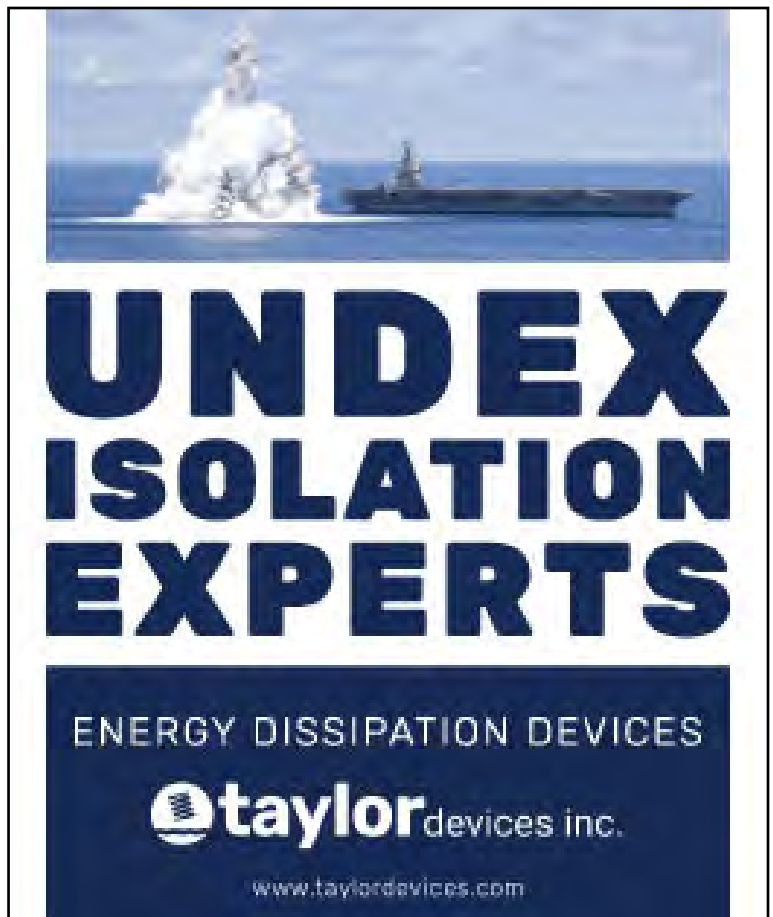


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SYMPOSIUM**

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SESSION 1: RAPID AND COST-EFFECTIVE APPROACH FOR NAVAL SHIP SHOCK DESIGN, ANALYSIS, AND EQUIPMENT QUALIFICATION

SESSION INTRODUCTION - RAPID AND COST-EFFECTIVE APPROACH FOR NAVAL SHIP SHOCK DESIGN, ANALYSIS, AND EQUIPMENT QUALIFICATION

Turkka Jappinen, Group Davie - Helsinki Shipyard

Hon. Nickolas H. Guertin, Former Asst. Secretary of the Navy for Research, Development and Acquisition

This session presents a comprehensive overview of rapid naval ship shock design and equipment qualification processes developed to meet the schedule-critical procurement requirements of many navies today. In addition to existing shock design criteria based on testing and operational experience, the session presents a process for developing tailored shipboard shock requirements for individual onboard equipment through simulation already in the early phases of the ship design.

The shock assessment of podded propulsion system and responses of hull whipping caused by the underwater explosion (UNDEX) are also discussed. These approaches support the wider application of modern commercial off-the-shelf (COTS) equipment onboard naval vessels and facilitate the shock qualification of new naval platforms, including those intended for Arctic operations.

The session also introduces a Hybrid Method for equipment shock qualification—an innovative and efficient alternative to traditional shock testing. By combining advanced analytical techniques for resiliently mounted equipment with targeted residual shock testing, the method enables rapid, reliable, repeatable, and cost-effective verification of equipment shock resistance while reducing testing time, qualification costs, project schedules, and overall program risk.

EARLY-STAGE SHIP DESIGN, MODELING & TAILORED SPECIFICATIONS FOR EQUIPMENT

Roope Kotiranta, Nesti

Turkka Jappinen, Davie - Helsinki Shipyard

Henri Lotvonen, Nesti

In this approach the backbone of the performed UNDEX simulations is an early-stage conceptual product model of the ship. This model contains all necessary information, including structures, equipment and loading conditions, for setting up a complete FEA analysis. The FEA model creation process has been automated to a high degree, which enables fast throughput of data between the design and analysis models. Furthermore, the post processing of the analysis results has also been semi-automated with the help of the product model information, which facilitates quick assessment of shock requirements, including equipment specific SRS-spectra. The overall process efficiency ensures that the shock requirements can be considered already from the conceptual design stage and that related specifications can easily be conceived, maintained and communicated for procurement purposes within the ship project.

SHOCK AND WHIPPING ANALYSIS WITH ABAQUS

Juha Virtanen, VTT Technical Research Centre of Finland Ltd

Turkka Jappinen, Davie - Helsinki Shipyard

This presentation describes an ABAQUS-based workflow for analyzing shock and whipping in ship structures and onboard equipment. It explains how finite element models developed during the concept

and basic design stages are used to predict both global and local shock responses. Shock response is evaluated with transient explicit analysis, using the primary shock phase as excitation, while whipping response is assessed with linear modal dynamics that also include excitation from explosion bubble pulsation. The results support design refinement for structural arrangements and equipment integration at different stages of a project. Broader excitation scenarios are also considered to ensure qualification requirements remain realistic and sufficiently conservative. Using ice-capable naval ship as a case study with validation references, the presentation demonstrates the practical value of numerical analysis in shock design.

SHOCK ANALYSIS FOR ELECTRICAL PODDED PROPULSION

Toni Partanen, ABB Marine & Ports

Juha Virtanen, VTT Technical Research Centre of Finland Ltd

Turkka Jappinen, Davie - Helsinki Shipyard

This presentation addresses shock analysis for electrical podded propulsion, focusing on the ABB Azipod® unit within the full ship shock and whipping response. It shows how a detailed propulsion model can be embedded into a global concept-stage ship model to capture critical load-transfer mechanisms. The approach allows engineers to assess whether propulsion equipment is subjected to realistic shock inputs under underwater explosion loading. By linking local equipment assessment with the vessel's overall structural response, it strengthens confidence in design and qualification decisions. An ice-capable naval ship with ABB Azipod® propulsion serves as the case study for validation and application.

EQUIPMENT SHOCK QUALIFICATION USING HYBRID METHOD (COMBINED CALCULATION AND RESIDUAL SHOCK TESTING)

Henri Lotvonen, Nesti

Turkka Jappinen, Davie - Helsinki Shipyard

Proof of shock resistance for shipboard equipment and machinery has traditionally been demonstrated with hammer impact test or explosion test on floating shock platform. This presentation describes the Hybrid Method as an effective alternative for traditional shock test methods. The Hybrid Method combines calculation procedures with residual shock testing as a faster and more affordable alternative to traditional shock tests. It introduces the theoretical basis of the method, including the use of pseudo-velocity shock response spectra to define the shock severity. With the Hybrid Method, shock qualification can be performed where traditional test facilities are not easily available. It is even possible to perform tests on the premises of equipment manufacturer, enabling quick fixes and modifications to the equipment in case of initial test failure.

The session explains how qualification requirements can be translated into procurement specifications and practical guidance for analysis and testing. It also compares the Hybrid Method with conventional approaches, clarifying its advantages in time, cost, and flexibility.

CASE STUDY EXAMPLES OF EQUIPMENT QUALIFICATION PROCESS - HYBRID METHOD IN PRACTICE

Aki Kinnunen, Vibrol

Kalle Vehvilainen, Vibrol

Arto Laine, Marioff

The hybrid Method of shock qualification relies on the input of shock requirement level and the tested equipment. Most critical factors are weight and centre of gravity location and overall dimensions. The

shock requirement is applied as input to shock response simulation, and the hybrid method testing is tailored to correspond the residual shock response spectrum from the simulation. In the simulation full nonlinear stiffness and damping characteristics of the wire rope isolator are used, based on manufacturer data, or preferably tested by means of dynamic test machine.

Hybrid Method shock qualification test is drop test. The test object is dropped onto tailored drop test mattress, that reproduces or supersedes the shock response spectrum corresponding to the simulated residual shock response spectrum. The tailoring parameters in the test are the drop test mattress characteristics affecting the shock pulse shape and the drop height effecting mainly the input energy. prior to actual test object tests, the drop test parameters can be checked with dummy mass drop test, also with scaled down dummy test.

The drop test is done in controlled manner and measurement taken with highspeed data acquisition setup, to be able to confirm in many enough locations the test object shock level and required responses. Testing environment requirement is mainly solid enough foundation for performing the test. Objects of various sizes can be tested, currently experience ranging from few kilograms to several tons. The testing can be done at customer specific location reducing shipping cost and time.

The test itself is time efficient, and the results are available immediately. In case the test object is not performing satisfactorily on testing, modifications can be implemented and tested immediately again. The test object performance is monitored according specification, i.e. prior to, during and after testing as specified.

The real case example presented is the application of the hybrid method on tested object.

SESSION 2: BLAST RESPONSE & MODELING

EFFECT OF FINITE ELEMENT MODELING APPROACH ON PREDICTING RESIDUAL STRENGTH OF DAMAGED INFRASTRUCTURE

2LT Thomas Vellenga, US Army

Dr. Eric Williamson, USMA

LTC Christopher Graves, USMA

To assess the performance of damaged infrastructure, finite element modeling (FEM) can be used to predict remaining structural capacity under a wide range of loading conditions. Such models enable researchers to explore many different scenarios that would otherwise be difficult or impractical to test in practice. This capability is particularly useful for military applications where key infrastructure is damaged, and external conditions make it impractical to inspect using traditional hands-on methods. Though finite element models of structures use consistent principles of mechanics, parameters associated with material behavior and geometric instability often lead to different conclusions when different modeling approaches are used to predict response. This project seeks to draw conclusions about the relative strengths of various FEM modeling approaches by comparing their results with specimen performance predictions. The specimens for this evaluation were scale model reinforced concrete bridge piers. These specimens were cast and loaded in compression to create a load-versus-displacement curve to compare with different FEM software packages. The models of the damaged infrastructure components were established by removing elements from an original undamaged model. This project compared common, commercially available FEM software packages and a specialized program used for modeling reinforced concrete and concrete anchors. The load-displacement curves

from each software package were then compared to the performance of the actual specimens. This paper describes the pros and cons of each program and associated modeling choices and recommends desired capabilities for similar future projects.

NUMERICAL CHARACTERIZATION OF FAR-FIELD BLAST LOADS RELATED TO MILD TRAUMATIC BRAIN INJURY

Dr. Andrew Bowman, US Army ERDC

Paul Sparks, US Army ERDC

Dr. Catherine Stephens, US Army ERDC

Dr. Andreas Frank, US Army ERDC

Jason Roth, US Army ERDC

Analysis of blast overpressure resulting from far-field explosions is critical for characterizing the blast exposure levels and cumulative pressure dosages that service members may experience from large warhead detonations. Understanding the relationship between the blast wave, the surrounding structural geometry, and the human body is essential for accurately predicting reflected overpressures, cumulative impulse, and the resultant traumatic brain injury (TBI) risk. To further investigate the far-field blast environment, a robust computational framework was developed using CTH—a Eulerian shock physics code—to simulate blast wave propagation into an open bunker and evaluate the subsequent dynamic loading on a representative human head model. The computational framework was validated against empirical field experiments designed to replicate realistic detonation scenarios. Subsequent parametric analysis demonstrated that dynamic environmental variables—specifically meteorological conditions and explosive cratering mechanics—must be integrated into the numerical models to accurately characterize the far-field blast environment and predict the resultant blast load applied to the head. Numerically adequate mesh refinement and low artificial viscosity were required to propagate the decaying, weak shock wave to far-field distances while capturing the peak overpressure. The simulations closely matched the experimental pressure-time histories within the bunker and head model, indicating a mostly uniform peak pressure loading. Utilizing this numerical framework, several blast mitigation strategies, such as vinyl strips and energy-dissipating foam, were simulated and shown to mitigate peak pressures. However, their capacity to attenuate positive-phase impulse was largely negligible.

Permission to publish was granted by Director, Geotechnical and Structures Laboratory.

NUMERICAL SIMULATION OF THE PABLO-I NEAR-FIELD BLAST EXPERIMENT USING CTH AND VIPER BLAST

Dr. Peter McDonald, Viper Applied Science

Dr. James Wurster, Viper Applied Science

Andrew Nicholson, Viper Applied Science

Dr. Photios Papados, US Army ERDC

The PABLO experimental test series provides high-quality data for the validation of numerical methods used in near-field blast loading of structures. One of these trials, PABLO-I, involved a reinforced concrete structure with a single fenestration opening exposed to a cylindrical explosive charge strictly in the near field. The opening was fitted with a blast-resistant laminated glass panel designed to fail, permitting pressure ingress into the internal volume. Although the primary objective of the test was the calibration of explosive JWL parameters, the experiment also provides a valuable benchmark for the validation of high-fidelity blast simulation tools.

In this study, the PABLO-I experiment is simulated using two Eulerian shock-physics solvers: CTH (v12.0) [1], developed at Sandia National Laboratories, and Viper Blast [2], a modern high-resolution solver

designed to exploit GPU acceleration. The experimental instrumentation comprised multiple external incident pressure gauges, reflected pressure gauges on the exterior façade, and internal gauges measuring both incident and reflected pressures. Numerical predictions of pressure–time histories and impulse are compared against experimental measurements at all gauge locations. Agreement is assessed in terms of peak overpressure, impulse, and waveform characteristics, and differences in numerical behaviour between the solvers are discussed. Finally, computational performance is evaluated through a comparison of wall-clock runtimes, highlighting the implications of GPU-accelerated blast simulation for large-scale and parametric studies.

INTERESTING INSTRUMENTATION READINGS AND APPROACHES RELATED TO ARENA BLAST TESTING

Dr. Jason Florek, Stone Security Engineering

David Holgado, Stone Security Engineering

Justin Huong, Stone Security Engineering

Dr. Rodrigo Mourao, Stone Security Engineering

Blast design is a challenging field because of the large array of building components potentially subjected to and impacted by a blast event and the intrinsic uncertainty of the load itself. These challenges become evident when arena blast testing is performed on elements such as door and glazing systems to demonstrate compliance with project specifications. The applied load typically must be translated from a design pressure/impulse value to a specific threat size, explosive material, and standoff with all associated uncertainties. Appropriate instrumentation and positioning are required to record the applied load and document the structural performance. This paper discusses the challenges associated with blast testing using live detonations from the development of a test plan to carrying out the test program to actual documentation and validation of building component response. Interesting pressure gauge readings tied to local and global blast wave clearing and data processing are highlighted, as is the use of high-speed imagery to monitor shock wave expansion and predict blast load parameters to supplement gauge readings.

HIGHER-ORDER HYPOELASTIC-PLASTIC BEAM ELEMENTS IN THREE-DIMENSIONS FOR EXPLICIT DYNAMICS

William Furr, US Army ERDC

Dr. Kent T. Danielson, US Army ERDC

Dr. Arun Srinivasa, Texas A&M University

Dr. J.N. Reddy, Texas A&M University

This work details a mass lumped, rate-type, C0 continuous, arbitrarily high-order, shear deformable (Timoshenko) beam finite element in three spatial dimensions. This element was developed using well-known hypoelastic–plastic type constitutive relations and demonstrated to remain stable in a variety of finite deformation and finite rotation problems. Higher-order elements permit geometric curvature, improved performance in bending and buckling, and resist hourglass modes present in low-order reduced integration elements. Historically, however, first-order elements have been prioritized in explicit finite element codes because of difficulties achieving robust and reliable mass-lumping. Rotational degrees of freedom further complicate mass lumping for structural elements by introducing lumped mass moments. The constitutive response is based on standard objective-rate hypoelastic–plastic relations commonly used in production explicit dynamics codes. The use of C0 interpolation avoids higher interelement continuity requirements, making the formulation suitable for problems involving localized plasticity and damage. The element formulation is presented first followed by a detailed discussion of mass moment lumping and numerical stability. Comparisons are made against beam elements in three-dimensional space in production explicit finite element codes. Finally, several

numerical benchmark examples of nonlinear finite deformation in elasticity and plasticity are presented demonstrating the accuracy and utility of the proposed beam elements while evaluating the performance of increased order compared to standard linear elements.

SESSION 3: DYSMAS I

SHOCK WAVE PROPAGATION AND FLOATING SHOCK PLATFORM RESPONSE TO BURIED SEABED UNDEX: TEST SUMMARY 2026

Roger Ilamni, NSW Indian Head

Dr. Bradley Klenow, NSW Indian Head

Greg Harris, ATR

Katherine Knowles, ATR

Tim App, ATRL

Swen Metzler, WTD-71

Sven Diedrichsen, WTD-71

Manfred Krüger, iABG

Adrian Salah, iABG

Previous symposia have provided updates on the U.S.-Germany DYSMAS Project Arrangement, which focuses on enhancing the capability of the DYSMAS code to predict underwater explosion (UNDEX) shock transmission in complex shallow-water environments. While Campaigns 1 and 2 successfully investigated shock wave propagation from explosive charges resting on the seabed, the third and final campaign shifts the focus to fully buried explosive charges.

The U.S.-Germany DYSMAS Test Team recently completed Campaign 3 of the UNDEX test program. The primary objectives of this follow-on testing were to measure shock wave pressure propagation through both the seabed and the overlying water column originating from a buried explosive charge. Additionally, a floating shock platform was deployed and instrumented to measure the dynamic surface response resulting from the buried detonation. This talk will review the Campaign 3 test setup, detailing the instrumentation used across the seabed, water column, and floating platform, and present the collected data. These critical datasets will be used for the ongoing validation of the DYSMAS code, supporting advanced predictions for Buried Mine Effectiveness, neutralization studies, and surface platform response in littoral environments.

UNDEX SHOCK WAVE LOADING FOR CHARGES ON THE SEA BOTTOM: QUANTIFYING DIFFERENCES BETWEEN IN-WATER AND IN-SEDIMENT SHOCK WAVE PROPAGATION

Greg Harris, ATR

Katherine Knowles, ATR

Roger Ilamni, NSW Indian Head

Understanding the effects of underwater explosion (UNDEX) shock and bubble loading within and near the seafloor is critical to the Navy. This topic directly pertains to evaluating weapon systems used to clear buried mines, as well as assessing the effects of buried mines on targets in the water column or on the water surface above. Historically, these effects have been poorly understood due to a severe scarcity of experimental test data. Furthermore, legacy modeling and simulation tools, such as the DYSMAS hydrocode, were not initially equipped to handle the complex, multi-phase mechanics of

seabed environments. Consequently, analysts lacked the validated tools necessary to predict how marine sediments attenuate and alter shock propagation compared to free-field water.

This talk presents a methodology to quantify the degradation and attenuation of UNDEX shock waves as they propagate through saturated bottom sediment, comparing these effects directly to traditional free-field water propagation. Utilizing experimental data from pressure gages embedded in the sea bottom, we analyze the non-classical shock profiles and energy flux density associated with charges detonated on the sea bottom. These experimental results are compared against DYSMAS simulations incorporating equation-of-state and material strength models.

The analysis establishes a framework for estimating the reduction in shock wave effectiveness through sediment, offering a simplified "equivalent charge weight" approach for rapid engineering estimates. This work demonstrates that DYSMAS capabilities can accurately simulate shock wave propagation through the seabed material.

ESTIMATING SEABED EOS PARAMETER VALUES FROM OBSERVATIONAL DATA FOR UNDEX SIMULATIONS

Dr. Eugenia Stanisauskis Weiss, Applied Physical Sciences

Dr. Emily Guzas, NUWC Newport

Dr. Peter Miklavcic, NUWC Newport

Dr. Joe Ambrico, NUWC Newport

The seafloor is composed of heterogeneous sediments and rock layers that control how underwater explosion (UNDEX) shock waves reflect, transmit, and propagate. Field-collected observational data including grain-size distribution, porosity, density, shear-strength, and in situ sound speed were obtained from Naval Oceanographic Office (NAVOCEANO) databases for several geographically distinct locations of interest. Using empirically derived relationships, each measured property is mapped to the input parameters of selected equations of state (EOS) for seabed materials employed in high-fidelity fluid-structure interaction (FSI) simulations using the Navy's Dynamic System Mechanics Advanced Simulation (DYSMAS) code. For each location, the multiple data sets are combined to define a minimum and maximum value for every EOS parameter. These parameter values are then used to generate plots of pressure, sound speed, and acoustic impedance versus volumetric strain, from which the bounding set of EOS parameters for a given material can be determined. Results from 2D DYSMAS simulations confirm that the derived bounding set of parameters provide an envelope of possible UNDEX responses. This straightforward, data-based method yields a clear estimate of how seabed variability influences shock-wave amplitude, rise time, and energy transmission, supporting more reliable UNDEX risk assessments in complex marine environments.

UPDATES ON SIMULATING NEAR-FIELD UNDEX AGAINST SUBMERGED CONCRETE STRUCTURES

Dr. Joseph Ambrico, NUWC Newport

Dr. Emily L. Guzas, NUWC Newport

Dr. Ryan E. Chamberlin, NUWC Newport

Dr. Jay Ehrigott, US Army ERDC

Joshua Payne, US Army ERDC

Roger Ilamni, NSWC Indian Head

The maritime domain encompasses a range of damage effects, including those from above the waterline, near the waterline, and underwater explosions (UNDEX). This domain contains many different structures, composed of largely single-material substances or multi-material, composite substances (e.g.

concrete). Physics-based modeling and simulation (M&S) tools can utilize fluid-structure interaction (FSI) to estimate the effects of near-field UNDEX sources on submerged structures composed of concrete material. This presentation covers key scenarios for UNDEX near concrete structures and discusses the application of FSI simulations, using the Navy's DYSMAS code, to predict structural response.

PREDICTING WEAPON EFFECTS ON CRITICAL UNDERWATER INFRASTRUCTURE: DATA GAPS AND FUTURE NEEDS

Joshua Payne, US Army ERDC

Jeffrey Holmes, US Army ERDC

Dr. John Ehrgott, Jr., US Army ERDC

Dr. Emily Guzas, NUWC Newport

Roger Ilamni, NSW Indian Head

Accurate prediction of weapon effects on critical underwater infrastructure, such as bridge pilings, piers, and quay walls, is essential for maritime mission planning, collateral damage estimation (CDE), and pre- and post-conflict repair estimations. However, a significant capability gap exists, as current fast-running models (FRMs) either do not exist or cannot reliably estimate damage in these complex environments. This shortfall is driven by the lack of well-characterized empirical test data. Well-controlled test data are critical to validate and enhance high-fidelity simulation tools, which in turn will support the development of validated, fast-running weaponizing tools to improve lethality assessments and tactical planning accuracy against maritime targets. This paper identifies key data gaps in our understanding of weapon effects on underwater infrastructure and presents strategic options for targeted data collection to support future FRM development.

SESSION 4: ELECTRONICS EVALUATION AND SENSING FOR HIGH-G ENVIRONMENTS

DEVELOPMENT OF A NEW EMBEDDED DEVICE ACCELERATION AND PRESSURE TEST (EDAPT) CAPABILITY

Dr. Adriane Moura, ARA

Zach Jowers, ARA

Jared Hammerton, ARA

Dustin Landers, ARA

Dr. Matthew Neidigk, Sandia National Laboratories

Embedded fuzes often experience extreme environments including coupled dynamic acceleration and pressure loading during hard target attacks. Experimentally validating coupled dynamic pressure and acceleration is costly, difficult to control, and historically unable to iterate rapidly. The goal of this work is to design an “in-lab” test apparatus which can produce a coupled dynamic pressure and acceleration environment for forward assembly validation; the apparatus will be easily controlled, repeatable, and low cost to conduct tests. This work used experimentally validated modeling to develop the Embedded Device Acceleration and Pressure Test (EDAPT) fixture and demonstrated coupled acceleration and pressure representative of embedded environments during high-speed engagements against hard targets. The data collected from such tests will be used to update material models for the embedded simulants and inform the mechanical design of embedded firesets.

EVALUATING 6DOF IMPACT DYNAMICS AND DECELERATION IN WATER ENTRY AIR DROP FLIGHT TESTS

Zach Jowers, ARA

Dr. Adriane G. Moura, ARA

Dustin Landers, ARA

James Scheppegrell, ARA

Dr. Alain Beliveau, ARA

Samuel Schemmer, AFRL

The Air Force Research Laboratory (AFRL) is working to better understand the dynamics involved with air-to-water impact. This includes the physical loads and munition trajectory when traveling in water. Quantifying the high-G deceleration forces and angular rates experienced by the weapon during the air-to-water transition is vital for the calibration of predictive modeling and simulation tools. The goal of this work is to instrument air-drop flight tests to characterize the impact and air-to-water transition dynamics. Specialized data recorder packages were designed and instrumented with 3 degrees of freedom (DOF) and 6 DOF sensors to measure the system dynamics. The collected data will be used to validate the modeling and simulation of the water impact and hydrostability and characterize the trajectory after impact.

DYNAMIC EVALUATION OF EMBEDDED FUZE ENVIRONMENTS ACROSS MIL-STD TEMPERATURES

Dustin Landers, ARA

Dr. Adriane G. Moura, ARA

Zach Jowers, ARA

Dr. Alain Beliveau, ARA

Fahad Abumohaimed, AFRL

Embedded fuzes must survive and function extreme environments experienced during hard target attacks across the MIL-STD temperature range. Historically, embedded fuze characterization (modeling and experimental testing) has been conducted at ambient temperature for cast simulants. The goal of this work is to characterize the embedded fuze environment at extreme temperatures through a series of cannon tests. Additionally, this work investigated the embedded fuze environment of pressed simulants at ambient temperature. Cannon tests were conducted at -55C, ambient, and 70C against targets of interest. The embedded acceleration and pressure were measured in the inert simulant. The collected data under these extreme conditions will provide validation data for the modeling efforts of the embedded simulants and inform the mechanical design of embedded firesets.

MODELING EMBEDDED FUZE RELIABILITY IN PENETRATING MUNITIONS

Dalton Gavin, Torch Technologies

Dr. Michael Nixon, Torch Technologies

Dr. Matthew Neidigk, Sandia National Laboratories

Accurately modeling the environment experienced by embedded fuzes is critical to ensuring reliability and survivability during the penetration of hard targets. Due to the viscoelastic behavior exhibited by plastic bonded explosives (PBXs), factors such as operating temperature and impact velocity can significantly alter the stresses imparted on an embedded fuze. Furthermore, the differences in coefficients of thermal expansion between materials can lead to gaps and complex interactions. Using Sandia National Laboratories' Sierra/SolidMechanics, a coupled implicit-explicit finite element software, this study evaluates and compares the environment experienced by an embedded fuze in various penetration scenarios. The mechanical response of the PBX is predicted using a viscoelastic constitutive

model fit to experimental characterization data. While increasing impact velocity correlates to more severe loading conditions, results suggest operating temperature and PBX fill shrinkage resulting from curing are also significant contributing factors to fuze reliability. The research presents a validated model that can be used to provide key insights into PBX behavior in future ordnance assessments.

RESIDUAL STRESS ANALYSIS OF SURFACE MOUNT VS. THROUGH-HOLE COMPONENTS

Dr. Matthew Neidigk, Sandia National Laboratories

Joel Limmer, Sandia National Laboratories

Presented is a finite element study comparing the stress states of surface-mount and through-hole resistors under different packaging strategies. The models evaluate how packaging materials and mounting configuration influence residual stress during thermal loading. Residual stress arises from coefficient of thermal expansion mismatch between dissimilar materials and can contribute to long-term degradation mechanisms such as creep and physical aging. This is especially critical in applications where extended service life and environmental survivability are essential. Through-hole components have a long history of survivability in many applications, but surface-mount components provide clear advantages in reduced size and packaging density. In many applications, surface-mount components have demonstrated survivability under severe thermo-mechanical environments. The results of this study provide a basis for selecting component type and packaging strategy for applications requiring high survivability and resistance to age-induced damage. *Sandia National Laboratories is managed and operated by NTESS under DOE NNSA contract DE-NA0003525.*

VENDOR SESSION A: EXHIBITOR PRESENTATIONS INCLUDING CASE STUDIES, NEW DEVELOPMENTS, TESTING & PRODUCTS

A METHOD TO PREDICT NON-LINEAR PERFORMANCE OF A DAMPED SPRING-MASS SYSTEM

Michael Czajka, Taylor Devices

This paper will compare the actual dynamic performance of a Damped Spring-Mass system vs a predictive model. Utilizing test data, characterization of a set of non-linear spring rates and an assumption of linear damping demonstrates predictive non-linear system behavior.

ROBUST SALVAGING OF SHOCK ACCELERATION DATA

Dr. Ted Diehl, Bodie Technoogy

Severe mechanical shock and pyroshock measurements often contain high-frequency content, large acceleration amplitudes, and instrumentation-induced distortions that make the resulting signals difficult to interpret with confidence. One especially problematic distortion is accelerometer zero shift, where the measured acceleration baseline changes during or after a shock event. This effect may be subtle or even imperceptible in the acceleration time history but becomes obvious after time-integration, producing nonphysical velocity or displacement drift. Similar implausible velocity and displacement results can occur when other low-frequency distortions, such as “barge bobbing,” are present in the shock environment. When retesting or directly separating such low-frequency environmental contributors is not possible, engineers may need to salvage the data while preserving as much physically meaningful content as possible. This is especially important when acceleration data will be used to drive transient FEA simulations, particularly multi-point driven models, where nonphysical displacements can create excessively large nonphysical stresses.

This talk presents a robust Kornucopia® ML™ workflow for salvaging distorted shock acceleration data using physics-guided digital signal processing. The approach begins with standard measurement validation steps, including pre-trigger offset correction, lowpass filtering consistent with sensor bandwidth, Fourier spectrum assessment, and integration-based plausibility checks. When implausible drift remains, the signal is salvaged using specially designed, numerically robust filtering algorithms. Special emphasis is placed on applying corrections in the kinematic form where the distortion is most visible — typically velocity or displacement derived from acceleration — and then differentiating back to obtain a salvaged acceleration signal.

A key challenge addressed in this work is the use of very low highpass cutoff frequencies on highly sampled shock or pyroshock data, where direct filtering can become numerically ill-conditioned. To overcome this, a split-band decomposition method with boundary-corrected resampling is automatically utilized within Kornucopia. The signal is separated into upper and lower frequency bands, the lower band is decimated to a numerically stable sampling rate, the desired highpass correction is applied, and the result is upsampled and recombined with the preserved upper-band content. Boundary assumptions, including flipped-mirror pre-extension, are used to reduce filter end-effect distortions. All filtering is performed bidirectionally to avoid phase distortion, and specialized upsampling filtering is used to avoid generating false high-frequency components. This is especially important because the salvaged result is typically first obtained as velocity or displacement and then differentiated to recover acceleration, a process that amplifies any algorithm-generated false high-frequency content.

The presentation emphasizes that salvaging is not equivalent to obtaining a clean measurement. All salvaged results must be documented, viewed skeptically, and judged against independent physical expectations such as final velocity, displacement limits, shock spectra, and, where available, alternate sensors or measurements. The powerful functionality in Kornucopia provides a practical, transparent framework for recovering useful engineering information from distorted shock acceleration data while clearly distinguishing robust post-processing from unjustified cosmetic filtering. Several examples using both PR and IEPE sensor data will be shown to demonstrate the capabilities.

HIGH SPEED IMAGING IN CONFINED AND REMOTE LOCATIONS

William Spinelli, Photron

An introduction to High-Speed cameras and accessory items, optimizing the challenges of imaging in tight and confined spaces, as well as remote locations requiring remote optical setups.

COMPARING TWR AND iTWR FOR HYDRAULIC AND ELECTRODYNAMIC SHAKER CONTROL

Dr. Brynnna Neff, Crystal Instruments

Time Waveform Replication (TWR) has become an important technique for reproducing measured field vibration environments in laboratory testing. Over time, multiple waveform replication approaches have emerged throughout the vibration test industry. This presentation examines the practical and algorithmic differences between TWR and Iterative Time Waveform Replication (iTWR) for both electrodynamic and hydraulic shaker systems. Crystal Instruments originally implemented a classical TWR approach and now supports both TWR and iTWR within a unified vibration control platform, allowing users to select the most appropriate method for a given application.

The presentation will discuss the operating principles behind each method, and the benefits and tradeoffs when used in both electrodynamic and hydraulic shaker applications will be evaluated. Electrodynamic systems often benefit from the straightforward implementation of traditional TWR, while iTWR can improve waveform fidelity for highly transient or dynamically complex environments. Hydraulic systems introduce additional challenges including servo-valve dynamics, actuator nonlinearities, oil column resonances, and large low-frequency displacement requirements, all of which can influence the effectiveness of each replication strategy. Experimental examples and application results will illustrate replication accuracy, convergence behavior, workflow considerations, and implementation differences between TWR and iTWR.

TRAINING I: ADVANCED MEASUREMENT TECHNIQUES FOR CAPTURING EXCURSION ENVELOPES DURING MIL-DTL-901E SHOCK TESTING

ADVANCED MEASUREMENT TECHNIQUES FOR CAPTURING EXCURSION ENVELOPES DURING MIL-DTL-901E SHOCK TESTING

Michael Poslusny, Leidos Gibbs & Cox

As shock isolation solutions continue to evolve for mission-critical shipboard equipment, accurately predicting and measuring the excursion envelope—maximum displacement in all directions—of Class II, principal units during MIL-DTL-901E shock testing has become increasingly important in U.S. Navy ship design. Modern ships often require dense equipment arrangements, and designers frequently face challenges fitting equipment, foundations, and required excursion envelopes into constrained compartments. These envelopes directly influence how closely adjacent equipment can be placed, making excursion calculations and measurements an essential step in the ship design process.

This one-hour training session explains the significance of accurate shock excursion envelope characterization and provides a technical comparison of innovative displacement measurement methods. Participants will also receive hands-on instruction, learning how to install simple passive displacement devices that offer a cost-effective way of measuring maximum excursions of Class II equipment. Be prepared for an Arts & Craft project!

TRAINING I: INTRODUCTION TO MEDIUM WEIGHT SHOCK TESTING

INTRODUCTION TO MEDIUM WEIGHT SHOCK TESTING

Jeff Morris, HI-TEST Laboratories, Inc.

This training will cover the necessary background information relative to medium weight shock testing per MIL-DTL-901E. This session is intended for engineers and product developers who are unfamiliar with the medium weight shock testing process. Subjects covered include pre-test planning, fixture selection, test set-up, test operations, and reporting. Some aspects of medium weight shock machine operation will be covered. Shock test requirements applicable to medium weight shock testing will be discussed.

SESSION 5: SHOCK STANDARDS ACROSS AUKUS

DEMYSTIFYING UK MAP01-470

Nicolas Misselbrook, Thornton Tomasetti

Gavin Colliar, Thornton Tomasetti

Alan Ferguson, Thornton Tomasetti

Helen Peterson, UK MOD SDA-NATG-VR

MAP 01-470 is the classified UK shock design standard. It is widely cited but it is not always interpreted correctly since the entire standard is not specified or promulgated. Over time, this means there are many inherited assumptions which can obscure what the standard actually requires, what engineering judgement it leaves open, and where its limits lie. This paper gives an overview of MAP 01-470 from a practitioner's perspective and addresses a number of recurring misconceptions that affect equipment qualification and mount-system design. The paper aims to improve the application of the standard, reduce avoidable conservatism and provide a clearer basis for discussion between designers, analysts, test authorities and approval stakeholders across AUKUS.

THE AUSTRALIAN SHOCK STANDARD

Ian Leaver, Thornton Tomasetti

Lachlan Maloney, Directorate of Naval Engineering, Australia

Matt Solon, Directorate of Naval Engineering, Australia

As AUKUS programmes mature, there is growing value in understanding how each partner nation frames shock qualification. This paper provides an overview of the Australian shock standard (DEF(AUST) 5000 Vol 07 Pt 23 Section 03), with emphasis on its underlying qualification philosophy, document structure and practical application. Broadly speaking, the DEF(AUST) is an SRS based standard which specifies 6 levels with vertical, transverse and longitudinal directions resulting in 18 specified levels. Both testing and analysis are used, depending on the system, with some acceptance criteria set out in the standard. The discussion considers how the standard defines the required evidence base, how it is intended to interface with design and procurement activities, and how it is interpreted in the context of contemporary naval programmes.

Attention is also given to areas where users may encounter ambiguity, including the relationship between standard requirements, test methods and engineering judgement. The aim is to summarise the Australian approach and place it in a form that is accessible to non-Australian practitioners who need to understand its intent, its practical consequences and its relevance to collaborative AUKUS programmes.

MIL-DTL-901E: THE US SHOCK STANDARD

Kurt Hartsough, 901E&T

MIL-DTL-901E is the principal US Navy standard for qualifying shipboard equipment against shock. It is widely recognised across the naval shock community, but its terminology, test pathways and qualification expectations can be difficult to interpret for practitioners more familiar with UK or Australian standards. This paper provides an overview of MIL-DTL-901E, with emphasis on its underlying qualification philosophy, document structure and practical application.

UK SHOCK TESTING FACILITIES

Gavin Colliar, Thornton Tomasetti

Nicolas Misselbrook, Thornton Tomasetti

Alan Ferguson, Thornton Tomasetti

The UK has developed a diverse set of shock testing facilities and methods to support naval equipment qualification, ranging from laboratory-scale approaches to large-scale and surrogate testing. These facilities do not serve identical purposes, and misunderstanding their respective strengths and limitations can lead to inefficient or poorly targeted qualification programmes. This paper provides an overview of the principal UK shock testing facilities and explains how they are typically used to qualify UK naval equipment to MAP 01-470, the UK's shock design standard.

It discusses the types of response each method is best suited to assess, the degree to which each can represent in-service conditions, and the practical considerations that influence selection, including cost, schedule, instrumentation and test article maturity.

The paper is intended as a guide for selecting an appropriate qualification pathway and for understanding how different forms of testing can be combined with analysis to support robust shock substantiation.

AUS SHOCK TESTING FACILITIES

Ian Leaver, Thornton Tomasetti

Gavin Colliar, Thornton Tomasetti

Alan Ferguson, Thornton Tomasetti

Australia's ability to qualify naval equipment against underwater shock is developing quickly as local shipbuilding and sustainment programmes require credible in-country evidence of survivability, and Thornton Tomasetti has been at the centre of that development through the establishment of its Melbourne-based shock testing capability.

This paper describes Thornton Tomasetti's current Australian offer, including modelling and simulation, shock standards and design support, shock and vibration test planning, portable JASSO testing, seismic airgun testing, and heavyweight barge-based underwater shock trials. Particular attention is given to the way these capabilities can be combined to support practical and proportionate qualification strategies, from early equipment assessment through to higher-fidelity testing.

The paper includes an overview of Thornton Tomasetti's work at DST's Underwater Explosive Test Facility at Nagambie, Victoria, and the associated floating shock platform / heavyweight barge capability, which have already been used to deliver Australia's first commercial shock test and qualification activity. In parallel, the introduction of JASSO has established the only mediumweight shock testing machine presently available in Australia, providing a portable and repeatable route for equipment-level shock testing without reliance on large explosive trials. Thornton Tomasetti also operates a paddlewheel test target in Australia which is available for use in AUKUS testing

Taken together, these facilities illustrate both the progress already made and the gaps that still remain in Australia's sovereign shock qualification capability. This paper reviews the respective roles, strengths and limitations of TT's portable and large-scale methods alongside existing national infrastructure, with

the aim of clarifying how Australian programmes can assemble an efficient, evidence-based qualification pathway for naval equipment and platform survivability.

COMPARISON OF AUKUS SHOCK QUALIFICATION STANDARDS

Nicolas Misselbrook, Thornton Tomasetti

Ian Leaver, Thornton Tomasetti

Helen Peterson, UK MOD SDA-NATG-VR

Brian Lang, NSW Carderock

The AUKUS partners share many shock survivability objectives, but the standards used to qualify naval equipment have developed through different national histories, authorities and programme needs. This paper compares the principal shock qualification approaches used across the three nations, with focus on qualification philosophy, categories of evidence, testing expectations, acceptance criteria and the role of analysis.

The comparison highlights where the standards are substantively aligned, where they differ in detail or emphasis, and where those differences matter to programme delivery. It also considers the practical implications for equipment suppliers, platform integrators and approval authorities seeking to transfer evidence or develop common qualification strategies across national boundaries.

The paper does not argue for artificial uniformity, it identifies where greater mutual understanding or selective harmonisation could reduce risk, improve efficiency and support more coherent shock qualification within AUKUS.

SESSION 6: MIMO VIBRATION

MULTI-EXCITER TESTING DEVELOPMENTS

Norman Trepanier, Raytheon

Eric Brogmus, Raytheon

Bryan Taylor, Raytheon

Multi-Exciter Testing (MET) has been a widely recognized form of testing as documented in MIL-STD-810, Method 527. While this technology has existed for many years, aerospace industry has been slow to adopt this test method due to lack of widespread equipment availability and understanding of consequences when transitioning from traditional Single-Exciter Test (SET) methods. Raytheon has demonstrated significant capability with Multiple Input Multiple Output (MIMO) testing and this has been a staple of testing large structures, but inputs have most commonly been aligned with a single input direction with re-configuration required to complete testing in all three axes of test. The reconfiguration process can often require lengthy interruptions to test progress which is acceptable when a single article is being tested but becomes prohibitive for the screening or testing of many small articles. MET capability promises to realize benefits for both efficiency and reproduction of field-representative environments. The following details an investigation into application of this method. It considers empirically derived equivalent fatigue life for a sample test structure with comparison to classical calculations, and FEA. Efforts have been undertaken to characterize this environment to determine how to best tailor specifications developed for single-axis input to a multi-directional input test. Test hardware and control system challenges are discussed along with findings related to both sinusoidal and random vibration testing.

OPTIMIZATION AND ASSESSMENT OF SHAKER PLACEMENT IN MULTI-EXCITER MULTI-AXIS VIBRATION TESTING

Ruben Araújo, Siemens Digital Industries Software

Umberto Musella, Siemens Digital Industries Software

Dr. Alberto Garcia de Miguel, Siemens Digital Industries Software

Dr. Bart Forrier, Siemens Digital Industries Software

Environmental qualification of aerospace systems demands high-fidelity reproduction of operational vibrations. Traditional single-axis or rigid-table multi-axis tests often fall short for free-flying or slender structures due to impedance mismatches, non-representative boundary conditions and load paths. Impedance Matched Multi-Axial Testing (IMMAT) addresses these challenges by using multiple shakers directly attached to the Device Under Test (DUT), approximating free-free conditions and better replicating scenarios where distributed loadings are prevalent. However, optimal IMMAT test planning currently relies heavily on engineering judgment, lacking robust tools for a priori quantification of environment replication accuracy, or even verification of shaker and amplifier operational limits. This gap can lead to suboptimal setups, compromised test fidelity, or even equipment damage.

This paper presents an optimization framework to systematically determine both the number and optimal placement of shakers for IMMAT campaigns. The methodology employs a coupled model, integrating the DUT's modal finite element representation with electromechanical lumped-parameter shaker models. This allows for early prediction of system behavior and performance. The framework selects candidate configurations by performing a least-squares fit of the target cross-spectral density matrix (SDM), while simultaneously minimizing both actuator/amplifier demands and control spectral error. The methodology is demonstrated on a representative aerospace structure, for which a target vibration environment was derived by acoustic excitation via loudspeakers, performed in laboratory conditions. The approach shows that an optimized multi-exciter setup can closely reproduce the complex operational vibration environment derived from this direct field acoustic test. This off-site test prediction provides increased confidence in the design of high-fidelity IMMAT campaigns, which in turn may enable more accurate and reliable aerospace component qualification.

SESSION 6: ISOLATION I

PERFORMANCE COMPARISON OF ARCH MOUNTS™ AND WIRE ROPE ISOLATORS

Andrew Liberatore, Shock Tech

Darko Gjoreski, Shock Tech, Inc.

Richard Rakowski, Shock Tech, Inc.

Elastomeric mounts such as Shock Tech's Arch Mounts™ and wire rope isolators (WRI) and have been widely used to protect naval equipment from near-miss shock events while mitigating the transmission of structure-borne vibration. The Arch Mount™ is a high-displacement elastomeric solution developed to improve shock attenuation and vibration isolation for shipboard systems and commercial off the shelf (COTS) electronics. This paper presents a comparative investigation between Arch Mounts™ and WRI across various levels of vibration and shock. Mount selection is first completed using 6DOF, discrete, dynamic, analytical methods to predict rigid-body response, transmissibility, and shock attenuation. The analytical predications are then correlated with empirical test data from controlled vibration and shock testing to evaluate model accuracy and quantify performance differences between the mounts. Results

compare the effect of dynamic stiffness, damping behavior, load and displacement capability, and isolation effectiveness between the two types of mounts.

AMPLITUDE-SPECIFIC EQUIVALENT DAMPING CHARACTERIZATION OF WIRE ROPE ISOLATORS FOR REDUCED-ORDER SHOCK MODELING

Chris Sjoroos, IDC

Wire rope isolators are often modeled in shock and vibration analysis using equivalent stiffness and damping values. These simplified parameters are useful for reduced-order engineering calculations, but they can also hide the nonlinear behavior caused by inter-strand friction, geometric deformation, and hysteresis within the cable structure. This study investigates how displacement amplitude affects hysteresis energy dissipation, nonlinear stiffness, and equivalent damping ratio in wire rope isolators under cyclic loading.

Force-displacement data are collected at multiple displacement amplitudes. The area enclosed by each hysteresis loop is used to calculate the energy dissipated per cycle. Peak force-displacement points from each amplitude are then used to construct a nonlinear backbone curve, which provides an estimate of the stored energy at each deformation level. Equivalent damping ratios are calculated by comparing the dissipated energy from each loop with the stored energy estimated from the backbone curve.

This distinction is important because hysteresis loop area and equivalent damping ratio do not necessarily increase together. Larger displacement amplitudes may dissipate more total energy while producing a lower equivalent damping ratio if stored energy increases more rapidly than loop area. For simplified shock and vibration models, this can lead to inappropriate damping assumptions, particularly when small-amplitude damping values are applied to large-amplitude shock events. The method presented here provides a practical basis for selecting amplitude-specific equivalent damping ratios in reduced-order simulations of wire rope isolator behavior.

DYNAMIC SIMULATION OF THE SHOCK RESISTANCE OF RUBBER ISOLATORS

Dr. Jun Han, Simu Hub

Simu Hub LLC. is an American company that provides state of art modeling and predictive technologies to global customers with high quality and cost-effective service. Simu Hub specializes in simulation-driven design based on rubber material, including Structural Analysis (FEA), Computational Fluid Dynamics (CFD), and Fatigue Analysis. We provide expert consulting to enhance the rubber-based product development to market quickly.

Simu Hub LLC. has a professional team comprised of experienced engineers with more than 20 years of experience in structural analysis, fluid dynamics, thermal / fatigue analysis, noise reduction and numerical modelling.

SESSION 7: DYSMAS II

INTERNAL BLAST MODELING OF POST-DETONATION COMBUSTION OF AN ALUMINIZED EXPLOSIVE UTILIZING DYSMAS

Colin Burns, NSWC Indian Head

Dr. Jeff St. Clair, NSWC Indian Head

While detonation is of significant importance for conducting lethality assessments, the combustion of detonation products also plays a crucial role through its contribution to quasi-static pressure and thermal impulse. DYSMAS, a Navy accredited hydrocode, has had a longstanding capability of modeling of energetic afterburning, and new explosive formulations require new material models to be created. Material model creation and simulation of a novel NSWC-IHD developed explosive was conducted with the intent of accurately predicting detonation and combustion energy release in an internal blast scenario. Experiments conducted by the Air Force Research Laboratory in the Modular Multi-Room Target provided data for validation. This presentation will detail the guidelines used for creating the combustion parameters, as well as provide the analysis and modeling methodology used to obtain simulation results that correlate well with experimental data.

DYSMAS SIMULATIONS OF NATURALLY FRAGMENTING MUNITIONS

Jim Warner, NSWC Indian Head

Brian Howell, NSWC Indian Head

Sean Tidwell, NSWC Indian Head

Tim App, ATR

This presentation describes the ability of the U.S. Navy's Dynamic System Mechanics Advanced Simulation (DYSMAS) hydrocode to predict natural fragmentation of the BLU-109B/C munition. Obtaining accurate predictions of weapon effects through high-fidelity modeling and simulation (M&S) is important for improving live-fire test planning, reducing overall program cost, and increasing confidence in lethality assessments. Fragmentation is a challenging weapon effect to simulate due to the large computational size required for the finite element models, the sensitivity of the results to a material's strength and fracture criteria, and the complex interface between the high-explosive detonation products and the expanding and/or fragmenting structural case. DYSMAS fragmentation results compare well with experimental results, which were compiled from 19 arena shots of the BLU-109B/C as part of the Joint Live Fire Fragmentation Modeling Challenge. This presentation discusses the DYSMAS simulation setup and results. It also discusses newly implemented code features in DYSMAS and how they will be leveraged moving forward to improve predictions of performance for next generation weapons.

INTERNAL BLAST TESTING IN SUPPORT OF DYSMAS AFTERBURN MODELING DEVELOPMENT FOR NON-IDEAL EXPLOSIVES

Colin Burns, NSWC Indian Head

Dr. Jeff St. Clair, NSWC Indian Head

A series of experiments were conducted at Naval Surface Warfare Center Indian Head Division (NSWC IHD) to quantify the internal blast performance of two novel, non-ideal explosives. The energetic efficiency and resultant quasi-static pressure were analyzed to determine their performance relative to one another and C4. This data will be leveraged to validate DYSMAS detonation and afterburning modeling efforts of the two non-ideal explosives. The modeling work using this data will be crucial to addressing gaps in predicting performance of these two explosives in a confined air environment. This

presentation will cover the experimental data analysis, the characterization of energetic performance, and the planned pathway for accurate modeling of non-ideal detonation and combustion.

LARGE-SCALE UNDEX PREDICTION OF NOVEL UNDERWATER FORMULATIONS USING EQUATIONS OF STATE CALIBRATED FROM SMALL-SCALE DATA

Orlando Andres Mulero Flores, NSWC Indian Head

Dr. George McDaniel, NSWC Indian Head

The Navy is undergoing efforts to increase the lethality of its underwater weaponry. This includes the development and qualification of next generation underwater explosive fills for future and current torpedoes and mines. This effort includes the development of modeling and simulation screening methods to reduce time and cost of explosive development and allow for efficient assessment of novel materials. DYSMAS predictive modeling in conjunction with an optimizer to fit small-scale experimental data were proposed to enhance the current screening capabilities. Equations of state were calibrated using small-scale data from the Moby Dick test and used to simulate free-field pond tests. The main goal was to investigate if the simulated shock and bubble performance of a novel formulation could mimic and/or predict the performance from an experimental pond test series. Results validated the predictive capability to rank the performance of various explosive formulations. In some cases, the predictions were considerably close to the test data. Future efforts will focus on improving the efficiency and predictability of the current optimization framework.

MACHINE LEARNING FOR UNDEX SHOCK HOLING RULE

Sujan Bashyal, ATR

Horacio Nochetto, NSWC Indian Head

Legacy Anti-Surface Warfare (ASuW) holing damage rules for underwater weapons are primarily based on data from underwater explosions (UNDEX) experiments against air-backed plates. While this foundational data was developed from a wide range of experiments, it inherently produces wide error bounds. These error bounds are further expanded by the omission of complex ASuW structures such as decks and bulkheads. To improve upon this legacy method, DYSMAS high-fidelity modeling of generic naval structures was employed to create a comprehensive holing dataset for training a new Machine Learning (ML) model. This latest ML-based rule significantly reduces error bounds and accounts for a broader range of structural parameters, including decks and bulkheads. This presentation emphasizes how DYSMAS simulation data is utilized to train the ML model and demonstrates how the model is applied to make rapid, accurate holing predictions.

SESSION 8: STRUCTURAL RESPONSE AND HAZARD EVALUATION

OVERVIEW OF THE MAGAZINE EARTH COVER UPDATE/REASSESSMENT STUDY, EXPERIMENT 10 (MERCURY 10)

Jeffrey Holmes, US Army ERDC

Joshua E. Payne, US Army ERDC

Dr. Paul T. Mead, US Army ERDC

Dr. T. Neil Williams, US Army ERDC

Dr. John Q. Ehr Gott, Jr., US Army ERDC

Denis D. Rickman, US Army ERDC

Earth-covered magazines (ECMs) are a primary method for ammunition and explosives storage throughout the Department of War (DoW). Per DESR 6055.09 (Defense Explosives Safety Regulations), ECMs require a minimum earth-cover thickness of 2 ft. Falling below this threshold mandates reclassification as an aboveground magazine (AGM), significantly restricting allowable net explosive weight (NEW) storage and potentially threatening the operational flexibility of DoW munition storage globally. There is no single-source document explaining the science behind the 2-ft earth-cover requirement, which relies on a patchwork of historical experiments and legacy DoD standards. Therefore, a series of experiments was developed, code-named Magazine EaRth Cover Update/Reassessment study (MERCURY), to investigate the effects of varying earth-cover thicknesses for ECMs. This effort was a collaboration among the U.S. Army Technical Center for Explosives Safety (USATCES), the U.S. Army Engineering and Support Center, Huntsville (CEHNC), and the U.S. Army Engineer Research and Development Center, Vicksburg (ERDC). The work presented here provides an overview of the MERCURY 10 (M10) experiment, which featured a 3/8-scale concrete arch as the donor magazine (the ECM that initially explodes) positioned adjacent to an instrumented soil berm simulating an acceptor magazine (the ECM hit by the donor blast). The work includes a summary of the test layout, the data collected, and a preliminary review of the test results.

EXPERIMENT PLAN TO QUANTIFY HD 1.3 THERMAL HAZARDS IN TEST CUBICLES

Adam Mayatt, US Army ERDC

No abstract provided.

SMALL MAGAZINE VOLATILITY TESTING OF HD 1.3 AND 1.4 MATERIALS

Jonathan Dahlem, US Army ERDC

Dr. John Q. Ehr Gott Jr., US Army ERDC

Jeremy Grey, US Coast Guard FORCECOM

The U.S. Army Engineer Research and Development Center (ERDC) conducted tests in support of the United States Coast Guard (USCG) to determine the hazards affiliated with fully loaded ARMAG 3 ft × 3 ft and 4 ft × 4 ft munition storage magazines. These magazines housed Hazard Division (HD) 1.3 and 1.4 munitions; testing evaluated the magazine's capacity to contain extreme deflagration and mild detonation events, as well as its resistance to prolonged, direct fire exposure. This effort aimed to validate that required standoff distances for these service magazines could be reduced without compromising safety standards. Ultimately, this reduction accelerates USCG munition deployment and simplifies facility siting requirements. To ensure a conservative evaluation, the test series utilized the magazine's maximum volume capacity to simulate a 'worst-case scenario,' subjecting the magazines to conditions far exceeding typical field environments. Under these extreme conditions, monitoring within

a 15-ft radius revealed no significant overpressure, hazardous thermal fluctuations, or fragmentation hazards during the internal munition reaction. The results demonstrate the experimental design and the safety data supporting hazard distances for this magazine configuration.

WAVE PROPAGATION CHARACTERISTICS THROUGH HOMOGENEOUS AND STRATIFIED MEDIA

Dr. Photios Papados, US Army ERDC

Dr. Nicholas Arnold, DTRA

Dr. Kent T. Danielson, US Army ERDC

Researchers at the US Army Engineer Research and Development Center (ERDC) evaluated wave propagation characteristics through various material configurations. The collected data were compared with simulations conducted using the Lagrangian-based finite element analysis (FEA) code EPIC [1] and the Eulerian-based code CTH [2].

The test articles consisted of concrete cylinders measuring 1.83 m in diameter and 1.83 m in height. A C-4 high-explosive disc measuring 91 cm in diameter by 1.27 cm in thickness, with a mass of 15.9 kg, was centered on the top surface of each concrete cylinder to provide the loading environment.

This presentation discusses two experimental arrangements:

- a) A stratified concrete cylinder featuring two parallel, horizontal joints located at heights of 0.60 m and 1.21 m from the cylinder base.
- b) The baseline cylinder configuration (described in a) with a central, horizontal tunnel measuring 1.83 m in length and 30.5 cm in diameter. The tunnel was oriented parallel to the cylinder's top, lined with A-36 steel, and centered both horizontally and vertically.

Each experimental configuration was instrumented with time-of-arrival (TOA) sensors and accelerometers (AGs) at select locations. The TOA sensors were spaced equidistantly along each cylinder's height, distributed across two radial lines extending from the center. The AGs were distributed along the central vertical axis of the cylinders. Researchers assessed each configuration twice to ensure consistency.

This paper presents experimental-to-numerical comparisons for select sensors, alongside numerical comparisons between EPIC and CTH.

References

- [1] Beissel, S. R., C. A. Gerlach, and T. J. Holmquist. "User Instructions for the 2023 Version of the EPIC Code," Southwest Research Institute, Minneapolis, Minnesota, September 2023.
- [2] Wong, K. M. "CTH User's Manual and Input Instructions-V13.1," Sandia National Laboratories, New Mexico, USA, 2021.

Permission to publish was granted by the Director, Geotechnical & Structures Laboratory

SESSION 8: TEST FACILITIES & QUALIFICATION SPECS

TUBE AND BREECH FATIGUE LAB OVERVIEW

Lucas Smith, US Army DEVCOM-AC-WSEC

Scott Lobdell, US ARMY/DEVCOM-AC-WSEC/Benet Labs

Benét Laboratories' Tube Fatigue Laboratory provides a unique capability to facilitate constant amplitude cyclic hydraulic fatigue testing on cannon and artillery to establish their Safe Service Lives. The Lab has three independent hydraulic testing cells which can accommodate test specimens up to 5' in length and 1-1/2' in width. The armament of choice can be tested in any one of the three test cells depending upon assigned test pressure. Given the test parameters, up to six mortar tube test specimens can be tested simultaneously. The results of the fatigue tests are evaluated from which an assigned Interim or Final Safe Service Life is determined in accordance with the International Test and Operation Procedure (ITOP 3-2-829). Broad maximum testing pressure capability range from 3,000 psi to 125,000 psi while safely containing up to 4.5 million pounds of force. Other components fatigue and/or burst tested in this facility include composite lined recoilless rifles, trunnion bearings and aircraft bearings. Composite and steel bore evacuator canisters have been pressure tested prior to field use.

The Breech and Baseplate Fatigue Simulation Facility is a dedicated Department of the Army facility established to provide cost effective, safe fatigue life determinations of all large caliber armament breech assemblies through dynamic hydraulic medium pressure cycling along with a capability to test all caliber mortar baseplates through dynamic pneumatic pressure cycling.

The lab consists of three impact test systems each capable of reaching different pressure ranges up to a maximum of 135,000 psi in under 10 ms. Testing is conducted over enclosed seismic mass test pits in the ground that contain the destructive energy produced during testing and any catastrophic failures of test assets. Dynamic high-pressure testing utilizes custom pressure transducers that are fabricated and calibrated in-house with a NIST-traceable dead weight test system capable of reaching up to 200,000 psi. Data acquisition of pressure, strain, and other sensors is conducted in a control room that allows for monitoring of equipment and assets during testing. A dedicated machine shop provides quick turnaround for minor test hardware modifications and fabrication of test support components.

RESTRUCTURING OF UFC 3-340-01 CHAPTER 12

Dr. Eric Kjolsing, Karagozian & Case, Inc

John Geringer, U.S. Army Corps of Engineers Protective Design Center

Mark Weaver, Karagozian & Case, Inc.

Brett Williams, US Army ERDC

United Facilities Criteria (UFC) 3-340-01 is used extensively in the protective design space as it provides guidance for the design and analysis of hardened structures to conventional weapons effects. The most recent version of UFC 3-340-01 was published in 2002, nearly 25 years ago. Recently, an effort has been undertaken to update UFC 3-340-01 in preparation for a new revision, planned to be released in the next few years. Expected improvements include updates to technical content, re-organizing chapters, and separating out commentary and supplemental information from mandatory guidance.

This paper specifically covers the restructuring effort for Chapter 12. Chapter 12, entitled 'In-Structure Shock Mitigation', describes how users develop shock loads (demand values); tabulates fragility spectra

(capacity values) for commonly deployed equipment; provides a theoretical background of the relevant equations of motion and response spectrum analysis; and describes characteristics of typical isolator systems.

Potential improvements to Chapter 12 include identifying and validating the source data of the tabulated equipment fragility values, providing an avenue for shock fragility testing (should specific equipment fragility values not already be provided within Chapter 12), and addressing the applicability of seismic fragility data in a shock environment. These topics, as well as secondary improvements, are discussed in this paper.

The paper discusses identified gaps in the chapter, a brief literature review performed to try and close the observed gaps, proposed modifications to the technical content of the revised chapter, and an overview of the proposed restructuring. The intent of this paper is to make practitioners aware of the forthcoming restructuring and promote continued community engagement in UFC 3-340-01 development.

VENDOR SESSION B: EXHIBITOR PRESENTATIONS INCLUDING CASE STUDIES, NEW DEVELOPMENTS, TESTING & PRODUCTS

REAL-TIME RESONANCE COMPENSATION TO IMPROVE THE ACCURACY OF BLAST WAVE PRESSURE MEASUREMENTS

Dr. Thomas Gerber, Precision Filters, Inc.

Alan R. Szary, Precision Filters, Inc.

Douglas Firth, Precision Filters, Inc.

Patrick Rule, Precision Filters, Inc.

Blast wave testing is critical for assessing the severity and injury potential of explosive shocks. Of particular concern are accurate measurements of blast wave peak pressure and impulse as a function of source magnitude, distance, and degree of confinement. The near instantaneous pressure spikes that characterize blast waveforms necessitate measurement systems with sufficient bandwidth to resolve the shock front. This requirement poses a problem for many pressure sensors: if the sensor's resonant frequency lies too close to the band needed to capture the shock waveform, the resulting measurements will be contaminated by sensor ringing. In addition, sensors mounted within a recessed cavity for protection can introduce aerodynamic resonances (i.e. Helmholtz or "organ-pipe") that occur at frequencies well below the sensor's natural mechanical frequency. While conventional analog filtering can suppress frequencies contaminated with resonance prior to sampling, even high-precision filters provide a somewhat blunt tool for isolating resonant effects and can have undesirable effects on the transient response of the measurement system. In this study, we demonstrate a novel approach to resonance compensation (REZCOMP) using a specially designed filter based on the frequency response of a typical resonator. Using Friedlander-type waveforms to represent sensor input, we model mechanical and aerodynamic resonance in the sensor output and compare compensated and uncompensated signals relative to the true pressure signal from the modeled blast wave. We also compare the output waveforms of compensated signals to those in which the resonance is eliminated with only a low-pass filter. Our analysis demonstrates that REZCOMP is an effective tool for measurement applications requiring bandwidth preservation in measurement systems affected by resonance.

VALIDATING A WRI SOLUTION THROUGH SIMULATION AND EXPERIMENTAL METHODS

Ozzie Irowa, Socitec

The onboard electrical and fluid systems of a reusable launch vehicle concept are exposed to significant levels of random vibration during operation. To ensure compliance with mission requirements, wire rope isolators (WRIs) were integrated into the system. WRIs attenuate vibrations by lowering the overall suspension frequency, thereby effectively filtering higher-frequency excitation.

A custom WRI was designed to remain within size constraints of the system. A prototype was tested to characterize its stiffness and damping characteristics. The experimental results were incorporated into SYMOS simulation software to assess the vibratory performance of the entire system.

Custom mounting fixtures were also designed to withstand the high vibration levels of this project. The designs underwent random vibration qualification testing in a laboratory. The laboratory test results validated the results obtained through numerical methods, thus strengthening confidence in the SYMOS computational models.

DEVELOPMENT OF A MIPS RESONANT BEAM SHOCK TEST MACHINE

Dr. Carl Sisemore, ShockMec Engineering

Mechanical Impulse Pyroshock Simulator (MIPS) testing is a common method for simulating certain pyroshock events in the laboratory. The method traditionally makes use of a large vibrating plate impacted by a hammer to produce a relatively shallow slope SRS response on a spacecraft component. The method typically works well but the equipment is usually large and setup and calibration can be time consuming. ShockMec Engineering has implemented an upgrade to their modular resonant plate shock test machine to support the addition of MIPS style testing. This presentation describes the theory and development of the small-scale MIPS resonant beam attachment to a modular resonant plate shock test machine. The resonant beam MIPS system allows for testing of many shallow slope spacecraft payload SRS test requirements with a small laboratory sized test machine. The MIPS attachment makes use of the existing shock machine's lightweight pneumatic hammers and control system. This allows one modular shock test machine to test both MIPS style specifications and high-energy resonant plate shock specifications. Experimental results will be presented for various sized sample components tested to several common commercial spacecraft shock environment levels.

VIPER BLAST FOR ADVANCED AIRBLAST SIMULATIONS

Dr. Peter McDonald, Viper Applied Science

Join us for an insightful vendor session exploring the advanced capabilities of Viper Blast — a GPU-accelerated Computational Fluid Dynamics (CFD) tool purpose-built for airblast simulations.

Viper Blast is a leading solution for blast analysis and extreme load modeling, offering high performance and ease of use through GPU acceleration and an intuitive interface. This session will highlight the features that make Viper Blast indispensable for engineers and researchers working in defense, aerospace, civil engineering, and related fields.

We'll begin with a look at the simulation engine's GPU-powered performance, enabling rapid turnaround without compromising accuracy. We'll also demonstrate the user-friendly workflows that make Viper Blast accessible to both new and experienced users.

The session will then showcase key workflows including building damage assessment, coupled fluid-structure simulations, and injury prediction. Real-world examples will highlight practical applications, with a particular focus on the updated post-processing pipeline and new options for integration with finite element tools.

Whether you're a current user or exploring modern CFD tools for blast analysis, this session offers valuable insights into the evolving capabilities of Viper::Blast and how it can support your work.

MODERNIZING VIBRATION TEST AUTOMATION VIA REST API AND AI-ASSISTED IMPLEMENTATION

Jacob Willett, m+p International

Most modern test and measurement companies offer an application programming interface (API). m+p international released a new REST API in 2026 with specific commands for its vibration controller. Attendees will learn how this standardized architecture enables "AI Vibe Coding," allowing mechanical engineers to leverage artificial intelligence to instantly generate test scripts and bypass traditional programming barriers. Through real-world deployment examples—including high-throughput assembly line automation, centralized remote lab monitoring, and custom "Easy Mode" operator interfaces—we will explore how upgrading to a REST framework reduces human error, safeguards testing data, and accelerates mission-critical validation programs in industries ranging from everyday manufacturing to cutting-edge aerospace.

VIBRATION AT CRYOGENIC TEMPERATURES

Roger Rutz, Experior Laboratories

At Experior Laboratories, we're redefining what's possible in extreme environmental testing with our newly activated cryogenic vibration and shock testing capability. Purpose-built for the aerospace and defense industries, this one-of-a-kind system allows dynamic vibration and mechanical shock testing on components that are externally conditioned to cryogenic temperatures as low as -305°F (-187°C, 85°K)—with no submersion or direct on-unit spraying.

TRAINING II: INTRODUCTION TO UERDTOOLS

INTRODUCTION TO UERDTOOLS

Rachel McIntyre, NSW Carderock

Ryan Hegarty, NSW Carderock

The UERDTools program is a collection of data processing and analysis routines integrated into a single package to provide a comprehensive tool for on-site data analysis. The real-time analysis of acquired test data necessitates a convenient, easy to use package for data processing, plotting, and manipulation routines to support rapid assessment and interpretation of measured test results. This suite of data analysis routines is designed to help standardize the way Navy shock programs analyze and process data. It also facilitates ease of generation of comparison plots of both measured and computed results in support of analytical correlations studies. This training summarizes the UERDTools suite of programs, illustrates its basic features (including curve comparisons), and describes the built in user-defined macro capability. Details of the development, architecture, and resident analysis modules are outlined.

SESSION 9: TEST EQUIPMENT MODELING & SIMULATION

CAN A THEORY OF WAVE PROPAGATION THROUGH LAYERED MEDIA EXPLAIN HOW RESONANT PLATE ANVIL DESIGN AFFECTS THE SHOCK PULSE ENERGY CONTENT?

Dr. Nancy Winfree, Sandia National Laboratories

Joshua Nowlin, Sandia National Laboratories

Dr. Carl Sisemore, ShockMec Engineering LLC.

In resonant plate impact testing, a sacrificial anvil block attached to the plate can be used to protect the plate against damage from the striker impact. Testing has previously demonstrated that the higher frequencies of the resonant plate's shock response spectrum are altered by varying the anvil's thickness, the anvil material, or by adding felt on the impact surface or an elastomer between the block and the plate. This paper investigates how well a theory of wave propagation through layered media can describe this filtering behavior and the resulting energy content of the shock pulse, which compares the analytical results based on the theory to test results.

FLUID STRUCTURE INTERACTION DUE TO SEISMIC AIRGUN LOADING

Dr. Daniel Clark, Thornton Tomasetti

Oliver Craggs, Thornton Tomasetti

Seismic airguns provide a safer, cheaper and more repeatable test environment for the simulation of the effects of an underwater explosion for the qualification of naval equipment on both surface ships and underwater vessels when compared to conventional UNDEX testing. Through the use of synchronized arrays, a wide range of test conditions can be generated; however, this requires a calibration process currently carried out physically. The development of a high-fidelity numerical approach would facilitate improvements to the efficiency of the calibration process.

The numerical modelling of seismic airguns has received little attention in the open literature and presents a number of challenges. Namely, the mechanism of expulsion of air from the gun and the interaction of the subsequent bubble with both the structure and the gun body. These factors necessitate the use of a fluid structure interaction approach in modelling airgun loading of naval structures. This work presents further progress towards a coupled CFD-FEA approach to modelling air gun trials. Comparison is made with available experimental data for both free field and structural loading cases.

NUMERICAL SIMULATION FOR LIGHTWEIGHT SHOCK TEST

Keisuke Terada, Japan Marine United Corporation

Daisuke Morimoto, Japan Marine United Corporation

This paper provides numerical simulations of lightweight shock tests for evaluating the shock resistance of naval ships subjected to underwater explosions (UNDEX). UNDEX are very damageable for naval ships and seriously affect the performance of onboard equipment negatively, as well as the ship's combat capabilities and structural integrity. Therefore, it is critically important to ensure that onboard equipment can withstand the shock of UNDEX while maintaining its functionality. Lightweight shock tests are conducted to evaluate such the requirement.

In this paper, a model of the lightweight shock machine (LWSM) is created, and numerical simulations of lightweight shock tests are conducted. Simulation results are adjusted to measured data from lightweight shock tests. During the fitting process, various parameters such as friction and damping are considered, and valuable parameters for adjustment are identified. Through parameter adjustment, simulation results are obtained that generally matched the measured results.

The results of this paper enable the preliminary evaluation of prototype before actually conducting lightweight shock tests. Consequently, it is expected to lead to reduction the number of retests for lightweight shock tests, product development costs, and lead times.

ENHANCED AND ACCURATE UPSAMPLING FOR DERIVATIVE-SENSITIVE SHOCK SIGNALS

Dr. Ted Diehl, Bodie Technology Inc

Upsampling is commonly used to improve the time-domain interpretation of coarsely sampled shock signals. It is also a critical component in split-band filtering and in many algorithms used to salvage distorted shock data. In principle, DSP-based upsampling increases the sampling rate without adding new physical frequency content beyond the Nyquist frequency of the original sampling rate. In practice, however, commonly used DSP-based upsampling approaches can create false high-frequency artifacts that may appear negligible in the original signal form but become significant or even dominant when derivatives are computed. This is especially important when distorted shock data are salvaged in velocity or displacement form and acceleration is then recomputed by differentiating the salvaged result.

This presentation examines the challenge of upsampling derivative-sensitive shock signals, especially cases where displacement is upsampled and then differentiated to velocity and acceleration. Traditional approaches, including “FFT-based zero-padding” and “zero-fill plus FIR lowpass reconstruction filtering”, can produce results that appear reasonable in displacement but yield severely distorted acceleration due to algorithm-created high-frequency content above the original Nyquist frequency. These artifacts are especially problematic in shock and vibration workflows where acceleration, velocity, displacement, and shock response quantities may all be derived from the same measured or processed signal.

The presentation demonstrates the source of these artifacts, including the harmonic high-frequency content created by the zero-fill insertion process and the endpoint distortion associated with applying FFT-based methods to non-periodic transient data. An example shock-derived displacement signal from an actual physically measured metal-on-metal severe shock test is used to compare several upsampling approaches, including classical FFT zero-padding, classical zero-fill plus FIR lowpass filtering, a historical Blackman-windowed FIR reconstruction method, and improved antialias-style IIR reconstruction filters.

A new Kornucopia® ML™ upsampling approach is presented that uses robust lowpass reconstruction filtering, optional additional lowpass cleanup, and advanced end-effect distortion minimization. The method is designed to suppress algorithm-created high-frequency artifacts while preserving the usable bandwidth of the original signal as much as practical. Results show that the improved default approach produces upsampled displacement signals that remain credible after two successive differentiations to acceleration, avoiding the severe nonphysical distortion produced by traditional methods.

The study highlights an important practical lesson: exact reproduction of the original sample points is not necessarily the best objective when the upsampled result will be differentiated. For derivative-sensitive shock signals, the more important requirement is a physically credible, bandwidth-preserving reconstruction that does not introduce false high-frequency content. The proposed approach provides a

robust and practical solution for shock and vibration analysts who need reliable upsampling of transient signals prior to differentiation or other high-frequency-sensitive processing.

SESSION 10: EXPERIMENTAL VIBRATION TECHNIQUES

SINE-ON-RANDOM TOLERANCES: COMPARING EXPECTED STATISTICAL VARIATION AND MIL-STD COMPLIANCE

Jade Vande Kamp, Vibration Research

Sine vibration tests, whether alone or in combination with broadband random vibration, require tuning to optimize the measurement of the sine tone. Selecting the appropriate parameters is critical. These parameters affect the control loop; optimizing them for product response allows for the best measurement of the control sensor and any response channels.

The guidance provided by test standards such as MIL-STD-810 regarding sine vibration test tolerances can be an obstacle for laboratories. Most industry-specific test standards refer to historical standards for shaker test controls, tolerances, parameters, etc. Engineers must interpret these standards for their laboratory setup. However, guidance on applying tolerances can be open-ended, and the required values are often defined for broad use. Using standard tolerance values without consideration of the test system's design may lead to control issues.

From the presenter's experience in test lab support, a recent trend toward tighter tolerances has led to issues with sine data, prompting questions related to tuning parameters. The proposed presentation will offer suggestions and best practices when implementing tolerance requirements for sine and sine-on-random (SoR) vibration testing. It will outline basic and advanced test tolerances and discuss them in relation to the behaviors of shaker control systems. It will include specific examples from MIL-STD-810 but point to the broader topic of defining test-specific values.

The proposed presentation will provide additional context for engineers seeking to build a sine test plan. Attendees will gain a better understanding of how to select appropriate tolerances while complying with test standards and how to use them to achieve consistent, repeatable results. It will review common issues that arise during sine testing, evaluate tuning mechanisms that can be adjusted to optimize measurements, and discuss issues related to the recommendations of standards like MIL-STD-810 and others.

CONTROLLING OUT HARMONIC DISTORTION ON A HYDRAULIC SHAKER

Raman Sridharan, Data Physics Corporation

Thomas Reilly, Data Physics Corporation

Harmonic distortion is commonplace on a hydraulic shakers, and driving such a system with a pure sine tone does not generate a pure sine tone response. The problem can be particularly bad the higher velocities around 20-80Hz. Harmonic distortion can be problematic when testing or analyzing sensitive devices which require a clean sinusoidal excitation.

This presentation will investigate a novel method implemented in the shaker's controller which counteracts harmonic distortion generated when the shaker is driven with a pure sine tone. In tests run on a hydraulic actuator, the THD was observed to drop by 95%.

TOWARDS AUTOMATED LUMPED PARAMETER MODEL IDENTIFICATION OF ELECTRODYNAMIC SHAKERS

Dr. Mattia Dal Borgo, Siemens Digital Industries Software

Francesco Bentivoglio, University of Trento

Umberto Musella, Siemens Digital Industries Software

Dr. Emiliano Rustighi, University of Trento

Electrodynamic shakers are at the core of vibration qualification testing, providing controlled dynamic loading that supports product reliability assessments. Accurately capturing the internal dynamics of the shaker is critical for ensuring reliable predictions of the coupled shaker-specimen behaviour and for optimizing test setups.

This contribution presents an automated procedure to identify linear lumped parameter models of electrodynamic shakers from a limited number of frequency response functions measured on an empty shaker configuration.

Firstly, the approach establishes a lumped parameter model representation focusing on the primary axial dynamics, enabling an extended frequency range for model identification. Frequency response functions are measured by initially driving the shaker with a broadband random signal and subsequently with an impact test. The acquired acceleration, force, current and voltage data sets are fed to a parameter fitting algorithm that outputs the estimates of a four-degree-of-freedom representation. Crucially, the procedure remains valid even if one or more of these signals are unavailable, ensuring flexibility in diverse test facility constraints.

Secondly, comprehensive experimental validation on a wide range of shaker sizes demonstrates that the identified model reliably captures the essential aspects of shaker behaviour, resulting in robust predictions in virtual shaker testing and improved correlation between test data and simulations.

Finally, we discuss how the methodology can be extended to address more advanced modelling requirements, including rocking modes and nonlinear effects, thus broadening its applicability. Overall, the proposed procedure provides a systematic and accurate path to high-fidelity shaker models, supporting enhanced vibration qualification strategies across a range of research and industrial applications.

EXPERIMENTAL AND NUMERICAL PACKING OF GLASS MICROBEADS FOR ELECTRONIC ENCAPSULATION

Joseph Erwin, Sandia National Laboratories

Glass microbeads have shown promise as an encapsulation medium for electronic components exposed to harsh mechanical environments such as shock and vibration. In addition to being removeable, glass microbeads do not have the same thermal expansion mismatch issues seen in encapsulants such as hard epoxies. To better understand this encapsulation method, experimental and numerical packings of glass microbeads were analyzed. Local and global packing density as well as contact number distribution and average were derived from experimental and numerical packings confined within two distinct, three-dimensional geometries. Additionally, an empirical model for radial packing fraction was compared with experimental and numerical data. Numerical, experimental, and empirical model data were shown to be highly consistent. It was demonstrated that order or disorder in the packed bed can be engineered by the confining geometry using numerical modelling. By better understanding the packing of glass microbeads, this encapsulant can be better engineered to optimize survivability.

SESSION 11: SHOCK QUALIFICATION ANALYSIS

EFFECTS OF MESHING PRACTICES ON LINEAR ELASTIC MODAL STRUCTURAL RESPONSE

Ian Larson, NSWCCardero

No abstract available.

EFFECTS OF MESHING PRACTICES ON ELASTIC PLASTIC STRUCTURAL RESPONSE

Katherine Jordan, NSWCCardero

No abstract available.

MASS FEEDBACK EFFECTS ON DECK ENVIRONMENTS

Serena Sauers, NSWCCardero

No abstract available.

STANDARD SHOCK QUALIFICATION OF MAST MOUNTED EQUIPMENT

Timothy McGee, NSWCCardero

Rachel McIntyre, NSWCCardero

Jake Mason, NSWCCardero

Matt Stevens, NSWCCardero

Currently, the Navy relies on case-by-case engineering efforts to define each shock qualification test for surface ship mast-mounted items. The purpose of this effort was to define a streamlined process by which shock qualification testing for mast-mounted equipment should be performed. In this study, the current case-by-case shock environment definition process was investigated at each step for possible process improvements. Based on this investigation, a new streamlined shock environment definition process was developed.

SESSION 12: BALLISTICS I

DEVELOPMENT OF FAST RUNNING DETAILED FINITE ELEMENT PROJECTILE MODELS

Logan Rice, US Army ERDC

Dr. Mark Adley, US Army ERDC

David Lichlyter, US Army ERDC

Dr. Darren Rice, US Army ERDC

Projectile penetration research is critical to both offensive and defensive military operations. Advancements in this domain facilitate the optimized design of protective infrastructure and enhance the predictive fidelity of weaponeering applications. However, the extensive computational time and expertise of the user required for high-fidelity finite element (FE) simulations often constrains their utility for rapid, yet accurate, mission planning. Models utilizing coarser meshes and simplified geometry offer rapid damage assessments for specific weaponeering applications. However, while effective at predicting primary munition failures like case fracture, they lack the fidelity to resolve complex munition

failure modes such as explosive fill deflagration. The models proposed in this study accept increased computational runtime to capture these complex failure modes, yet execute significantly faster than existing high-fidelity FE models. These new enhanced-mesh-density models incorporate component-level surrogates to predict advanced failure modes, such as explosive fill deflagration, by accurately simulating internal munition dynamics (e.g., movement of the explosive fill inside the weapon and fuze thread failure). The types of weapon failure being analyzed can be implemented via algorithms and weapon mesh libraries integrated into PENCURV+ v2.9, removing the need for a finite element expert for operational use.

INVESTIGATION INTO MOMENTUM TRANSFER FROM BUILDING AND EARTHWORKS COLLATERAL DEBRIS

Dr. Zane Roberts, US Army ERDC

The objectives of this work were to characterize the relative difference in momentum transfer, correlating to secondary debris hazard potential, between common construction and earthworks materials projected during explosive and impact events. Four types of cylindrical projectiles were launched using an 83-mm powder gun: clay, sand, concrete, and wood. On impact, kinetic energy is not conserved, but momentum is conserved, and it was expected that these materials could be ranked by a momentum transfer efficiency. To measure this, a momentum trap was constructed wherein two shafts freely slid on linear bearings with a heavy, 44-cm-wide, steel target plate and counterweight. The sliding target portion of the momentum trap was designed to be 70-kg, representing the International Commission on Radiological Protection and NATO STANAG standard human reference mass. Projectiles were launched from the gun in a nylon sabot with the same 550 g mass and presented area (70-mm diameter), though the different density materials required different lengths. The sabots separated in flight and were stopped, allowing only the debris material to impact the target plate. Diagnostics included a draw-wire displacement sensor (yo-yo gauge), a 2000 g accelerometer, and high-speed video. These experiments were conducted at the Projectile Penetration Research Facility (PPRF) of the U.S. Army Engineer Research and Development Center (ERDC) Geotechnical and Structures Laboratory (GSL) Impact and Explosion Effects Branch (IEEB).

JOINT DTRA/AFLCMC PENETRATION EXPERIMENTS AGAINST PRISTINE AND BLAST-DAMAGED ROCK TARGETS

Mark Green, Geomechanics Research & Analysis, LLC

Dr. James Cargile, J Donald Cargile Consultancy LLC

Scott Blouin, Applied Research Associates, Inc.

Brandon Artis, Applied Research Associates, Inc.

Maj. John Imhoff, Defense Threat Reduction Agency

Greg Glenn, United States Air Force Life Cycle Management Center

Koby Kennison, Integrated Solutions for Systems, Inc.

Dr. Danny Frew, Dynamic Systems Research, Inc.

The Defense Threat Reduction Agency and Air Force Life Cycle Management Center jointly performed a series of scaled penetration experiments against pristine and blast-damaged limestone rock targets to obtain penetration data for use in developing new penetration models for damaged rock. The large blocks of rock used to construct the targets were obtained from a quarry located in the state of Indiana. One test was conducted against a pristine, undamaged target. Five penetration tests were conducted against blast damaged targets which was achieved by detonating a cylindrically cased charge at a desired depth in the target. The thickness of targets were varied to ensure that some of the follow-on projectiles perforated the target back face while the others penetrated into but did not perforate the target. All of the projectiles were launched out of a smooth-bore powder gun. In addition to measuring

impact conditions and depths of penetration, the projectile's axial deceleration was recorded during impact and penetration of the target. These decelerations were measured using an instrumentation package (developed by Dynamic Systems Research, Inc.) that was compression mounted in an internal cavity of the projectile. This paper provides an overview of the test setup, results, and comparisons to model simulations.

VENDOR SESSION C: EXHIBITOR PRESENTATIONS INCLUDING CASE STUDIES, NEW DEVELOPMENTS, TESTING & PRODUCTS

REDUCING SHIPBOARD VIBRATIONS BY APPLICATION OF POLYURETHANE SHOCK MOUNTS IN A DOUBLE RESILIENTLY MOUNTED GENERATOR SET

Danny Smit, Vulkan

For naval ships, minimising underwater radiated noise is crucial. This ensures effective sensor operation and reduces detectability. While propellers are a major source of noise, internal machinery vibrations contribute significantly as well. One key contributor is the diesel generator set which powers the electric propulsion system during quiet operations. The vibrations from the internal combustion engine and alternator propagate through the ship's structure into the water.

To reduce this, ships often use a system called "double resilient mounting" for the generator set. This approach places the engine - and sometimes the alternator - on two layers of shock-absorbing resilient mounts separated by an intermediate frame. These mounts, typically made of rubber, absorb shocks and isolate vibrations. However, rubber mounts have limitations: their internal natural frequencies often overlap, reducing their effectiveness at blocking vibrations. Adding weight to the base frame is a common 'last resort' method to improve isolation, but is not favourable on ships due to weight constraints.

A new approach replaces rubber with polyurethane foam in these mounts. Polyurethane foam is lighter and provides superior damping of vibrations. Because of its lower density, the problematic internal natural frequencies shift to a range where engine vibrations are less dominant, improving isolation. This paper introduces the parameters involved in a basic structure-borne noise isolation model of a double resiliently mounted generator set and demonstrates the effect of an alternative material in a resilient mount.

CHAMP – CRITICAL HIGH-VALUE ASSET MONITORING PLATFORM

Dylan Pike, enDAQ/Hutchinson

The proposed data service is designed to provide comprehensive monitoring and analysis of space asset shipments. The solution focuses on capturing critical sensor data during transportation and delivering actionable insights through automated processes and cloud-based visualization.

The service includes automated data collection from multiple devices, recording acceleration at high frequency when in motion, as well as GPS, temperature, and humidity at regular intervals. Data is transmitted to the cloud without manual intervention using 4G connectivity for significant events and Wi-Fi for bulk uploads. Remote control of devices is enabled via API, allowing start/stop acquisition and firmware updates over-the-air. Power optimization features distinguish between stationary and in-motion states to extend battery life and reduce unnecessary data capture.

Once collected, data undergoes pre-processing at the gateway and further processing in the cloud, where it is filtered and organization for analysis. The system provides real-time alerts for threshold exceedances such as shocks, temperature, and humidity during transit. A web application offers visualization of key summary metrics and access to raw data, ensuring timely review and decision-making. Summary data is retained permanently, while raw data is purged after twelve months.

This service ensures accurate, reliable insights for every shipment, reducing risk, improved operational efficiency, and supporting data-driven decision-making across the transportation process.

BETTER DATA FROM IMPERFECT FOOTAGE: ADVANCES IN IMAGE MOTION ANALYSIS

Daniel Bissell, Image Systems

High-speed video remains central to characterizing shock, blast, and vibration events, but real-world footage is rarely ideal. Poor lighting, occlusions, motion blur, low native contrast, and more can complicate the extraction of clean, quantitative data from image sequences. This talk introduces new capabilities aimed at overcoming such challenges. By combining cutting-edge techniques with AI-driven insights, we'll present commercially available tools built to get the most out of your imagery.

MIL-DTL-901E: THE GOOD, THE BAD, AND THE MISLEADING

Kurt Hartsough (901 Engineering & Training)

No abstract available.

TRAINING III: PRELIMINARY DESIGN ASSESSMENT STRATEGIES FOR STRUCTURAL INTEGRITY IN SHOCK AND VIBRATION

PRELIMINARY DESIGN ASSESSMENT STRATEGIES FOR STRUCTURAL INTEGRITY IN SHOCK AND VIBRATION

Dr. Charles Hull, Lockheed Martin

Initial structural design assessments are often based upon stress and strength concerns. This presentation provides an overview of the preliminary design method described in the Equipment Design chapter of the Shock & Vibration Handbook. The method leverages the proportionality relationship between modal velocity and stress. The presentation summarizes the rationale for the approach and provides illustrative examples across shock and vibration. Limitations of the method are discussed.

SESSION 13: UNDEX SIMULATION & DOUBLY ASYMPTOTIC APPROXIMATION

EFFICIENT SIMULATION OF SUBMARINE UNDERWATER BLAST USING THE DOUBLY ASYMPTOTIC APPROXIMATION (DAA)

Jason Krist, Siemens

Accurate prediction of submarine structural response to underwater blast (UNDEX) loading remains a critical requirement for survivability assessment, design evaluation, and shock qualification. However, high-fidelity fluid-structure interaction methods for UNDEX analysis can be computationally expensive and difficult to apply during early design studies, trade assessments, and large-scale parametric investigations. This presentation examines the use of the Doubly Asymptotic Approximation (DAA) as an

efficient method for simulating underwater blast effects on submarine structures while maintaining the key physics needed for engineering decision-making.

The DAA approach provides a practical boundary element representation of the surrounding fluid, enabling analysts to capture important acoustic radiation and added-mass effects without the cost of fully discretizing the fluid domain. For submarine applications, this offers a valuable balance between computational efficiency and response fidelity, particularly when evaluating shock loading on pressure hull structures and attached internal systems. The presentation will review the underlying assumptions of the DAA method, its applicability to submerged naval platforms, and key considerations for model setup, including structural-fluid coupling, treatment of blast loading, boundary conditions, and interpretation of results.

Emphasis will be placed on the engineering questions most relevant to analysts and designers: When is DAA an appropriate choice for UNDEX simulation? What aspects of the submarine response can be captured reliably, and where are the important limitations? How should results be used in the context of design screening, vulnerability assessment, and comparison to more detailed methods or test data? The discussion will highlight the role of DAA in reducing model turnaround time, supporting sensitivity studies, and improving insight into load paths and dominant response mechanisms.

By focusing on a representative submarine structural model, this presentation will show how DAA-based analysis can support practical shock and vibration workflows for underwater blast problems. Attendees will gain a clearer understanding of how this method can be integrated into naval structural assessment processes to improve efficiency while preserving confidence in the simulation results.

UNDERWATER SHOCK AND WHIPPING ANALYSIS OF COMPOSITE NAVAL SHIP STRUCTURE USING TRIDENT DAA SOFTWARE

Dr. Sergio G. Arias, Lloyd's Register

Dr. Lei Jiang, Lloyd's Register Advisory

Dr. T.S. Koko, Lloyd's Register Advisory

Tom MacAdam, Lloyd's Register Advisory

The doubly asymptotic approximation (DAA) is a proven method for underwater shock and whipping assessment of naval vessels. DAA and other fluid-structure interaction methods are available in the Trident software by Lloyd's Register. This software is a robust and well tested finite element analysis (FEA) tool which has been used mainly for steel structures. Now, the methodology has been updated to deal with ship structures made of advanced composite materials. This paper showcases an example for modeling and UNDEX analysis of a generic naval vessel constructed entirely of composite materials. Highlights of the composite structure modeling capabilities and how the DAA method has been adopted for composite structures will be comprehensively discussed. The paper will demonstrate how composite failure criteria such as the Tsai-Wu failure criterion has been used for computing the ship's UNDEX capacities and whipping indices. Lastly, it will illustrate how the new Trident features can be easily utilized as a design and analysis tool to predict performance of composite structures subjected to UNDEX loads.

VALIDATION OF A GEERS-HUNTER UNDEX LOADING MODEL COUPLED WITH OPENRADIOSS USING VIPER CORAL

Andrew Nicholson, Viper Applied Science

Elliott Cuccioli, ENSTA University

Peter McDonald, Viper Applied Science

James Wurster, Viper Applied Science

This paper presents the development and validation of an underwater explosion shock loading capability for transient structural response analysis in OpenRadioss. The work focuses on the integration of an in-house Geers-Hunter based UNDEX loading model with OpenRadioss, enabling efficient simulation of structural response to underwater shock without requiring a fully coupled fluid-structure CFD calculation for every case.

The Geers-Hunter implementation is assessed through a series of representative validation problems, with structural response predictions compared against results generated using Viper CORAL, Viper's in-house UNDEX CFD code. The comparison examines key response quantities, including pressure-time loading characteristics, impulse transfer, deformation, and transient structural response. This provides a practical basis for assessing the accuracy and limits of the reduced-order Geers-Hunter approach when applied to engineering-scale UNDEX problems.

The study demonstrates how the Geers-Hunter/OpenRadioss workflow can provide a computationally efficient loading methodology for UNDEX response problems in regimes where full CFD simulation is not required. The paper will discuss model setup, coupling methodology, validation results, and practical considerations for selecting between reduced-order Geers-Hunter loading and higher-fidelity Viper CORAL analysis.

SESSION 14: ANALYSIS TECHNIQUES

A PARAMETERIZED SHOCK WAVEFORM MODEL FOR IMPROVED MECHANICAL SHOCK SYNTHESIS

Garrett Wiles, NSWCDahlgren

A unique fundamental shock waveform has been formulated for the characterization of surface ship mechanical shock. This waveform, dubbed the "Piecewise Exponential Function (PEF) Waveform", has served as the foundation for synthesizing realistic shipboard shock time-histories using only shock spectra. Synthesis techniques bolstered by data-driven optimization algorithms allow the PEF Waveform to be expanded into multi-modal applications using a large-scale parameter identification approach. Evidence that broadband SRS matching is feasible while maintaining time-history characteristics will be presented. Development history, applications, and current efforts using the PEF Waveform will be discussed.

PARAMETRIC OPTIMIZATION OF BOX AND REMOVAL (BARC) MODELS FOR SHOCK TESTING

Jason Krist, Siemens

Box and Removal Component (BARC) models are widely used in shock and vibration qualification workflows to represent equipment mass, stiffness, interface conditions, and mounting characteristics when actual hardware is unavailable, immature, or impractical to test. For government engineers supporting naval, aerospace, and laboratory test programs, BARC models provide a critical bridge between system integration, fixture design, and dynamic test planning. However, traditional BARC

development often relies on manual geometry updates, analyst judgment, and iterative finite element rework, which can limit responsiveness and design-space understanding.

This presentation describes a parametric optimization workflow for rapid development and refinement of BARC models using integrated parametric CAD, structural analysis, and automated design exploration technologies. The approach treats key BARC characteristics — such as envelope geometry, wall thickness, internal stiffening layout, mass distribution, center of gravity, mounting interface details, and dynamic response targets — as design variables in a connected digital process. Automated studies are then used to evaluate sensitivity, identify feasible design regions, and converge on BARC configurations that better satisfy competing requirements for mass properties, static strength, manufacturability, and modal or frequency response behavior.

The work builds on prior efforts in parametric structural modeling and design-space exploration, extending those ideas to the specific needs of shock and vibration test article representation. Particular attention is given to use cases relevant to SAVE participants, including surrogate hardware for qualification by similarity, early-stage fixture and test setup development, and efficient generation of BARC families for multiple equipment variants. Results demonstrate how a parametric optimization framework can reduce manual model rebuild effort, improve traceability of assumptions, and provide a more defensible basis for matching target dynamic characteristics. The methodology also supports faster trade studies when requirements evolve, such as changes in payload weight, interface constraints, or frequency placement goals.

Rather than presenting BARC design as a one-off modeling exercise, this work frames it as a repeatable and scalable process that can improve consistency across programs and organizations. The presentation will discuss workflow architecture, representative optimization objectives and constraints, and lessons learned from applying the method to a BARC case study intended for vibration testing applications. The goal is to provide attendees with practical insight into how parametric optimization methods can strengthen BARC model development, reduce schedule risk, and improve confidence in test-correlated surrogate designs.

AI SURROGATE MODELS FOR SHOCK AND VIBRATION ANALYSIS OF A SHIP STRUCTURE

Jason Krist, Siemens

The accurate assessment of structural integrity under dynamic loading conditions, particularly shock and vibration, is paramount for high-performance systems in defense and aerospace applications. Traditional high-fidelity finite element analysis (FEA) of complex structures, such as naval vessels, while providing detailed insights, often demands significant computational resources and time. This presents a challenge for design optimization, rapid trade studies, and uncertainty quantification, especially when exploring a vast design space.

This presentation introduces a novel approach to significantly accelerate shock and vibration analysis through the development of mesh-based surrogate models. We leverage advanced machine learning techniques to create highly accurate, physics-informed representations of complex structural responses. Our methodology begins with a comprehensive set of shock frequency response simulations, performed using industry-standard FEA software on a detailed structural ship model. These simulations systematically explore a wide range of design variations, where geometric features of the FEA model are parametrically altered using advanced meshing and morphing tools, and various material and boundary condition parameters are systematically swapped.

The resulting high-dimensional simulation data, encompassing a spectrum of shock and vibration characteristics, serves as the foundation for training our AI-driven surrogate model. This model effectively learns the intricate, non-linear relationships between input design parameters and the corresponding structural responses, such as accelerations, stresses, and displacements across critical locations. By capturing these underlying physics, the surrogate model can then predict the shock and vibration behavior of new, unseen design configurations with remarkable speed and accuracy, bypassing the need for computationally expensive full-scale FEA runs.

The benefits of this approach are particularly relevant to engineers working with large simulation datasets. This presentation will demonstrate how these AI-driven surrogate models enable rapid design exploration by significantly reducing the time required to evaluate numerous design iterations, facilitating more thorough optimization studies. They also provide real-time performance prediction, offering near-instantaneous predictions of structural response to shock and vibration, aiding in rapid decision-making. Furthermore, this methodology allows for efficient uncertainty quantification, assessing the impact of design and operational uncertainties on system performance, and drastically reduces the computational cost needed for extensive parametric studies.

We will discuss the architecture of the AI model, the strategies employed for data generation and model training, and present compelling examples showcasing the accuracy and efficiency of this methodology in predicting shock frequency response for a ship-like structure. This approach offers a powerful pathway for engineers to unlock the full potential of their existing simulation data, leading to more robust, resilient, and efficiently designed systems.

FINITE CELL METHOD FOR QUICK-TURN VIBRATION ANALYSIS AND MAC-BASED CORRELATION

Jason Krist, Siemens

Engineers supporting shock and vibration qualification often face a difficult tradeoff between analysis speed and modeling fidelity. Traditional finite element workflows can require significant time for geometry cleanup, defeaturing, meshing, contact definition, and solver tuning before useful dynamic results are available. For test support activities—especially when hardware schedules are tight and rapid insight is needed—this overhead can limit the practical use of simulation. This presentation examines a meshless-style structural and thermal analysis approach based on advanced numerical approximation methods that operate directly on CAD geometry and avoid the conventional element-by-element meshing process.

The paper will describe the core calculation concepts that make this approach possible, including high-order solution approximations, adaptive local enrichment, and methods for representing connections and contact across complex assembled structures without requiring conformal meshes. By embedding the solution formulation directly around geometric features and regions of interest, the method can efficiently capture global stiffness, local load paths, and modal behavior for complex parts and assemblies. The presentation will discuss how these techniques support linear static, modal, and thermal analyses with substantially reduced preprocessing effort compared to traditional finite element methods, while still producing accuracy appropriate for engineering decision-making.

Particular emphasis will be placed on shock and vibration applications where engineers need rapid turnaround to estimate resonant frequencies, mode shapes, stiffness trends, and boundary-condition sensitivity before or during test campaigns. For many component- and subsystem-level problems, the

method enables analysts to move from native CAD to usable results in far less time, making it practical to evaluate design variations, fixture concepts, mounting schemes, and test anomalies on compressed schedules. The resulting workflow is especially relevant to organizations that must support frequent design-test iteration with limited analysis resources.

The presentation will also address the role of simulation correlation in a test-driven environment. Modal results produced by this class of solver can be exported for Modal Assurance Criterion (MAC) evaluation, enabling direct comparison between predicted and measured mode shapes. This provides a practical path for checking whether the reduced-modeling-effort approach captures the dominant dynamic characteristics needed for test interpretation and model confidence. For engineers engaged in qualification, survivability, and vibration response assessment, the combination of faster setup, faster solution times, and reasonable correlation capability offers a useful alternative for quick-look analysis and test support.

PREDICTION OF NASA SHOCKSAT FRANGIBLE JOINT SHOCK ENVIRONMENTS – DERIVING THE FORCING FUNCTION

Joshua Gorfain, Quartus

Frangible joint separation systems are a common source of the most severe pyroshock environments encountered during launch. The complexities of ordnance device functional performance along with its line-like configuration results in a completely unknown forcing function that cannot be measured directly by testing. Industry standard practices rely solely on empirical methods based upon previous response measurements, known to be highly uncertain and lacking information on the true shock excitation. A novel simulation approach for end-to-end prediction of ordnance-induced shock environments has been presented previously. Here, this coupled hydrocode-explicit dynamics technique is applied to NASA ShockSat frangible joint tests. A key element of this technique is the analytical derivation of the unknown forcing function, in-situ. Fully predictive simulation results are directly compared to experimental measurements. Accuracy of correlation is discussed along with insightful observations on the nature of the frangible-joint induced environment. This work shows that credible results from physics-based simulation of this challenging pyroshock event are possible.

SESSION 15: DYSMAS III

HIGH FIDELITY MODELING OF SHOCK HOLING AGAINST A GENERIC SUBMARINE PRESSURE HULL

Rachael Busby, NSW Indian Head

Dr. Jeff St. Clair, NSW Indian Head

Both full and scaled testing of shock holing against submarines can be economically difficult to complete. In lieu of physical testing, high-fidelity hydrocodes can be used to generate large virtual data sets that can feed into the development of damage rules or fast running models typically utilized within vulnerability and lethality codes. Testing can then be limited to the most promising scenarios, which can be used further as modeling and simulation (M&S) validation. This presentation discusses a collaborative effort between the UK and US Navies to model large-scale near-contact underwater explosion (UNDEX) events against a generic externally-framed submarine pressure hull using each nation's preferred hydrocode and modeling methodologies. The analysis compares Dynamic System Mechanics Advanced Simulation (DYSMAS) generated results from Naval Surface Warfare Center Indian Head Division to those generated by the UK team's coupled hydrocode, UK-JAC. These comparisons will provide valuable

feedback to the Anti-Submarine Warfare (ASW) communities of both nations and their lethality modelers that will build up these larger datasets for foreign threat targets of interest.

SHOCK HOLING TESTING AGAINST A SCALED PRESSURE HULL

Rachael Busby, NSWC Indian Head

Jeff St. Clair, NSWC Indian Head

Reece Roehsler, NSWC Carderock

Jason Craft, NSWC Carderock

Katherine Knowles, ATR

High-fidelity hydrocodes can be used to generate large virtual data sets to supplement development of damage rules or fast running models typically used within vulnerability and lethality codes. Scaled testing to validate the high-fidelity hydrocode analyses instills confidence in the virtual data set. In this test series, a small-scale framed pressure hull was loaded by an underwater explosion (UNDEX) shock wave. This presentation discusses the modeling and simulation (M&S) predictions that guided the test series, test details, and target damage resulting from the UNDEX events.

HIGH SPEED, SCALED WEAPON PENETRATION TESTING AGAINST A POPULATED MARITIME STRUCTURE

Andrew Cammenga, NAWC China Lake

David Spencer, NAWC China Lake

Rachael Busby, NSWC Indian Head

Horacio Nochetto, NSWC Indian Head

Dr. Jeff St. Clair, NSWC Indian Head

There is continual interest regarding high speed strike weapons and their effectiveness against maritime targets. Significant effort has been placed on understanding weapon lethality and target vulnerability in both water entry and through-target mission configurations for underkeel and internal attack. The primary objective of the test series presented was to characterize the through-target scenario with representative shipboard objects between scaled deck plates to support future weapons development and high-fidelity modeling validation. The test series was executed at NAWC China Lake's Weapons Survivability Lab (WSL). Test details, high speed images, target damage, and vehicle accelerations are discussed along with conclusions and lessons learned for future modeling and testing efforts.

DYSMAS SIMULATIONS OF HIGH SPEED WEAPON PENETRATION AGAINST A POPULATED MARITIME STRUCTURE

Horacio Nochetto, NSWC Indian Head

Rachael Busby, NSWC Indian Head

Dr. Jeff St. Clair, NSWC Indian Head

There is a continual interest regarding high-speed strike weapons and their effectiveness against maritime targets. This presentation summarized recent DYSMAS predictive analyses and validation efforts, including the modeling of penetration tests recently performed at NAWC China Lake's Weapons Survivability Lab (WSL). DYSMAS analyses are described, and the results presented and compared to test results when applicable. Metrics of interest include plastic deformation and overall weapon damage as well as fuze accelerations are analyzed to determine weapon survivability during the penetration event.

SESSION 16: HYDROSTATIC IMPLOSION AND UNDEX

COMPOSITE PRESSURE VESSEL HYDROSTATIC IMPLOSION MODELING AND TESTING PART 1

Dr. Benjamin Medina, NSWCCD Carderock

Elio Cusi, NSWCCD Carderock

This work describes the development of analysis procedures to predict the hydrostatic implosion pulse of submerged composite pressure housings. Analysis results are compared to novel fiberglass and carbon fiber composite cylinder implosion tests conducted at NSWCCD. The analysis method uses the DYSMAS hydrocode to predict the implosion pulses. Composite damage model and element deletion parameters were generated to capture the failure modes observed from testing. Solid elements are used to model the through thickness geometry of the composite structures compared to thinner metallic structures which can often utilize thin shell elements. The proposed analysis procedure utilizes vectorized matrix operations to perform simultaneous 3D material axes rotations across large finite element datasets in order to properly define arbitrary fiber orientations across different material plies. It implements the Rodrigues Rotation Formula to ensure precise, gimbal-lock-free transformations with maximum computational efficiency.

COMPOSITE PRESSURE VESSEL HYDROSTATIC IMPLOSION MODELING AND TESTING PART 2

Elio Cusi, NSWCCD Carderock

Dr. Benjamin Medina, NSWCCD Carderock

This work describes the development of analysis procedures to predict the hydrostatic implosion pulse of submerged composite pressure housings. Analysis results are compared to novel fiberglass and carbon fiber composite cylinder implosion tests conducted at NSWCCD. The analysis method uses the DYSMAS hydrocode to predict the implosion pulses. Composite damage model and element deletion parameters were generated to capture the failure modes observed from testing. Solid elements are used to model the through thickness geometry of the composite structures compared to thinner metallic structures which can often utilize thin shell elements. The proposed analysis procedure utilizes vectorized matrix operations to perform simultaneous 3D material axes rotations across large finite element datasets in order to properly define arbitrary fiber orientations across different material plies. It implements the Rodrigues Rotation Formula to ensure precise, gimbal-lock-free transformations with maximum computational efficiency.

AUTOMATED HIGH FIDELITY LETHALITY ASSESSMENTS OF SUBVALUE MODEL

Gregory Gorman, Thornton Tomasetti

Nicholas Valm, Thornton Tomasetti

Christopher Craig, Thornton Tomasetti

Adam Hapij, Thornton Tomasetti

Rebecca Dickey, NSWCCD Carderock

Jonathan Lee, NSWCCD Carderock

A lethality assessment in the Submarine Vulnerability and Lethality Undersea Evaluator (SubVALUE) is fast-running and provides an analyst with a full range of scaled-effects from degraded mission performance to target destruction. However, there are scenarios where high-fidelity structural responses are required to gain better insight into structural response patterns. Presented in this work is the automated workflow to assess the UNDEX-induced structural response of a SubVALUE model using

the Elastic-Plastic Shell Analysis (EPSA) finite element program, including validated modeling methodologies. The automated EPSA assessment workflow generates the finite element model from a simplified definition of a subsurface asset, including the user-defined UNDEX loading scenarios, deploys the calculation, and post-processes the structural response.

AN APPLICATION OF THE IDU FRAMEWORK TO CREATE ML MODELS FOR HYDROSTATIC IMPLOSION

Dr. Abilash Nair, Thornton Tomasetti

Nicholas Valm, Thornton Tomasetti

Christopher Craig, Thornton Tomasetti

Adam Hapij, Thornton Tomasetti

Dr. Benjamin Medina, NSWCCardero

Dr. Joe Ambrico, NSWCCardero

Elio Cusi, NSWCCardero

The Implosion Database Utility is a tool that integrates Implosion data of Implodable volumes with machine learning modelling and training technology. In this talk we deploy a ML pipeline that (a) spawns coupled FSI calculations to sample under-represented regions of the Implodable parameter space, based on analytics of data contained within the IDU, (b) leverages data analytics on new data to discover trends and relationships between input and output parameters of interest, and (c) generates ML models that are verified and validated using datasets included in the Implosion database. In conclusion, we propose a framework to automate continuous learning and improvement of ML models.

TRAINING IV: SHOCK RESPONSE SPECTRUM PRIMER

SHOCK RESPONSE SPECTRUM PRIMER

Dr. Carl Sisemore, ShockMec Engineering

The shock response spectrum (SRS) is the most common way of characterizing transient excitation. The SRS is advantageous due to its ubiquity and ability to substantially reduce the shock data complexity to a manageable level. An overview of the origins and methods for calculating the SRS will be provided. The various types of shock spectra will be discussed in detail along with their applications. A comparison of SRS results from both classical and oscillatory shocks will be presented along with a discussion of the important characteristics of each type of shock when transformed to the SRS.

SESSION 17: ELASTOMERIC ISOLATION

BUSHING DYNAMIC STIFFNESS ESTIMATE FROM RANDOM VIBRATION TESTING

Dr. Ricky Stanfield, Corvid Technologies

Dung Chi Pham, Corvid Technologies

Richard Rakowski, Shock Tech

Darko Gjoreski, Shock Tech

An array of eight Shock Tech 71989-Series compliant ring and bushings were tested for vibration and shock isolation performance in a sounding rocket flight electronics vibration management application. Three different silicone and one fluoroelastomer variants of the bushing were evaluated, each with a different target stiffness constant. From these measurements, updated dynamic-load force-deflection profiles were produced and dynamic stiffness constants as a function of dynamic loading were

computed. Initial selection of these vibration isolating bushings was based on target stiffness constants computed from static-load force-deflection measurements made by Shock Tech. Corvid flight vibration testing included a series of random vibration, swept sine vibration, and half-sine mechanical shock tests of varying magnitudes. By determining the displacement of the isolated mass as a function of the time-varying force applied to the assembly during the vibration tests, a dynamic-load force-deflection profiles was generated. The static-load force-deflection profiles and the dynamic-load force-deflection profiles for each variant of the bushings are compared. The bushings also had a small damping constant which results in a small damping ratio for the array. This too was experimentally verified. Stiffness and damping performance across the three types of bushings were compared to assess changes needed to achieve optimal isolation in this application.

CONSIDERATIONS WHEN DEFINING TEST ENVIRONMENTS TO CHARACTERIZE ISOLATOR PERFORMANCE: HIGHLIGHTED BY A NEWLY DEVELOPED ELASTOMER

Grete Bressner, Hutchinson Aerospace & Industry

Elastomeric isolators are designed into systems to protect equipment and components from the damaging effects of shock and vibration. These isolators are frequently selected based on specific performance requirements, which in theory, is simple. The difficulty here is that due to the non-linear nature of elastomeric materials, the performance of these isolators is largely a function of the environment in which they are exposed to.

In practice, margins are often added to test specifications to ensure that there is satisfactory protection of the system that is being isolated. Unfortunately, this can lead to results that may not align with material characterization tests or in-service performance. Properties such as stiffness and damping can vary significantly with changes in strain, load, and temperature. Therefore, properly defining test specifications and understanding material correlation is key during the development of these systems.

This paper will explore the importance of establishing well defined and representative test parameters by comparing the effects of strain sensitivity and temperature dependence across different materials, including both high and low damped aerospace grade material, and a new family of elastomers, developed by Hutchinson and given the name XLT3, designed to minimize performance changes across a wide temperature range.

DESIGN AND DYNAMIC CHARACTERIZATION OF A STEWART PLATFORM INSPIRED PASSIVE VIBRATION ISOLATOR

Dr. Peter Woerner, KDS Dynamics

This paper presents the design and preliminary dynamic characterization of a passive vibration isolation architecture for harsh dynamic environments inspired by Stewart platforms. The work is motivated by the challenge of achieving low dynamic compliance while maintaining controlled displacement and adequate strength under combined static and dynamic loading.

In conventional isolation systems, reductions in dynamic stiffness are often coupled with increased static compliance, reduced load-carrying capability, and large displacement response. These effects limit applicability in load-bearing aerospace, naval, and other high shock and vibration environments. Isolator performance is also frequently dependent on payload-specific tuning. That is, system mass and boundary conditions strongly influence isolator performance.

The proposed architecture is based on a six-degree-of-freedom parallel kinematic system derived from Stewart platform concepts. The design emphasizes shaping modal response through structural configuration maintaining rigid kinematic connections. This allows the design to target desired frequency-dependent dynamic behavior while maintaining bounded displacement and sufficient strength under service conditions. This approach also reduces sensitivity to payload-specific tuning. The architecture is intended to remain compatible with conventional mounting and integration approaches for isolation systems.

Preliminary analysis is performed using finite element models and reduced-order representations to evaluate static load paths, stress distribution, strength limits, and modal characteristics. Dynamic response is assessed using frequency response functions and transmissibility estimates, with emphasis on identifying dominant modes governing isolation performance within the operational frequency range.

Experimental work is conducted on bench-top subcomponents. These include individual compliant strut elements and supporting substrate structures. Testing is used to characterize stiffness, strength, and dynamic behavior at the component level. These results validate design hypotheses. They also inform system and component level modeling assumptions. Full system integration testing of a complete six-degree-of-freedom platform remains ongoing.

A preliminary comparison is performed against representative wire rope isolator models. Reduced-order models represent the wire rope isolators for this comparison. The results contextualize the dominant natural frequency and isolation behavior of the proposed architecture. Differences in modal structure and stiffness distribution are observed relative to conventional isolator designs.

RESONANT CHARACTERISTICS OF THE PAYNE EFFECT

Noah Zimmerman, Raytheon

Dr. Peter Vo, Raytheon

Jay Paz, Raytheon

Teri Stoner, Raytheon

The Payne effect is often observed in filled elastomeric materials under small strain, cyclic, and dynamic loading conditions. It is characterized by a reduction in the storage modulus of rubber compounds as strain amplitude or vibration input increases. This study investigates the influence of this phenomenon on the transmissibility of a filled-rubber isolator excited by a flat random vibration profile with incrementally increased amplitudes. As input vibration amplitude increases, both isolator resonant frequency and dynamic amplification (Q) decrease. The findings from this work provide insights into the reversible dynamic behavior of filled elastomers for isolation systems that are sensitive to resonant frequency. For rubber-filled isolators that are highly sensitive to resonance, the influence of the Payne effect cannot be overlooked. In these cases, testing should be conducted using input levels that closely replicate real operating conditions.

SESSION 18: VIBRATION DATA ANALYSIS

POSSIBLE USAGE IF GENERAL SPECTRAL DENSITY THEORY FOR ENVIRONMENTAL SPECIFICATIONS

Neil Loychik, LANL

This presentation continues the investigation of General Spectral Density (GSD) theory, which decomposes arbitrary statistics into the frequency domain to characterize non-Gaussian behavior. Specifically, this work examines the feasibility of creating a statistical envelope for GSDs to support environmental specifications. The presentation briefly reintroduces skewness spectral density (SSD) and kurtosis spectral density (KSD) as spectral measures of non-Gaussian behavior. These transforms are applied to vibration data from a transportation container. Results show that non-Gaussian characteristics can be localized to specific frequencies and that the responses exhibit statistical dispersion consistent with point-to-point variability models. Finally, the presentation introduces the TRUE Qual project, an effort to develop the processes and procedures needed to use GSDs for qualification testing.

USING ADVANCED MATHEMATICS TO ENHANCE VIBRATION TESTING WHILE REDUCING OVERALL COSTS

Stewart Slykhous, Spectral Dynamics

Vibration testing and control were originally performed using fully analog systems, with filtering and control managed by complex electronic circuits. As digital technology advanced, these signals were digitized, enabling software algorithms to improve vibration measurement, generation, and control. Historically, digital signal processing was constrained by limited computing power, but recent advances have greatly accelerated the parallel computations needed for real-time operation. As a result, modern vibration measurement and control systems deliver improved structural analysis and more effective diagnostic data while reducing the need for costly motion-restriction accessories.

FFT SPECTROGRAM FOR DAMPING LOGARITHMIC DECUREMENT

Dr. Ricky Stanfield, Corvid Technologies

FFT spectrogram analysis of vibration data from a set of low sampling rate dead-blow hammer impulses applied to the boom of a sounding rocket launcher was used to identify natural frequencies and logarithmic decrement damping ratio. Sounding rocket launchers are surveyed and maintained periodically. Vibration data is not usually collected. In this case it was to support other analysis. Low frequency random vibration data was the objective. Dead-blow hammer impulses were applied simply to verify accelerometers were active. Out of curiosity, we processed the impulse responses. Data was sampled too slowly for typical SRS analysis. So, a classical PSD spectrogram was computed which showed the first few natural frequencies and, somewhat unexpectedly, clear rates of decay of each. We recomputed the spectrogram using FFT magnitudes instead of PSD magnitudes. We overlapped one-second long time domain data sets by all but one sample to generate the FFT spectrogram with high time resolution. We adjusted FFT size relative to sampling rate to achieve finer frequency resolution. A logarithmic decrement approach was applied to the FFT magnitude in each natural frequency bin over the duration of decaying oscillation which resulted in the unique damping ratio of the structure for each of its lower natural frequencies. These results were consistent for a full formal modal survey performed on a second identical launcher by a separate organization.

SESSION 19: BALLISTICS II

USING EPIC TO BUILD A MACHINE LEARNING DATABASE FOR STEEL PENETRATION

David Lichlyter, US Army ERDC

The U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC) Terminal Weapons Effects (TWE) program includes research on how steel fragments from exploding munitions penetrate steel targets. This research analyzes various steels, fragment sizes, and impact conditions to better understand these interactions. To efficiently evaluate the substantial variable set, a series of automated methods/tools were developed by the researchers. A key goal is to create a machine learning model for predictive analysis. To support this, the team used the EPIC software to conduct over 2,000 automated, high-fidelity simulations, validated against experimental data to ensure accuracy.

DEVELOPMENT AND IMPLEMENTATION OF MACHINE LEARNING MODELS FOR FRAGMENT TERMINAL PERFORMANCE PREDICTIONS

Christopher Shackelbord, US Army ERDC

David N. Lichlyter, US Army ERDC

Dr. T. Neil Williams, US Army ERDC

Dr. John Q. Ehrgott, Jr., US Army ERDC

A primary initiative of the U.S. Army Engineer Research and Development Center's Terminal Weapons Effects (TWE) program is to support and enhance the capabilities of the Warfighter through the development and improvement of fast-running weapons effects codes and tools. These tools need to accurately predict the weapon's terminal performance and lethality against structures and other critical targets. This initiative includes the enhancement of established fragment perforation algorithms without increasing computational overhead. By leveraging historical, experimental, and validated simulation data, modern machine learning (ML) technology provides a capacity to achieve this goal. Once trained, ML models can be integrated into established analytical methods for predicting steel-on-steel impacts, potentially improving accuracy and expanding the predictive bounds of the algorithm. The work presented here details the development of ML models utilizing validated fragment terminal performance data and their implementation into fast-running weapon effects codes to predict damage from fragmenting munitions against structural targets.

COMPARATIVE ANALYSIS BETWEEN PREDICTIVE METHODS AND EXPERIMENTAL DATA OF SHAPED CHARGE JET PENETRATION INTO CONCRETE

Glynn Harrington, US Army ERDC

Understanding the penetration dynamics of shaped-charge jets into concrete targets is critical for evaluating structural survivability, designing hardened structures, and weapon design. This study presents an extensive comparison of analytical prediction modes against experimental penetration data focusing on concrete targets. The experimental data were selected to represent a broad range of test configurations, including variations in the shaped-charge liner geometry and material, explosive type, charge size, standoff distance, and target strength. These configurations produced depth-of-penetration measurements that were used to evaluate model performance. Comparing predictions with the wide-ranging experimental database provides insight into the accuracy and applicability of each prediction method for varying cases. The results provide a basis for validating and refining existing predictive

methodologies while supporting the continued development and accreditation of predictive tools used in protective structure vulnerability assessments and weaponeering.

EXTENSION OF THE FORRESTAL PENETRATION EQUATIONS TO CONCRETE PERFORATION INCORPORATING VELOCITY-DEPENDENT TARGET RESISTANCE

Dr. Kyle Crosby, US Army ERDC

No abstract available.

TRAINING V: INTRODUCTION TO MULTI SHAKER TESTING

INTRODUCTION TO MULTI SHAKER TESTING

Raman Sridharan, Data Physics/NVT Group

This training course will cover the basics of multi shaker (MIMO) testing. The training will begin with a focus on a two shaker setup and expand to cover full 6 Degree of Freedom (DOF) testing. The training will utilize a live dual shaker table to reinforce concepts and offer attendees insight into the challenges of multi-shaker and Multi-DoF control.

The course will include:

- Vibration Fundamentals
- Digital representation of a vibrating system
- Degrees of Freedom
- Effect of modes
- Multi-Shaker Control
- Common Multi-Shaker Configurations
- Concepts behind Impedance Matched Multi Axis Testing (IMMAT)

TRAINING VI: INTERPRETING FINITE ELEMENT RESULTS

INTERPRETING FINITE ELEMENT RESULTS

Barton McPheeters, Leidos Gibbs & Cox

It is a special skill to build a big finite element model and run it, but when the run finishes, you're only halfway there. Then you have to interpret the results. This can be fraught with just as many issues as the actual model construction and debugging. This class will discuss the different kinds of element and nodal results available from most finite element analysis (FEA) programs. The class will focus on the more common FEA outputs and discuss implications of output locations in the element, type of result presented and different display techniques. Some common pitfalls in interpreting results will be covered, such as element stress averaging, result orientation, and choosing the right result vector. We will touch on some sanity checks that can be done to assure that the results actually make sense, including both hand checks and Pre/Post diagnostics.

TRAINING VII: INTRODUCTION TO HEAVYWEIGHT SHOCK TESTING

INTRODUCTION TO HEAVYWEIGHT SHOCK TESTING

Jeff Morris, HI-TEST Laboratories

An understanding of both the history and physics of mass ratio are presented. For the layperson, the ratio requirement was introduced into the shock specifications to keep the tail from wagging the dog. Onboard Navy ships, decks are typically relatively massive compared to the equipment installed so that under shock loadings, the deck drives the equipment.

In the shock qualification test world, the goal is to simulate the physics onboard shipboard installations in order to demonstrate the survivability or shock hardness of shipboard equipment during an underwater explosion (UNDEX) event. There are several parameters that affect whether or not a test setup reasonably simulates the shipboard installation. This presentation discusses the impact of mass ratio on heavyweight shock tests and applicable parameters established in MIL-DTL-901E.

SESSION 20: MIL-STD-167 VIBRATION & SHIPBOARD TEST METHODOLOGIES

STANDARDS DRIVEN SYNTHESIS AND DELIVERY OF SHAKER TEST PROGRAMMES

Neil McRae, Thornton Tomasetti

Gavin Colliar, Thornton Tomasetti

This paper describes practical approaches to the development and delivery of shaker test programmes, where requirements are shaped by multiple governing standards, engineering baselines and by operational processes. Drawing on UK and US programme requirements, this addresses the full cycle, from initial request definition and scope clarification through contract review, planning, scheduling and test delivery.

Particular attention is given to the technical feeds and applying chronologies that ensure the success of shaker programmes. These include resolving ambiguity in the test request, deriving a technically justified basis, maintaining representativeness of the intended service environment replication; and avoiding adding cost, delay or compromises that do not improve program outcomes. The paper examines how these decisions affect test configuration control, schedule resilience and the credibility of the final results.

The management disciplines utilised include management by facts, Plan-Do-Check-Act, process-based control, constraint management, competency management, client-focused project management, and integrated risk and safety management. These are discussed in the context of the ISO/IEC 17025 framework, to suitably align technical quality, configuration control and delivery effectiveness.

The paper concludes that robust shaker programme delivery is achieved not only through standards compliance, but through integrating correctly selected elements from standards, with engineering judgement and solid programme processes. This combined approach provides a coherent basis for reducing programme risk and assuring compliant delivery of shaker test projects.

UPDATE TO SHIPBOARD VIBRATION TEST METHODOLOGIES

Dr. Luke Martin, NSWC Dahlgren

For the first time since the release of MIL-STD-810G in 2008, significant updates to the U.S. Navy's shipboard vibration test methodologies are being introduced in the upcoming MIL-STD-810J revision. This paper details the technical rationale and scope of these changes, which affect both Method 528, "Mechanical Vibrations of Shipboard Equipment," and Method 514, "Vibration."

Method 528, which was largely transposed from MIL-STD-167-1A, has been revised to formally permit alternative and tailored testing approaches, particularly for complex Combat and Aviation Systems. This modernization was driven by a body of work at NSWC Dahlgren where a tailoring philosophy has been adopted for large combat weapon systems.

Concurrently, the shipboard vibration section of Method 514, which previously had limited historical traceability, has been updated. The motivation for this change was to establish a vibration test specification clearly traceable to shipboard environments, specifically addressing the requirements for shipboard cargo. This paper will outline these critical updates, explain their technical basis, and discuss their impact on future shipboard equipment qualification.

SESSION 21: NEXT GENERATION SHOCK RESPONSE SPECTRUM

SRS-BASED TRANSFER FUNCTIONS: A NUMERICAL STUDY

Daniel Bluedorn, Sandia National Laboratories

Dr. Evan Saunders, Sandia National Laboratories

In the shock testing of engineered components and systems, the primary goal is to identify the damage susceptibility of a device under test (DUT) to a given shock environment. To this end, the shock response spectrum (SRS) is a staple of shock testing and analysis. Past research has investigated a generalization of shock analysis by developing SRS-based "transfer functions" to predict the response of a DUT under an arbitrary shock loading. Further, several standards documents such as from MIL-STD and NASA present curves formed as the ratios of SRSs in order to predict SRSs at locations downstream from a pyroshock. However, it would be valuable to examine the validity of these methods in greater detail. The present work applies the SRS-based transfer function method to an 8-DOF spring-mass-dashpot structure. Classical transmissibility response functions are developed along with SRS-based transfer functions via initial shock test data. Then, data from a second shock test is used to predict responses and evaluate the accuracy of the SRS-based transfer function scheme and alternative methods. Variants of the DUT are also examined under the addition of nonlinear terms to assess the limits of applicability of this approach.

MODAL SHOCK RESPONSE SPECTRUM

Dr. Evan Saunders, Sandia National Laboratories

Troy Skousen, Sandia National Laboratories

Randy Mayes, Sandia National Laboratories

The shock response spectrum (SRS) has long served as the standard tool for shock qualification specifications and testing. However, it provides greater insight into the base excitation than into the response of the actual device under test (DUT). This paper proposes a modal shock response spectrum

(MSRS) that uses the same base input while directly characterizing the vibratory response of the DUT. Similar to the way the SRS represents the peak response of a series of hypothetical single-degree-of-freedom oscillators, the MSRS represents the peak response of each fixed-base mode of the DUT. Unlike the SRS, which must be recalculated separately for each translational input axis, the MSRS can capture the DUT response for one to six degree-of-freedom base excitation within a single plot. An analytical example is presented to illustrate the concept.

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SHOCK TIME SERIES SYNTHESIS VIA MULTIPLE WAVELET ENSEMBLE METHOD

Syed Raza, Los Alamos National Laboratory

Dr. Dustin Harvey, Los Alamos National Laboratory

Adam Watts, Los Alamos National Laboratory

A Shock Response Spectrum (SRS) is calculated from a system of Single Degree of Freedom (SDoF) oscillators responding to a transient acceleration (shock). An SRS is derived from environmental data recorded from a material or payload responding to a given shock. The SRS generated from the field data is simulated with artificial shocks in a test environment. Traditional SRS testing attempts to search or optimize for shocks that meet a given SRS; however, does not always map accurately to the given SRS. In test engineering, finding and delivering an adequate shock that replicates a target SRS is essential. A computational solution to find an adequate shock is to synthesize shocks until it meets a given SRS. However, synthesizing shocks from an SRS creates a non-trivial high dimensionality time domain search problem. The classical algorithm to synthesize shocks is Sum of Decayed Sines (SDS). Conventional SDS creates an output, but it is not completely representative of the field shock environments. Current methods at Los Alamos National Lab (LANL) uses ML to digitally reconstruct SRS through a few different times-series wavelet bases like SDS. The LANL ML strategy is deterministic based on the wavelet bases inputted and leaves a gap for additional synthetic data generation to enhance the ML solution. Within this study, additional wavelet bases are implemented to the synthetic training data to create an ensemble of wavelets that is more representative of field shock environments. The additional benefit of increased combinations of wavelets is to give multiple possible solutions for test engineers to match a target SRS, advancing past non-diverse solution sets provided by existing methods.

SESSION 22: PACKAGING & ISOLATING FOR SHOCK SURVIVABILITY

SHOCK QUALIFIED PAYLOAD STOWAGE SOLUTIONS FOR SUBMARINE APPLICATIONS

Teresa Gangi, NUWC Newport

Naval Undersea Warfare Center Division, Newport (NUWC DIVNPT) has developed a wide variety of shock-qualified stowage solutions, approved for use in the torpedo rooms of various classes of United States submarines. The stowage solutions—ranging from flat stowage pallets to electronics racks—provide a flexible means to safely stow and access undersea vehicles and their associated payloads, electronics, spare parts, and Temporary Alteration (TEMPALT) equipment. The flat plate stowage solutions maximize flexibility and available space for integrating various undersea vehicles in the torpedo room. Additionally, electronics enclosure racks were developed for stowing payload electronics,

enabling sailors to control and monitor vehicle operations from the torpedo room. Undersea vehicle and TEMPALT hardware developers can leverage these existing solutions to integrate new undersea vehicles onto submarines while maintaining shock qualification and avoiding the cost of developing new stowage hardware. This presentation describes available torpedo room shock-qualified stowage solutions.

HIGH ENERGY ROPE MOUNT ISOLATOR RELAXATION

Javier Garcia-Rivera, Raytheon

The HERM (High Energy Rope Mount) is commonly used for NAVY shock isolation and rafted deck systems to attenuate UNDEX shock inputs transmitted into sensitive electronics equipment. The HERM is composed of a steel wire rope mount encased in a proprietary elastomer formulation. Testing indicates that HERM isolators experience relaxation as they reach their excursion limits. The change in isolator response directly correlates to the acceleration transmitted into the sensitive electronics equipment and the ability to functionally operate through a qualification level event.

A comprehensive evaluation was performed to characterize cyclical isolator relaxation. The isolator load deflection curves are measured using an INSTRON machine as the isolator is cycled through its limits. An isolator break-in process was developed to exercise the isolators to a prescribed deflection range and thereby achieve a desired consistent cabinet shock response in alignment with pretest analysis and design. The isolator relaxation process was successfully demonstrated during recent SPY-6 MIL-DTL-901E Shock testing.

PREDICTING COMPLEX SHOCK FAILURE MODES OF SPECIALIZED PACKAGING AND HANDLING SYSTEMS USING EXPLICIT NON-LINEAR FEA

Aayush Gandhi, Naval PHST Center

The development of robust packaging and container systems for high-value assets necessitates rigorous design validation to prevent costly failures during physical testing and deployment. This paper demonstrates the efficacy of employing explicit non-linear Finite Element Analysis (FEA) to predict complex failure modes in specialized containers and pallets subjected to severe shock loading. Two case studies are presented to validate the use of LS-Dyna, a transient dynamic simulation software, as a critical tool in the pre-production design phase. The first case examines a Navy ordnance container prototype that unexpectedly failed a vertical drop test due to the bottom plate rebounding from shock loading, a failure mode not predicted by antecedent static analysis. The subsequent explicit dynamic simulation accurately replicated the location and nature of the deformation observed in the physical test. The second case presents a strong correlation between the simulated deformation of a container undergoing both a cornerwise drop and a rough forklift handling event, and the results of the corresponding physical tests. These findings conclude that integrating high-fidelity, event-based simulation into the design process provides crucial engineering insights, enabling the early identification and mitigation of critical design flaws. This predictive approach significantly reduces program risk, minimizes the need for costly iterative prototyping, and de-risks the procurement cycle.

VALIDATING FEA MODELS FOR WIRE ROPE ISOLATION SYSTEMS AGAINST ANALYTICAL METHODS

Justin Lam, Naval PHST Center

To enhance predictive analysis capabilities for complex payloads, a study was performed for comparative evaluation of modal analysis techniques applied to an isolation system utilizing wire rope isolators. Two parallel approaches were conducted to evaluate the dynamic response of a naval

commodity mounted on a 14-isolator array. The first approach utilized an analytical mathematical model, developed from established industry reference standards, to calculate the natural frequencies, mode shapes, and Equivalent Modal Mass Ratios (MMRs) for the first six modes. The second approach employed a detailed Finite Element Analysis (FEA) to simulate the system's dynamic behavior.

By comparing the two methods and isolating individual parameters through simplified scenarios, a robust set of best practices for validating FEA simulation setups were established. Application of these techniques yielded FEA results that aligned with the analytical baseline, demonstrating an average deviation of 0.91% for the first 5 modes. The 6th mode was found to vary by 30.92%. This variance is due to the analytical model's assumption of a rigid body as opposed to the flexible body in the FEA. The flexible modeling in the FEA provides a more accurate simulation of real behavior versus the analytical model.

SESSION 23: BLAST CHARACTERIZATION

PLASTIC BONDED EXPLOSIVE PERFORMANCE UNDER VACUUM

Noah Meisner, Karagozian & Case, Inc

Michael Vena, Karagozian & Case, Inc.

Daniel Portillo, Southwest Research Institute

Nicholas Oberts, Karagozian & Case, Inc.

Joseph Magallanes, Karagozian & Case, Inc.

Characterization of high explosives for both military and industrial use are typically focused on terrestrial environments. While there is a wide breadth of domain knowledge and test data available for high explosive detonations in atmosphere, characterization of explosive performance in vacuum conditions is lacking from the literature. Understanding the performance and characteristics of military grade explosives is critical to advancing technology for spaceflight applications and military campaign efforts for dominance of the extraterrestrial realm.

Karagozian and Case, Inc., in partnership with Southwest Research Institute (SwRI) engaged in a modeling and simulation effort coupled with a rapid test campaign designed to characterize the performance of PBXN-5 and PBXN-110 under various vacuum conditions. The tests were conducted at SwRI in the “Minnesota Tank” which is blast rated up to 5lb TNT equivalent, and capable of reducing ambient pressure down to 5 torr. Pressure and impulse measurements were taken along with quasi-static pressure buildup in the tank after detonation in atmospheric conditions and vacuum (5 torr) conditions.

Additionally, explosives were tested against thin steel plates to determine their effectiveness of imparting load onto structural elements under vacuum conditions. 16 tests were performed. 10 explosive tests to characterize explosive performance and 6 tests with plates where structural response was considered. This presentation will discuss the numerical modelling approach of simulating explosive detonation in vacuum using ArunaCFD, K&C’s in-house compressible multi-phase chemically reacting finite-volume computational fluid dynamics software. There will be discussion about the test setup, results, comparisons with simulation pre-test predictions for both blast and structural response, and conclusions and recommendations for future work.

AUTONOMOUS MOMENTUM GAGE FOR MUTIPHASE FLOW

Dr. Paul Cammarata, Applied Research Associates

Damian Camo, Applied Research Associates

Dr. Robert Abernathy, Defense Threat Reduction Agency

Raul Reyes, Applied Research Associates

Grant Spear, Applied Research Associates

Dr. Sean Cooper, Applied Research Associates

Kiran Shah, Defense Threat Reduction Agency

In an explosive event, a key parameter of interest is the loading applied to exposed structures. The blast loads depend on dynamic pressure, which is conventionally defined as the difference between stagnation and static overpressures measured by pressure transducers. However, this is inadequate for multiphase flows since pressure transducers only measure the air pressure, not the effect of entrained debris in the blast loading. To obtain a more complete understanding of the loads as a function of time, a novel instrument, the Autonomous Momentum Gage (AMG) was developed in coordination with the Defense Threat Reduction Agency as part of the Instrumentation and Infrastructure Research and Development and Upgrades effort. The basic principle behind the AMG is the measurement of acceleration and rotation of an article that moves with the flow of a blast. After data corrections and integrations, the three-dimensional velocity and position over time of the AMG is derived yielding a time history of the dynamic pressure impulse from the multiphase blast. This study builds on the experience using a lower range AMG for the Medium Scale Shock Tube as previously presented at MABS. This study also involves high-g loading between 120 g and 6,000 g whereby a pendulum was used to further statistically evaluate the tracking algorithm using high speed camera data as the ground truth. We will present in-house algorithmic results compared to the results from the Sensor Fusion Toolbox in MATLAB, both relative to the ground truth video data.

EMPIRICAL DATA OF THE BLAST OVERPRESSURE (BOP) ENVIRONMENT INSIDE A DEPARTMENT OF WAR TACTICAL BREACHING TRAINING FACILITY

Deborah C. Lockett Weatherspoon, US Army ERDC

Dr. Kellan M. Sullivan, US Army ERDC

Dr. Catherine S. Stephens, US Army ERDC

Traumatic brain injury (TBI) remains a critical health concern across the military, prompting increased effort to reduce blast exposures for the Warfighter during both combat engagements and routine training operations. Recent research, outside of the medical field, has increasingly focused on characterizing the blast overpressure (BOP) environments that have resulted in known TBI diagnoses. Among the environments identified as presenting elevated TBI risk are indoor or enclosed spaces involving repeated exposure to internal detonations. Therefore, when training for tactical breaching occurs in indoor training facilities, personnel can experience multiple BOP exposures over the course of the training. The cumulative effects of repeated detonations can create a complex BOP environment in which the resulting pressure-time histories no longer resemble the Friedlander waveform (i.e., the typical airblast pressure-time history).

To better understand the BOP environment during tactical breaching training, the U.S. Army Engineer Research and Development Center (ERDC) conducted experiments to characterize blast conditions inside a room of a shoot house at Ft. Bragg's Training Facility. For each experiment, a single explosive breaching charge was placed on a steel plate positioned within a door frame and oriented toward the interior of the room to mimic the use of a breaching charge on a door. A steel plate was utilized to allow

multiple experiments to be completed without having to replace the door after every experiment. Multiple pressure gauges measured the resulting airblast pressure-time histories at different locations within the room. The experimental methodology and subsequent empirical datasets are presented across multiple detonation scenarios. Ultimately, the empirical data set advances the understanding of complex BOP environments within tactical breaching training facilities.

BLAST DOSE ACCUMULATION METHODOLOGY

Noah Meisner, Karagozian & Case, Inc
Joseph Hamilton, Karagozian & Case, Inc
Dr. Youcai Wu, Karagozian & Case, Inc
Dr. William Chen-Mertens, Karagozian & Case, Inc
Jonathan Raygoza, Karagozian & Case, Inc
Isabela Cardenas, Karagozian & Case, Inc
Joseph Magallanes, Karagozian & Case, Inc.
Dr. Michael Shields, Johns Hopkins University,
Dr. Allison Nelson, Virginia Tech
Dr. Pamela VandeVord, Virginia Tech

This presentation introduces an extensible modeling and simulation (M&S) framework for modeling and interpreting blast dose accumulation into the brain from single and multiple blast exposures. There are currently significant gaps in M&S tools for understanding the effects of single or repeated blast overpressure exposure and blast-induced Traumatic Brain Injury (b-TBI) on service members. Acute single-insult blasts cause injuries that are complex and depend on many factors like the exposure level (e.g., pressure and impulse), orientation, among anatomical and biological factors. Furthermore, the community recognizes that lower-level b-TBI injuries can occur from multiple repeated, low-level blast doses. Examples are sub-concussive b-TBI injuries, like those common during training and operation of heavy weapon systems, which remain poorly understood and difficult to quantify [1]. Existing modeling approaches are limited by anatomical fidelity, statistical variations, challenges in simulating fluid-structure interactions (FSI) in the brain, and the absence of validated methods to link physical exposure to clinical injury outcomes. As a result, both researchers and mission planners lack reliable tools to assess risk, particularly for complex blast environments.

The Blast Dose Accumulation Methodology, or BDAM, is introduced in this presentation as a possible path for the community to realize a computational toolset capable of modeling individual blast events and predict cumulative injury risk across repeated exposures. There are three important aspects of BDAM that are discussed in this presentation. The first are person-specific human head models that can be rapidly created based on MRI data. This aspect of BDAM is made possible by using specific MRI data ingested and used with a meshfree Reproducing Kernel Particle Method (RKPM) solver, FEMFRE, to conduct brain exposure computational solid dynamics (CSD) simulations. We demonstrate the use of these models with viscoelastic constitutive models, including several time-dependent and adjustable integral output response metrics that show promise to cumulate doses into the brain over multiple exposures. We demonstrate use of these output metrics, in contrast with those used in the past by previous researchers, and how cumulative metrics like these could be used to relate to risk of injury. The second aspect is FSI simulations of the blast and the meshfree human head models. We demonstrate these simulations with three different heavy weapon systems, including a mortar, the Carl-Gustaf, and M777 Howitzer modeled using a finite-volume multi-phase chemically reacting computational fluid dynamics software, ArunaCFD. These are three very different weapon systems that can expose servicemembers to varying levels of pressure/impulse levels. We use the computational model to

evaluate the accumulation of these damage metrics over number of exposures to demonstrate use of BDAM to generate statistical data from any number of exposures. Finally, we introduce the concepts of a fast-running tool based on the results of these simulations, and the laboratory and clinical data that is needed to realize the tool.

This work establishes the technical feasibility of BDAM and delivers a foundational framework for modeling and quantifying cumulative blast exposure risk.

PANEL DISCUSSION: INTEGRATING ARTIFICIAL INTELLIGENCE (AI) INTO ENVIRONMENTAL QUALIFICATION TESTING (EQT)

PANEL DISCUSSION: INTEGRATING ARTIFICIAL INTELLIGENCE (AI) INTO ENVIRONMENTAL QUALIFICATION TESTING (EQT)

Allison Vella, Leidos Gibbs & Cox

Greg Budriss, NSW Philadelphi

This panel will examine the opportunities and challenges associated with integrating Artificial Intelligence (AI) into Environmental Qualification Testing (EQT), specifically with shock, vibration, and electromagnetic interference (EMI) applications. AI has the potential to improve efficiency, technical accuracy, consistency, and affordability by extracting information from engineering drawings, identifying applicable test requirements, supporting shock-isolator selection, automating data analysis, and assisting with the preparation and review of test reports and submittal packages. These capabilities may help address recurring issues identified by technical authorities, reduce administrative burdens, accelerate design and construction processes, and improve the quality and timeliness of EQT decisions. At the same time, AI adoption introduces important disadvantages and concerns, including the risk of inaccurate or incomplete outputs, inadequate understanding of engineering context, inconsistent results across platforms, cybersecurity and data-protection vulnerabilities, uncertainty regarding accountability and approval authority, potential overreliance on automated recommendations, and the need to preserve qualified human judgment in safety-critical environments.

The discussion will bring together government, shipyard, contractor, vendors, and technical-authority perspectives to assess current AI practices, share lessons learned, identify common pain points, and explore practical safeguards for responsible implementation. Particular attention will be given to developing common terminology, data standards, validation and verification practices, documentation requirements, user training, governance processes, and mechanisms for human review. Through an open forum and collaborative brainstorming session, participants will consider how organizations can create greater cohesiveness by coordinating AI initiatives, centralizing and standardizing appropriate tools and workflows, establishing trusted sources of technical data, and defining clear boundaries for AI-supported decisions.

The panel will ultimately focus on developing a shared, disciplined approach that captures AI's benefits while managing its risks and ensuring that its use strengthens (not replaces) the expertise, accountability, and technical rigor essential to military EQT.

TRAINING VIII: INTRODUCTION TO LIGHTWEIGHT SHOCK TESTING

INTRODUCTION TO LIGHTWEIGHT SHOCK TESTING

Jeff Morris, HI-TEST Laboratories

This training will cover the necessary background information relative to lightweight shock testing per MIL-DTL-901E. This session is intended for engineers and product developers who are unfamiliar with the lightweight shock testing process. Subjects covered include pre-test planning, fixture selection, test set-up, test operations, and reporting. Some aspects of lightweight shock machine operation will be covered. Shock test requirements applicable to lightweight shock testing will be discussed.

SESSION 24: INSTRUMENTATION FOR DYNAMIC TESTING

HIGH-G SHOCK ACCELEROMETERS: DAMPED VS. UNDAMPED

James Nelson, PCB Piezotronics

Picking the right sensor for your test can be mystifying, with spec sheets that include a lot of information, but not always the information you are looking for. Oftentimes there are key differences between the options which aren't always stated in plain English. When choosing an accelerometer for high-g shock testing, eventually the question arises whether to pick a damped or undamped accelerometer. Each type has its advantages and disadvantages. Damped sensors are more robust, while undamped ones are extremely linear. Damped sensors may attenuate high frequency content while undamped sensors may amplify it. Additionally, damped sensors may introduce a mild time lag, or "phase delay", compared to the input event. The choice on whether to go damped or undamped is a tradeoff, and should be evaluated for each use case.

This paper will outline the usage of piezoresistive MEMS accelerometers for shock data acquisition, and the various considerations when deciding on a damped or undamped shock accelerometer for your tests. Example data will be provided for direct comparisons between damped and undamped models in simultaneous testing, including lower G ranges (2,000g) and higher G ranges (60,000g). Sensors will be evaluated for various performance characteristics such as phase delay, amplitude linearity, resonance, and frequency response. The paper will provide additional technical context to aid in the general accelerometer selection process.

AN IMPROVED FLASH TEST FOR PRESSURE TRANSDUCER DESIGN

John Hilton, Kulite Semiconductor Products

Cameron Stekelenburg, Kulite Semiconductor Products

Steve Carter, Kulite Semiconductor Products

Joseph VanDeWeert, Kulite Semiconductor Products

Flash Sensitivity Testing has been a standard practice in validation of pressure transducers manufactured for blast testing since the 1950s. The purpose of flash testing is to characterize a transducer's sensitivity to light/temperature gradient/flash. The method prescribed in the 1950s, still technically the standard, requires igniting a No. 25 Flash Bulb 2 feet from the transducer face. Unfortunately, No. 25 bulbs are no longer manufactured and so a replacement procedure must be found. Flashbulbs are also understood to have large variation from bulb-to-bulb, stemming from the legacy manufacturing techniques used to produce them. Our goal was to develop an alternative test

method that is repeatable from test-to-test and facility-to-facility. Our approach is to compare test results from flashbulbs and modern electric bulbs side-by-side and scale the output to generate a fair comparison. We find that an electric flash can produce consistent transducer outputs with similar characteristics to that of the legacy flashbulbs. Electrical flash bulbs can also produce shorter, higher peak intensity flashes that allow for more sensitive control of flash mitigation while keeping the overall energy imparted by the test consistent with the legacy approach. In addition, we compare the effects of well-known flash mitigation methods on transducer flash sensitivity using the new method. This comparison matches well with previous testing of flash mitigation methods using flash bulbs.

HIGH-SPEED IMAGING & PYTHON SCRIPTING FOR VIBRATION EXTRACTION

Prof. Kyle Gilroy, Vision Research/Phantom Cameras

In this talk, we will discuss how high speed imaging coupled with open-source Python scripts can be used to characterize a wide range of shock and vibration environments, namely for non-contact displacement and vibration extraction and quantification. Some applications include characterization of mechanical shock, drop and impact testing, shaker tables tests, and explosive events. Critical considerations such as precise synchronization with data acquisition systems, reliable triggering, high intensity lighting, data integrity, and camera survivability under high G shock and sustained vibration will be addressed. The session will feature real world test examples and the challenges presented therein.

MIL-DTL-901 SUBSIDIARY SHOCK PROGRAM DEVELOPMENT UPDATES – PRINCIPAL UNIT TESTING AND MODEL DEVELOPMENT

Matthew Forman, NSWC Dahlgren

Dr. Bryan Joyce, NSWC Dahlgren

Navy electronics cabinets require periodic updates to internal components throughout its lifecycle due to obsolescence or performance improvements. MIL-DTL-901 qualification requires any changes made to a previously qualified principal unit must be accompanied by a new principal unit test or qualification extension with supporting rationale and OQE (i.e. subsidiary component shock test). Each subsidiary component shock test requires upfront DAA/TWH discussions, analysis, and review prior to test. NSWC Dahlgren Division (NSWCDD) in collaboration with NAVSEA 05P1 has developed a notional standardized process for new electronics cabinet programs to follow, allowing the creation of “Subsidiary Shock Process Documents.”

Updates to the standardized process with an ongoing electronics cabinet program will be presented and will cover lessons learned with respect to instrumentation placement, data collection, and FEA modeling techniques.

SESSION 25: LAB & FLIGHT PYROSHOCK

ISOLATION PROPERTIES OF CUBESAT MOUNT ASSEMBLY

Darko Gjoreski, Shock Tech

Richard Rakowski, Shock Tech, Inc.

Shane Jansen, Shock Tech, Inc.

Pyroshock attenuation and vibration mitigation in spacecraft structures is commonly evaluated using performance characteristics of individual mounts. Catalog specification sheets typically list axial and

radial stiffness, frequency at nominal loads and damping for individual mounts. However, the dynamic behavior of a multi mount system can differ significantly due to load distribution, structural coupling, and rotational frequency modes. Expanding on the previous work investigating damped-sine synthesis methods for pyroshock analysis using discrete dynamic modeling, this paper examines the relationship between individual mount performance and system level response. Analytical models were developed to compare single mount behavior against a representative CubeSat Mount assembly subjected to pyrotechnic shock and flight vibration environments. Differences in transmitted acceleration, transmissibility and strain dependent stiffness and damping are investigated. Laboratory testing is also performed to validate analytical predictions and quantify the extent to which system level dynamics alters the performance effectiveness observed in component (individual mount) level testing. The results demonstrate that mount performance measured independently may not directly correlate to assembled system response, highlighting the importance of integrated dynamic analysis and testing for spacecraft qualification and isolation design.

DAMPING TREATMENTS AND BOUNDARY CONDITIONS IN RESONANT PLATE SHOCK TESTING AND THEIR EFFECT ON THE PLATE'S MODAL RESPONSE

Dr. Carl Sisemore, ShockMec Engineering

Pyroshock testing in the laboratory is frequently performed on a resonant plate shock test machine. Due to the inherently short duration of most pyroshock events, the testing traditionally involves the use of some type of damping treatment to control pulse duration. However, some damping treatments can alter the modal response of the resonant plate either directly or by corrupting the intended boundary condition. If the modal response is altered, the plate will typically vibrate at a frequency quite different from the intended frequency, sometimes resulting in an out of tolerance test. Modal analysis of resonant plates, whether experimental or from finite element modeling, is a powerful tool for studying the possible dynamic characteristic of the system. However, the actual response can only be determined once loads are applied to the physical system. In order to understand which resonant plate modes are excited and to what extent, it is necessary to apply a high shock load and examine the response from that particular load. The problem is further complicated when the boundary condition is uncertain. Mathematically pure boundary conditions are difficult to obtain and suspending a resonant plate does not necessarily guarantee a free boundary. This paper presents the results of multiple resonant plate shock test experiments that show how various damping treatments can alter a resonant plate's boundary condition and by extension, the plate's vibration response under high-shock loading conditions.

REUSABLE AERIAL DELIVERY EQUIPMENT

Dr. Daryoush Allaei, QRDC, Inc.

Msgt. Drew Holsenback, QRDC

Prof. Arezoo Emdadi, Missouri Univ. of Science and Technology

During the past two SAVE symposiums (2024 & 2025), advancements in reusable aerial delivery equipment were discussed. This exhibition will provide an update on newly integrated features, enhanced performance, and statistics regarding aerial deliveries conducted across multiple Air Force bases.

Aerial delivery platforms, including the Container Delivery System (CDS), facilitate the transportation of equipment that exceeds the load capacity of individual paratroopers, as well as consolidated supplies for ground units. Since their inception during the Korean and Vietnam Wars (1950–1975), CDS platforms

have evolved to operate effectively under challenging conditions such as darkness and adverse weather, enabling aircraft to resupply troops without compromising their positions. The efficiency of CDS bundles has made them the predominant method for both military and humanitarian airdrop operations. Currently, approximately eighty-five to ninety percent of U.S. military airdrops are dedicated to training riggers, loading personnel, and aircrew members. Frequently deployed CDS bundles typically range from 550 to 2,200 pounds. Although our reusable equipment was originally designed for CDS airdrop training, it is also compatible with other airdrop platforms, including CEPs, LCLAs, and Door Bundles.

Reusable equipment has supplanted expendable materials—such as cardboard honeycomb and plywood skid boards—which previously could only sustain one to three uses before becoming unsuitable for further deployment. The adoption of reusable aerial delivery equipment has improved Air Force readiness by supporting or increasing the volume of airdrop training flights for aircrews. Diminishing availability of expendable products due to supply chain challenges has underscored the value of reusable solutions, which are manufactured in Minnesota and classified as USA-made products. These reusable items are now successfully employed at twelve Air Force bases in the United States, Germany, and Japan. Their performance has consistently met or exceeded customer expectations, prompting several Air Force bases to fully transition to reusable equipment.

SESSION 25: COMBINED SHOCK & VIBRATION CHARACTERIZATION & TESTING

COMBINED VIBRATION AND SHOCK TESTING DEVELOPMENT

Dr. Jim DeClerck, Michigan Technological University

Dr. Cora Taylor, Michigan Technological University

David Soine, Sandia National Laboratories

Steve Carter, Sandia National Laboratories

Field environments often subject components to simultaneous shock and vibration. Recreating these combined environments in a laboratory is challenging because standard vibration shakers are not designed to handle the heavy feedback loads caused by shock testing.

Prior to solving this problem, we must first determine if a combined test is truly necessary to accurately predict a component's lifespan. The high-intensity shock event might render the vibration environment negligible, or conversely, the ambient vibration could create a critical stochastic initial condition that severely compounds the shock's impact.

Therefore, the goal of this work is to evaluate the necessity of introducing these combined environments. Additionally, this work demonstrates developments in a minimal footprint testing method that approximates these combined field environments without risking damage to laboratory equipment.

SESSION 26: SHOCK TESTING MODELING & METHODS

A METHOD FOR RECOVERING STRUCTURAL EFFECTIVE MASS IN A COUPLED ACOUSTIC-STRUCTURAL MODAL ANALYSIS USING THE STRUCTURAL MASS MATRIX

Pedro Jimenez, Newport News Shipbuilding

For an analysis of a structure submerged in fluid, it is necessary to capture the effects of fluid-structure interaction by modeling the fluid using acoustic elements. For a modal analysis, results like effective mass per mode are of importance for further analysis. Low effective masses are reported for an Abaqus frequency extraction of a submerged structure, where the fluid is modeled with acoustic elements, using the Lanczos eigensolver with acoustic-structural coupling enabled. Low reported values arise as a result of using the combined acoustic-structural mass matrix in the effective mass calculation. A method for recovering structural effective mass is proposed that does not include the dilution effects of the surrounding fluid.

IMPROVING SHOCK MODELING AND SIMULATION REQUIREMENTS AND CRITERIA FOR SURFACE COMBATANTS

Steve Arturo, Newport News Shipbuilding

Modeling and Simulation (M&S) is increasingly desired as a cost effective alternative for shock qualification of equipment for Navy surface combatants. For complex problems that the Dynamic Design Analysis Method (DDAM) is not well suited to address, transient shock analysis (TSA) offers an alternative to physical testing. Current NAVSEA guidance identifies the required contents of a TSA verification, validation and accreditation (VV&A) package, including model assumptions, quantities of interest and acceptance criteria, but it does not describe how a TSA should be developed or evaluated. As a result, critical analytical judgments depend on a small group of experienced practitioners. An NSRP funded effort led by Huntington Ingalls Industries and NSWC Carderock Division 661 is creating a detailed TSA guidance document for NAVSEA 05P1 review. The effort will be described with focus on objectives, approach, and anticipated benefits.

APPLICATION OF CONTINUOUS HIGH AMPLITUDE BIDIRECTIONAL FORCE SYSTEM (CHABFS) ISOLATION SYSTEMS OF US NAVY SHIPBOARD EQUIPMENT TO MINIMIZE EXCURSIONS OF, AND TRANSMITTED ACCELERATIONS TO, ISOLATED EQUIPMENT

Dr. Christopher Merrill, CMA& Engineering

This paper explores the application of Continuous High Amplitude Bidirectional Force System (CHABFS) isolation systems as an optimal means for isolating US Navy shipboard equipment from shock excitations. This work assesses the effectiveness of CHABFS isolation in minimizing excursions and transmitted accelerations during MIL-DTL-901E shock transient events. The paper introduces a straightforward methodology for developing CHABFS-based isolation systems by normalizing traditional elastic and damping forces into a selected CHABFS force with an absolute value dependent on maximum allowable excursion and sensitive equipment shock sensitivity (maximum shock excitation) of the equipment. This approach ensures that the isolated mass acceleration closely approaches, but does not exceed, the maximum shock acceleration specified for shipboard equipment during transient events. The process is founded with classical analysis and validated through numerical simulations of a single-degree-of-freedom (SDOF) model subjected to MIL-DTL-901E shock profiles. This analysis considers elastic spring forces, viscous damping, and the optimal CHABFS force functions, allowing for a comprehensive comparison of performance. By analyzing the SDOF system with elastic, damping, and

CHABFS forces individually and collectively, the simulation will demonstrate that, given sufficient excursion capacity and equipment fragility limits, the proposed CHABFS system can potentially reduce excursion from traditional shock isolators by approximately 50%, depending on the shock magnitude, frequency, shape, and phase characteristics of the shock excitation. Configuration of CHABFS isolators suggest that the optimal CHABFS system would be compatible with the form, fit, and function of current isolators, enabling both future shock isolation designs and retrofit applications for existing Navy systems. This approach offers a promising avenue for enhancing shock mitigation capabilities while maintaining practical implementation standards.

Expected Result: Comparison of the numerical analysis of the SDOF example with elastic springs and with or without the proposed hybrid damping will result in a 30% to 50% reduction in excursion with no increase in the maximum transmitted acceleration for the SDOF analytical case with superposed elastic stiffness and proposed hybrid damping.

SUBMARINE UNDERWATER EXPLOSION TESTING

Johan Jeppsson, Saab

For more than half a century Saab Naval has maintained a world leading position in submarine shock design through a systematic program of research, development and testing. Central to this expertise is the continuous execution of controlled shock trials on both scale models and operational submarines. Unlike laboratory tests, shock tests of complete and manned submarines provide a unique validation platform. They confirm the robustness of the hull, assess the performance of internal systems, and generate high fidelity data that feed back into design optimization, measurement methodology development, and risk mitigation studies for future submarine designs.

This presentation traces the evolution of Saab Kockums' shock testing practice from its inception in the 1940s to the present day. It highlights the methodological framework that links test planning, instrumentation, and post test analysis, and it illustrates how the acquired data have been used to:

- Validate and refine computational shock response models.
- Evaluate innovative concepts and material selections.

The results of this shock testing legacy have repeatedly confirmed that Saab Naval submarines meet or exceed the shock resistance requirements of naval customers, thereby delivering a tangible confidence benefit to operators and crew. Moreover, the systematic knowledge base generated by the full scale trials has become a strategic asset, enabling rapid assessment of design practices and new concepts.

By examining the historical trajectory, technical achievements, and future implications of Saab Naval's explosive testing legacy, the talk underscores how disciplined, data driven experimentation can sustain technological superiority in the demanding field of submarine engineering.

SHOCK QUALIFICATION OF HAZARDOUS EQUIPMENT USING A PORTABLE SHOCK TEST MACHINE

Liam Rayner, Thornton Tomasetti

Gavin Colliar, Thornton Tomasetti

This presentation describes the shock qualification of hazardous equipment using the portable shock test machine JASSO. The equipment under test can range from batteries both lithium-ion and lead-acid all the way to live ordnance, requiring a testing approach that combines shock engineering with robust safety management.

This presentation will outline the process used to plan and execute these tests, with particular emphasis on risk assessment, safety mitigation measures, and the analysis undertaken to determine safe working distances. These considerations are especially important where a catastrophic failure is possible, for example during battery thermal runaway or the response of energetic items. The portability of the shock machine also allows testing to be undertaken at remote locations, thereby reducing risk to personnel and facilities.

In, addition, the presentation will explain how JASSO operates and how it can be configured to deliver both standard and non-standard shock responses. Particular attention will be given to the methods used to tailor the machine to customer-specific requirements while maintaining safe and controlled test conditions.

Overall, the paper will show how portable shock testing can be applied to hazardous equipment in a manner that is technically robust, operationally flexible, and proportionate to the safety risks involved.

SESSION 27: STRUCTURAL RESPONSE & FRM DEVELOPMENT

BRIDGE AND PIER VULNERABILITY: SUBSCALE DECK BREACHING EXPERIMENTS FOR FAST-RUNNING MODEL ENHANCEMENT

Gabriel Riveros, US Army ERDC

The strategic importance of military logistical networks necessitates accurate predictions of weapon effects against critical infrastructure, such as bridges and piers. To address this requirement, the US Army Engineer Research and Development Center (ERDC) is generating high-fidelity weapon-effect and structural-response data through targeted experimental testing. This data will validate predictive lethality codes, enabling the weaponeering community to optimize precision-strike weapons and minimize collateral damage to vital infrastructure.

Bridge and pier deck slabs (10 × 10 ft; 8, 12, and 16 in. thick) were cast from 6000-psi conventional strength Portland limestone cement (CSPLC) concrete with 1.2–1.7% reinforcement. These targets were subjected to bare and cased cylindrical charges at impact angles of 0° to 60°.

The study considers the effects of charge casing, concrete thickness, steel reinforcement ratio, and angle of incidence on the resulting damage. By comparing the performance of bare charges against cased charges, which adds significant fragmentation damage, this research quantifies the damage mechanisms associated with each. The variation in slab thickness and reinforcement provides crucial data points for understanding failure thresholds and the transition from spalling and cratering to complete perforation. Furthermore, the systematic variation of impact angles allows for a detailed characterization of how obliquity influences energy transfer and the geometric extent of damage.

The results of this comprehensive test series will provide data essential for refining the computational tools used in mission planning. By enhancing the fidelity of weapon-effect predictions, this research directly supports the strategic objective of disabling critical logistical links effectively while ensuring the most efficient use of advanced weaponry.

EFFECTS OF VARYING VENT GEOMETRIES ON BLAST INTRUSION OF EXTERNALLY DETONATED BARE CHARGES IN SCALED STRUCTURES

Patrick Camacho, US Army ERDC

Bowen G. Woodson, US Army ERDC

Shelby B. Buckley, US Army ERDC

Austin C. Hopkins, US Army ERDC

Accurate prediction of blast loads entering structures is critical for assessing the vulnerability of facilities and safeguarding personnel. To support the continued validation and enhancement of fast-running models (FRMs), the U.S. Army Engineer Research and Development Center (ERDC), under the Terminal Weapons Effects program, conducted a series of twenty-four 1/6-scale experiments to characterize the blast environment in and around a structure subjected to an external detonation. The experimental setup consisted of a concrete box culvert with bolted steel plates on the front and back. The back plate sealed the rear of the structure. The front plate, designed with a vent opening, was interchangeable, allowing for plates with different vent geometries to evaluate their effects on blast wave ingress. The setup was instrumented with incident overpressure, reflected pressure, and internal pressure gauges, while the explosive events were captured using high-speed videography. A 32-gram bare Composition C-4 charge was detonated at standoffs of 7.5, 15, and 30 in. from the structure. To evaluate the effects of vent geometries on blast intrusion, three distinct vent configurations were evaluated: a circular window, a rectangular window, and a floor-aligned rectangular door. The results of these experiments provide critical validation points for refining blast predictive models, utilized in ERDC's BlastX tool. This presentation discusses the findings from these scaled experiments and compares the results from the three varying vent geometries.

EVALUATING EXPEDIENT OVERHEAD COVER SOLUTIONS FOR SURVIVABILITY FROM EMERGING THREATS

Marcus Barksdale, US Army ERDC

Gabriel Riveros, US Army ERDC

George Kantrales, US Army ERDC

Omar Esquilin-Mangual, US Army ERDC

One-Way Unmanned Aerial System (OWUAS) attacks on critical infrastructure are a pressing challenge in modern warfare, creating an urgent need for rapidly deployable, cost-effective protective structures. To address this, the U.S. Army Engineer Research and Development Center (ERDC) developed an experimental series to evaluate expeditionary overhead cover (OHC) systems using Class IV materials. Designs were evaluated for both constructability and performance against a range of surrogate OWUAS payloads. These experiments demonstrated high survivability and rapid constructability, achieving a construction rate of under one hour per square meter (h/m^2) of protected space. This presentation details the experimental evaluation, confirming this Class-IV OHC design series as a viable and effective countermeasure to OWUAS attacks.

Permission to publish was granted by the Director, Geotechnical & Structures Laboratory.

A PHYSICS-INFORMED EMPIRICAL MODEL FOR STRUCTURAL BREACHING UNDER CONTACT OR NEAR-FIELD EXPLOSIVE LOADING

Ernesto Cruz, US Army ERDC

Dr. Will McMahon, US Army ERDC

Dr. Photios Papados, US Army ERDC

Dr. Mark Adley, US Army ERDC

Jonathan Dahlem, US Army ERDC

Joshua Payne, US Army ERDC

Dr. Andrew Groeneveld, US Army ERDC

Predicting structural breaching and localized damage from contact and near-contact detonations is critical for evaluating infrastructure survivability and protective system performance. Existing empirical breach methodologies are often limited to idealized charge configurations and simplified loading assumptions, while high-fidelity finite element simulations remain computationally intensive for rapid engineering assessments. This paper presents an ongoing effort at the U.S. Army Engineer Research and Development Center (ERDC) under the Terminal Weapons Effects (TWE) program to develop a physics-informed empirical methodology for predicting localized structural damage from near-field explosive loading. The proposed approach incorporates physically based approximations to model extreme near-field blast effects. Specifically, the framework accounts for the coupled interaction between reflected shock pressures and expanding detonation products, which are the dominant drivers of contact and near-contact loading environments. Unlike traditional spherical-charge formulations, the proposed methodology explicitly accounts for weapon Length-to-Diameter (L/D) ratio and charge orientation relative to the target surface, enabling directional loading and asymmetric pressure distributions to be represented within an efficient empirical framework. The model combines segmented charge discretization, nonlinear impulse accumulation, and regime-dependent loading transitions to evaluate breaching, cratering, and spall damage in reinforced concrete targets. The proposed methodology incorporates key physical mechanisms that govern localized blast damage while maintaining highly efficient computational performance. Consequently, it provides practical intermediate capability, bridging the gap between overly simplified empirical correlations and computationally expensive finite element analyses.

TRAINING IX

AN INTRODUCTION TO DYNAMIC ANALYSIS

Barton McPheeters, Leidos Gibbs & Cox

Shock and Vibration are inherently dynamic phenomena. But what exactly makes a problem dynamic? And what types of analyses are available to me to evaluate a model for shock and vibration fitness? This class will discuss the different types of dynamic analysis techniques available, including normal modes analysis, forced vibration, transient analysis, random analysis and response spectrum analysis. A simple derivation of the governing equations as well as some practical definitions will be presented. The common applications of each type will be discussed as well as limitations of each.