

## Course Outline (continued)

### 13. Embedded Sensing: Acoustic Emissions

- Sensing systems
- Data analysis
- Performance comparison and discussion
- Applications to aerospace structures

### 14. Unsupervised Learning Methods

- Outlier analysis
- Statistical process control
- Projection techniques

### 15. Supervised Learning Methods

- Hypothesis testing
- Neural networks
- Support vector machines
- Regression analysis

### 16. Data Normalization

- Environmental/ operational effects on SHM
- Parametric modeling environmental effects
- Look-up table technique
- Machine learning techniques

### 17. Optimization SHM System Design and Sensor Placement

- Sensor optimization
- Bayesian risk analysis
- Detector design
- System design framework

### 18. Examples/Applications

- Validation data sets
- Aerospace applications
- Mechanical systems applications
- Civil engineering applications

### 19. Software Demonstration

- Software overview
- Wave propagation software
- General purpose SHM software
- Validation data

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

## About the Instructors

### Dr. Charles “Chuck” Farrar

Dr. Farrar is currently the director of the Engineering Institute at Los Alamos National Laboratory, which focuses on developing SHM and model validation technology.

### Prof. Michael Todd

Prof. Todd is currently Associate Professor of Structural Engineering and lead for Engineering Institute activities at UC—San Diego. Mike was awarded the Structural Health Monitoring “Person of the Year” award at the 2005 International Workshop on SHM.

### Prof. Jerome “Jerry” Lynch

Prof. Lynch is currently an Associate Professor in both the Department of Civil and Environmental Engineering and the Department of Electrical Engineering and Computer Science at the University of Michigan. His research focuses on the development of wireless sensor nodes for SHM applications. Jerry was awarded the SHM “Person of the Year” Award at the 2009 International Workshop on SHM and the 2009 PECASE Award by the U.S. White House.

### Prof. Keith Worden

Prof. Worden is in the Department of Mechanical Engineering at the University of Sheffield, UK. He is the author or co-author of two books and over 400 journal and conference papers. He was jointly awarded SHM “Person of the Year” in 2004.

## Course Registration

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

Please visit [www.la-dynamics.com](http://www.la-dynamics.com) to download a registration form and make a secure online payment

### Course Fees:

Full Registration Fee:	US \$1795
Early Registration*	US \$1495
Full-time Student Registration Fee	US \$795

\* To qualify for early registration discount, payment must be received at least 30 days prior to the start of the course (August 11, 2011)

**Course fees include:** Course notes (hardcopy & CD-ROM), refreshments, certificate of completion, meeting facilities, and individual consultation with instructors.

Attendees are responsible for their own transportation and lodging. Hotels convenient to the intersection of El Camino Real and University Avenue in Palo Alto are appropriate for this course. More detail course logistics information will be sent to registrants in mid-August .

## Los Alamos Dynamics

Structural Dynamics Consultants

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

# Structural Health Monitoring Using Statistical Pattern Recognition

Palo Alto, California

September 10-12, 2011

A 3-Day Short Course for  
Aerospace, Civil and  
Mechanical Engineers

This course is designed for those who seek a thorough understanding of the analytical techniques for Structural Health Monitoring as well as an appreciation for the theoretical and practical issues.

Los Alamos Dynamics is an independent company not affiliated with Los Alamos National Laboratory

# “Structural Health Monitoring is a Problem in Statistical Pattern Recognition... Because the Assessment of Damage Always Entails a Comparison.”

## Structural Health Monitoring Using

Statistical Pattern Recognition

will introduce engineers to the most recently developed techniques for detection and location of damage in structures from changes in their measured dynamic properties. In addition to the historical motivation and development of the methods, the course will cover the theory, application, and computerized implementation of this technology. Many **real-world** examples and results will be presented from the fields of aerospace, civil, and mechanical engineering. The application of techniques involving **statistical pattern recognition** will be emphasized.



## Course Goals

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

- Describe structural health monitoring as a problem in statistical pattern recognition
- Describe and classify the primary methods of structural health monitoring, with their associated advantages and disadvantages
- Describe the historical and current real-world applications of damage identification in the aerospace, civil, and mechanical engineering fields
- Discuss the primary practical implementation issues, including relevance of baseline measurements, importance of measurement statistics, and aspects of comparative studies between methods
- Explain recent developments in sensing technology relevant to SHM

## Course Outline

### 1. Introduction

- Motivation for SHM, (NDE vs SHM)
- Statistical pattern recognition paradigm
- Fundamental axioms
- Historical overview: aerospace/ civil/ mechanical application
- Operational evaluation

### 2. Data Acquisition I

- Sensor network components
- Sensor network paradigms
- Sensor fusion
- Excitation

### 3. Data Acquisition II

- Typical Sensors (accels, strain gages, fiber optic, PZT, acoustic)
- Telemetry/recording
- Power (energy harvesting)
- Emerging sensing technologies

### 4. Basic Statistical Tools

- Statistical moments/distributions
- Density estimation
- Multivariate analysis
- Principal component analysis

### 5. Introduction to Statistical Inference

- The need for statistical models in SHM
- Supervised vs unsupervised learning
- Group classification, regression modeling, outlier analysis
- Monte Carlo/bootstrap methods

### 6. Damage Sensitive Features I

- Feature selection criteria
- Feature vs metric
- Basic statistics
- Waveform/image comparisons

### 7. Damage Sensitive Features II

- Transition from linear to nonlinear response
- Physical model parameters
- Data-Based model parameters
- Residual errors from model predictions

### 8. Embedded sensing: MEMS

- Basic micro-fabrication process
- Various applications
- Markets for MEMS and microsystems
- MEMS accelerometers

### 9. Telemetry

- Embedded systems overview
- Autonomous intelligence
- Wireless communications
- System integration

### 10. Multi-functional Materials for SHM

- Enabling nanotechnologies
- Material characterization
- Examples of self-sensing materials

### 11. Embedded Sensing: Piezoelectric Active Sensing & Guided Waves

- Introduction to Piezoelectric Materials
- Lamb wave theory
- Impedance methods
- Sensor self-diagnostics

### 12 Embedded Sensing: Fiber Optics

- Basic fiber optic sensing concepts (interferometry, multiplexing)
- Common sensing methods
- Performance comparison and discussion
- Deployment examples (I-10, patrol boat)

(course outline continued on next page)

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.