EI Annual Workshops

EI hosts an annual workshop with focus on the broad areas of predictive modeling, advanced sensing and information technology. The reports from these workshops are available on our website. We also work with other LANL organizations to co-host workshops. For more information, please contact Chuck Farrar at farrar@lanl.gov, 663-5330.

Events

- **Los Alamos Dynamic Summer School Lecture Series**
  - **Tutorials**
    - July 11-15th: Wave Propagations, Anthony Puckett (W-13)
    - July 18-22nd: **Model Validation**, Francois Hemez (XCP-1)
    - July 19-21st: **Nonlinear Dynamics**, Michael D. Todd (UCSD)
  - **Guest Lectures**
    - July 7th: **Structural Dynamics Research Activities at the Structural Dynamics Research Lab at the University of Cincinnati,** Randall Allemang (U. of Cincinnati)
    - July 12th: **Applications of Long-Span Bridge Monitoring with Accelerometer and Differential GPS Networks,** Andrew Smyth (Columbia University)
    - July 21st: **Programming for GPU,** Matt Bement (XCP-1)
    - July 26th: **Aerospace Structural Dynamics**, Nick Lieven (U. of Bristol, UK)
    - July 28th**: Fiber Optic Sensing**, Mike Todd (UCSD)

These lectures are open to all LANL staff and students. Staff members can use the tutorials and guest lectures to meet the continuing education credit requirements needed to maintain a professional engineer's license. We will issue certificates of attendance to staff for the purpose of documenting attendance in order to verify PE continuing education requirements. All lectures will be held in Suite 100 (IMMS) or Suite 300 in the Research Park building. For more information, contact Kathie Womack, 663-5206.

Engineering Institute News Letter July 2011

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Engineering Institute

UCSD Jacobs School of Engineering | Los Alamos NATIONAL LABORATORY

this issue

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The Engineering Institute

The Engineering Institute (EI) is a collaboration between LANL and the University of California at San Diego (UCSD) Jacobs School of Engineering whose mission is to develop a comprehensive approach for 1) conducting mission-driven, multidisciplinary engineering research and 2) recruiting, revitalization and retention of the current and future staff necessary to support LANL's national security missions.

The components of the Engineering Institute are 1) the Los Alamos Dynamic Summer School 2) a joint LANL/UCSD degree program, 3) joint LANL/UCSD research projects, 4) annual workshops, and 5) industry short courses.

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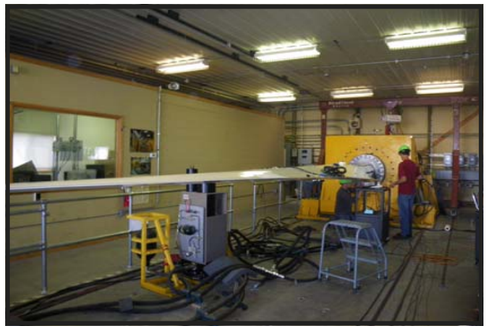
A full-scale Fatigue Test of a Wind Turbine Blade

Wind turbines are becoming a larger source of renewable energy in the United States. The turbine manufacturers have been increasing the length of the turbine blades, often made of composite materials, to maximize power output. As a result of severe wind loadings and the material level flaws in composite structures, blade failure has been a more common occurrence in the wind industry. Monitoring the structural health of the turbine blades is particularly important as they account for 15-20% of the total turbine cost. In addition, blade damage is the most expensive type of damage to repair and can cause serious secondary damage to the wind turbine system due to rotating imbalance created during blade failure. Therefore, it is imperative that a SHM system be incorporated into the design of the wind turbines in order to monitor flaws before they lead to a catastrophic failure.



EI researchers led by Curtt Ammerman (AET-1) in collaboration with several staff members across the laboratory (AET-6, CCS-3, EES-16, ISR-3, W-13, CCS-1, P-23 and INST-OFF) have been investigating the development of structural health monitoring techniques for wind turbine blades. The strategy for this research is divided into three components: a) local and active sensing to monitor incipient and propagating damage, b) global sensing to assess operational conditions and provide essential data for model validation, and c) optimal sensing to maximize observability for given failure and degradation mechanisms. Successful completion of multi-scale monitoring will result in a system capable of predicting the behavior of damaged components in wind turbines and the implications of that damage on system performance. With the proposed sensing strategy, a series of full scale fatigue tests are currently being performed in collaboration with Sandia National Laboratory and National Renewable Energy Laboratory.

The test structure of a 9-m CX-100 blade is shown in the Figure. This blade is instrumented with more than 50 piezoelectric transducers, accelerometers, strain gauges, and acoustic emission sensors. The location of the sensors and the actuator in relation to the blade geometry is shown in the bottom figure. Specially designed hardware developed by this research team is also implemented for performance comparison. This mid-scale blade has been well characterized in the literature and will serve as a solid platform to test our sensing and modeling capabilities. The results obtained from this fatigue test will be fed into the design of the final sensing system and the prognostic analysis to characterize the undamaged and damaged operational states of the blade. These results will also be used in preparation for the final validation experiments of this project where three CX-100 blades will be instrumented and deployed at the Wind Energy Technology Test Site in Bushland, TX. This final set of experiments will be designed to evaluate low-frequency structural monitoring, and mid- to high-frequency SHM sensing systems whose data will be used in the prognostic analysis to monitor each blade's operating condition, as well as load transmission to the turbine hub.

UCSD Course Sequences

Signal Processing
Digital Signal Processing
Array Processing
Detection Theory
Parameter Estimation
Stochastic Processes
Sensor Networks
Random Processes

Embedded Systems
Introduction to Embedded Systems
Software for Embedded Systems
Validation and Testing of Embedded Systems
Design Automation and Prototyping for Embedded Systems

Parallel Computing
Large Scale Computing
Parallel Computation

Controls
Linear Systems Theory
Nonlinear Control Systems
Approx Identification and Control
Applied Structural Control

NDE/SHM
Experimental Mechanics and NDE
Structural Health Monitoring

Structural Dynamics
Structural Dynamics
Advanced Structural Dynamics
Nonlinear Mechanical Vibration
Random Vibrations
Wave Propagation in Elastic Media
Wave Propagation in Continuous Structural Elements

Applied Mechanics
Theory of Elasticity
Theory of Plasticity/ Viscoelasticity
Structural Stability
Solid Mechanics for Structural and Aerospace Engineering
Mechanics of Laminated Composite Structures

Computational Mechanics
Numerical Methods
Finite Element Analysis I & II
Computational Fluid Dynamics
Model Verification and Validation

If you are interested in having any of these classes or a class sequences offered at LANL, please contact Kathie Womack (Womack@lanl.gov, 663-5206)

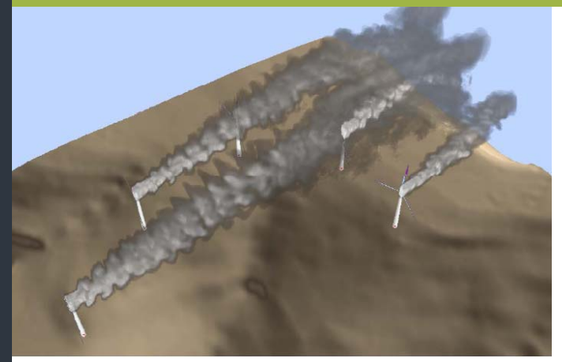
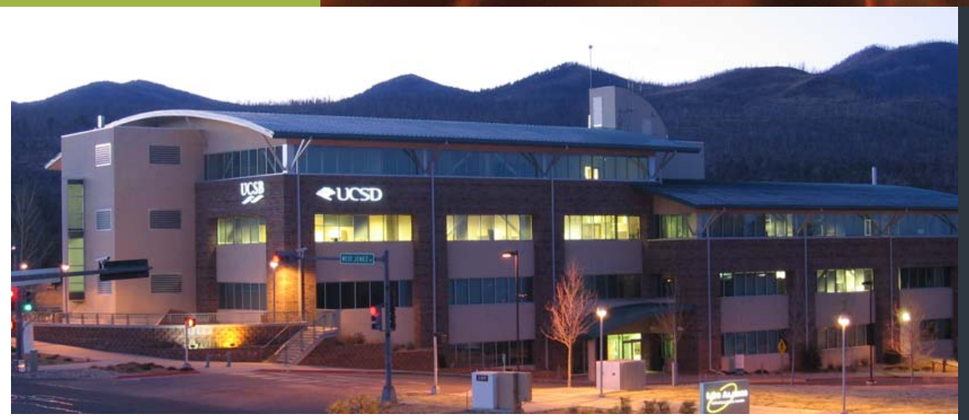


Figure courtesy of Rod Linn and Eunmo Koo (EES-16)

EI Workshop on Wind Energy Engineering

The 2011 LANL Wind Energy Engineering Workshop on *Modeling of Turbine-Turbine Interaction with Experimental Validation* was successfully held on March 2-3rd with more than 100 participants from academia, industry, and national laboratories. This workshop was jointly hosted by the LANL Intelligent Wind Turbine Project (project leader: Curtt Ammerman, AET-1) and EI. The workshop focus was modeling realistic turbine-turbine interactions and validation of these models. One theme of interest was investigating modeling techniques that enable simulation of aero-elastic rotors exposed to realistic operating phenomena (e.g. rotating turbulent wakes, low-level jets, gravity waves, and Kelvin-Helmholtz instabilities). Interaction between turbines and surrounding atmosphere could generate highly variable and often cyclic loads on wind turbine blades and life-reducing asymmetric loads on the rotor and gearbox. These interactions also impact the kinetic energy that is available for harvesting by downstream turbines. Another theme of interest was experimental approaches to obtaining both aerodynamic and structural data needed for system-level model validation. Aerodynamic approaches include novel wind tunnel and field measurements of velocity and turbulence around rotating turbines, including PIV, LIDAR, and flow visualization. Structural approaches include the use of low- and high-frequency, fiber optic, and acoustic sensing techniques.

The goals for the workshop were to examine the state-of-the-art in research and practice and develop R&D roadmaps to guide future research. Several presentations were given during the workshop to provide an overview of important research subjects. The attendees were then assigned to working groups to participate in the discussion sessions of several areas. The outcome of this workshop will be a summary report documenting the current state-of-the-art along with R&D roadmaps. The workshop report and presentations will be made available online (http://institute.lanl.gov/ei/annual-workshops/), which could provide a comprehensive overview of the selected research topics. In addition, this workshop provided participants with opportunities to make contacts, foster collaborations, and identify future complimentary efforts.



A new postdoc at EI—Steve Anton

Steven R. Anton joined the Engineering Institute in July after completing his Ph.D. in mechanical engineering at Virginia Tech under the direction of Dr. Daniel J. Inman. Steve's dissertation involved the investigation of multifunctional concepts in piezoelectric energy harvesting where a single multilayer harvester design capable of harvesting vibrational energy, storing the harvested energy, and supporting structural load was developed. While at LANL, Steve will expand upon his research in energy harvesting by examining the feasibility of multi-mode energy harvesting, which involves simultaneously harvesting energy from multiple ambient energy sources through the use of various transduction mechanisms. Some of the materials under investigation will include piezoelectrics, electroactive polymers (EAPs), thermoelectrics, and photovoltaics, all of which utilize unique conversion principles. Beyond the characterization of each material, one of the primary challenges of this work will involve the development of efficient electronic conditioning circuitry capable of processing and combining several disparate electrical output signatures. Steve is an alumni of 2006 Los Alamos Dynamic Summer School.

2011 Los Alamos Dynamic Summer School

A 9-week program of Los Alamos Dynamic Summer School has started on June 9th. The purpose of this summer school is to focus a select group of prospective upper level undergraduate students and first year graduate students (limited to US citizens) on the broad field of engineering structural dynamics. Structural dynamics encompasses technologies such as flight dynamics, vibration analysis, earthquake engineering, structural health monitoring, blast loading, signal processing, system identification, and experimental modal analysis. This year there are 16 students participating in the summer school, each involved in one of the following research efforts,

- Embedded Active Vibration Cancellation of a Piston-Driven Cryocooler for Nuclear Spectroscopy Applications
- Identifying and Modeling Physics Based Damping in Finite Element Analysis
- Assessment of the finite element code NLBeam for modeling large amplitude structural dynamic response of wind turbine blades.
- Dynamic Characterization of Wind Turbine Blades
- Characterization of Bio-Inspired Synthetic Hair Cell Sensors

Advisory Board for EI

The EI has formed an internal advisory board to help guide its educational and research activities. The purpose of this Board is to maximize the positive impact the EI's recruiting, training and retention activities have on LANL engineers and maximize the number of line organizations impacted by these activities.

The roles and responsibilities of the EI Advisory Board include

- Represent their respective line organization's needs in terms of recruiting, training and retention to the EI staff.
- Guide the collaborative research projects and educational activities of the EI
- Help to define other EI activities such as workshops and development of proposal writing teams
- Bridge a gap between line organization and EI for summer internships, for post-doctoral research appointments, or for staff hiring.

The following members will serve on this advisory board for a two-year period,

Frank Addessio (T-3)
Don Hush (ISR-2)
Doug Kautz (WCM-2)
Thomas Mason (W-6)
Evelyn Mullen (IAT-DO)
R. Alan Patterson (MST-DO)
Ray Guffee (AET-1)
Daniel Rees (AOT-RFE)
Angela Mielke (ISR-3)