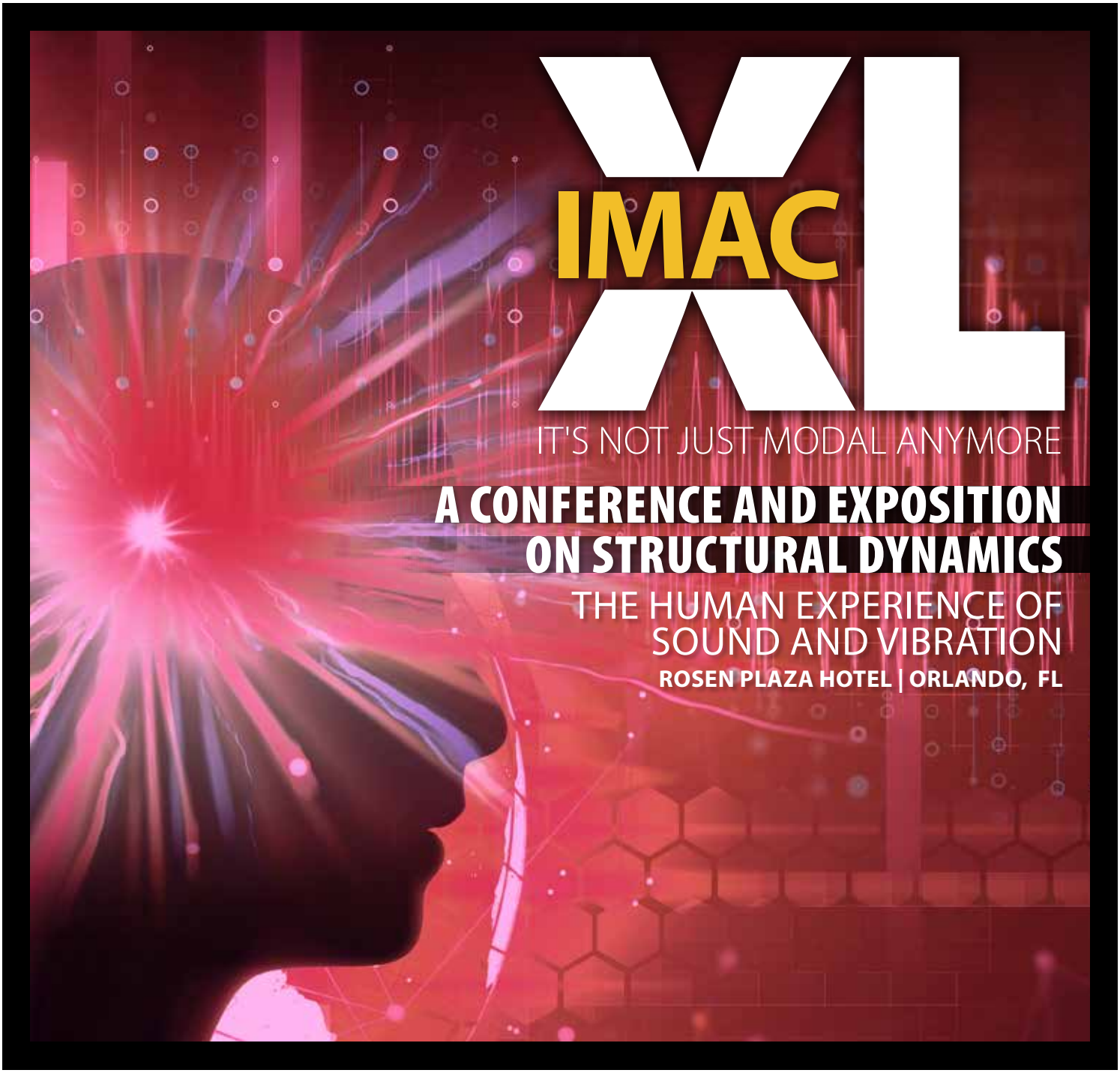

Preconference Course(s): February 5-6, 2022
Conference: February 7–10, 2022
Exposition: February 8-9, 2022

IMAC XL
Society for Experimental Mechanics

Organized by the
Society for Experimental Mechanics, Inc.
7 School Street, Bethel, CT 06801 USA | 203-790-6373 | sem.org

CONTENTS

THANK YOU TO OUR SPONSORS

Welcome Message:

On behalf of the IMAC Advisory Board, it is my pleasure to welcome you to the 40th IMAC at the Rosen Plaza Hotel in Orlando Florida. And it truly will be a pleasure to see you again in person after having only virtual meetings last year due to the pandemic! We have an excellent program encompassing many of our traditional topics while also highlighting our theme, "The Human Experience of Sound and Vibration."

The conference this year opens with four pre-conference courses on Saturday and Sunday. We are excited to, once again, offer Modal Analysis: Theory and Applications for the first time in several years as well as two new courses: MDOF Laboratory Vibration to Simulate the Field Response - Principles Derived from IMMAT and Optical Techniques for Experimental Modal Analysis; and the return of Bayesian Model Updating and Uncertainty Quantification: Theory, Computational Tools, and Applications.

During the week, we have 78 sessions over four days covering a very broad range of technical topics. Jonathan Rathsam, Senior Research Engineer at NASA's Langley Research Center in Hampton, Virginia, will be presenting our conference keynote address, "NASA's Low Boom Flight Demonstration," and Javad Baqersad from Kettering University will be presenting the SAGE Publishing Young Engineer Lecture on "Non-contact Optical and Vision Techniques for Dynamic Measurements and Structural Monitoring". We also have many tutorial sessions throughout the week on a broad range of topics from Dynamics Environments Testing to Optical Measurement Techniques and Nonlinear Dynamics. Everyone from undergraduate students to experienced engineers should find interesting topics to learn about and discuss in the program this year.

I hope that you will find IMAC to be an engaging and friendly community where you can learn from cutting edge research being done all over the world and present your latest work. We encourage all IMAC participants to join a Focus Group or Technical Division or to talk to the conference organizers about getting involved in other ways. Your participation and ideas are needed to keep IMAC responsive to the needs of the structural dynamics community.

See you in Orlando!

Matt Allen | *Advisory Board Chair / Program Planning Committee*

As the incoming IMAC Conference Director, it is my honor to welcome all of you back to an in-person IMAC-XL this year. I am excited to meet up with old friends again, meet new attendees, discuss our shared technical passions, talk with exhibitors about their newest innovations, learn as much as I can, and generally feel the friendly atmosphere I love about IMAC.

Since it was first held in 1982, IMAC has become a comprehensive meeting on a broad spectrum of technologies related to structural dynamics. This broad focus on structural dynamics includes topics in simulation and modeling, nonlinear dynamics, sensors, signal processing and control spanning the full range of engineering disciplines. This year we are focusing on "The Human Experience of Sound and Vibration", our theme for IMAC-XL. At this conference you will find products, presentations, and tutorials to move your research and technology interests forward, whether you are from industry, academia, or a national laboratory.

One of the unique attributes of IMAC, nurtured over the years, is the mix of analytical and experimental topics, bringing the analyst and the experimentalist together as a team. The traditional barriers have been removed to foster constructive dialog amongst all our attendees. As lofty as this sounds, IMAC remains a friendly meeting where exhibitors, presenters and attendees spend several days exchanging the ideas that fuel the coming year.

This year is unique since we are all meeting again after having isolated ourselves for the pandemic in the last two years. SEM and the IMAC conference organizers are all committed to making this a successful and safe meeting. So, you may see some changes from past years such as the masks and social distancing we are all getting used to. Please be patient with the organizers and each other, respect everyone's varying comfort with this foray into an in-person meeting, and make the best of this opportunity.

I would like to thank outgoing IMAC Conference Director Mike Mains for his service and to acknowledge his predecessor Al Wicks, and IMAC founder Dick DeMichelle. Their leadership has shaped IMAC into a great conference. I am humbled by the opportunity to continue these longstanding traditions.

Welcome everyone to IMAC-XL!

David Epp | *Conference Director*

New to IMAC?

IMAC has something to offer whether you're a student, recent graduate, in a laboratory, or you're in industry. Panels, sessions, New/Young Engineer Program and networking are just some of the benefits you can expect from attendance.

Technical Program and Presentations

At most IMACs, there are 7 concurrent rooms holding presentations every 20 minutes. Most rooms will be organized with blocks of presentations on a particular topic or track. While this may seem daunting, there is a method to the madness. Blocks of presentations occur in the early morning, late morning, early afternoon and late afternoon on similar topics (often referred to as "Tracks" or Symposia). Our Advance Program, Final Program and downloadable app, Whova, will have all presentations and meetings listed. Whova is a great resource for searchable content by track, author or specific presentation. Go to sem.org/imac for details.

New/Young Engineer Program

The field of Modal Analysis continues to evolve and mature. In order to allow new or young engineers in the modal field to extract meaningful information from paper presentations at the IMAC Conference, a program has been developed to familiarize the new/young engineer with some of the very basic material related to modal analysis. Held on the first day of the conference, the Basics of Modal Analysis lecture sessions are geared towards those individuals who have very limited or no experience in the modal field or need a refresher on some of the basic modal nomenclature. The material is centered on the topics of single degree of freedom theory, multiple degree of freedom theory, measurements and parameter estimation. The intent is to familiarize the new/young modal engineer with the nomenclature and basic techniques involved in modal analysis; the most basic fundamental equations will be explained in an overview sense rather than developed from a theoretical standpoint.

Early Career Panel

This panel is focused on addressing questions that early-career engineers have regarding their career planning. The panelists are active SEM members at various stages of their careers representing careers in industry, academia and government.

First Time IMAC Attendee Reception

All first time IMAC attendees will be invited to attend this inaugural reception. Partake in food and beverage and get acquainted with the conference. IMAC Conference Director, David Epp, and other long-time IMAC participants will be on hand to mingle and answer questions. There will be prize raffles!

Welcome Reception

Everyone at IMAC-XL is invited to attend the Welcome Reception. A staple at every IMAC, this reception is a terrific chance to reacquaint yourselves with fellow attendees, students, exhibitors, and guests, as well as meet those who are new. It is a wonderful way to begin the conference.

Technical Division Lunch

All Technical Division Groups will meet on Tuesday, February 8 at 12:20 p.m. These gatherings are a perfect opportunity to discuss area and topic specific content with individuals sharing the same interests. For a full listing of SEM's Technical Divisions, please go to sem.org/technicaldivisions.

Networking

Vendors in our Exhibit Hall will have their latest technology offerings on display. Network with experts, in hardware and software, that can provide you a competitive edge. Form connections that will last throughout your career and help you along its path. ■

Course (2-Day): Modal Analysis: Theory and Application

Saturday, February 5, 2022 — Sunday, February 6, 2022 | 8:00 a.m. - 6:00 p.m. | Salon 14

Course Description

Modal analysis theory, modal test methods, modal parameter estimation and applications are explored in this intensive two-day course by distinguished lecturers in this field. Lectures will be reinforced with demonstrations and/or videos as lecture material is discussed. This format provides immediate comprehension and understanding of the theoretical and practical aspects of modal analysis methods. At the completion of this course you will have an understanding of modal analysis theory, experimental techniques and potential applications. Based upon the time limitations, the course will only focus on providing an overview of the subject material. Demonstrations will include excitation techniques, parameter estimation techniques and some advanced processing of data.

Course Instructors

Dr. Randall J. Allemang

Dr. Allemang is a Professor Emeritus of Mechanical Engineering at the University of Cincinnati, where he also serves as Director of the UC-Structural Dynamics Research Laboratory. Randy has been very active in experimental modal analysis research and has published numerous technical articles in the area of experimental modal analysis, measurement and modal vector assessment and modal parameter estimation. Randy has served as Chairman of the IMAC Advisory Board and President of SEM and has over 45 years of experience in measurements and experimental modal analysis.

Dr. Peter Avitabile

Dr. Avitabile serves as Co-Director of the Structural Dynamics and Acoustic Systems Laboratory and Professor Emeritus in Mechanical Engineering at the University of Massachusetts Lowell. Pete has over 40 years of experience in design and analysis using FEM and experimental modal analysis techniques. Pete's main area of research is structural dynamics specializing in modeling, testing and correlation of analytical and experimental models. Pete has published his research and contributed many technical papers and articles to SEM including his "Modal Space" article series in *Experimental Techniques*.

Who Should Attend

The course is directed toward people currently working in this technology who want to increase their understanding of current and updated modal analysis theory and application. The material presented is also appropriate for product design engineers, design evaluation engineers and in-service structural failure investigators concerned with the methodology of correlating experimental modal analysis and analytical modal analysis.

Quotes from Prior Attendees

"This is a course I would recommend to people involved with measurements, ... so that they can understand the data and, ... work toward better results."

"This class reinforced concepts I already knew and added concepts which will improve my work in this field."

"I believe that this course is an excellent resource for engineers that have some experience with experimental modal analysis and have questioned data or practices that they have experienced in the past."

Course Fee

The regular course fee is $1000 and the student fee is $500. Course fee includes lunches, course handout material, and refreshment breaks. Lodging and additional food or materials are not included.

Cancellation Liability

If the course is cancelled for any reason, the Society for Experimental Mechanics' liability is limited to the return of the course fees.

Day 1 – Saturday

7:30-10:00	Registration
8:00-9:00	Objective & Application of Modal Analysis (Allemang)
9:00-10:00	Basic Modal Analysis Theory – Part 1 (Avitabile)
10:00-10:15	BREAK
10:15-11:00	Basic Modal Analysis Theory – Part 2 (Avitabile)
11:10-12:00	Discrete FFTs and DSP Theory (Allemang)
12:00-1:00	BOX LUNCH
1:00-2:00	FFT Accuracy Improvements/Windowing (Allemang)
2:00-3:00	Modal Measurements (Allemang)
3:00-3:15	BREAK
3:15-4:15	Transient & Steady State Excitation Techniques (Allemang)
4:15-5:00	Impact Measurement Demonstration (Allemang, Avitabile) (Hammers, Tips, Gxx, H, Coh, misc problems)
5:00-6:00	Shaker Excitation Demonstration (Allemang, Avitabile) (Random, Burst Random, Cyclic Averaging, Chirp, SISO, MIMO)

Day 2 – Sunday

8:00-9:00	Basic Modal Parameter Estimation Methods (Allemang)
9:00-10:00	Advanced Modal Parameter Estimation Methods (Allemang)
10:00-10:15	BREAK
10:15-11:00	Modal Parameter Estimation Tools (Avitabile)
11:00-12:00	Modal Parameter Estimation Demonstration (Allemang)
12:00-1:00	BOX LUNCH
1:00-1:30	Operating Data – Output Only Systems (Allemang)
1:30-2:00	Autonomous Modal Parameter Estimation (Allemang)
2:00-3:00	Case Histories (Allemang)
3:00-3:15	BREAK
3:15-4:00	Structural Dynamic Modification – Modal Models (Avitabile)
4:00-4:30	Structural Dynamic Modification – Impedance Models (Avitabile)
4:30-5:15	Test Analysis Correlation (Avitabile)
5:15-6:00	Case Histories (Avitabile)

Course: MDOF Laboratory Vibration to Simulate the Field Response: Principles Derived from Impedance Matched Multi-Axis Testing (IMMAT)

Saturday, February 5, 2022 | 9:00 a.m. - 6:00 p.m. | Salon 13

Course Description

For years vibration engineers have known that the boundary conditions imposed by standard laboratory shaker tables cause their simulations to deviate radically from the field environment. In this course we demonstrate system level testing in the laboratory by a coarse approximation of the field mounting of the system and controlling multiple shakers to achieve a much better match to the field environment. The target for the control system is a cross spectral density matrix derived from accelerations measured in a system field test. One implementation of the technique was named the Impedance Matched Multi-Axis Testing (IMMAT) method in 2014. Since that time, several organizations have accomplished pleasingly accurate IMMAT or other Multi-Degree-of-Freedom (MDOF) input simulations. Advantages over single degree-of-freedom shaker tables are:

- More accurate response control over the entire test article
- Elimination of frequency bands of gross over-testing
- Elimination of frequency bands of gross under-testing
- A small fraction of the power requirement
- All axes are addressed simultaneously in a single test
- Possible resource savings
- Elimination of the need for force and response limiting

The course covers the Multi-Input Multi-Output (MIMO) control equations, guidance on choosing target sensors, optimization of shaker locations and control methods to maximize response levels with limited shaker and amplifier capability. Two live control demonstrations with hardware are planned. A modal characterization of the target cross spectral density response matrix demonstrates the key features enabling approximation of the field response in the laboratory. The modal principles for test planning are extended to 6 DOF shaker tests for components and large 3 DOF platforms for system testing. Some data quality checks, metrics and best practices are included.

Course Instructors

Randy Mayes
Retired; Sandia National Laboratories,
Albuquerque, USA

Ryan Schultz
Sandia National Laboratories,
Albuquerque, USA

Dan Rohe
Sandia National Laboratories
Albuquerque, USA

Acknowledgements

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Course Fee

The regular course fee is $500 and the student fee is $250. Course fee includes lunches, course handout material, and refreshment breaks. Lodging and additional food or materials are not included.

Cancellation Liability

If the course is cancelled for any reason, the Society for Experimental Mechanics' liability is limited to the return of the course fees.

Course Schedule

1. Introduction of Instructors and Students and breakfast snacks/coffee
2. General Overview
   a. *What is MIMO? Why is it good?*
   b. *MIMO random theory*
   c. *Control equations*
   d. *Terminology*
   e. *Examining data – MDOF metrics*
3. Comparing the field environment and laboratory environments through the modal construction of cross spectral density matrices
4. BREAK
5. Example system & models
   a. *Our example system – missile on a wing (beam & plate), models, modes, FRFs*
   b. *Different configurations*
   c. *Field Environment & response*
   d. *How to use these models to simulate these tests*
6. Demo 1 shaker (SISO) - Missile on wing
7. Lunch 12:00 - sandwiches in / near room
8. Demo 2 shaker multi-response control Missile on Wing with Rattlesnake
9. Test Design, Input and Output DOF optimization
10. BREAK
11. Rattlesnake & Control Methods
    a. *Overview of Rattlesnake*
    b. *Demo focusing on software – describe what's happening under the hood*
    c. *Different control laws and modal or kinematic transformations*
12. Data Quality and Common Issues
13. 6 DOF table and 3 DOF platform testing with multi-response control
14. Wrap-up and course critique forms

Course: Optical Techniques for Experimental Modal Analysis

Sunday, February 6, 2022 | 9:00 a.m. - 6:00 p.m. | Salon 13

Course Description

Optical techniques have the ability to measure large quantities of data on surfaces of test articles to produce full-field datasets for model validation. While several commercial and open-source optical measurement packages exist, there is no complete modal analysis software that incorporates optical techniques, so practitioners are often left assembling an optical experimental modal analysis capability on their own. This course will provide basic instruction for those practitioners who would like to develop an experimental modal analysis capability using optical techniques.

This course will cover the basics of optical measurements, including cameras and lenses, lighting, patterning, and 2D and stereo DIC. It will then discuss practical aspects of combining optical techniques with experimental modal analysis. Finally advanced topics in optical methods will be discussed.

Course Instructors

Dan Rohe
Sandia National Laboratories
dprohe@sandia.gov

Bryan Witt
Sandia National Laboratories
blwitt@sandia.gov

Phil Reu
Sandia National Laboratories
plreu@sandia.gov

Acknowledgements

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Course Fee

The regular course fee is $500 and the student fee is $250. Course fee includes lunches, course handout material, and refreshment breaks. Lodging and additional food or materials are not included.

Cancellation Liability

If the course is cancelled for any reason, the Society for Experimental Mechanics' liability is limited to the return of the course fees.

Course Schedule:

1. Introduction – Bryan Witt
   a. Introduce instructors and students
   b. General overview of optical techniques
   c. When are optical techniques useful
   d. Comparison to Laser Doppler Vibrometry
2. Cameras and Lenses – Dan Rohe
   a. Camera Geometry and Pinhole Model
   b. Lenses for Optical Modal Analysis
      i. Depth of field
      ii. Field of view
      iii. Focal Length
   c. Camera calibration
      i. Calibration targets
      ii. Camera models
3. BREAK
4. DIC – Phil Reu
   a. Overview of 2D DIC and test parameters
      i. Subset and step sizes
      ii. Interpolants
      iii. Correlation settings
   b. Patterning and Lighting of test article
   c. Stereo DIC
   d. List of current software packages
   e. Measurement uncertainty?
5. LUNCH
6. Practical aspects of Optical Testing for Experimental Modal Analysis – Bryan Witt
   a. Test planning
      i. Frequency range
      ii. Estimating pixels of displacement
      iii. Additional instrumentation/data acquisition system
   b. Test setup
      i. Camera Selection
         1. **High resolution**
         2. **Memory requirements**
         3. **Nonvolatile memory**
      ii. Camera Mounting
      iii. Part preparation/speckling
   c. Test Execution
      i. Synchronizing camera and data acquisition system data
      ii. Averaging reference images to reduce noise
      iii. Excitation strategy
         1. **Hammer excitation difficulties**
         2. **Shaker excitation/advantages and drawbacks of specific excitation signals**
         3. **Shaping excitation signals**
      iv. Image averaging
   d. Postprocessing and Mode Fitting
      i. Handling Correlation drops
      ii. Aligning coordinate systems
      iii. Combining optical and sensor data
      iv. Computing FRFs
      v. Fine alignment of time delay between data acquisition and camera
      vi. Noise mitigation
7. BREAK
8. Advanced Techniques – Dan Rohe
   a. Motion Magnification
      i. Speak to tutorial in the sessions
   b. Synthetic Images
      i. Blender/MatchID
   c. Phase-stepping approaches
   d. Radiography
9. Conclusions and Wrap up – Phil Reu

Course: Bayesian Model Updating and Uncertainty Quantification: Theory, Computational Tools, and Applications

Sunday, February 6, 2022 | 9:00 a.m. - 6:00 p.m. | Salon 12

Course Description

In simulations of complex physical systems, uncertainties arise from imperfections in the mathematical models introduced to represent the systems and their interactions with the environment. Such uncertainties lead to significant uncertainties in the predictions using simulations. Since such predictions form the basis for making decisions, the knowledge of these uncertainties is very important. The course will present the Bayesian model updating framework, the associated computational tools, and selected applications, along with the main challenges for quantifying and propagating uncertainties in complex structural dynamic simulations.

Who Should Attend

Engineers, researchers and graduate students who deal with model validation as well as uncertainty quantification and propagation in structural dynamics simulations using sensor measurements.

Course Instructors

Professor Babak Moaveni
Tufts University

Dr. Moaveni is a Professor at the Department of Civil and Environmental Engineering at Tufts University. Dr. Moaveni's main research interests include vibration-based system and damage identification of civil structures; Bayesian inference and model updating; and uncertainty quantification and propagation in structural dynamics. He has co-authored several papers on related topics. He chaired the ASCE technical committees "Structural Health Monitoring and Control", and "Methods of Monitoring Structural Performance" and currently serves as associate editor for journal "Structural Health Monitoring", and "Frontiers in Built Environment – Sensors".

Professor Costas Papadimitriou
University of Thessaly, Greece

Dr. Papadimitriou (PhD CalTech) is Professor of Structural Dynamics at the University of Thessaly (Greece). He served the European Association of Structural Dynamics (EASD) as Executive Vice-President (2011- 1017) and currently as member of the Senior Advisory Board. He has over 30 years of experience in the areas of Bayesian uncertainty quantification and propagation, computational structural dynamics, finite element model validation, structural health monitoring and structural reliability. He has co-authored one book and over 300 papers in journals and conference proceedings, co-edited one book and four special journal issues, and the section on Structural Health Monitoring in the Encyclopedia of Earthquake Engineering. He has organized more than fifty minisymposia on the subject and has given invited semi-plenary and keynote lectures in international conferences. He chaired the "Dynamics" committee of ASCE-EMI and the "Identification, Model Updating and Inverse Problems" committee of European Association of Structural Dynamics.

Course Fee

The regular course fee is $500 and the student fee is $250. Course fee includes lunches, course handout material, and refreshment breaks. Lodging and additional food or materials are not included.

Cancellation Liability

If the course is cancelled for any reason, the Society for Experimental Mechanics' liability is limited to the return of the course fees.

Course Outline

Bayesian uncertainty quantification and propagation in structural dynamics simulations

- Bayesian model parameter estimation / model updating
- Bayesian model class selection
- Updating robust predictions and robust reliability
- Bayesian Hierarchical modeling
- Structural health monitoring using Bayesian model selection and updating

Bayesian computational tools

- Asymptotic approximations
- Sampling techniques

High performance computing for Bayesian UQ of complex models

- Component mode synthesis
- Surrogate techniques (kriging, polynomial chaos)
- Parallel computing
- Demonstration on high fidelity linear/nonlinear bridge models

Optimal experimental design

- Expected Kullback-Leibler divergence and information entropy
- Asymptotic and sampling techniques
- Optimal sensor placement (OSP)
- Virtual sensing and OSP
- Optimal excitation characteristics

Case studies

- Dowling Hall Footbridge
- 10-story RC building
- 2-story RC building
- Metsovo Bridge
- Small-scale laboratory vehicle model
- Offshore structure

Keynote: Jonathan Rathsam
NASA's Low Boom Flight Demonstration

Monday, February 7, 2022 | 11:10 a.m. | Ballroom C/D

Abstract

NASA will soon begin a series of tests that will collect nationally representative data on how people perceive low noise supersonic overflights. For half a century, civilian aircraft have been required to fly slower than the speed of sound over land to prevent "creating an unacceptable situation" on the ground due to sonic booms. However, new aircraft shaping techniques have led to dramatic changes in how shockwaves from supersonic flight merge together as they travel to the ground. What used to sound like a boom on the ground will be transformed into a thump. NASA is now building a full-scale, piloted demonstration aircraft called the X-59 to demonstrate low noise supersonic flight. In 2024, the X-59 aircraft will commence a national series of community overflight tests to collect data on how people perceive "sonic thumps." This community response data, which represents the human experience of sound and vibration, will be provided to national and international noise regulators as they consider creating new standards that allow supersonic flight over land at acceptably low noise levels. This is an overview presentation.

Biography

Jonathan Rathsam is a Senior Research Engineer at NASA's Langley Research Center in Hampton, Virginia. He conducts laboratory and field research on human perceptions of low noise supersonic overflights. He currently serves as Technical Lead of Survey Design and Analysis for Community Test Planning and Execution within NASA's Commercial Supersonic Technology Project. Recently he served as co-chair for the annual Defense and Aerospace Test and Analysis Workshop (DATAWorks) and as chair for a NASA Source Evaluation Board. He holds a Ph.D. in Engineering from the University of Nebraska, a B.A. in Physics from Grinnell College in Iowa, and completed postdoctoral research in acoustics at Ben-Gurion University in Israel, programs including Space Launch System (SLS), Orion, Exploration Ground Systems (EGS), the two Commercial Crew Program (CCP) partner vehicles, and development in the Advanced Exploration Systems (AES). He also oversees engineering efforts in operational programs including the International Space Station (ISS), Space Communication and Navigation (SCaN), and the Launch Services Program (LSP), and the Human Research Program (HRP). ■

SAGE Publishing Young Engineer Lecture: Developing Multi-Disciplinary Skillsets for a High-Speed Future

Tuesday, February 8, 2022 | 11:20 a.m. | Ballroom C/D

Abstract

Recently, there has been a surge of research in the area of non-contact measurement techniques. Optical techniques have received considerable attention due to their ability to achieve full-field measurement and their robustness to work on testing articles and in environments that other measurement techniques may not be practical. Researchers have used these techniques to study transient phenomena and to perform measurements on vibrating structures. The presentation reviews the most current trends in optical techniques (computer vision, digital image correlation, and laser vibrometry) and highlights their novel structural dynamic measurement concepts and applications. Furthermore, the presentation discusses how the data obtained using optical techniques can be processed for system identification and structural health monitoring. The talk also discusses the future directions for non-contact optical methods.

Biography

Dr. Javad Baqersad is currently an associate professor in the Department of Mechanical Engineering and the director of Noise Vibration Harshness & Experimental Mechanics Laboratory (NVH&EM Lab) at Kettering University. His research interests and expertise are related to vibration and acoustics, computer vision and digital image correlation, structural health monitoring, and finite element analysis. He has published more than 70 journal articles and conference papers contributing to the literature in these areas. He is currently an editor for Mechanical Systems and Signal Processing and an associate editor for Experimental Techniques, and also chairs the optical technique and Computer Vision & Laser Vibrometry technical division at IMAC. He has received several awards, including DJ DeMichele Scholarship from SEM, Outstanding New Researcher and Outstanding Researcher Awards from Kettering University, and Colwell Merit Award from SAE International. ■

The SAGE Publishing Young Engineer Lecture recognizes a member of SEM in early to mid-career (generally 5 to 10 years after degree receipt) whose work demonstrates considerable potential in the field of Experimental Mechanics.

The Society has a number of awards which, by their nature, are intended to recognize senior members of the Society for their work in Experimental Mechanics. However, it is also important that the Society recognize members early in their career whose work demonstrates considerable potential in the field of Experimental Mechanics. That is the focus of this lecture.

As with all SEM awards, we strongly solicit nominations from the members of the Society and the IMAC community for this lecture. The nominee should be recognized for the potential of work early in his/her career, and should be a member of the Society. On the academic side, this could be someone at the Assistant or Associate Professor level. On the industrial or Government Lab side, it could be someone up to 10 years after hire. These are only guidelines and not absolute rules.

Please visit https://sem.org/awards to learn more about nominating a person for this award. ■

Basics of Modal Analysis for the New/Young Engineer Program

Monday, February 7, 2022 | 9:00 a.m. - 5:50pm | Salon 13

Sponsored by:

Modal Analysis /Dynamic Systems Technical Division

The field of Modal Analysis continues to evolve and mature. In order to allow new or young engineers in the modal field to extract meaningful information from paper presentations at the IMAC Conference, a program has been developed to familiarize the new/young engineer with some of the very basic material related to modal analysis. Held on the first day of the conference, the Basics of Modal Analysis lecture sessions are geared towards those individuals who have very limited or no experience in the modal field or need a refresher on some of the basic modal nomenclature. The material is centered on the topics of single degree of freedom theory, multiple degree of freedom theory, measurements and parameter estimation. The intent is to familiarize the new/young modal engineer with the nomenclature and basic techniques involved in modal analysis; the most basic fundamental equations will be explained in an overview sense rather than developed from a theoretical standpoint. These tutorial sessions should not be considered a training seminar but rather an overview of basic definitions that are inherent in most of the presentations at the conference. By attending these sessions, the new or young engineer should be able to better appreciate and comprehend more of the material that is presented in the technical paper presentations. Topics will include: Measurements for Modal Analysis, Impact Testing, Shaker Testing, and Modal Parameter Estimation. ■

Early Career Panel

Wednesday, February 9, 2022 | 6:30 p.m. | Location TBD

This panel is focused on addressing questions that early-career engineers have regarding their career planning. The panelists are active SEM members at various stages of their careers representing careers in industry, academia and government. Bios of each panelist will be provided ahead the panel. Additionally, participants can submit questions to the panel before the session using the conference app, Whova (watch for the app announcement about one week prior to the conference).

The goal is to have the audience drive the discussions through their questions, hence the discussion will start with the panelists answering questions raised by the participating audience or submitted online. Examples of questions raised in past early career panel sessions include:

1. Is there anything you know now that you wish you knew when you were deciding on your career path?

2. How do you approach work-life balance in your career?

3.. What is the most rewarding aspect of your job? ■

Computer Vision and Laser Vibrometry

Organized by:

Technical Division on Computer Vision and Laser Vibrometry

The Technical Division on Computer Vision and Laser Vibrometry aims to share knowledge on advances in the area of optical measurement techniques that are applied to the area of vibrations, structural dynamics, structural health monitoring, and dynamic measurement. This group covers presentations including, but not limited to, operating data measurement, modal parameter estimation, model updating, full field dynamic strain extraction, damage detection, and high-speed deformation measurement.

Meeting: Technical Division on Computer Vision and Laser Vibrometry

Tuesday, February 8, 2022 | 12:20 p.m. - 2:20 p.m.

All IMAC attendees eager to know more about the optical methods and computer vision technology and its application are invited to join the Technical Division meeting. The Technical Division also welcomes volunteers for organizing or chairing sessions in this track. The Technical Division on Computer Vision and Laser Vibrometry aims to share knowledge on advances in the area of optical measurement techniques that are applied to the area of dynamic measurements. This technical division organizes presentations that use optical techniques for operating data measurement, modal parameter estimation, model updating, full field dynamic strain extraction, damage detection, and high-speed deformation measurement.

Tutorial: Generating Meaningful Data with Scanning Laser Doppler Vibrometry

Pam Cravenor - Polytec, Inc.
Jörg Sauer - Polytec GmbH
Jerome Eichenberger - Polytec, Inc.
Wednesday, February 9, 2022 | 11:10 a.m. | Session 44

Validating dynamic simulation models or non-destructive evaluation based on non-contact scanning laser Doppler vibrometer (SLDV) data is key for industrial product development, but even more for verification of new evaluation methods in science. This tutorial deals with the basics of laser Doppler vibrometry, its applications in modal testing and NDT, and multi-path interferometric setups that enable a breakthrough in data quality while reducing the measurement time by orders of magnitude.

Generating meaningful data requires a critical assessment of the experimental setup, excitation methods and data acquisition settings. In this tutorial you will learn about the pros and cons of excitation methods for non-linear structures and experiments in the ultrasonic frequency range. A special emphasis is on the influence of surface effects and the most effective noise mitigation methods, both through the correct choice of the experimental setup and the optical setup of the SLDV. For a better assessment of the optimal setting for your application, an overview of the physical background of laser Doppler vibrometry and signal processing will be given.

Each topic will be illustrated by relevant application examples and shall encourage the participant to ask questions and lead discussions. This tutorial continues the IMAC XXXIX SLDV tutorial and is designed for both experienced users as well as scientists looking for a suitable experimental validation based in non-invasive methods.

Computer Vision and Laser Vibrometry

Tutorial: Phase-Based Motion Magnification

Daniel Rohe - Sandia National Laboratories
Wednesday, February 9, 2022 | 2:30 p.m. | Session 50

Motion magnification has become popular in the past few years for its ability to magnify small, imperceptible motions in structural dynamics images so they are visible to the user. There are a number of steps to this process, including creating the complex filter bank, performing the filtering, and reconstructing the magnified images. This tutorial will provide a deep-dive into the mathematics and implementation details of the phase-based motion magnification approach. It will also discuss approaches to isolate specific motions that the user might wish to magnify and practical issues that the user may encounter when attempting to magnify motions.

Tutorial: Continuous Scanning LDV use and Abuse Over the Past 20 Years

Dario Di Maio - University of Twente
Milena Martarelli - Universita' Politecnica delle Marche
Paolo Castellini - Universita' Politecnica delle Marche
Wednesday, February 9, 2022 | 4:40 p.m. | Session 56

Continuous Scanning LDV methods have been applied to several engineering challenges where vibrations had to be investigated. The major advancement in the vibration analysis by CSLDV was to be able to characterize deflection shape by exploiting a single LDV output signal. Therefore, deflection shapes could be measured in a matter of seconds and exploited for several purposes such as damage detection, modal analysis, transient analysis, model updating. There are over 100+ papers available for interested readers which outline the past and present of the CSLDV techniques. However, such literature might not help the appreciate the nuances of this measurement technique. Hence, the authors have decided to produce a tutorial that will provide information about (a) the measurement test setups and (b) data processing to retrieve the deflection shapes. Furthermore, the authors will also provide some basic demonstrations on carrying out the measurements, including all "lab" tricks that are never reproduced in publications.

Computer Vision & Laser Vibrometry Best Paper Award by Polytec

The Computer Vision & Laser Vibrometry Best Paper Award was established in 2018 to attract high-quality publications and presentations of interest to the DIC, Computer Vision, and Optical Techniques community at IMAC. The Best Paper award is recognized with a certificate and a monetary award of $500, funded by Polytec Inc. The award will be presented at the Awards Luncheon on Wednesday of the conference. ■

Data Science Applications

Organized by:

Data Science Technical Division

The Data Science Technical Division promotes the application of data analytics in structural and mechanical engineering. Machine learning, deep learning, neural networks, big data, statistics, and related methods define the analytical toolset, referred to as Data Science, to process vast volumes of measurements and predictions, analyze complex phenomena, identify trends and relationships, and guide predictive models through empirical data. Progress in sensing technologies (high-speed video, laser sensing, unmanned aerial vehicles, and other platforms, etc.) increasingly requires data management strategies and big data frameworks. High-performance computing and cloud systems are becoming unavoidable to store, classify, interpret, and visualize these data. Statistical and machine learning methods provide fast, resilient, adaptive, scalable engines for the online monitoring of structures and mechanical systems, and to support decision-making and risk analysis. The TD proposes technical sessions on Wednesday and Thursday that present applications of Data Science to structural monitoring and damage detection, advanced manufacturing, and optimization. Consider attending to learn recent developments, share points-of-view, and contribute to moving Data Science forward.

Meeting: Data Science Technical Division

Tuesday, February 8, 2022 | 12:20 p.m.

The Data Science Technical Division needs your involvement! The TD's charter is to advocate for Data Science within SEM and the engineering community at-large, develop educational opportunities, support young professionals, and encourage practitioners and researchers to present their work. IMAC attendees are encouraged to attend the TD meeting. Everybody is welcome! The TD meeting is an opportunity to propose technical sessions and tutorials for the next IMAC (2023), suggest panel discussion and training events, discuss outreach opportunities. The TD will also solicit ideas for activities that would be beneficial to IMAC and SEM. The meeting is a great way to connect and network with IMAC attendees who share similar interest in Data Science. ■

Dynamic Environment Testing

Organized by:

Dynamic Environments Testing Technical Division

The Dynamic Environments Testing Technical Division was recently established to assess and improve upon laboratory tests that are conducted in order to deem products as fit for service in their operational environments. This testing is often referred to as endurance, qualification, acceptance, or certification testing. The standards for performing these tests has remained largely unchanged for the past 50 years, however research in the field has accelerated significantly in the past decade.

The primary components of this type of testing include: characterization and specification of the service environment, determination of appropriate laboratory test excitation techniques, and design of a test fixture (adapter) to attach the product to the laboratory test equipment. This year's sessions and papers will showcase a variety of research spanning all of these focus areas. The topics covered within this technical division overlap notably with those of other technical divisions, and we invite all IMAC attendees to participate in our diverse sessions.

Meeting: Dynamic Environment Testing Technical Division

Tuesday, February 8, 2022 | 12:20 p.m.

The purpose of this technical division is to expand upon the exciting research being done for dynamic environments testing and help to evolve advanced test techniques across both the research community and industry. Join us to discuss technical developments of the emerging methods, learn about the latest collaboration efforts underway on the Dynamics Environments Testing round robin test bed (BARC), and help us pave a path forward for future research via new challenge problems and/or test benches. We invite anyone with an interest, curiosity, or need for dynamic environments testing to join this group and participate in this exciting research—together we can help shape the future of dynamics testing! ■

Dynamic Substructures

Organized by:

The Technical Division on Dynamic Substructures

Substructuring is a general paradigm in engineering dynamics where a complicated system is analyzed based on the dynamics of each subcomponent and the interactions between subcomponents. In numerical simulations, substructuring allows one to reduce the size of the model for a subcomponent of the system and reduce the computational burden by discarding those dynamics that are not important to the assembly/environment of interest. In other applications, a subcomponent model is derived experimentally from hardware, which can be beneficial when the substructure is difficult to model or when there is not enough information to create an accurate finite element model. Substructuring can also be used to couple numerical simulation with real-time testing of components. Such approaches are known as hardware-in-the-loop or hybrid testing.

Whether experimental or numerical, all substructuring approaches have a common basis, namely the equilibrium of the substructures under the action of the applied and interface forces and the compatibility of displacements at the interfaces of the subcomponents. Experimental substructuring requires special care in the way the measurements are obtained to establish acceptable equilibrium and compatibility in the presence of noise and a relatively small number of sensor degrees of freedom. In numerical approaches, the fundamental quest is the efficient computation of reduced order models describing the substructure's dynamic motion. For hardware-in-the-loop applications difficulties include the fast computation of the numerical components and the proper sensing and actuation of the hardware component. Recent advances in experimental techniques, sensor/actuator technologies, novel numerical methods, and parallel computing have rekindled interest in substructuring. The program this year contains several sessions focusing on different aspects of dynamic substructuring.

Meeting: Dynamic Substructures Technical Division

Tuesday, February 8, 2022 | 12:20 p.m.

The Technical Division on Dynamic Substructures, is eagerly organizing sessions, keynote talks and activities of interest for both analytical and experimental substructuring. During a lunchbreak at IMAC, the annual meeting will be held. We meet to organize sessions, pre-conference courses, keynote talks and panel discussions for the next IMAC conference and to coordinate efforts on benchmark systems. All interested and curious persons are welcome to attend. For more information see: www.sem.org/tdsubstructures ■

Dynamics of Civil Structures

Organized by:

Dynamics of Civil Structures Technical Division

The Dynamics of Civil Structures TD serves as a primary focal point within the SEM umbrella for technical activities devoted to civil structures analysis, testing, monitoring, and assessment. This TD covers all types of civil engineering structures such as buildings, bridges, stadiums, dams, and so on. Please note that the TD holds its annual meeting during IMAC (IMAC-XL: Tuesday, Feb. 8, 12:20 PM). The Dynamics of Civil Structures TD welcomes members and guests to attend our annual meeting.

Special sessions focusing on civil engineering research and applications are scheduled during the conference. This year's sessions and papers discuss a variety of topics including structural vibrations and dynamic analysis of buildings, bridges, and other civil structures, fatigue and safety analysis of structures, localization and characterization techniques for human occupants, ground and machinery induced vibrations, damage identification, structural health monitoring, human-structure interaction, vibration control, isolation and damping, model updating, experimental modal analysis and experimental testing of in service structures, and innovative measurement techniques among many other topics. In addition, many of the technical sessions present new and innovative analytical and experimental methods applicable to a variety of civil structures. Many other topics of interest are also presented throughout the conference. The Dynamics of Civil Structures TD has also organized a competition this year for the Best Student Paper which will be awarded during the conference from student authored and presented papers that are included in several of the technical sessions. The Dynamics of Civil Structures TD welcomes all attendees to enjoy a very full and diverse technical program organized in the multi-disciplinary style unique to IMAC and SEM.

Meeting: Dynamics of Civil Structures Technical Division

Tuesday, February 8, 2022 | 12:20 p.m. - 2:20 p.m.

The Dynamics of Civil Structures TD is established to address the needs of its SEM community members working on civil structures and to improve structural safety, serviceability, and human-infrastructure interaction issues in the larger civil engineering professional community and related technical disciplines. The TD holds its annual meeting during IMAC highlighting the significant technical content and TD members' conference activities devoted to the study of civil structures under dynamic loads. The TD provides a unique multidisciplinary forum to disseminate and exchange information on new research and technical developments in the design, analysis, testing, monitoring, and assessment of civil structures.

TD goals include the identification of critical research needs, the validation and dissemination of emerging methods and promising technologies and growing the research and professional community that address the unique demands of the civil structures. Conference activities of the TD include organization of special sessions, program tracks, and short courses among others.

New members and conference participants are welcome to attend the TD annual meeting. ■

Modal Analysis and Dynamic Systems

Organized by:

SEM/IMAC Modal Analysis/Dynamic Systems Technical Division

The Modal Analysis and Dynamic Systems Technical Division serves as a primary focal point within SEM for technical activities devoted to general Modal Analysis and Structural Dynamics. The above sessions outline a track for all subjects pertaining to Modal Analysis.

Meeting: Modal Analysis/Dynamic Systems Technical Division

Tuesday, February 8, 2022 | 12:20 p.m. - 2:20 p.m.

IMAC attendees interested in promoting modal analysis and dynamic systems activities within SEM are welcome to attend the annual meeting of this Technical Division. The Division is constantly seeking new ideas and volunteers to participate in activities which will further the scientific and educational knowledge of modal analysis and dynamic systems.

The Modal Analysis and Dynamic Systems TD has sponsored the Basics of Modal Analysis for the New/Young Engineer program for many years. This TD has organized several round robin sessions covering many special topics within Modal Analysis over the years. The Modal TD has also developed and sponsored several special sessions and programs over the years such as Dynamic Environments Testing, Laser Vibrometry, Optical Methods, and several others. If you have ideas for special sessions or programs at IMAC bring your ideas to this meeting.

At this year's meeting, we will be making plans for IMAC 2023, the 41st anniversary of the conference. In addition to plans for 2023, we will also be discussing how this Technical Division can serve all engineers and technicians working in the field by being a source of knowledge and information. Once again, all are welcome to attend. Please bring us your ideas. ■

Model Validation and Uncertainty Quantification

Organized by:

SEM/IMAC Model Validation and Uncertainty Quantification (MVUQ) Technical Division

Numerical models and simulations are approximate representations of the actual systems they represent. Verification and Validation (V&V) along with uncertainty quantification (UQ) activities provide a means to establish model credibility in a quantitative and objective manner. Model verification ensures that the mathematical model is being solved correctly while model validation ensures that model is a sufficient credible representation of reality. Uncertainty quantification seeks to evaluate the effects of uncertainties that originate from numerous sources and track the propagation of those uncertainties to the final prediction(s) of the model. MV&UQ processes are necessary to ensure that advanced numerical models may be relied upon with confidence.

The MV&UQ sessions at IMAC-XL are intended to be of interest to both newcomers and experienced hands in this field and should appeal to all conference attendees whose work makes use of model predictions. The full program of talks over the four days will cover a broad span of recent work in this field, from the development of new tools for uncertainty quantification through to industrial applications of validation procedures. Highlights include the MVUQ Best Paper Award session, plus special sessions on topics as diverse as fusing the outcomes of test and analysis; machine learning, Bayesian filters for real time structural identification; digital twins in a dynamics context; uncertainty in early stage design and its propagation; and decision-makings regarding a variety of applications.

Meeting: Model Validation & Uncertainty Quantification Technical Division

Tuesday, February 8, 2022 | 12:20 p.m.

Model Validation and Uncertainty Quantification (MV&UQ) refers to a broad range of activities carried out to provide evidence that measurements and predictions are credible and scientifically defensible. The purpose of the MV&UQ Technical Division at the Society for Experimental Mechanics (SEM) is to advance the capabilities and disseminate knowledge of MV&UQ methods with an emphasis on Structural Dynamics. Among the goals of the Technical Division is an aim to broaden the impact of MV&UQ practices incorporating all stakeholders, from industry to academia, to ensure that MV&UQ practices continue to grow and mature in a manner that benefits all. Over the past ten to fifteen years, the TD has been very active in organizing technical sessions and tutorials at SEM conferences and awards an MV&UQ Best Paper Award during IMAC. All who share our interest for MV&UQ are welcome to attend the meeting, join the TD, and help to define its role and mission. ■

Nonlinear Structures & Systems

Organized by:

Nonlinear Structures and Systems Technical Division

Most real engineering structures behave nonlinearly. Therefore, it is necessary to address the presence of nonlinearity in all the steps of the engineering design process: in the experimental testing (to collect the most informative data), in the data analysis (to estimate nonlinear parameters correctly), in the mathematical modelling (to obtain accurate models of the structure) and in the numerical methods (to simulate and study the response effectively). In doing so, it will be possible to create a model that is more representative of reality and that can be used for better predictions once validated.

The nonlinear sessions address theoretical and numerical aspects of nonlinear dynamics as well as experimental techniques and analysis methods. Several sessions are also dedicated to joints and interfaces due to their omnipresence in structures. To introduce the participants to the fundamentals of nonlinear dynamics and provide an overview of some active research areas in the field, the nonlinear sessions also comprise four tutorials: one on the fundamentals of nonlinear oscillations by Prof. Douglas Adams (Vanderbilt University), one on analytical approximations using perturbation methods by Prof. Dane Quinn (University of Akron), one on nonlinear vibration mitigation by Prof. Malte Krack (University of Stuttgart), and one on nonlinear dynamics in biological systems by Prof. Mehmet Kurt (Stevens Institute of Technology).

Meeting: Nonlinear Structures and Systems Technical Division

Tuesday, February 8, 2022 | 12:20 p.m.

All interested people are welcome to join the officers of the Nonlinear Structures and Systems Technical Division to organize the tutorials and sessions for the next IMAC conference and discuss the future of the division.

Tutorial: Nonlinear Oscillations - The Fundamentals

Prof. D. Adams, Vanderbilt University

Monday, February 7, 2022 | 9:00 a.m. | Session 6

Nonlinear oscillations are as useful as they are fascinating in structural dynamics. Natural frequencies, damping levels, mode shapes, and amplitudes of response can all change in seemingly surprising ways when nonlinear behaviors arise. How can we use the tools of modal analysis to understand nonlinear oscillations? How can we use nonlinear oscillations for engineering problem solving in areas like structural health monitoring? This tutorial is intended for participants who are new to nonlinear topics in vibration or who have begun to investigate nonlinear phenomena and want to engage in an interactive session on the topic. The tutorial will begin by introducing some of the fundamental mechanisms associated with nonlinear oscillations and will then use case studies to introduce tools and methods that analyze nonlinear oscillations. Case studies are drawn from aerospace and automotive applications involving advanced materials, components, and structures. Questions and discussion are encouraged.

Tutorial: When the Answer is Almost Right: An Introduction to Perturbation Methods

Prof. D. D. Quinn, University of Akron

Tuesday, February 8, 2022 | 2:20 p.m. | Session 30

We like simple equations; linear equations are simple; we like linear equations. More specifically, we can often solve linear equations to obtain a closed form solution that can be used for prediction and design. Unfortunately, most systems in science and engineering are not linear and their models have no closed form solution. As a result, such nonlinear models are often difficult to use for design. However, models of physical systems are often "close" to linear; the model for the physical system looks like a linear system but with some extra nonlinear terms that are small, and it's these small nonlinearities that destroy our perfect linear world.

Nonlinear Structures & Systems

Perturbation methods describe a collection of approaches to approximate the solution to nonlinear equations that are almost linear, referred to as weakly nonlinear. These techniques make use of the known solution for the related linear problem, which is then modified to develop an approximate solution to the original nonlinear problem. This tutorial talk will introduce a variety of such techniques including regular and singular perturbation methods, and will highlight both how they are developed and when they can be applied.

Tutorial: Nonlinear Vibration Mitigation

Prof. M. Krack, University of Stuttgart

Wednesday, February 9, 2022 | 9:00 a.m. | Session 42

The intentional use of nonlinearity to mitigate vibrations under impulsive, periodic or self-excitation is a research field of increasing importance. Many concepts for mitigating vibrations show intrinsically nonlinear behavior. In other concepts, nonlinearity is deliberately introduced. In either case, one can exploit salient nonlinear phenomena, such as the targeted energy transfer among different time and length scales, to achieve effectiveness and robustness never reached by linear means. On the other hand, nonlinearity brings specific challenges to the theoretical analysis, numerical simulation and experimental investigation. This tutorial reviews the ideas and fundamental principles of available means of nonlinear vibration mitigation. The opportunities and limitations are compared to conventional linear vibration mitigation concepts. The tutorial covers the range of theoretical aspects, experimental results and technical applications.

Tutorial: Nonlinear Dynamics of the Living Matter

Prof. M. Kurt, Stevens Institute of Technology

Wednesday, February 9, 2022 | 11:10 a.m. | Session 48

Heart pulsatility, muscle contractions, pulmonary expansion, DNA replication, molecular motors rotation; at all scales and at all times during the life of any living being, there is movement. In fact, movement is one of the essential features characterizing all types of biological systems and is intertwined with the normal homeostatic processes of life in a number of obvious and less-obvious ways. Yet, the manner in which movement propagates through living matter is still poorly understood due to a lack of characterization methods, analytical models and experimental tools. While advances in medical imaging techniques are enabling organ movement assessment for a variety of diagnostic purposes, virtually all methods rely exclusively on linear motion information. But due to the extremely soft and geometrically heterogeneous nature of organs, nonlinear behaviors might be present even under physiological conditions, offering the promise to gain higher order information which would deliver clinical insights absolutely inaccessible when studying living matter in the linear regime. One critical challenge is that flow and motion must be imaged at extremely high spatial and time resolutions to identify nonlinearities in the dynamics of biological tissues. Clinical researchers are starting to address this challenge via non-invasive medical imaging techniques that are pushing the field of imaging resolution to unprecedented limits. At the same time, the structural dynamics community is developing empirical system identification methods to transform a high-dimensional data-set into a lower degree of freedom, thereby enabling researchers to characterize the dynamics of a system to obtain its distinct behavior. These exciting advances open the possibility of finally deciphering the nonlinear dynamics underlying biological movement.

In this tutorial, I will talk about the recent advances in nonlinear system identification methods to study the dynamics of the living matter. I will introduce novel imaging methods that allow for the characterization of the living matter dynamics in vivo and conclude with how a synergistic combination of these methods can be used in real-life clinical applications. ■

Sensors and Instrumentation

Sponsored by:

J. F. Lally Sensors & Instrumentation Technical Division

The SEM Sensors and Instrumentation Technical Division mission is to promote and encourage the exchange of non-proprietary information relating to transducers, data and control systems, and related components used to test and measure structural dynamic behavior. We continuously organize a series of IMAC tutorial sessions for those who are interested in improving their knowledge and skill in the use of sensors and instrumentation.

This TD sponsors annual sessions for OEMs to demonstrate their new technology and provide roadmap of their future efforts. We encourage sessions for unique instrumentation use cases of challenging tests and measurements of novel uses of traditional instrumentation. We sponsor "best practices" sessions ranging from instrumentation selection, installation techniques, data acquisition selection, cabling, and proper grounding techniques. The Sensors and Instrumentation TD provides benefits from students to seasoned engineers across multiple engineering disciplines.

Meeting: J. F. Lally Sensors & Instrumentation Technical Division

Tuesday, February 8, 2022 | 12:20 p.m.

We encourage all that have an interest or want to learn more about the Sensor and Instrumentation TD to attend our annual planning meeting. At this year's meeting we will again evaluate recurring session topics and encourage new participants to join us to submit their session ideas for IMAC 2023. Engineers and technicians of all disciplines are welcome to attend, participate, and collaborate on sessions and topics that are significant to the application and measurements of dynamic structures.

Technology Applications

Tuesday, February 8, 2022 | 9:00 a.m.
Session 22 | Salon 12

Due to the great interest in this session over the past few years, we are pleased to be able to offer it at IMAC-XL. Several IMAC Exhibitors will provide brief presentations highlighting their hardware and software applications and services. Come visit this extremely timely session and then you will have the opportunity to obtain additional information from the exhibitors during the IMAC-XL Exposition Hours. ■

Social and Award Events

IMAC-XL Welcome Reception

Monday, February 7, 2022 | 7:00 p.m.

Everyone at IMAC-XL is invited to attend the Welcome Reception. A staple at every IMAC, this reception is a terrific chance to re-acquaint yourself with fellow attendees, students, exhibitors, and guests, as well as meet those who are new. It is a wonderful way to begin the conference.

IMAC-XL Awards Luncheon

Wednesday, February 9, 2022 | 12:30 p.m.

SEM President, Eric N. Brown, and IMAC Conference Director, David Epp, will conduct the Awards Luncheon ceremony by presenting various awards in recognition of outstanding achievements in structural dynamics and service to SEM/IMAC.

SEM Gold and Silver Certificate Members

The following SEM members have reached a Silver or Gold membership milestone. We sincerely thank them for their years of service and dedication to SEM. Seeing these certificates awarded is a wonderful way to show our appreciation to these longstanding SEM members.

50 Year Members | Gold Certificate

Frank Adam, Hiroshi Nyuko, John Quinley,
Sameh Issa, Karl Stetson

25 Year Members | Silver Certificate

K. Ramesh, Jeffrey Helm, Michael Andruszkiewicz,
Ghatu Subhash

2021 Awards and Recipients

SAGE Publishing Young Engineer Lecture: Luke Martin

D.J. DeMichele: Jason Blough

Best Paper: Computer Vision and Laser Vibrometry:
Moise Silva-Federal University of Pará; Andre Green-Los Alamos National Laboratory; John Morales-Los Alamos National Laboratory; Peter Meyerhofer-Los Alamos National Laboratory; Yongchao Yang-Michigan Tech University; Eloi Figueiredo-Universidade Lusófona de Humanidades e Tecnologias; David Dennis Mascarenas-Los Alamos National Laboratory

Best Paper: Computer Vision and Laser Vibrometry:
Mehrdad Shafiei Dizaji-University of Massachusetts, Lowell;
Zhu Mao-University of Massachusetts, Lowell

Best Paper: Data Science:
Georgios Tsialiamanis-University of Sheffield; Charilaos Mylonas-ETH Zurich; Eleni Chatzi-ETH Zurich; David Wagg-University of Sheffield; Nikolaos Dervilis-University of Sheffield; Keith Worden-University of Sheffield

Best Paper: Dynamic Environments Testing:
Matthew Tuman-University of Wisconsin-Madison; Christopher Schumann-University of Wisconsin-Madison; Matthew Allen-University of Wisconsin-Madison; Washington DeLima-Honeywell Federal Manufacturing & Technologies; Eric Dodgen-Honeywell Federal Manufacturing & Technologies

Best Paper: Dynamics of Civil Structures:
Jonathon Fagert-Carnegie Mellon University; Mostafa Mirshekari-Stanford University; Pei Zhang-Carnegie Mellon University; Haeyoung Noh-Stanford University

Best Paper: Dynamics of Civil Structures:
Eleonora Maria Tronci-Columbia University; Homayoon Beigi-Recognition Technologies, Inc.; Maria Feng-Columbia University; Raimondo Betti-Columbia University

Best Paper: Dynamics of Civil Structures:
William Locke-Clemson; Laura Redmond-Clemson;
Matthias Schmid-Clemson

Best Paper: Model Validation and Uncertainty Quantification:
Andrew Brown-NASA/Marshall Space Flight Center;
Jennifer DeLessio-JSEG/ESSCA - NASA/Marshall Space Flight Center;
Timothy Wray-NASA/Marshall Space Flight Center

Best Paper: Nonlinear Structures and Systems:
Jie Yuan-Imperial College London; Loic Salles-Imperial College London;
Christoph Schwingshackl-Imperial College London

2022 Awards and Recipients

Fellow: Peter Avitabile, Randall Mayes

SAGE Publishing Young Engineer Lecture: Javad Baqersad

D.J. DeMichele: Matthew Allen

F.G. Tatnall: Paul Reynolds

Open Meetings

Exhibit Planning Committee

Tuesday, February 8, 2022 | 12:20 p.m. | Ballroom A/B

All Exhibitors are invited to attend this open meeting to discuss opportunities, provide valuable insight/feedback and guide future Exposition planning. Your participation is critical in making the Exposition a success and in providing the best experience for conference attendees.

Program Planning Committee

Wednesday, February 9, 2022 | 9:00 a.m.

The committee will meet to receive IMAC-XL feedback from Technical Divisions, Focus Groups, and others as well as to discuss plans for IMAC-XLI. **Each Technical Division and Focus Group is asked to send a representative to this meeting if possible**. If not possible, please BE SURE to return your TD/Focus Group form to the IMAC registration desk **prior** to this meeting.

Research Committee on the Mechanics of Jointed Structures Meeting

Tuesday, February 8, 2022 | 9:00 a.m. | Salon 1

The Research Committee on the Mechanics of Jointed Structures is holding their spring meeting at IMAC. This research organization focuses on developing collaborations across academia, industry, and government to advance the physical understanding of the behavior of jointed and assembled systems. This meeting will focus on the development of the new roadmap for joints research. The international community that composes this research committee focus on multiple fields of research: solid mechanics, nonlinear dynamics, uncertainty quantification, numerical methods, and tribology. For more information, please contact brake@rice.edu

Registration Information

Conference:
February 7-10, 2022

Pre-Conference Courses
February 5-6, 2022

Course fee includes lunch each day of the course, course handout materials, and refreshment breaks. Lodging and additional food or materials are not included.

Registration Policy
Online registration and payment/PO† must be received by January 3, 2022 for pre-payment savings. Payments received after January 3, 2022 will be charged standard pricing.

On January 3, 2022 at 5:01 PM (EST) standard pricing will prevail. All checks must be in US funds, drawn on a US bank payable to SEM.

Cancellation Policy
If the course or conference is canceled for any reason, the Society for Experimental Mechanics' liability is limited to the return of the registration fees.

We understand that circumstances may arise that require you to cancel. If you need to cancel, your conference fee, less a $75.00 nonrefundable cancellation fee, will be refunded when the cancellation is made in writing and received by January 10, 2022. No refunds will be given for cancellations received after January 10, 2022. Cancellation notification should be faxed or emailed to Shari Matthews: Fax: 203-790-4472; shari@sem.org

† Payments made with PO must be submitted no later than January 3, 2022. After January 3, 2022 PO will not be accepted as a form of payment. + Payment Net 30 days.

Conference Registration
Registration fee entitles the registrant to a free downloadable conference submission (available for 30 days after the conference) and includes the following: Welcome Reception on Monday, February 7, Exposition, and one ticket to the Awards Luncheon on Wednesday, February 9.

Conference participants, including authors, coauthors, students, and session chairs, should preregister online at sem.org. Your badge, tickets, and other conference materials will be ready for you when you arrive at the registration desk.

All those who register prior to the January 3, 2022 deadline are eligible to win one of many door prizes being offered by IMAC Exhibitors.

Students
To qualify for student rates, you must be a full-time engineering or science student at the time of the conference. This includes Graduate and/or Undergraduate students. Post-Doctoral do not qualify and must pay regular rate. An unofficial transcript showing proof of student status MUST be emailed to Shari Matthews (shari@sem.org).

Conference Registration Hours
Course Only Registration:

Saturday, February 5, 2022 ..... 7:30 AM –10:00 AM
Sunday, February 6, 2022 ..... 7:30 AM –10:00 AM

Conference Registration:

Sunday, February 6, 2022 ..... 4:00 PM–6:00 PM
Monday, February 7, 2022 ..... 7:00 AM–4:00 PM
Tuesday, February 8, 2022 ..... 7:30 AM–4:00 PM
Wednesday, February 9, 2022 ..... 7:30 AM–4:00 PM
Thursday, February 10, 2022 ..... 8:00 AM–1:00 PM

Exposition Directory

Exposition Hours:

Tuesday, February 8	**10:00 a.m.–5:00 p.m.**
Wednesday, February 9	**10:00 a.m.–12:00 p.m.** **2:00 p.m.–5:00 p.m.**

S = IMAC-XL Sponsor
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ATA Engineering Inc. (ATA) is an engineering consulting firm that provides innovative solutions through test- and analysis-driven design by focusing on the engineering needs of manufacturers in addressing their cost, quality, and time-to-market challenges for mechanical and aerospace systems. ATA supports the IMAC community as modal test and analysis experts.

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Founded in 1996, Crystal Instruments (CI) is a leading manufacturer of dynamic measurement, signal analysis, and vibration testing equipment. CI's products vary from laboratory testing instrumentation to in-field data acquisition equipment. CI manufactures hardware and develops software for vibration control, structural testing, condition based monitoring, and general-purpose data acquisition.

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The Shock and Vibration Exchange was founded in 2012 in order to serve as a clearing house for persons interested in shock and vibration and related specialties. The primary goals of "SAVE" are to maintain the continuity and offerings of the annual Shock and Vibration Symposium and its two 5-day shock courses.

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SEM Membership

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SEM Membership has its benefits! Among those benefits is free electronic access to a number of journals. To sign up for any of the above options, select them upon registration.

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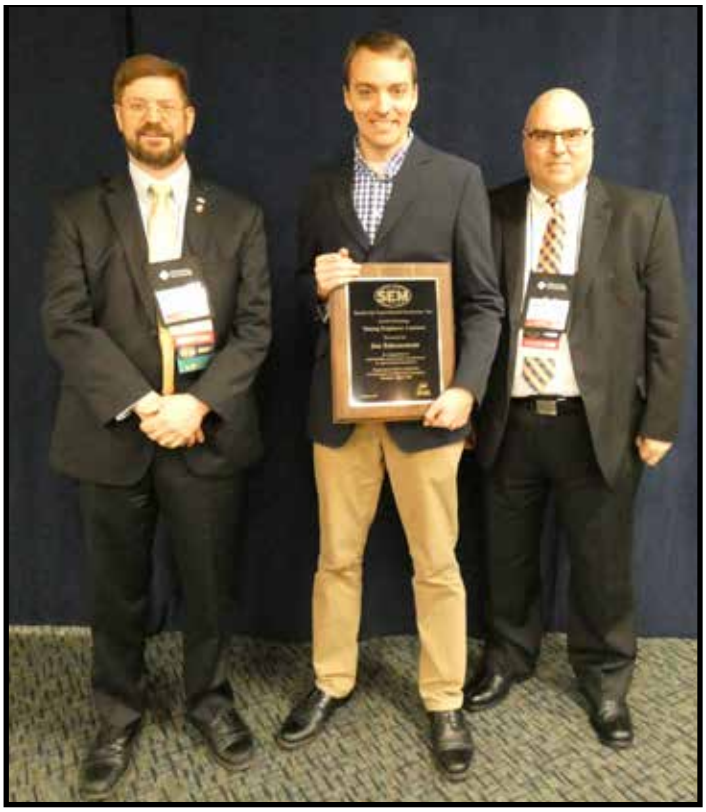
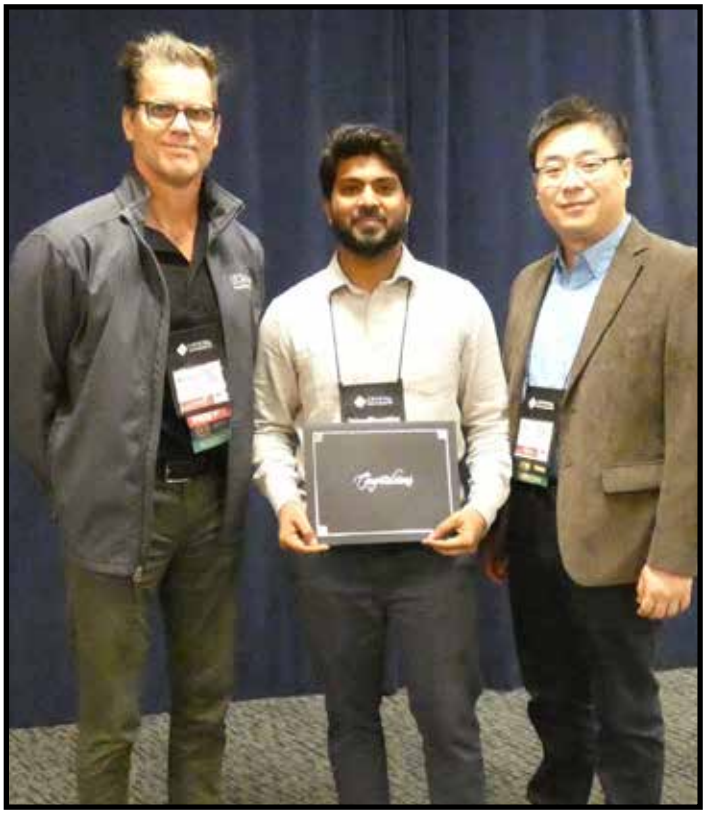
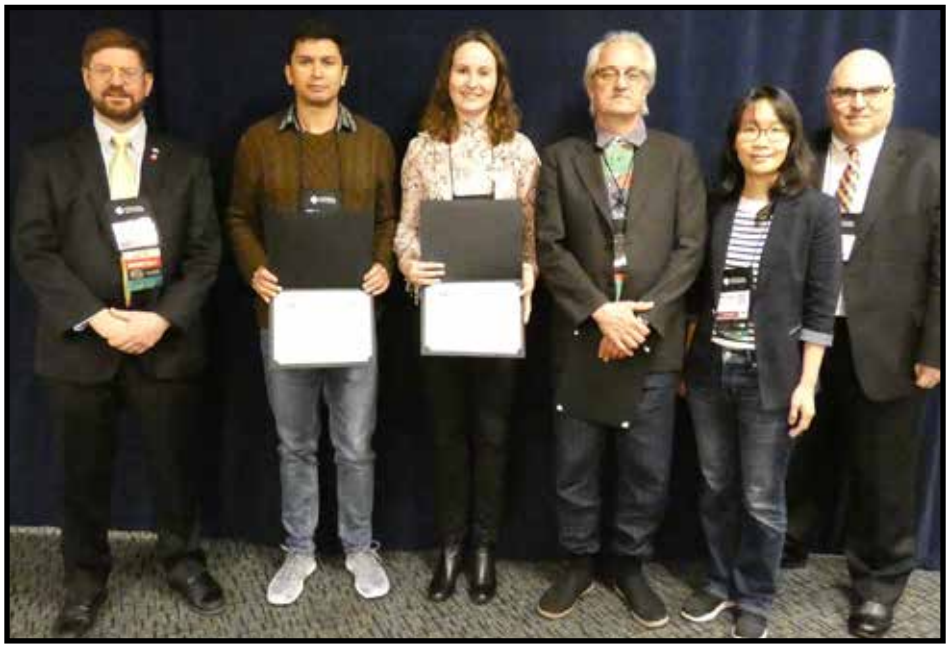
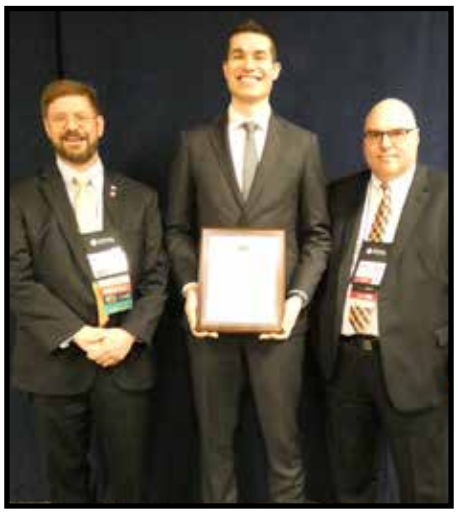
Memories From 2020

Houston, TX









Opposite Page, clockwise from top-left: Mike Mains *(then IMAC Conference Director)* and John Lambros *(then SEM President)* with Joe Schoneman *(SAGE Publishing Young Engineer Lecture)*; Joe Schoneman presents his lecture; Neera and Raj Singhal *(Distinguished Service Award)*; Winners of the Exposition Passport Prizes - Stephen Franco *(Lawrence Livermore National Laboratory)*, Martin Volvert *(University of Liège)*, and Luke Jurmu *(Michigan Technological University)*

This page, clockwise from top-left: Michael Todd *(University of California San Diego)*, Mukesh Ramancha *(MVUQ Best Paper)*, Zhu Mao *(then University of Massachusetts Lowell)*; Scott Cogan and his sisterShoshanna Cogan *(D.J. DeMichele Award)*; Joel Sills *(NASA)* presenting "The Artemis Challenge: Another Revolution in Structural Dynamics"; Mike Mains and John Lambros with Andrea Lupini *(2020 D.J. DeMichele Scholarship Award)*; Mike Mains and John Lambros with winners of Best Student Paper Award in Dynamics of Civil Structures - Sandro D.R. Amador, Pernille Lysgaard, Rune Brincker and Hae Young Noh *(Chair of Dynamics of Civil Structures TD)*

SEM/IMAC Code of Conduct

The Society for Experimental Mechanics, Inc. is committed to making its SEM/IMAC Conferences inclusive spaces for sharing ideas and knowledge by providing a safe and productive meeting environment that fosters open dialogue and the exchange of scientific ideas, promotes equal opportunities and treatment for all participants, and is free of harassment and discrimination. All participants are expected to treat others with respect and consideration, follow venue rules, and alert staff or security of any dangerous situations or anyone in distress. Speakers are expected to uphold standards of scientific integrity and professional ethics. The policies herein apply to all attendees, speakers, exhibitors, staff, contractors, volunteers, and guests at SEM/IMAC Conferences and related events.

SEM/IMAC prohibits any form of harassment, sexual or otherwise. Harassment should be reported immediately to SEM/IMAC Conference staff and via email: director@sem.org or (203) 790-6373 extension 100.

What is Harassment?

Harassment includes speech or behavior that is not welcome or is personally offensive, whether it is based on ethnicity, gender, religion, age, body size, disability, veteran status, marital status, sexual orientation, gender identity, or any other reason not related to scientific merit. It includes stalking, unnecessary touching and unwelcome attention.

Behavior that is acceptable to one person may not be acceptable to another, so use discretion to be sure that respect is communicated. Harassment intended in a joking manner still constitutes unacceptable behavior. Retaliation for reporting harassment is also a violation of this policy, as is reporting an incident in bad faith.

Reporting Harassment

SEM/IMAC is committed to supporting a productive and safe working environment for everyone at our conferences. If an individual experiences, or witnesses, harassment, they should contact SEM/IMAC Conference staff and via email: director@sem.org or (203) 790-6373 extension 100, or, if during a conference, by using a venue phone and ask for security if they feel unsafe. All complaints will be treated seriously and responded to promptly.

If an individual experiences harassment, it is recommended that, in addition to notifying SEM/IMAC Conference staff, they write down the details, as they may be asked to fill out a report. They are not expected to discuss the incident with the offending party. Their confidentiality will be maintained to the extent that it does not compromise the rights of others.

Filing a Formal Complaint of Harassment

If an individual wishes to file a formal complaint of harassment:

- Notify SEM/IMAC Conference staff and via email: director@sem.org or (203) 790-6373 extension 100
- SEM/IMAC staff will discuss the details first with the individual filing the complaint, then with the alleged offender; seek counsel if the appropriate course of action is unclear; and report findings as needed to the SEM Executive Board
- SEM/IMAC will consult with the individual filing the complaint prior to taking any action

SEM/IMAC reserves the right to request the removal of any individual engaging in harassment type behavior from its Conferences. All conference fees shall not be refunded, the individual(s) will be prohibited from attending future SEM/IMAC Conferences and their employer or institution will be notified.

For any questions about this policy, please contact Nuno Lopes, Managing Director at director@sem.org or (203) 790-6373 extension 100. ■

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Using our website indicates your acceptance of our terms and conditions. Your continued visits to our website after changes are posted to these terms and conditions will signify your acceptance of those changes.

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Event participants grant SEM the absolute right to take photographs and/or make audio and visual recordings of an event for any purpose in SEM-related publications, promotion or website, at its sole discretion.

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Conferences, courses, and sessions: Recordings of any kind are strictly prohibited without prior written consent of both SEM and the session presenter(s) or instructor. Attendees may not capture or use materials presented in any session/course room without written permission. Individuals not complying with this policy will be asked to leave a given session and/or asked to surrender their recording media. Refusal to comply with such requests is grounds for expulsion from the event.

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One paid Conference registration is limited to no more than two presentations per registered individual. Author(s)/presenter(s) wishing to present more than 2 presentations must pay for two registrations or have a co-author/presenter register for the Conference.

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Hotel Registration cut-off is January 19, 2022 @ 11:59 PM or until the contracted room block is sold out, whichever comes first.

To make your hotel reservation, go to sem.org/imacvenue.

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