CAV Review '11-'12

CENTER FOR ACOUSTICS & VIBRATION

CAV Update

Spring workshop dates set

The CAV's annual workshop will be held at the Penn State Nittany Lion Inn May 14-15. This year the workshop will have a different format with the event lasting for two full days. On Monday morning, following the formal presentations, we will have a panel discussion that relates back to the early talks. We will be following this pattern for the afternoon session and Tuesday sessions. As in the past laboratory tours will be given to familiarize attendees with some CAV facilities. There will also be a tour of the new Millennium Building on campus. Monday evening will also have a different look to it with a student poster session at the Hintz Alumni Center. As in the past, the program will mix presentations from technical group leaders, international liaisons, several corporate sponsors, and new government liaisons. Graduate students and their advisors will be available for discussions concerning their research. While formal presentations are organized to allow for the exchange of technical information, we have lengthened the allotted time for breaks to offer ample opportunities for informal discussions.

Student poster session held during workshop

This year, we are holding a student poster competition during our CAV workshop, to be held 14-15 May. The poster competition will be at our Monday evening social at the Hintz Alumni Center, between 6 and 9 pm. Our corporate sponsors, government guests, and international liaisons will cast votes for the best posters, and we'll award small prizes for 1st, 2nd, and 3rd places ($150, $100, and $50).

CAV seminars archived online

Remember that CAV members may now access our previous lunchtime seminar series online. Videos of the presentations from Fall 2009 to present may be viewed. This is a service to our members only, so please contact us for the site location.

PENNSTATE

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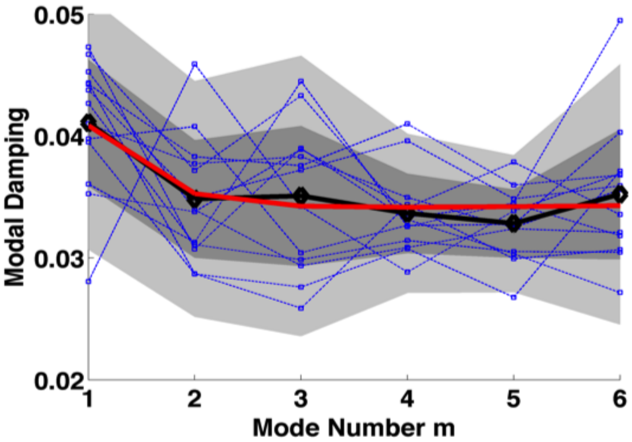
Cable Dynamics Research

Spacecraft electrical cables and wiring harnesses can significantly affect the dynamic response of spacecraft structures. Increasing power and data requirements in combination with decreasing structural density can lead to situations in which cabling accounts for more than 25% of spacecraft dry mass! Accurate dynamics models are essential for spacecraft design: they are used to predict response to launch loads as well as to design precision shape, pointing, and vibration control systems. Current structural dynamics models primarily address the effects of cable mass and stiffness, and over-predict response levels—cables add damping that must be included with some fidelity.

XSS-11 spacecraft bus
(Ardelean et al., 2010)

Researchers at the Air Force Research Laboratory (AFRL), Sandia National Laboratories, Moog / CSA Engineering, and Schafer Corp. characterized the dynamic behavior of individual cables and developed a shear beam model that includes first-order transverse shear effects. While this model accurately predicts cable resonance frequencies, the "structural" damping model used is useful only for linear frequency-domain calculations. A time-domain damping model is needed to address transients as well as impacts and other nonlinear response. Considering available experimental data, such a model would ideally be capable of delivering approximately constant damping over a broad frequency range, with higher damping in higher modes. Conventional time-domain damping models such as proportional viscous damping are unsatisfactory from these points of view.

Penn State CAV researchers, working with counterparts at AFRL and Sandia, developed a new two-term viscous damping model for shear beams; the independent terms depend on the shear- and bending-angle rates. This model results in much weaker frequency dependence than proportional damping models: approximately constant in the bending- dominated (low mode number) regime, and increasing linearly with mode number in the shear-dominated (high mode number) regime. A key feature of this model is its ready implementation in finite element analysis, requiring only the typical mass, stiffness, and "geometric" stiffness matrices as developed for an Euler-Bernoulli beam. Such an analysis using empirically determined damping coefficients generates damping values that agree well with available spacecraft cable bundle data.



Corporate Members & International Liaisons

Corporate Members & Representatives
Bettis Atomic Power Lab—Eric Salesky
Boeing—Joseph Wat
Electric Boat—Michael Thiel
Fisher Controls Technology International, LLC—Al Fagerlund
General Electric Global Research Center—Andrew Gorton
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Siemens Corporation—Justinian Rosca
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Volvo Construction Equipment—John Wang
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ISVR (UK) - Jeremy Astley
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CIRA (Italy) - Antonio Concilio
INSA de Lyon—Jean-Louise Guyader
KAIST—Yang-Hann Kim

CAV Members Receive Honors and Awards

Dr. Victor Sparrow—2012 Outstanding Faculty of the Year, Federal Aviation Administration's Center of Excellence for Aircraft Noise and Aviation Emissions Mitigation

Dr. George Lesieutre—Keynote speaker , "Adaptive Structures: The Journey to Flight" AIAA Structures, Structural Dynamics and materials

Dr. Martin W. Trethewey—PSEAS Outstanding Teaching Award

Sang Cho—Penn State Alumni Association dissertation Award

Kieran Poulain—Outstanding young presenter-in Noise Award" Acoustical Society of America fall 2011 meeting in San Diego, CA

Kimberly Reigel—elected to the Board of Directors of the Institute of Noise Control Engineering, 2012-2014

Jeff Kauffmann—finalist for the best student paper award at SPIE Smart Materials and Structures Conference, 2011

Whitney Coyle—National Science Foundation Graduate Research Fellowship

CAV Welcomes New Corporate Sponsors

The CAV is pleased to announce five new corporate sponsors for 2011-12.

Boeing—corporate liaison, Joseph Wat
Boeing is the world's largest aerospace company and leading manufacturer of commercial jetliners and defense, space and security systems. A top U.S. exporter, the company supports airlines and U.S. and allied government customers in 150 countries. Boeing also has a long tradition of aerospace leadership and innovation as the company continues to expand its product line and services to meet emerging customer needs. With corporate offices in Chicago, Boeing employs more than 170,000 people across the United States and in 70 countries. This represents one of the most diverse, talented and innovative workforces anywhere. More than 140,000 employees hold college degrees -- including nearly 35,000 advanced degrees -- in virtually every business and technical field from approximately 2,700 colleges and universities worldwide.
For more information please visit http://www.boeing.com/companyoffices/aboutus.

Moog, Inc—corporate liaison, Eric Anderson
Moog started in 1951 as designer and supplier of aircraft and missile components. Today, our motion control technology enhances performance in a variety of markets and applications, from commercial aircraft cockpits, to power-generation turbines, to Formula One racing, to medical infusion systems. Moog provides products for quiet actuation on naval systems, active vibration control on rotorcraft and vibration isolation and damping for aerospace and industrial systems. The company is based in East Aurora, NY, near Buffalo, and operates in over 25 countries. The Moog culture supports our talented people, allowing them to approach their work with energy, enthusiasm, and the promise of success in supporting and providing the best possible products and solutions for our customers.

Siemens Corporate Research—corporate liaison, Justinian Rosca
Located in Princeton, New Jersey, USA, Siemens Corporate Research and Technology is Siemens' largest research and development center outside Europe. Founded in 1977, its nearly 300 research scientists, engineers, and technology experts provide technological solutions to the global family of Siemens' businesses and work closely with Siemens' customers, government agencies, universities, and other organizations. Siemens Corporate Research and Technology also drives innovation through Siemens Technology-To-Business (TTB). Located in Berkeley, California, TTB serves as a channel for Siemens to systematically access innovations from outside Siemens and quickly move them into commercial products or solutions.
For more information on Corporate Research, visit www.usa.siemens.com/research .

Toyota Technical Center —corporate liaison, Yeongching Lin
In 1957, when Toyota first came to America, Elvis was king of rock n' roll, big cars with tailfins were "in" and postage stamps were just 3 cents. After a poor start with a car called the "Toyopet," Toyota came back strong in 1965 with the popular 90-horsepower Corona sedan. Today, Toyota is one of the top-selling brands in America and is committed to continuous improvement in everything they do, along with breakthrough products for the future. The Toyota Motor Engineering & Manufacturing (TEMA) is responsible for Toyota's engineering design and development, R&D, and manufacturing activities in the U.S., Mexico and Canada. In 14 manufacturing locations across North America, team members are producing 12 vehicles. The Toyota Technical Center (TTC) is a division of TEMA, and is located in Ann Arbor, Michigan. The expansion in York Township has increased investment by $187 million. This location is home to Toyota's first full safety test facility outside Japan. Toyota's total direct investment in the U.S. has now grown to more than $18 billion, and our annual spending on parts, goods and services from hundreds of U.S. suppliers totals more than $25 billion.
For more information please visit http://www.toyota.com/.

Volvo Construction Equipment—corporate liaison, John Wang
Volvo Group is one of the world's leading suppliers of transport solutions for commercial use. They also provide complete packages for financing and service. By creating value for the customer they create value for the shareholders. Expertise is used to create transport-related hard and soft products of superior quality, safety and environmental care. The company works with energy, passion and respect for the individual. These values have a long tradition and permeate the organization, the products and the way of working. Volvo Construction Equipment is a world wide business with 101,381 employees in 2008. The company has a worldwide distribution to over 150 countries of products such as wheel loaders, backhoe loaders, asphalt compactors, soil compactors, and compact excavators to name a few.
For more information please visit http://www.volvo.com/

Welcome New CAV Members

The CAV has experienced growth in the membership of faculty and research staff this past year. Those who have joined us bring experience in their respective fields, fresh ideas and possible avenues for research collaboration. We welcome the following new members.

Dr. Cliff Lissenden is a professor of engineering science and mechanics, having joined The Pennsylvania State University in August 1995 as an assistant professor. His ongoing research is in the area of structural health monitoring and nondestructive evaluation using ultrasonic guided waves. Phased array transducers are being designed to provide mode control and steer an ultrasonic beam that is sensitive to degradation of joints on composite structures. Piezoelectric strip transducers are being investigated to monitor hot spots in plate and shell structures. Tomographic imaging algorithms are being developed to visualize fatigue crack growth in multilayer metal structures. Nonlinear ultrasonic guided waves are being researched in order to characterize the evolution of microstructure due to thermal aging, creep, and plasticity through the generation of higher harmonics.

Dr. Daniel G. Linzell, P.E. is the John A. and Harriette K. Shaw Professor of Civil Engineering and Director of the Protective Technology Center at The Pennsylvania State University. He received his Ph.D. in Civil Engineering from the Georgia Institute of Technology in 1999, his M.S. in Civil Engineering from Georgia Tech in 1995 and a B.S. in Civil Engineering from the Ohio State University in 1990. He served as a visiting professor at TECNUN, the engineering campus of the University of Navarra in San Sebastian, Spain, during the 2008-09 academic year. Dr. Linzell has published over 40 refereed articles in areas related to structural engineering that have included research related to: protective barrier systems; building and bridge systems and components under blast and impact loads; the behavior of bridges during construction and under service loads; and ship structural components under static and dynamic loads. structural inspections on bridges, buildings and other infrastructure systems.

CAV Members Organize Conference

Steve Hambric, General Chair and Steve Conlon, Technical Chair, are organizing this year's Internoise conference, to be held 19-22 August in New York City. Internoise is sponsored by the International Institute of Noise Control Engineering (I-INCE) and the USA branch—INCE-USA. Over 1,000 papers will be presented at the conference, with over 65 vendors displaying hardware, software, and noise and vibration control solutions. To learn more about the conference and to register see www.internoise2012.com.

New Distance Education Director

Russell Joins Acoustics Program

The Graduate Program in Acoustics is pleased to announce that Dr. Daniel A. Russell (formerly of Kettering University/GMI Engineering & Management Institute) has joined Penn State as Professor of Acoustics and Director of Distance Education. Dr. Russell is widely known for his acoustics animations website and for his research involving the acoustics and vibration of sports equipment and musical instruments. For 16 years while at Kettering University, Dr. Russell worked with many co-op students working in the automotive and manufacturing industries. In addition to teaching several of our acoustics courses, Dr. Russell oversees, manages, and markets the distance education component of Penn State' Acoustics program. For example, in Spring 2012 Dr. Russell taught ACS 537 Noise Control Engineering to a record enrollment, in a blended environment, to both in-resident and distance education students. To contact Dr. Russell please email drussell@engr.psu.edu. Please join us in welcoming him to Penn Sate

CAV Anechoic Room Recharacterized

Paul Bauch, M.S. student in our Acoustics program, has recharacterized our CAV hemi-anechoic room. Combined with Andrew Orr's (M.S. Acoustics, 2011) recharacterization of the CAV reverberant room, Paul is preparing to update and benchmark sound tramsmission loss procedures through our window between the two roms.

Technical Research Group Highlights

Acoustics Characterization of Materials

Bernhard R. Tittmann, Group Leader
brt14@psu.edu

The mission of the Acoustics Characterization of Materials group is to develop a new understanding of how various types of waves, i.e., ultrasonic x-ray, thermal, optical, electromagnetic, acoustic, etc., interact with advanced materials; to translate this understanding into techniques for monitoring and controlling industrial processes; and to apply these techniques to the development of materials processes.

Recent graduate students—
Manton Guers received his Ph.D. in August 2011. he is to be employed at the Applied Research Laboratory. He can be reached at mjg244@psu.edu.

Sahar Masghsoudy-Louyeh graduated in May 2011 and is now at Airspace Cor., Los Angeles, CA.

Cliff Searfass received is Ph.D. this May and will shortly be working at Hitachi Research Laboratory, Tokyo, Japan.

David Parks received his Ph.D. and is now at Idaho National Laboratory, Idaho Springs, Idaho.

Shawn Getty has earned his M.S. and will be working at General Motors Co. Chicago, Michigan.

Ongoing work—
Xiaoning Xi is continuing her work on her Ph.D. research and thesis.
Brian Reinhardt is continuing his work on his Ph.D.

New graduate students to our group are—
Robert Cyphers—M.S. candidate.
Jeoung Kim (Acoustics) - M.S. candidate.

Current Undergraduate Students —
Christiane Pheil
Kyle Sinding

Visiting Scholar—
Taesung Park is a Ph.D. candidate from the Korean Institute of Technology and will be at Penn State for 6 months. His research is in "Nondestructive Evaluation of Thin Films by Optical and Acoustic Microscopy."

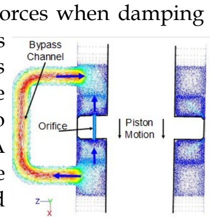
Active Structures and Noise Control

George Lesieutre, group leader
gal4@psu.edu

The mission of the Active Structures and Noise Control Technical Group is to pursue strategies Control Technical Group is to pursue strategies for reducing vibration and noise in engineering systems. This involves the development of active materials and devices, accurate modeling approaches, passive control methods, discrete and distributed sensors and actuators as well as placement strategies, structural integration methods, fast and stable adaptive control algorithms, and experiments to evaluate real-world performance. In complex mechanical/acoustical systems with multiple sensing and source/actuator locations, significant challenges remain.

Professor George Lesieutre and his students are pursuing a number of projects in vibration control and active structures. Working with Prof. Frecker's group, and with the support of the National Science Foundation, they are pursuing the development of high-strain-capable ceramic materials. The National Rotorcraft Technology Center (NRTC) supports a project that involves the active deployment of small trailing-edge devices to improve rotor performance. The Lord Corporation sponsors a program to improve the dynamic behavior of helicopter lag dampers. Finally, NASA supports a research effort that aims to damp vibrations of integrally-bladed turbomachinery rotors using piezoelectric materials.

Title: Multi-State Lag Dampers
Sponsor: Lord Corporation
Summary: A multi-state lead-lag damper is designed to reduce damper forces when damping is not required. This is achieved via a set of bypass channels than can be opened or closed in order to vary the damper forces. A first generation prototype was built and bench tested to validate the multi-state behavior. Additionally, to predict the damper behavior, an analytical model and a computational fluid dynamics (CFD) model using the commercial program FLUENT were developed. The prototype damper was bench tested over a range of frequencies and dynamic displacements in both the open and closed configurations. Comparison between the open and closed configurations demonstrated the ability of the bypass channels to reduce damper force by more than 70%, with the capability to tune this value by varying the bypass channel diameter. The CFD model allows detailed investigation into the internal flow dynamics of the damper device and is able to capture the general shape of the experimental force vs. displacement hysteresis loops. Rotor tests confirmed the validity of the bypass damper concept.



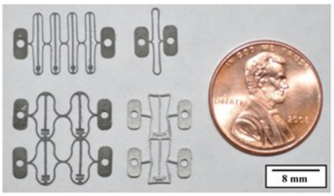
Collaborator: Dr. Edward Smith (Aerospace)
Student: Conor Marr, Ph.D. expected May 2012

Title: High-Strength High-Strain Structures Using Ceramic Cellular Contact-Aided Compliant Mechanisms (C3M)
Sponsor: NSF
Summary: Cellular Contact-Aided Compliant Mechanisms (C3M) are cellular structures with integrated contact mechanisms that provide stress relief. C3M are capable of large strains compared to their bulk material constituents and, due to the stress relief, are capable of even greater strains than their non-contact cellular counterparts. Originally developed by Drs. Frecker and Lesieutre for the skin of morphing aircraft vehicles, C3M have the potential to be used in many applications requiring large strain. In this project we are developing integrated design and fabrication methods for high-strength high-strain ceramic C3M. Ceramic materials are of interest because of their high strength particularly at the mesoscale, with over 2 GPa bend strength, and potential high temperature capability. Bulk ceramic materials also have high strength, but low strain at failure, perhaps 0.2 – 1.0 percent, depending on the size. In contrast, ceramic C3M are capable of ultimate strains of 11 to 13 percent, an order of magnitude higher than the ultimate strain of the bulk material. This project brings together expertise in materials, fabrication, modeling, and design.
Collaborators: Dr. Mary Frecker (ME), Dr. Jim Adair (MatSci)
Student: Jennifer Hyland, M.S. expected August, 2012

Title: Reduction of High-Cycle Fatigue in Integrally Bladed Rotors through Piezoelectric Vibration Damping and Control
Sponsor: NASA Glenn Research Center
Summary: A robust vibration damping system for integrally bladed rotors can dramatically reduce high-cycle fatigue in turbomachinery. Such a system can be implemented using piezoelectric materials in both passive and active roles. Current research focuses on semi-active resonance de-tuning, and modeling using an assumed-modes method. The approach involves detuning the structural resonance frequency from a (changing) excitation frequency by altering the structural stiffness (by switching the electrical boundary conditions of a piezoelectric element), thus limiting the structural dynamic response. Including a switch back to the original stiffness state, detuning requires two switches per resonance / excitation frequency crossing, orders of magnitude fewer than other state switching approaches that require four switches per cycle of vibration. The detuning method provides the greatest normalized vibration reduction for slow sweeps, low damping, and high coupling coefficient.
Student: Jeff Kauffman, Ph.D. expected August, 2012

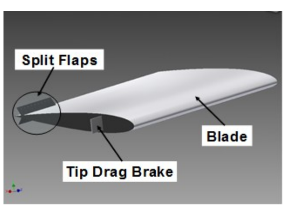
Technical Group Research Highlights

Title: Radial Bearing Isolator for Helicopter Noise Reduction
Sponsor: Fellowship
Summary: Main transmission bearings are of critical importance to flight safety, noise, and maintainability/reliability. Reduced cabin noise is becoming more critical as hearing loss issues develop for DoD passengers. A major source of noise is gear-meshing vibration that is transmitted to the cabin via hard mounts, bearings, and the housing. Considerable research has addressed interior noise reduction strategies. In general, these involve modification of the vibration and acoustic transmission paths from the gearbox to the cabin. Examples include the use of mounts to isolate the gearbox from the fuselage, and tailored fuselage panels. Passive approaches are preferred, but are not always capable of meeting demanding requirements. This research is pursuing a multilayered metal-elastimer bearing isolator that will reduce the vibration transmitted from the gearbox to the transmission housing and noise to the cabin.



Collaborator: Dr. Edward Smith (Aerospace)
Student: Pauline Autran, M.S. expected August, 2012

Title: Controllable Lag Damping via Deployable Drag Devices
Sponsor: Fellowship
Summary: Traditional root-end lag dampers are required to prevent ground- and air-resonance instabilities in rotorcraft, and thus find widespread use. Although these instabilities are of concern under limited operational conditions, the dampers are always active, leading to persistent loading of the damper and rotor. Significant benefits would ensue from the ability to deploy damping only when it is needed. One concept for variable lag damping is a deployable drag brake. Such a device, located on the outer span, towards or at the tip, would be deployed only when the blade is oscillating at its lag natural frequency, and actuation without power external to the rotor is a key goal. This damping concept requires some method to sense blade lag motion, and means for accomplishing this are also being investigated.



Collaborator: Dr. Edward Smith (Aerospace)
Student: Anna Winslow, M.S. expected December 2012

Title: Variable Thermal Conductivity Structures for Spacecraft Thermal Control using Ceramic-Metal Cellular Contact-aided Compliant Mechanisms
Sponsor: AFOSR
Summary: C3M are cellular structures with novel integrated contact mechanisms that provide local stress relief under high loads; when active, these contact mechanisms also introduce new thermal conduction pathways. C3M are capable of sustaining very large effective strains compared to those of their bulk material constituents, and are capable of greater strains than their non-contact cellular counterparts. We are exploring the potential benefits of C3M in applications requiring high thermal performance along with structural functionality, with emphasis on spacecraft thermal control. The research effort spans synthesis and fabrication over multiple length scales, and brings together a unique interdisciplinary team to pursue enhanced thermomechanical performance in structural applications relevant to Air Force needs.
Collaborators: Dr. Mary Frecker (ME), Dr. Jim Adair (MatSci)
Student: Rebecca Stavely, M.S. expected August 2013

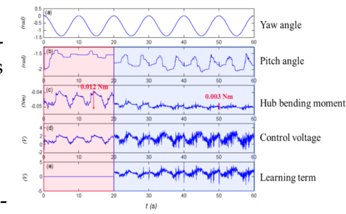
MECHATRONICS RESEARCH LAB

C. Rahn - Director

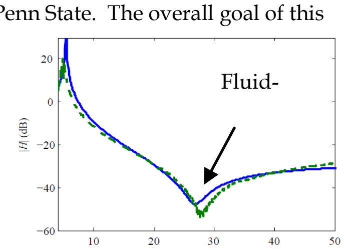
The Mechatronics Research Lab specializes in a multi-physics model-based approach to control and design of mechatronic systems. The research has been supported by funding from NSF, NIH, AFOSR, ONR, Army, DOE, DOC, and industry. Research in the MRL is currently concentrated in three areas: Smart structures, battery systems engineering, and advanced actuators.

Smart Structures. Our focus has been on the model-based control of distributed parameter systems. Distributed parameter models accurately represent the physics of many electromechanical systems. These models typically consist of partial differential equations (PDEs) for the distributed mechanical subsystem, boundary conditions, electromechanical coupling equations, and ordinary differential equations (ODEs) for the electrical subsystem. Applications include flexible cable cranes, high-speed machining spindles, active noise control systems, flexible robot arms, marine cable systems, and high-speed web and fiber handling systems. Traditionally, the distributed equations are discretized to a finite number (N) of low order modes, resulting in a set of ODEs that can be used for control design using standard tools. For systems with low damping, however, choosing N too small can cause spillover instabilities in the high order modes. Alternatively, choice of a large N may result in a high order compensator that is difficult to implement.

Using Lyapunov-based approaches that do not require discretization, we design controllers that asymptotically stabilize the distributed model. This mathematically elegant method eliminates the spillover instabilities associated with traditional control approaches, produces simple, low order, physically intuitive controllers, and is applicable to nonlinear systems. The approach applies mathematical tools based on functional analysis, semigroup theory, and Lyapunov's Direct Method to a specific mechatronic system. In addition, Lyapunov-based techniques such as adaptive and backstepping control can be used to account for parametric uncertainty and electrical dynamics, respectively. Unlike most researchers in this area who focus exclusively on mathematics, we experimentally implement the proposed controllers and demonstrate the improved performance provided by the control. This often requires the development of novel mechatronic sensing and actuation schemes to measure the required feedback variables and apply the required system inputs. The figure shows, for example, a distributed parameter model-based control experiment for repetitive learning force tracking in a whisker sensor for the Navy.

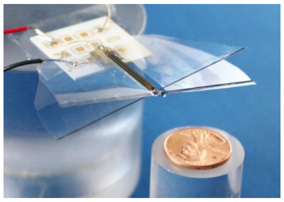


NSF is currently supporting an EFRI project in smart structures with Prof. Kon-Well Wang and two other PIs from Michigan and Prof. Chuck Bakis here at Penn State. The overall goal of this research is to create a transformative multifunctional adaptive structure concept through investigating the unique and desirable characteristics of plants; including nastic (rapid plant motions) actuation with large force and stroke and self-sensing/reconfiguration/healing. More specifically, we propose to develop and investigate new bio-actuation/bio-sensing ideas building upon innovations inspired by the mechanical, chemical, and electrical properties of plant cells. We have already demonstrated the vibration isolation characteristics of a fluidlastic cell coupled to a mass. The figure shows the theoretically predicted and experimentally demonstrated transmission isolation zero at around 28 Hz. One of our challenges



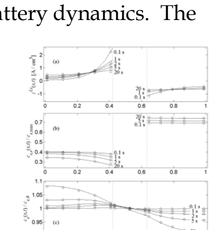
in this project is to extend the initial success in a discretized structure to a distributed, hypercellular structure.

Advanced Actuators. Working with colleagues in the Electrical Engineering department, we are helping to develop small and lightweight actuators for vehicles and medical applications. AFOSR is currently supporting a project to develop piezoelectric (PZT) actuators and wings for Nano Air Vehicles (NAVs). Prof. Srinivas Tadigadapa and MRL team members invented the T-beam actuators that provide two-axis displacement from bulk PZT structure. These actuators have been integrated with polymer flexures to produce the clapping wing NAV shown at right.



EAP Actuators for Braille displays are being developed under funding from NIH. Prof. Qiming Zhang provides the materials that are then cast into films, stretched to the desired thickness using a zone heating machine, placed on frames, sprayed with conductive polymer electrodes, laminated to form a bi-layer, cut and wound into tubes, thermally bonded in a vacuum oven, and metallically electroded on the top and bottom to form a longitudinal straining actuator. Many of the steps in this process have been automated using mechatronic systems designed and fabricated in the MRL.

Battery Systems Engineering. Prof. Chao-Yang Wang and MRL team members are the originators of the new field of battery systems engineering. We have funding from DOE and industry to develop model-based estimators and battery management systems for hybrid vehicles. Norfolk Southern and DOE are supporting the development of hybrid locomotives like the NS-999 that was unveiled last year. This work involves the development of first principles models of the diffusion and electrochemistry that govern battery dynamics. The figure at right compares the results for a reduced order Li-Ion battery model (solid lines) with an experimentally validated CFD model (circles), showing excellent agreement for current density (a) and Lithium ion concentration on the active particle surfaces (b) and in the electrolyte (c). These reduced order models can then be used as the basis for Kalman filters and parameter estimators that predict real-time state of charge, internal battery conditions, and state of health. Dynamic current limits, based on minimizing the predominant damage mechanism, enable long lived energy storage systems.



Students and Graduation Dates
Bin Zhu (PhD), Spring 2014
Chris Ferone (MS), Spring 2013
Githin Prasad (PhD), Spring 2013
Kiron Mateti (PhD), Summer 2011
Lloyd Scarborough (PhD), Winter 2012
MICHAEL ROBINSON (MS), Spring 2012
Nicolas Kurczewski (PhD), Spring 2015
Rory Byrne-Dugan (MS), Spring 2012
Varma Gottimukkala (MS), Spring 2011
Ying Shi (PhD), Spring 2013
Zheng Shen (PhD), Winter 2014

Professor Mary Frecker and her students are pursuing a number of projects related to active structures.

Title: High-Strength High-Strain Structures Using Ceramic Cellular Contact-Aided Compliant Mechanisms (C3M)
Sponsor: NSF
Summary: Cellular Contact-Aided Compliant Mechanisms (C3M) are cellular structures with novel integrated contact mechanisms that provide stress relief. C3M are capable of very large strains compared to their bulk material constituents, and, due to the stress relief, are capable of even greater strains than their non-contact cellular counterparts. Originally developed by Drs. Frecker and Lesieutre for the skin of morphing aircraft vehicles, C3M have the potential to be used in many applications requiring large strain. In this project we are developing integrated design and fabrication methods for high-strength high-strain C3M made of both metallic and ceramic materials. Recent efforts have focused on design, fabrication, and testing of meso-scale C3M with curved walls. The curved walled structures are capable of higher global strains and are better suited for meso-scale fabrication than C3M with straight walls.
Collaborators: George Lesieutre (Aerospace Engineering) and Jim Adair (Materials Science & Engineering)
Students: Greg Hayes (PhD May 2011), and Samantha Cirone (MS expected August 2011), Jennifer Hyland (M.S. expected August 2012

Title: Nanoparticulate Enabled Surgical Instruments
Sponsor: NIH
Summary: The project is focused on developing design and fabrication methods for meso-scale surgical instruments. The target application is natural orifice transluminal endoscopic surgery, where small flexible surgical instruments are required to advance this incision-less technique. Recent efforts have focused on developing design methods for instruments with improved performance by implementing multiple materials and multiple contact surfaces. Recent efforts have focused on design of intruments using superelastics NiTinol, which offers high strength and flexibility and is biocompatible.
Collaborators: Jim Adair (Materials Science & Engineering), Abraham Mathew (Gastroenterology), Randy Haluck (Surgery), Chris Muhlstein (Materials Science & Engineering)
Students: Milton Aguirre (PhD May 2011), Greg Hayes (PhD May 2011), Jiening Liu

Title: Passively Morphing Ornithopter Wings
Sponsor: AFOSR
Summary: The goal of this project is to provide increased lift and agility in ornithopters through passive wing morphing. A compliant spine has been developed that is flexible during the upstroke and stiff during the downstroke to provide wing morphing inspired by the continuous vortex gait in bird flight. Bench top experiments have shown that the ornithopter equipped with the compliant spine produces more lift, experiences no thrust penalities, and uses less power than the same ornithopter without the complaint spine. Recent efforts have been aimed at developing optimization methods for three dimensional compliant elements to account for bending, sweep and twist simultaneously.
Collaborators: James Hubbard (University of Maryland)
Students: Yashwanth Tummala (Ph.D. expected December 2013)

Flow-Induced Noise

Dean Capone – Group Leader

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The mission of the Flow-Induced Noise Group of the Center for Acoustics and Vibration is the understanding and control of acoustic noise and structural vibration induced by fluid flow. A summary of the accomplishments of the members of the Flow-Induced Noise Technical Group is presented below.

Dr. Stephen Hambric continues to consult for the NRC on flow-induced vibration and fatigue failure problems in U.S. commercial nuclear power plants.

Dr. Bill Bonness and Dr. Dean Capone are working with one graduate student and two undergraduate students on using arrays of hydrophone to localize cavitation bursts in water tunnels.

Technical Group Research Highlights

Dr. Dennis McLaughlin and Mr. Russell Powers continue their work in experimental measurements of supersonic jet noise. During the past year they have tested a variety of nozzles with various interior hard wall configurations. All of the configurations tested showed reductions in high frequency noise at low polar angles from the jet centerline.

Dr. Phillip Morris and his graduate students are continuing their work in numerical simulations of high speed jet noise. The computations being performed lend themselves to parallel computing and can currently be run on nVidia graphics processing units (GPUs) using the CUDA programming language.

Machinery Prognostics and Condition Monitoring

Karl Reichard, group leader
Kmr5@psu.edu

The Machinery Prognostics and Condition Monitoring Technical Group is focused on methodologies and technologies for accurate and reliable assessment of equipment condition and predicting remaining useful life in machinery. Below are descriptions of one current and one recently completed project.

Powertrain Diagnostics

Jeffery Banks, Mitch Lebold, Scott Pflumm, and Jon Bednar

This project is a collaboration between the Penn State University Applied Research Laboratory and the US Army Tank Automotive Research Development Engineering Center (TARDEC) Condition Based Maintenance (CBM) team. The project focused on the development of algorithms capable of detecting diesel engine injector misfire events in real time. The goal is to enable TARDEC's Engine Control Management (ECM) research and development efforts to evaluate the technical feasibility of integrating automated on-board condition monitoring algorithms with future ECM monitoring and control operations.

During this investigation, it was shown that multiple techniques can correctly detect and identify injector cylinder misfiring. Each individual technique has its own advantages, and the investigation focused on signal processing methods that would be suitable for embedding in an engine controller or processor. The list below includes six injector fault analysis approaches that were evaluated for this effort:

1. Injector signal analysis
2. Cylinder head vibration analysis
3. Crankshaft speed analysis in time domain
4. Crankshaft speed analysis in order domain
5. FFT classifier selection technique
6. Time domain classification technique

The six injector fault analysis techniques can be grouped into three processing domains: time domain, order domain, and classification. Injector signal analysis, cylinder head vibration analysis, and crankshaft speed analysis are all performed on time-domain signals. Crankshaft speed signals can also be examined in the frequency or order domain. Classification domain techniques include general techniques using classification/reasoning algorithms on time or frequency data. Note that the distinction between the time and order domain techniques and the classification domain techniques, even though they may both operate on the same data, is that the time and order domain techniques use simple signal metrics to detect the fault, while the classification techniques use reasoning and pattern matching approaches to classify the fault.

Figure 1 illustrates how the injector signal analysis algorithm identifies an injector misfire (in this case on cylinder number 3). The identification of the specific cylinder in which the misfire occurs is predicated on knowledge of cylinder one top dead center (TDC). Once the cylinder one TDC is located, the algorithm measures the injector signal energy in each detection window. If the signal energy does not exceed the threshold condition, the algorithm identifies the respective injector as a misfire fault.

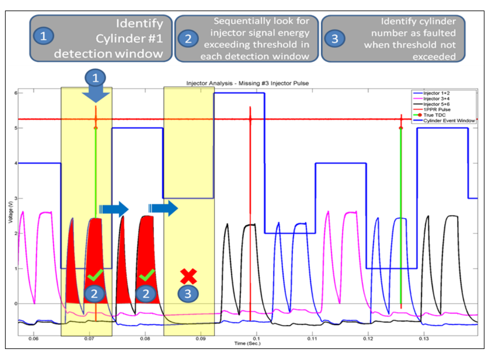

Figure 1 Illustration of injector signal analysis detecting an injector misfire in cylinder number 3.

The motivation for investigating a vibration-based fault detection approach was to provide an alternative method for detecting combustion related faults. Such an approach could be used for engines without injector firing signals or engines having mechanical injectors. The investigation also examined the minimum number of accelerometers needed to correctly detect a fuel injector misfire in any given cylinder. The investigation demonstrated 100% detection capability of any of the six respective cylinder injector faults by means of using only one accelerometer mounted above any cylinder head. Figure 2 shows examples of the accelerometer and injector firing signals. This example clearly shows the difference in the vibration signal for a misfire compared to a normal cylinder firing event. For both examples presented here, data were collected on an engine dynamometer test stand while seeding each injector fault electronically.

The order domain approach uses data from a

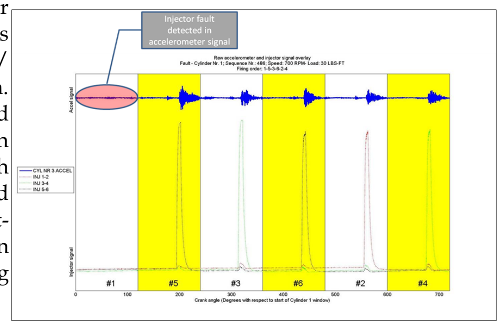

Figure 2 Overlay of accelerometer and injector firing signals: injector misfire on cylinder number 1.

crankshaft encoder. An order domain analysis of the data collected during the injector fault test schedule suggests that cylinder faults can be identified by monitoring the amplitude of the crankshaft's orders lower than two. When an injector fault was introduced into the test system at low, medium, and high load/speed engine conditions, noticeable modulation of the crankshaft occurred between orders one-half and two. A shaft order can be defined to describe the frequency of a particular synchronous event that occurs at each shaft revolution. From this definition, one can conclude that a shaft's one half order contains information about events that occur once every two shaft revolutions. For a six cylinder, four-stroke engine this order specifically characterizes the frequency of a crankshaft's torsional loads that result from an injector fault. This approach can detect both the existence of an injector fault and the location.

The brief summary presented here describes three approaches for detecting fuel injector misfire events; an injector signal based approach, a vibration signal approach and a crankshaft speed order analysis approach. All three approaches demonstrated the capability of detecting individual injector misfires on a seven liter diesel engine over the (30 lbs-ft @ 700 RPM) to (560 lbs-ft @ 2100 RPM) operating range when tested on an engine dynamometer. Furthermore, each approach equally demonstrated the ability to correctly identify the specific cylinder location of the faulted injector. The signal analysis and vibration based approaches both require a TDC/one PPR or 360PPR encoder signal for synchronization or the camshaft speed encoder signal, along with their respective analysis signals

Technical Group Research Highlights

(cylinder firing signal or accelerometer). The crankshaft speed order analysis requires access to the 360 PPR encoder signal. The injector signal based approach does require access to the signal taps for the six respective injectors while the vibration based approach requires one accelerometer mounted to the top of the engine. Due to the nature of vibration monitoring, this approach should also work for detecting any combustion related faults but must be first validated on an actual platform to ensure it is immune to externally induced vibrations.

The results of this work were presented in a series of two papers at the 2012 Annual Conference of the Society for Machinery Failure and Prevention Technology (MFPT).

M. Lebold, S. Pflumm, J. Banks, J. Bednar, K. Fischer, J. Stempnik, "Powertrain Diagnostics – Part 1 – Detecting Injector Deactivation Failure Modes In Diesel Engines Using Simple Time Domain Approaches," MFPT 2012: The Prognostics and Health Management Solutions Conference, Dayton, OH, April 2012.

J. Bednar, M. Lebold, K. Reichard, S. Pflumm, J. Banks, K. Fischer, J. Stempnik, "Powertrain Diagnostics – Part 2 – Detecting Injector Deactivation Failure Modes In Diesel Engines Using A Crankshaft Speed Order Domain Approach," MFPT 2012: The Prognostics and Health Management Solutions Conference, Dayton, OH, April 2012.

Development of an Optical Fiber Pressure Sensor for Nuclear Power Plant Applications
Mark Turner, Jon Bednar, Karl Reichard

The goal of this project is the development of a pressure sensor for nuclear power plant applications based on optical fiber Bragg grating sensors. An average nuclear power plant in the United States contains between 1,000 and 2,000 pressure transmitters (Figure 3). Traditional nuclear power plant pressure sensors are based on a capacitive cell design and include integrated electronics to condition the measurement signals and provide low-noise transmission of the measurement signals from the measurement location to the monitoring location. The presence of the measurement electronics limits the life of these sensors and drives maintenance and sustainment costs. An all-optical pressure sensor would remove the transducer interface and communication electronics from the sensing environment— extending the sensor's life and reducing sensor maintenance and lifecycle costs. Funding for this project was provided by the Electric Power Research Institute (EPRI).

Figure 3 Capacitance cell pressure transmitter.

This project examined the design and experimentally evaluated a fiber Bragg grating optical pressure transducer. The primary transduction mechanism of this design relates pressure in a fluid filled pipe to strain in a sensing diaphragm using optical strain measurements as shown in Figure 4. Similar to capacitance cell pressure transmitter designs, the proposed pressure transducer is susceptible to measurement bias induced by temperature perturbations. To minimize measurement bias, a fiber Bragg grating temperature compensation sensor is used to calculate a temperature independent diaphragm strain measurement.

The transducer design was fabricated and thermal experiments were conducted while the sensing diaphragm was mechanically unconstrained in a thermal chamber. During these experiments, the sensing diaphragm's temperature corrected strain was calculated while the ambient temperature was perturbed. An experimentally developed coefficient of thermal expansion

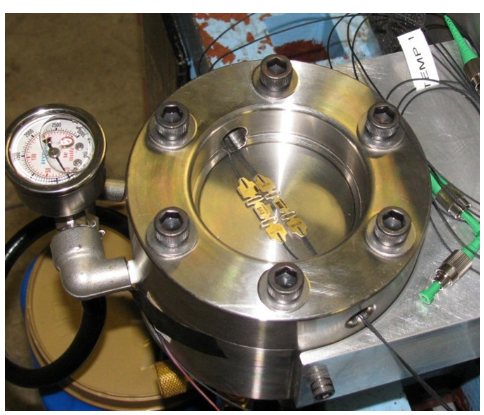
Figure 4 Optical fiber pressure transducer diaphragm

was found to improve the accuracy of strain temperature compensation. Testing also showed that the time dependence of strain compensation caused the fiber Bragg grating sensing diaphragm to ultimately exhibit 4x the maximum temperature error expected from a capacitance cell pressure transmitter in the same environment.

The assembled pressure transducer was experimentally evaluated using a hydraulic test system. The transducer's sensitivity between 0 and 1,200 psig was experimentally determined to be 1.64 psi/με. A multi-step pressure experiment was conducted to confirm the transducer's measurement repeatability. During this test, the maximum difference between pressure measurements made using the optical transducer and reference instrumentation was 44.3 psi. The mean measurement difference for this test was 19.0 psi. A capacitance cell pressure transmitter in similar conditions is expected to have an overall measurement accuracy of ± 2.5 psi.

The largest source of measurement error from the fiber Bragg grating pressure transducer is likely to be the time dependent, transient response of diaphragm strain temperature compensation measurements. Future development of the pressure transducer concept should focus on reducing temperature compensation errors. Given this improvement, the proposed fiber Bragg grating pressure transducer has significant potential for nuclear power plant applications. Phase 2 of the project is ongoing and will produce a prototype sensor which can be tested as a replacement for an existing capacitive cell pressure transmitter.

Propagation and Radiation

Victor Sparrow—Group Leader
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There were many highlights in 2010 for the Propagation and Radiation Group. There have been a number of new research projects begun, and several other projects have successfully wrapped up.

Our work with Wyle, Arlington, VA continues. One project on sonic boom transmission into buildings using finite elements completed, and another began on sonic boom focusing. Both projects originate at NASA Langley Research Center, and we are very grateful to collaborate with Wyle as subcontractors. In the new sonic boom focusing work Penn State will also be working closely with Gulfstream Aerospace Corp. of Savannah, GA.

New projects began in 2010 on outdoor propagation and the optimization of aircraft flight paths near military bases. Both of these new projects are subcontracts with Blue Ridge Research and Consulting of Asheville, NC.

The Propagation and Radiation Group also continued its work for the Federal Aviation Administration through the FAA/NASA/Transport – Canada PARTNER Center of Excellence (www.partner.aero). One of the ongoing PART NER research projects is to better synthesize sonic boom signatures that might be heard on the ground in the vicinity of buildings, incorporating the sound reflecting from the buildings. Another project is related to the en-route noise of jet aircraft while at cruise conditions at altitude. En-route noise is a particularly important topic for assessing the noise impact of aviation on U.S. National Parks and other wilderness areas. Studies at Penn State in 2010 have shown that having knowledge of the humidity as a function of height for atmospheric attenuation coefficients leads to more accurate predictions of en-route noise heard on the ground.

Penn State's research on predicting the loading forces on buildings due to sonic booms for NASA also continued in 2011. Two complementary models for low frequency and high frequency content have been developed and refined. The finite difference time domain approach works well for low frequencies, and the combined ray-trace/radiosity method works well for high frequencies. Our work in the next few months is to seamlessly combine these approaches to provide NASA a full-frequency prediction method for building loading due to arbitrary sonic boom signatures.

Graduate Students:
Sang Cho, Ph.D. expected summer 2012
Thesis topic: Sonic boom diffraction around buildings and hybrid model implementations
Sponsor: NASA
Advisor: V. Sparrow

Andrew Christian, M.S. expected summer 2012
Thesis topic: Flight profile and ground track optimization for aviation noise abatement around military airfields
Sponsor: Blue Ridge Research and Consulting / U.S. Navy
Advisor: V. Sparrow

Whitney Coyle, M.S. expected fall 2012
Thesis topic: Outdoor sound transmission using a Green's Function Parabolic Equation model with realistic atmospheres
Sponsor: Blue Ridge Research and Consulting / U.S. Navy
Advisor: V. Sparrow

Alexandre Jolibois, Ph.D. expected summer 2013
Thesis topic: Optimization of low-height noise barriers using a boundary element approach
Sponsor: Graduate Program in Acoustics and French building research center (CSTB)
Advisors: V. Sparrow, D. Duhamel, J. Defrance

Beom Soo Kim, Ph.D. expected summer 2013
Thesis topic: Sonic boom and subsonic aircraft noise transmission from outdoors to indoors
Sponsor: NASA/Wyle and FAA
Advisor: V. Sparrow

Amanda Lind, M.S. spring 2011, Ph.D. expected spring 2013
Thesis topic: Low-boom sonic boom prediction around buildings
Sponsor: FAA
Advisor: V. Sparrow

Kimberly Riegel, Ph.D. expected spring 2012
Thesis topic: Ray-trace/radiosity methods for the propagation of sonic booms in urban canyons
Sponsor: NASA
Advisor: V. Sparrow

Rachel Romond, Ph.D. expected summer 2014
Thesis topic: Acoustic propagation simulations sing emissions dispersion modeling program models for meteorology
Sponsor: FAA
Advisor: V. Sparrow

Joe Salamone, Ph.D. expected summer 2013
Thesis topic: A new Tricomi-equation solver including dissipative effects for the prediction of focused sonic booms
Sponsor: NASA and Gulfstream Aerospace Corp.
Advisor: V. Sparrow

Brian Tuttle, Ph.D. expected summer 2012
Thesis topic: Nonlinear acoustic streaming in conical thermoacoustic devices
Sponsor: Office of Naval Research
Advisor: V. Sparrow

Rotorcraft Acoustics and Dynamics

Ed Smith, group leader
ecs5@psu.edu

The Penn State's CAV Rotorcraft Acoustics and Dynamics Group continues to be at the core of our Vertical Lift Research Center. Penn State is home to one of only three NRTC Vertical Lift Research Centers of Excellence (VLRCOE) in the country. In summer of 2011, our Center was successfully renewed for another 5 years. As part of our new program, we will be starting 12 new research projects. We are grateful to our industry partners at LORD Corp., Timken, Goodrich, Bell, and Sikorsky for their support of our proposal. New projects include: airfoil design methods for unsteady flow (Prof. Maughmer), rotor hub flow physics for drag reduction (Prof. Schmitz), Icing physics, modeling, and detection (Dr. Palacios, Prof. Brentner, Dr. Lindau), autonomous multi-lift systems (Profs. Horn and Langelaan), nano-tailored composites for improved toughness and durability (Profs. Bakis and Adair), aeroelastically tailored wing extensions and winglets for large Civil Tiltrotors (Profs. Smith and Maughmer), control redundancy on compound rotorcraft for performance, handling qualities, and survivability (Profs. Horn, Brentner, and Gandhi), physics of active rotors for performance and acoustics (Profs. Schmitz, Maughmer, and Brentner), comprehensive analysis of gearbox loss of lubrication (Prof. Kunz and Drs. Saribay and Bill), health monitoring for joints in composite structures (Profs. Lissenden and Rose), advanced response types/cueing systems for naval operations (Prof. Horn), and autonomous shipboard take-off and landing (Prof. Langelaan). This Center currently supports more than 40 full-time graduate students and involves more than 20 Penn State faculty members in a wide range of technologies supporting rotary-wing aircraft. Seeking cost and weight efficient solutions to lower interior noise and vibration levels, and reduced exterior noise signatures is a high priority. We have experienced particular growth in programs focused on structural health monitoring, and ultrasonic ice protection systems. Acoustics and dynamics issues associated with active rotor systems, and variable speed compound rotorcraft are driving many of our technical objectives. Our various research projects are presently supported by the US Army, US Navy, NASA, and the industry sector (including large airframe manufacturers, sub-system vendors, and numerous small high- technology companies). Emphasis areas include; interactional source noise, acoustical scattering of rotor noise, gearbox noise, actively controlled and morphing rotors, active airframe vibration control, crashworthy and impact resistant structures, anti-icing systems, variable speed rotors, structural health monitoring, and rotor loads monitoring. Several new facilities have recently been brought online. The Adverse Environment Rotor Test Stand (rotor icing chamber) has proven to be a versatile and heavily used facility.

Projects and Graduate Students:
Lord Corporation
Title: Conceptualization, Modeling, and Characterization of a CF Driven Multi- State Lead-Lag Bypass Damper
Sponsor: LORD Corp.
PIs: Ed Smith, George Lesieutre
Student: Conor Marr (PhD May 2012)

Title: Vibration Control via Coupled Fluidic Pitch Links
Sponsor: LORD Corp.
PIs: Ed Smith, Chris Rahn
Student: Lloyd Scarborough (PhD candidate)

Title: High Fidelity CFD Analysis and Valida-

tion of Rotorcraft Gear Box Aerodynamics
Sponsor: NASA
PIs: Rob Kunz
Student: Sean MacIntyre

Title: Wind Turbine Ice Protection Coating Performance Evaluation
Sponsor: GE Global Research
PI: Jose Palacios

Title: Ice Accretion Shapes to Wind Turbine Airfoils
Sponsor: GE Global Research
PI: Jose Palacios

Title: Ice Accretion to Cascade Flow Configurations of Engine Compressors
Sponsor: GE Global Research
PI: Jose Palacios

Title: Durability Evaluation of Single Crystal Energy Harvesters
Sponsor: NRTC Vertical Lift Consortium
PI: Steve Conlon, Ed Smith, Karl Reichard
Student: Michael Wozniak

Title: Evaluation of Pericyclic Transmission Concepts (Rao, Saribay, Bill, Smith)
Sponsor: NRTC Vertical Lift Consortium
PIs: Suren Rao, Ed Smith, Zihni Saribay, Bob Bill
Student: Eric Froede

Title: Static and Dynamic Characterization of Composite Materials for Future Driveshaft Systems
Sponsor: NRTC Vertical Lift Consortium
PIs: Chuck Bakis, Ed Smith
Student: Todd Henry (PhD Candidate)

Title: Centrifugally Driven Pneumatic Actuators for Active Rotors
Sponsor: NRTC Vertical Lift Consortium
PIs: Jose Palacios, Ed Smith

Title: Modeling of Rotor Blade Ultrasonic Deicing and Experimental Comparison with Electrothermal Ice Protection Systems
Sponsor: NRTC Vertical Lift Consortium
PIs: Jose Palacios, Ed Smith
Student: Austin Overmeyer

Title: A Multi-Functional Ultrasonic Sensor System for Composite Rotor Blade Ice Protection, Ice Sensing, and Structural Health Monitoring
Sponsor: NAVAIR, FBS Inc. (SBIR)
PIs: Jose Palacios, Ed Smith
Student: Nic DiPlacido

Title: Civil Certification Noise Prediction Tools
Sponsor: Bell Helicopter TEXTRON
PI: Ken Brentner
Student: Ben Goldman

Title: Analysis of Rotor Startup/Shutdown in Complex Winds
Sponsor: Bell Helicopter TEXTRON
PIs: Ed Smith, Rob Kunz, Jianua Zhang

Title: Alternate Control Laws for Fly-by-Wire Helicopters
Sponsor: Bell Helicopter TEXTRON
PI: Joe Horn
Student: Ben Goldman

Structural Vibrations and Acoustics

Steve Hambric, group leader
sah19@arl.psu.edu

The mission of the Structural Vibration and Acoustics Technical Group is to better understand the mechanisms of vibration generation and propagation in structures and the interaction of structural vibrations with acoustic media, and to develop novel methodologies for the analysis, measurement, and control of structural vibrations and radiated noise.

Projects and Graduate Students:
Title: Characterization of the CAV Anechoic Room and Sound Transmission Loss capability
Sponsor: ARL Walker Fellowship Program
PIs: Andrew Barnard, Steve Hambric
Student: Paul Bauch (M.S. candidate)

Title: Carbon Nanotube (CNT) Loudspeakers
Sponsor: JNLWD
PI: Andrew Barnard, Timothy McDevitt, Timothy Brungart

Title: Offshore wind turbine flow-induced vibration and structural integrity
Sponsor: DoE
PIs: Rob Campbell (part of interdisciplinary PSU team)
Student: Javier Motta-Mena (MS – Mechanical Engineering)

Title: Artificial pulmonary valve fluid structure interaction modeling
Sponsor: ARL Walker Fellowship
PIs: Rob Campbell, Brent Craven
Student: Ken Aycock (PhD – Biomedical Engineering)

Title: Actuator noise characterization calculations
Sponsor: Moog
PI: Rob Campbell, John Fahnline

Title: Structural damage detection
Sponsor: Penn State VLRCOE
PI: Steve Conlon
Student: Kevin Brennan (MS – Aerospace Engineering)

Title: Actuator noise characterization measurements
Sponsor: Moog
PI: Steve Conlon

Title: Fast acoustic boundary element analysis on computer clusters
Sponsor: ARL/Penn State
PIs: John Fahnline
Student: Ken Czuprynski (MS – Computer Engineering)

Title: Non-lethal munitions impact force characterization
Sponsor: Joint Non Lethal Weapons Directorate
PI: Tim McDevitt

Title: Behavior of marine propellers in crashback conditions
Sponsor: NAVSEA 073R
PI: Steve Hambric and Rob Campbell
Student: Abe Lee (Ph.D., Acoustics)

Title: Development of Acoustically Tailored Composite Rotorcraft Fuselage Panels
Sponsor: NASA
PIs: Steve Hambric, Kevin Koudela, and Ed Smith

Title: Optimization of TBL-excited ribbed aircraft panels to minimize sound radiation
Sponsor: NASA
PIs: Steve Hambric
Student: Micah Shepherd (Ph.D., Acoustics)

Title: Commercial Nuclear Reactor Flow-Induced Vibration and Fatigue Failure
Sponsor: Nuclear Regulatory Commission
PI: Steve Hambric

Title: Aircraft jet engine sonic fatigue modeling
Sponsor: Pratt and Whitney
PIs: Steve Hambric, Rob Campbell
Student: Matt Shaw (Ph.D., Acoustics)

Title: Acoustic radiation and scattering from finite submerged bilaminar plate- 3 D solution
Sponsor: NAVSEA/ONR
PI: Sabih Hayek and J.E.Boisvert

Underwater Acoustics

Chris Barber group leader
cbarber@psu.edu

The mission of the Underwater Acoustics Technical Group is to better understand the propagation of sound in the ocean and the systems with projects in the fields of underwater propagation and radiation, marine biology, and acoustical oceanography.

Dr. Lee Culver is looking at passive sonar range and depth estimation using a variety of techniques based upon ocean physics and knowledge of the environment. One technique makes use of the waveguide invariant, which characterizes the striations which are seen in time-frequency plots. Another looked at the statistical differences between signals originating from different locations in the water col-

Technical Group Research Highlights

umn. A third is focused on the modal structure of the received signal, and makes use of source depth dependence of modes that are excited. Dr. Culver and his students are looking at active sonar classification and generation of CLOC curves to determine best operating point, including quite a lot of test and evaluation of new sonar signal processing algorithms. He also investigated the potential of a cognitive sonar to discover environmental characteristics and utilize a transmitter-receiver feedback channel to optimize performance.

Dr. Jennifer Miksis-Olds' team has been collecting data from passive and active acoustic sensors deployed on moorings in the Bering Sea over the past 3 years. They are relating environmental variables to the acoustic presence of vocalizing marine mammals to aid in predictive modeling. Their latest project involves examining over a decade of low frequency recordings from the Comprehensive Test Ban Treaty Organization system to gain a better understanding of low frequency ocean sound level, variability, and contributing sound source.

Dr. Charles Holland is conducting research on characterization of marine sediments (with special focus on frequency dependence of sound speed and attenuation), sonar clutter mechanisms related to the seabed, and acoustic propagation in range-dependent waveguides (oceanic and other environments).

Dr. Tom Gabrielson and Mr. Chad Smith have been the academic partners on an SBIR Phase II with the goal of assessing the potential for active detection of targets through particle-velocity sensing. They are currently performing scaled measurements in air in the CAV anechoic chamber.

Dr. Tony Lyons' 2011 research focused on understanding temporal and spatial SAS image statistics, physical and acoustic characteristics of rock outcrops, and related environmental inversion possibilities. Ph.D. students Derek Olson and Dan Brown were involved with much of this work. They participated in two experiments in 2011 in support of this work, including the Hugin HiSAS Change Detection and Seafloor Complexity Experiment aboard the HU Sverdrup II as part of the ARL/PSU – Norwegian Defence Research Establishment (FFI) joint research program, Characterization and Modeling of Synthetic Aperture Sonar, which took place in Larvik, Norway, April, 2011. The second field experiment was conducted at the Naval Surface Warfare Center – Panama City Detachment test pond in Panama City, Florida in August, 2011, in support of synthetic aperture sonar data characterization and modeling projects.

Dr. Chris Barber and Brian Fowler (MS Candidate in Acoustics), along with four Penn State undergraduate students, returned to the Navy's Acoustic Research Detachment in Bayview, ID, in July – August 2011 to conduct Phase II testing is support of ONR-sponsored nearfield acoustic holography and nearfield radiated noise projects. Preliminary results from several parts of the experiment will be presented at the Inter-noise 2012 Conference in New York City in August 2012.

Dr. David Bradley was elected President of the Acoustical Society of America for 2012 – 2013 and will assume leadership of the Society at the conclusion of the 163rd Meeting in Hong Kong this May. He was also appointed Editor of the US Navy Journal of Underwater Acoustics by the Office of Naval Research.

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