

## About the Instructors

### Dr. Francois Hemez

Dr. Hemez has over 10 years of experience in the development of Verification and Validation (V&V) and its application to structural dynamics and computational physics. His experience includes finite element model updating for both linear and nonlinear structural dynamics models. He has also worked extensively in the disciplines of code and calculation verification, sensitivity analysis, test-analysis correlation and uncertainty quantification. Dr. Hemez is currently a Technical Staff Member on the Methods and Verification Team at Los Alamos National Laboratory.

### Dr. Charles "Chuck" Farrar

Dr. Farrar has been a pioneer in the development of SHM for a variety of engineering applications. He is currently the director of the Engineering Institute at Los Alamos National Laboratory, which focuses on developing SHM and model validation technology.

## Location, Lodging & Transportation Information

Attendees are responsible for their own transportation and lodging. See IWSHM conference web site for lodging information. Detailed course location information will be sent to registrants by September 1.

**Download Sample Course Notes at  
[www.la-dynamics.com](http://www.la-dynamics.com)**

## Registration Form

Finite Element Model Validation

Download a larger form at [www.la-dynamics.com](http://www.la-dynamics.com)

Direct questions to [farrar@la-dynamics.com](mailto:farrar@la-dynamics.com)

**Fax to:**  
(814) 284-8772

**or**

**Mail to:**  
PO Box 1193  
Los Alamos NM 87544

Please circle one:

Full Registration Fee: US \$1695

Early Registration\* US \$1495

Full-time Student Registration Fee US \$795

(Class size limited to 30 participants.)

### Course Fees Include:

Course notes (hardcopy & CD-ROM), catering for morning and afternoon breaks, certificate of completion, and meeting

Name:
E-mail Address:
Company:
Mailing Address:
City/State/ZIP:
Phone Number:
FAX Number:
Payment by (circle):    VISA    MC    Check

**To pay by credit card, please place a secure online payment on our web site,  
[www.la-dynamics.com](http://www.la-dynamics.com)**

### Make Checks Payable to:

Los Alamos Dynamics, LLC (US Dollars only)

\*To qualify for early registration discount, form must be received by FAX or postmarked by August 10, 2007

## Los Alamos Dynamics

Structural Dynamics Consultants

[www.la-dynamics.com](http://www.la-dynamics.com)

# Finite Element Model Validation, Updating, and Uncertainty Quantification

For Linear and Nonlinear Models

to be held at

**Palo Alto, California  
September 13-15, 2007**

**A 2.5-Day Short Course for  
Aerospace, Civil and Mechanical  
Engineers**

**in conjunction with the  
6th International Workshop on  
Structural Health Monitoring  
September 11-13, 2007  
Palo Alto, California**

[structure.stanford.edu/workshop](http://structure.stanford.edu/workshop)

Los Alamos Dynamics is an independent company  
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# “Do You Know Everything That You Should About Your Finite Element Model?”

- How closely do your results match the real-world response of your structure?
- How will small errors in your model input parameters affect the accuracy of your prediction?
- Which of your FEM input parameters have the greatest influence on your prediction quantities of interest?

**W**hen an engineer builds a finite element model, the results should be trustworthy. But how do we know (and prove quantitatively) that the predictions can be believed with confidence? Recent research in the areas of finite element model validation, sensitivity analysis, uncertainty analysis, and test/analysis correlation has led to the development of techniques to answer these questions and more, enabling you to use your finite element model predictions with confidence. This course will provide an overview of the latest technology for evaluating and improving the accuracy and validity of linear and nonlinear finite element models. The course provides a blend of research and real-world applications in the fields of aerospace, automotive, and civil engineering.

## Course Goals

Upon completion of this course, attendees will be able to:

- Describe the model validation paradigm of sensitivity analysis, test/analysis correlation, and uncertainty analysis
- Summarize the history of finite element model test/analysis correlation and model validation
- Discuss current techniques for global sensitivity analysis and parameter screening
- Describe the process for selecting and computing appropriate response features from the model outputs
- Explain the role of DOE and ANOVA in model validation
- Define appropriate test/analysis correlation metrics for model revision and parametric updating

## Course Outline

### Introduction

- Description of model validation process
- Definitions of key terminology
- Overview of finite element modeling
- Input output models: Parameters and features

### Historical Overview

- Discipline specific applications (Aerospace, civil, automotive)
- Linear test/analysis correlation methods (modal parameter correlation, time history comparisons)
- Example of test/analysis correlation applied to linear structure
- Problems of interest for nonlinear model validation

### Feature Extraction: “What Should the Model Predict?”

- Desirable properties of response features
- Selection process for response features
- Features commonly used for different types of model response (e.g. modal parameters, peak strains, temporal moments)

### Metamodeling: “Simplifying the Response Space”

- Overview of surrogate modeling / metamodel forms
- Parameter space sampling
- Model regression & error estimation
- Optimization using metamodels

### Sensitivity Analysis:

#### “What is the Model Output Saying?”

- Global sensitivity analysis/ local sensitivity analysis
- Parameter screening
- Design of experiments (DOE)/ Analysis of variance (ANOVA)

### Design of Validation Experiments: “Measuring Reality”

- Screening of variables to study experimentally
- Control and measurement of experimental variables
- Placement of instrumentation
- Variability: Replication of experiments
- Estimating and accounting for experimental uncertainties

### Test/Analysis Correlation: “How do they agree?”

- Comparisons between predictions & experimental data
- Definitions of feature fidelity metrics
- Statistical testing
- How good is good enough?

### Model Revision and Updating:

#### “How to improve the Prediction?”

- Revising conceptual model form and assumptions
- Model parameter calibration
- Independent parameter assessment
- Optimization under uncertainty

### Uncertainty Quantification:

#### “How much Confidence do we Have?”

- Classification of simulation uncertainties
- Estimation of input parameter distributions
- Propagation of input parameter uncertainties

### Sample Applications from the Notes:

#### • Linear

- Aerospace structures and vehicles
- Automotive engine assembly
- Steel & concrete highway bridge

#### • Nonlinear

- Impact of polymer foam layer
- Explosively driven impulse on threaded joint
- Three-dimensional shell buckling and crush

### Demonstration of Software Packages:

- Design Expert<sup>®</sup>
- Matlab<sup>®</sup>-based model validation tools

**Learn** the latest techniques for evaluating the accuracy of your models over a range of parameter values

**Learn** how to design validation experiments that will help determine the model’s true range of validity

**Learn** how to calibrate your model parameters to reflect the measured response from the experiment — even for nonlinear models!

The instructors will assume a basic knowledge of structural mechanics, dynamics, and mathematics, such as that obtained in a bachelor’s level aerospace, civil, or mechanical engineering program.

To ensure top-quality content, the instructors reserve the right to alter the course schedule.