SAVIAC
Shock and Vibration Information Analysis Center
Current Awareness
June 2005

Flex Template System (FTS)

Providing Advanced Damage Assessment of Building Structures

Editor's Note: This article was contributed by David Vaughn, Principal, Weidlinger Associates, Inc., one of this year's featured organizations. This article is intended to educate the community on the capabilities of our featured organizations. The views expressed here are not necessarily the views of SAVIAC.

Introduction

The ability to perform advanced, high fidelity simulations of a building's response to a terrorist bomb blast offers a powerful tool to better comprehend vulnerability assessments and enable the development of protective design technologies. Additionally, to be able to provide 3D animations with photorealistic quality showing a bomb's blast effect clearly demonstrates these effects to a non-technical audience of policymakers, military leaders, and protective building design engineers.

The Flex Template System (FTS) is a high technology blast analysis tool that simulates the deformation and damage to building structures from explosive threats. This allows FTS to accurately determine the structural impact of a terrorist bomb explosion on 3D building models. Additionally, the highly refined modeling approach used by FTS provides a visually rich set of results for visual presentation and education.

Background

FTS was developed by Weidlinger Associates, Inc. (WAI) to reduce the manpower intensive modeling time required to perform finite element analysis (FEA) simulations of structures subjected to blast. WAI's history of advancing the technology for blast, shock, impact, penetration, and vibration effects on military and civilian structures dates back to the 1950s. Their expertise is based on developing and applying state-of-the-art computational tools to a wide range of structural modeling applications. WAI develops, maintains, applies and licenses their software to government agencies and commercial companies.

Technology originally developed for missile silo hardness assessment and design is now being applied to the protection of commercial and government buildings against the threat of terrorist bomb explosions. The nonlinear (NL) version of the Flex software has the capability to compute the dynamic response of a structure through yield, failure and post-failure regimes. NLFlex is a first principles, state-of-the-art software package backed by a 20 year history of development, verification, and validation for blast-related studies.

FTS's unique capability to import SiteSeer survey data to

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Sam Feldman

The shock and vibration community lost long time associate Sam Feldman on the 14th of May 2005. He was a passenger in a car that was involved in an accident near his home in Rockville, Maryland. Sam was 88. He had a long and accomplished career with the Department of the Navy and as a professional consultant developing expertise in ship acoustics and vibration dynamics.

Sam attended Cooper Union Institute of Engineering in New York City, graduating in 1942 with a Bachelor of Electrical Engineering degree. He did post-graduate study work at Brooklyn Polytechnic Institute in acoustics and dynamics between 1949 and 1952. His career with the Navy started in 1940 in New York, and he held various positions involving vibration and noise control with

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Correction

The Sea Systems Live Fire Test and Evaluation Call for Papers announcement in the May 2005 newsletter did not include the Naval Sea Systems Command in the list of Navy activities "interested in reviewing new and emerging technologies that could improve the technical adequacy and cost effectiveness of sea systems (both system and component-level) survivability simulation and testing". As the organization charged with ensuring survivability of Naval platforms, this was a critical omission. SAVIAC regrets the error.

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the Bureau of Ships and the Navy Material Laboratory.

Sam moved his young family to Washington in the early 1950's and continued his career with the Navy. In 1956 Sam began work on the first of two major developmental programs that marked his career with the Navy. He was engaged in the Navy's Special Projects Office as Director of the Polaris Underwater Launch Program. He was responsible for the research and development associated with underwater launch of the missile including the hydrodynamics and structural dynamics of the missile as it was ejected from the submarine tube, its underwater flight, and then its transition to rocket powered flight in air. The successful underwater launch of the Polaris missile in 1959 and its operational deployment in 1960 had a profound impact on the relationship of the superpowers emerging from World War II, and was a significant development in the ensuing cold war.

In 1966 Sam was head of the Deep Vehicle Program of the Navy Deep Submergence Systems Project. The USS THRESHER had recently been lost, and the Navy needed a deep-sea rescue vehicle for submarines. The developmental program resulting in the DSRV included development and testing of: high-pressure capable spheres, a new generation of fully submersible machinery, high-capacity batteries and fuel cells, a new generation of undersea search sonar, support systems from both surface and submerged vessels, and a sophisticated coordinated control system. Two operational DSRVs were built and kept at the ready to be deployed rapidly to any of the world's oceans. One unit remains operational today and will be phased-out of service soon.

The contributions of these two programs to the nation were two of Sam's proudest achievements from his career with the Navy.

Starting in 1953 Sam was engaged as a professional consultant in the areas of noise and vibration, in addition to his work with the Navy. Ed Noonan, Bill Knopfle, and Sam were colleagues with similar expertise in vibration and acoustics of ships, and with the blessing of the Navy, partnered in NKF Engineering Associates, Inc. In 1971 Sam left the Navy and devoted full time to NKF. In 1979 the company had seven full-time employees and was purchased by three investors active in the Navy ship design community who saw the value of the small but highly competent consulting firm. Ed and Bill retired but Sam stayed on as a Senior Vice President and later Senior Consultant to the company. His technical expertise and accomplishments were invaluable to the growth of the company during this time.

Sam was also active during this period in the American National Standards Institute (ANSI), and the International Standards Organization (ISO), serving on four committees on shock, vibration, and machinery dynamics. He was also in demand as an expert witness for legal cases involving issues of machinery performance and failure, noise, and vibration.

Sam retired from NKF in 1995. He continued participation on the standards committees and enjoyed frequent travel with his wife, Golde. He remained active and was working on his memoirs at the time of his death.

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facilitate quick generation of structural models and its ability to automatically provide the Raven visualization software with high quality video animations of a building's response due to bomb blast effects makes it particularly useful for performing high fidelity vulnerability and threat assessments, improving protective building designs and clearly displaying the blast damage done to a structure..

FTS Features

FTS allows an engineer or blast analyst to easily develop 3D models of structures by defining structural components (columns, beams, slabs, and walls) and assembling those components to form standard building structures. In data sparse environments, the built-in building design expert system can size structural members according to overall building dimensions, number of floors, and locale-specific design practices while providing an extensible capability for the future. The FTS user can change any of the member parameters as necessary and appropriate. Since high fidelity models are computationally intensive, analyzing the blast effect on an entire building requires significant computing resources which are usually not available. Therefore, FTS allows any subsection of a building to be selected, exported, and analyzed automatically, so that model size may be tailored to meet the computational resources available. Additionally, FTS provides a 'component-by-component' analysis option in which detailed analysis of individual structural components are quickly performed and damage levels assessed, without the high cost of computing the response of larger structural assemblies.

With FTS, you can:

- Quickly define a detailed model of the structure
- Define and place the explosive threat near the building
- Choose a portion of the building to analyze
- Submit a high fidelity simulation of the building section of interest
- View an assessment of the damage level for each structural component contained in the computational model.

FTS has been rigorously validated against a wide range of experimental test data and actual bombing events.

Current Capabilities

FTS is an extensible system designed to address the types of structures and threats of interest to the counter-terror community. Its range of applicability is expected to expand over time. FTS currently supports the following building con-

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Tutorial Committee Update

The Tutorial Committee, chaired by Andy Anderson of United Defense, LP, met at ESTECH 2005 in Schaumberg, Il and reviewed the Shock and Vibration Tutorial Certificate Program. The idea behind the program is to offer tutorials at the Shock & Vibration Symposium, IEST's ESTECH, SEM's IMAC, and MFPT's Annual Meeting towards completion of a certificate of attendance. By providing the opportunity at many meetings, a student can complete the required coursework in a reasonable amount of time. Note that this is a certificate of attendance, which is different from a certification. Neither SAVIAC nor any of the participating Societies makes any warranty about the students abilities to perform a job after receiving a certificate.

The committee put together a tutorial matrix of potential courses grouped by subject and complexity (Beginning (B), Intermediate (I), and Advanced (A)) ranking. They plan on offering a number of them at this year's Symposium. In addition, the tutorials submitted by other instructors for the Symposium will be reviewed and Andy will contact the instructors to determine if they fit into the matrix. Final approval of the plan rests with the SAVIAC Director.

In addition to the chair, Andy Anderson, the committee consists of Curt Nelson, Team Corp., Dr. Robert Monson, Lockheed Martin, Yvonne Young, NavAir, Joel Leifer, SAVIAC, Erick Sjoblom, NavAir, Daniel Worth, NASA, Dr. Fred Nelson, Tufts U., Tom Paez, Sandia labs, Dave Ball, Andrews Corp., Phil Winters, Filtration Group, Stanley Poynor, Lockheed Martin, and Ed Dyer, UDLP. If you would like to join the committee, please contact Andy at Andy.Anderson@udlp.com.

Many thanks to all who gave of their time and expertise to make this happen.

Young Engineer's Forum

SAVIAC is please to announce the debut of the Young Engineer's Forum at the 76th Shock & Vibration Symposium. The forum, to be chaired by Margaret Tang of Weidlinger Associates, will provide an opportunity for younger engineers to network with their peers and develop the skills needed to move into leadership positions in the community. Mrs. Mary Lacey, PEO National Security Personnel System and Keynote Speaker at the 75th Shock & Vibration Symposium has agreed to address the forum. Others on the program include Prof Ted Krauthammer, Protective Technology Center, Penn State University who will describe how a building is assembled and a representative form General Dynamics Electric Boat who will show a video on how a submarine is constructed. There will also be a presentation on the SAVIAC sponsored Mentor Program and a discussion with the participants on the future direction of the Forum.

Details are still being worked out, but the Forum will be scheduled for Tuesday afternoon, November 1, after the last session but before the evening activities. Restrictions on attendees age for attendance has not yet been decided. If you have ideas for this Forum please e-mail them to Joel Leifer, joel.leifer@saviac.org or Margaret Tang, tang@wai.com. More details will be published on the web site, www.saviac.org, and in this newsletter as they become available.

Many thanks to Margaret for suggesting the Forum and agreeing to chair it and to all those offering suggestions and agreeing to make presentations to the attendees.

INDUSTRY NEWS

Miniature, Lightweight, Triaxial ICP® Accelerometer Family

The Vibration Division of PCB Piezotronics, Inc., introduces a new family of 0.45 inch (11.4mm) cube shaped triaxial accelerometers that simultaneously measure vibration in three orthogonal directions. PCB Models 356A30, A31, A34, and A35, which cover a sensitivity range from 5 mV/g to 100 mV/g and corresponding measurement range of 1,000 g to 50 g peak, are all TEDS compatible. In addition, Models 356A30 and A31 use an 8-32, 4-pin mini, electrical connector, while the Models 356A34 and A35 use a traditional 1/4-28 4-pin connector with positive keyway, both of which achieve the convenience of a removable cable without risk of bent pins. They are ideally suited to modal analysis of large rigid bodies, structural component testing, and general laboratory vibration work. This sensor family features built-in microelectronic signal conditioning circuitry which offers a low noise, low impedance output signal while permitting long distance signal transmission and simplicity of operation and is enclosed in a lightweight, hermetically sealed, titanium housing. The available TEDS (Transducer Electronic Data Sheet) option further simplifies set up of multiple sensor array testing. These durable designs are adhesive mounted, operate in -65 to +250 °F temperatures, and survive accidental shock inputs to 5000 g. For additional information, contact the Vibration Division of PCB Piezotronics, Inc. toll-free at 888-684-0013 (in the U.S. and Canada); E-mail: vibration@pcb.com; or fax at 716-685-3886. For other PCB products, contact PCB directly at 716-684-0001, or visit www.pcb.com.

Preamplifier with High-Pass Filter

The Vibration Division of PCB Piezotronics, Inc. introduces a new model to its line of acoustic products. Model 426A10 is a 1/2" preamplifier that operates from ICP® sensor power. The distinguishing feature for this preamplifier is the built-in 20 Hz high pass filter. This filter can improve resolution by minimizing unwanted low frequency sounds that may saturate the analyzer. The operating temperature on this new unit has been enhanced to -40° C to +80° C. The 426A10 has low noise specifications and great phase characteristics. The 426A10 terminates in a BNC connector and uses standard coaxial cables. This modern, prepolarized design allows for significant savings in power supplies and cabling, greater ease-of-use and operates from the same power required for ICP® accelerometers. This provides the advantage of using microphones with ICP® accelerometers in the same test, with the same signal conditioning equipment, and minimizes set-up time. For additional information, contact the Vibration Division of PCB Piezotronics, Inc. toll-free at 888-684-0013 (in the U.S. and Canada); E-mail: vibration@pcb.com; or fax at 716-685-3886. For other PCB products, contact PCB directly at 716-684-0001, or visit www.pcb.com.

Dynamic Impact ForceSensors Measure Millions of Cycles for Automotive Durability Testing

Piezoelectric dynamic impact force sensors from the Force/Torque Division of PCB Piezotronics, Inc., accurately measure dynamic impact force. These impact force sensors possess the necessary response and endurance to accurately follow fast-rising, repetitive and short-duration force events such as actuation or operation of various automotive accessories and components. The sensitivity of piezoelectric force sensors does not change with time, thus they are suitable for continuous automotive durability testing. Series 200B, 200C and 210B offer a variety of sizes and ranges and all feature a durable impact surface to evenly distribute impacts into the force sensor. ICP® and charge output versions are available; signal conditioning is also offered. Durability applications include compression, impact and fatigue testing of latches, doors, hoods, trunks, seats, springs, actuators, suspensions, chassis, brackets and other automotive accessories and components. For additional information, contact the Force/Torque Division of PCB Piezotronics, Inc. toll-free at 888-684-0004 (in the U.S. and Canada) or 716-684-0001; e-mail: force@pcb.com; fax 716-684-8877; or visit www.pcb.com.

New 16-Bit Rotary Torque Sensor System for Automotive Powertrain Dynamometers

TORKDISC® Rotary Torque Sensor System from the Force/Torque Division of PCB Piezotronics, Inc. is a compact in-line rotary torque sensor, ideally designed for automotive powertrain dynamometers and other torque measurement applications that require a robust torque transducer where axial space is at a premium. The TORKDISC® features a field proven telemetry system that consists of an on-board electronic module that converts torque signals into a high-speed digital representation. Once in digital form, this data is transmitted to a non-contacting pick-up loop, with no risk of noise or data corruption. A remote receiver unit converts the digital data to a high-level analog output voltage, frequency output, and a serial digital output. This series was recently updated with additional features including a 2-pole low pass butterworth analog output filter and 16-bit resolution. The compact, low weight TORKDISC® features high torsional stiffness and low sensitivity to axial and thrust bending moments. For additional information, contact the Force/Torque Division of PCB Piezotronics, Inc. toll-free at 888-684-0004 (in the U.S. and Canada) or 716-684-0001; e-mail: force@pcb.com; fax 716-684-8877; or visit PCB's web site at www.pcb.com.

struction types and structural components:

- Building Types
  - Steel and concrete moment frame structures
  - CMU reinforced and un-reinforced structures
- Design Codes
  - Non-seismic
  - Seismic post-1950
- Building Component Types
  - Columns - steel and reinforced concrete
  - Beams - steel and reinforced concrete
  - Walls - reinforced concrete, CMU, brick and stone
  - Slabs - reinforced concrete

FTS Builder

Using FTS' Graphical User Interface (GUI), you can construct models of buildings and define threats through the "Builder" function. Once a model is defined, FTS will automatically construct and assemble a high fidelity finite element model of each column, beam, wall, and slab component of the structure. Additionally, FTS includes an "expert" system that provides generic defaults when structural details such as steel reinforcement layouts are not available.

FTS Controller

Once a building model is constructed and the threat has been defined, the "Controller" function launches the Flex simulations and displays the damage assessments. The FTS model automatically calculates the damage level of each component during an analysis, identifying low, medium and severe damage levels for each. Often, due to time or computer resource constraints, a structure is too large for the Flex response to be computed for an entire building. In this case, a "component-by-component" analysis can be performed. This type of analysis does the following:

- Simulates response of each individual component (column, beam, wall) loaded by blast pressure,
- Evaluates damage state for each component, and
- Displays combined damage states for the building.

The component-by-component analysis technique allows you to conserve computer resources while providing damage assessments on regions of greatest concern in a timely manner. In addition, once the critical section of a structure has been identified using this approach, a multi-component model of that local sub-region of the building can be exported by FTS and the combined structural assembly analyzed by Flex to produce an animation of the assembled model's response to blast pressure.

When FTS is applied to real structures, it can quickly construct models using as much or as little structural detail information as is available. It performs a sophisticated nonlinear analysis of a building's response to blast using one of the most advanced blast effects modeling software codes available. The code has been verified and validated against a wide range of test data.

FTS in Use

In addition to use within Weidlinger Associates, FTS is currently installed at the CIA and the U.S. Army Corps of Engineers Protection Design Center as it undergoes testing prior to wider distribution.

Summary

Performing high fidelity first principles simulations of building structures subjected to blast loads is usually a manpower intensive process. It typically requires high-level training to use the technologically advanced software needed to perform these simulations. FTS removes both these hurdles and allows for rapid and accurate model generation, analysis, and damage assessment in an easy-to-use graphical environment. The FTS finite element approach is computationally intensive and models of entire buildings are generally well out of scope, however, FTS was designed to allow the analyst to select only the most critical section of a building for analysis, thus reducing computational demands to a more manageable level. Also, if more powerful computing hardware is available, models generated by FTS under Windows can be computed using the FLEX analysis software installed on an alternative system.

The ability of FTS to import SiteSeer survey files to help define a model of a building can simplify model generation and reduce the potential for errors in the model construction process. RAVEN's ability to import FLEX's high resolution graphics information showing structural deformations and damage allows for effective visualization of FTS results in an easy-to-use, end-to-end framework.

Make sure your events get into the 2006 SAVIAC Calendar!

The 2006 SAVIAC Calendar is being compiled for distribution among the 76th Shock & Vibration Symposium attendees, as well as hundreds of other SAVIAC community members around the globe! Don't miss your opportunity to have your event placed in our calendar. Contact Joel Leifer with your event dates and details at *joel.leifer@saviac.org*.

MAJOR TECHNOLOGICAL BREAKTHROUGH

Contributed by the daughter of Jon Wilson, The Dynamic Consultant

Introducing the new Bio-Optic Organized Knowledge device, trade named BOOK.

BOOK is a revolutionary breakthrough in technology: no wires, no electric circuits, no batteries, nothing to be connected or switched on. It so easy to use, even a child can operate it.

Compact and portable, it can be used anywhere even sitting in an armchair by the fire yet it is powerful enough to hold as much information as a CD-ROM disc. Here's how it works:

BOOK is constructed of sequentially numbered sheets of paper (recyclable), each capable of holding thousands of bits of information. These pages are locked together with a custom-fit device called a binder which keeps the sheets in their correct sequence.

Opaque Paper Technology (OPT) allows manufacturers to use both sides of the sheet, doubling the information density and cutting costs. Experts are divided on the prospects for further increases in information density; for now, BOOKS with more information simply use more pages.

Each sheet is scanned optically, registering information directly into your brain. A flick of the finger takes you to the next sheet. BOOK may be taken up at any time and used merely by opening it.

BOOK never crashes or requires rebooting, though like other display devices it can be unusable if dropped overboard. The browse feature allows you to move instantly to any sheet, and move forward or backward as you wish. Many come with an index feature, which pin-points the exact location of any selected information for instant retrieval.

An optional BOOKmark accessory allows you to open BOOK to the exact place you left it in a previous session even if the BOOK has been closed. BOOKmarks fit universal design standards; thus, a single BOOKmark can be used in BOOKs by various manufacturers. Conversely, numerous BOOKmarkers can be used in a single BOOK if the user wants to store numerous views at once. The number is limited only by the number of pages in the BOOK.

You can also make personal notes next to BOOK text entries with an optional programming tool, the Portable Erasable Nib Cryptic Intercommunication Language Stylus (PENCILS).

Portable, durable, and affordable, BOOK is being hailed as a precursor of a new entertainment wave. Also, BOOKs appeal seems so certain that thousands of content creators have committed to the platform and investors are reportedly flocking.

Look for a flood of new titles soon.

Heard a Funny One Lately?

Send it to Joel Leifer at joel.leifer@saviac.org
We'll give you credit when its printed

Conference & Short Course Announcements

Practical Shock Analysis & Design Course
MFPT Society
July 25-29, 2005
Portland, Maine
Sept. 19-23, 2005
Virginia Beach, VA

Participants in this course will have an opportunity to increase their knowledge and understanding of the analytical and experimental tools that are available for shock design and qualification particularly with respect to requirements that are imposed for shipboard equipment. The lectures will provide a basic review of vibration and shock theory and will present the analytical and experimental methodology in the context of particular design applications. Analytical lectures will emphasize the physical significance of the results. Examples and case histories will be used as illustrations of design approaches; workshop problems that involve class participation will be used to advantage throughout the course. Class members will be encouraged to propose real design problems. The instructors will provide guidance for solutions or the problems may be used as class exercises. Although this course is aimed primarily at shock design applications on ships, the analysis and design techniques presented are equally applicable to problems related to design for seismic loads or blast induced ground shock. Thus, engineers in these related areas may find the course to be useful. For all who participate, the course will provide a comprehensive coverage of shock design practice and a solid basis for further exploration of shock technology. Please visit http://www.saviac.org/Courses/Shock%20Course.htm for a more comprehensive overview of the course, and for a list of instructor bios.

Random Vibration and Shock Testing Training
Equipment Reliability Institute (ERI).
August 24-26, 2005
Santa Barbara, CA

A short course on practical vibration and shock testing, measurement, analysis and calibration, also HALT, ESS and HASS. The course will be taught by Wayne Tustin, internationally recognized vibration and shock educator and also president of ERI. This course is for engineers and technicians who conduct developmental and production vibration and shock tests, designers of products that must survive tests and rigorous service conditions, metrologists and sales/applications engineers involved in the sales of equipment used in test (shakers, shock test machines, etc.) and measurement (transducers, data acquisition etc.). Registration and course details can be found at http://www.equipment.reliability.com/sb1.htm. To register, visit http://www. equipmentreliability.com/regist_form.htm.

Structural Design of Buildings and Industrial Facilities for Bomb Blasts and Accidental Chemical Explosions
ASCE
August 4-5, 2005
New York City, NY

This course teaches how to analyze and design steel/concrete buildings and industrial facilities subjected to bomb blasts or accidental chemical explosions. Learn how to compute loads generated by bomb blasts and accidental chemical explosions, how to determine structural response to blast and explosion loads. Understand structural material behavior under intense short duration dynamic loads, design steel and concrete members, receive a completely worked out design example of a steel and concrete building, including step-by-step calculations, receive a comprehensive set of notes and books containing tables, charts and graphs necessary for the analysis and design. Registration and course details can be accessed at http://www.asce.org/conted.

Explosion Effects and Structural Design for Blast
September 27 and 28, 2005
Huntsville, AL.

Engineers have an opportunity to improve their skills in understanding explosion effects and designing facilities that are safer to occupants by understanding and minimizing the effects of explosive detonations on structures. Architects and builders will also benefit by appreciating the impact of explosive design decisions early in the process. All new government buildings now require some level of blast resistant design and this training will specifically address those requirements. The course will focus on the fundamentals of explosion effects, determining blast loads on structures, computing structural response to blast loads, and the design and retrofit of structures to resist blast effects. The emphasis will be on terrorist threats from vehicle bombs, but the fundamental concepts can be applied to other explosive scenarios. Currently available software and publications for blast effects and design guidance will be demonstrated and discussed. Much of the design guidance is restricted distribution to government agencies and their contractors, however specific information on how qualified users may obtain the software will be provided. The participant will gain an understanding of how to compute blast loads on a structure, how a structure responds to blast loading, and practical methods for designing and retrofitting structures to resist blast effects. Participants will be provided with a complete set of class notes. More information about the instructors, the course, and accommodations can be found at http://www.blastdesigntraining.com/ or http://www.uah.edu/BevillCenter/. This is the fourth offering of this popular course and previous offerings have been full to capacity; so register early to ensure your place is reserved. Secure on-line registration is available. Questions should be directed to Dr. Sam Kiger at 573-882-3285, KigerS@missouri.edu or Dr. Stan Woodson at 601-636- 4429, woodsoneng@netzero.net.

Applied Measurements Engineering Training
Equipment Reliability Institute (ERI).
October 17-19, 2005
Las Vegas, Nevada

The course will teach you the principles underlying design and operation of effective computer-driven measurement systems, so that you can provide your clients with demonstrably valid test data on purpose, the first time, and on your client's tight test budget and schedule. The course will be taught by Charles P. Wright, who has three decades of successful experience in the design and operation of advanced multichannel, computer-driven measurement systems for mechanical engineering test and evaluation. Measurement engineers, Data Acquisition engineers & senior technicians, Instrumentation engineers & senior technicians, Test laboratory engineers, Experimental stress engineers and analysts, Analysts and design engineers (customers), Product engineers, Metrologists (an allied but separate field), Vibration test engineers, etc. Contact Information tustin@equipment-reliability.com.

Web seminars on LMS Virtual.Lab Structures

LMS organizes a series of web seminars on LMS Virtual.Lab Structures. For more information and registration for one of these web seminars, please visit www.lmsintl.com or phone Kim Winkler @ 1 248 952 5664.

SAVIAC / HI-TEST Laboratories Inc.
5136 Celestial Way
Columbia, MD 21044
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Program Manager
Joel Leifer
(301) 596-0100
joel.leifer@saviac.org

Administrative Services
Darnise Johnson
(301) 596-0100
darnise.johnson@saviac.org

Manager of Technical Services
Henry Pusey
(540) 678-8678
mfpt@adelphia.net

SAVIAC/HI-TEST Laboratories Inc.
5136 Celestial Way
Columbia, MD 21044
(301) 596-6400 (fax)

SAVIAC Director
Dr. Charles Robert Welch
US Army Engineer Research and Development Center
Vicksburg, MS 39180
saviac@wes.army.mil