CAV Review '10-'11

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 9-10. On Monday, following the formal presentations, we will offer laboratory tours to familiarize attendees with some CAV facilities. George and Annie Lesieutre will host a picnic for all participants on Monday evening. 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, there will be ample opportunity for informal discussions.

CAV lunch seminars now archived online

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

CAV reverberation room re-characterized

Andrew Orr, a graduate student in our Acoustics Program, has re-characterized the CAV reverberation room. Andrew has measured frequency-dependent reverberation times (T60's), the spatial variability of sound, and the low-frequency modal behavior of the room. We will post Andrew's thesis to our website when it's completed along with an updated summary of the key room acoustic parameters.

New CAV group

We welcomed Dr. Chris Barber's new Underwater Acoustics group to the CAV last year. This group conducts basic and applied research related to the propagation of sound in the ocean and the systems, natural and manmade, that generate and receive sound underwater. Projects in propagation and radiated noise often involve large scale multi-vessel ocean acoustic experiments or measurements on instrumented acoustic ranges, while projects in Marine Bioacoustics may involve measurements of marine mammals and fish habitats using a few hydrophones over periods of time. Acoustical Oceanography studies use acoustic data to determine physical properties of the ocean environment. Applied research efforts include characterizing the performance of underwater acoustic systems, design and development of transducers and application of signal processing techniques.

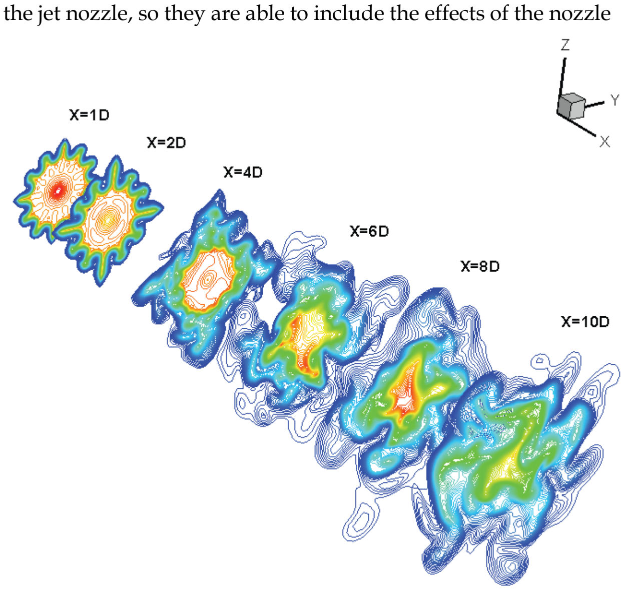
Morris Seeks to Quiet Military Jet Engines

The noise generated and radiated by modern military fighter aircraft engines represents a health hazard to carrier deck and support personnel and is annoying to communities in the vicinity of air bases. Unlike the high bypass-ratio turbofan engines used on commercial aircraft, high performance military engines are very low bypass-ratio turbofans with extremely high temperatures and exhaust velocities. Because noise is proportional to jet exhaust velocity raised to a high exponent, reducing it in these engines is particularly challenging.

There are two main sources of noise in supersonic jet engines. The dominant noise source is associated with the turbulence generated by the mixing of the high speed exhaust with the surrounding air. The turbulence travels downstream at a velocity greater than the speed of sound in the surrounding air, giving rise to very efficient noise generation, often called Mach wave radiation. In addition, the engines typically operate in an off-design condition. That is, the pressure at the jet exhaust is not equal to the external pressure. This results in a series of expansion and compression waves in the jet exhaust. These waves are known as the jet's shock-cell structure. The passage of the jet turbulence through this shock pattern results in another noise source known as broadband shock-associated noise (BBSAN).

Philip Morris, Boeing/A.D. Welliver professor of aerospace engineering, is conducting research concerned with the prediction of the noise associated with these two mechanisms. His research group is taking two different approaches. The first addresses BBSAN. It uses a steady Reynoldsaveraged Navier-Stokes (RANS) solution to establish the average flow in the shock-containing jet. Then a model is introduced to describe the noise sources that are scaled by outputs from the RANS solution. Predictions for BBSAN from single axisymmetric and rectangular jets as well as dualstream jets show good agreement with noise measurements.

The second approach involves the numerical solution of the unsteady, compressible, Navier-Stokes equations. The calculations include the jet nozzle, so they are able to include the effects of the nozzle geometry and the flow upstream of the jet exit. This is especially important for military aircraft engine nozzles because the flow can separate or shocks can form inside the nozzle. The calculations are computationally intensive and require many days (and sometimes weeks) using 100 computer processors. Comparisons of the predicted flow and noise properties with measurements have shown good results.



Contours of axial velocity at different axial distances from the jet exit showing the effects of chevrons on jet mixing

In addition to predicting how nozzle geometries affect noise, it is important to be able to predict the effect of noise reduction devices. The use of chevrons (serrations seen on the exhausts of many new commercial aircraft engines) has become popular as a noise reduction technology. These devices at the nozzle exit break up the large scale, low frequency turbulent structures. They only protrude a small distance into the jet exhaust and so should have a minimal impact on engine performance. The devices can reduce the lower frequency noise and with careful design do so without affecting the higher frequency noise that causes more human annoyance.

CAV Members Receive Honors and Awards

Dr. Kenji Uchino—PSEAS Premier Research Award, April 2011

Dr. Uchino, Dr. Seyit O. Ural, and Mr. Yuan Zhuang—1st place Best Poster Award for Navy Workshop on Acoustic Transduction Materials and Devices, May 2010

Dr. R. Lee Culver—Fellow, Acoustical Society of America, November 2010

Jason Slaby and Austin Overmeyer—Vertical Flight Foundation Fellowship from American Helicopter Society

Dr. Soundar Kumara—PSEAS Outstanding Advisor Award, April 2011; finalist in INFORMS 2010 Service Science Competition, IERC

Dr. Jennifer Miksis-Olds—Young Investigator Award from ONR, April 2011

Samuel Denes—National Defense Industrial Association Award, April 2011

Dr. Joseph Rose—SPIE Lifetime Achievement Award for NDE/SHM/Smart Structures, March 2011

Dr. Bernie Tittmann, Steven Lin, and Tony Huang—1st place Poster, IEEE-UFFC Symposium, October 2010

Dr. Eric Paterson, Royal Academy of Engineering, Distinguished Visitor Fellowship, 2011; Honorary Visiting Professor, College of Engineering, Mathematics, and Physical Sciences, University of Exeter, UK, 2011-2014

Whitney Coyle—ARCS Bennett-Coppersmith-Palmer Award

Amanda Lind—Robert Graham Endowed Graduate Fellowship

Kieran Poulain—PARTNER center of excellence 2011 Student of the Year

Joyce Rosenbaum—Amelia Earhart Award

Russell Powers—SMART Scholarship from the Department of Defense and one of the top two posters at the CERS Symposium

New Books by CAV Faculty

Advances in Aeroacoustics, in honor of Professor Geoffrey M. Lilley, edited by Dr. Phil Morris, Penn State Aerospace Engineering, Multi-Science Publishing, 2010

Engineering Mechanics: Dynamics, by Gary Gray, Francesco Costanzo, and Michael Plesha, McGraw-Hill, 2010

Corporate Members and International Liaisons

Corporate Members & Representatives

Applied Physical Sciences Corp.—Marty Pollack
ATA Engineering—Mike Yang
Bettis Atomic Power Lab—Eric Salesky
Dresser-Rand—Zheji Liu
Electric Boat—Michael Thiel
Fisher Controls Technology International, LLC— Al Fagerlund
General Electric Global Research Center—Huangang Luo
Gulfstream—Kristopher Lynch
KCF—Jacob Loverich
Lockheed Martin/KAPL—Steve Dunn
Lord Corporation—Mark Downing
Martin Guitars—Albert Germick
HII Newport News Shipbuilding—Kevin Smith
United Launch Alliance—Ed Heyd
United Technologies Research Center—Jeff Mendoza
Westinghouse Electric Company—Larry Corr

International Liaisons and Representatives

ISVR (UK) - Steve Elliott
DLR (Germany) - Lars Enghardt
CIRA (Italy) - Antonio Concilio
INSA de Lyon—Jean-Louise Guyader
KAIST—Yang-Hann Kim

CAV Welcomes New Corporate Sponsors

The CAV is pleased to announce four new corporate sponsors for 2010-2011.

Gulfstream—corporate liaison, Kristopher Lynch

The company that evolved into Gulfstream Aerospace Corp. stared in the late 1950s when Grumman Aircraft Engineering Co., who is known for military aircraft production developed a business aircraft in Bethpage, New York. Over the years there have been mergers, however Gulfstream remains a leader in innovation and was the first to design and develop a means of reducing the sonic boom. Gulfstream puts as much effort into maintaining its aircraft as it does into manufacturing them.

Today, Gulfstream employs more that 9,700 people at seven major locations: Savannah, GA; Appleton, Wis.; Dallas; Long Beach, CA.; Brunswick, GA.; London, England and Mexicali, Mexico. Gulfstream is The World Standard® in business aviation.

KCF—corporate liaison, Jacob Loverich

KCF Technologies is a dynamic technology company that develops and commercializes products and solutions for industry and the military. The company was founded in November 2000 by three researchers from Penn State University and specializes in energy harvesting wireless sensors, underwater navigation and smart material devices. Their vision is to be a leader in the development of federally-funded technologies and bridge the gap to successful commercial products by establishing strategic partnerships. (more can be found at KCF's website, http://www.kcftech.com/.

Lord Corporation—corporate liaison, Mark Downing

Lord originated in Erie, Pennsylvania over 85 years ago and is now a worldwide leader in adhesives and coatings, vibration and motion control, and magnetically responsive technologies. They have provided solutions to aerospace, defense, automotive and industrial customers. Operating from the world headquarters in Gary, North Carolina, Lord has 17 facilities in nine countries with 90 strategically located sales and support centers worldwide.

Martin Guitars—corporate liaison, Albert Germick

C.F. Martin & Co. is the premier builder of acoustic guitars and is the 2nd oldest family owned music instrument maker in the world. Now in its 178th year of business, Martin Guitar produces over 100,000 acoustic guitars per year and continues to be regarded as the leader in quality and tradition. In addition to guitars, Martin also manufactures and distributes guitar strings worldwide. The mission of the company is to "be the best fretted instrument and string manufacturer in the world, providing the highest quality products and service for our customers while preserving and enhancing our unique heritage".

Due to the regulation in the harvesting of several traditional wood components, Martin is active in developing acoustic guitars from alternative species and synthetic materials. Martin is committed to utilizing the most advanced technologies available in the field of vibration and acoustics to help quantify the performance of musical instruments made with traditional and alternative materials.

Welcome New International Liaisons

The CAV is also pleased to welcome a new International Liaison – the Korea Advanced Institute of Science and Technology (KAIST) We look forward to interacting with Dr. Yang-Hann Kim, director of the Center for Noise and Vibration Control (NOVIC). You can learn more about the Center at: http://novic.kaist.ac.kr

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. Swagata Banerjee joined the Pennsylvania State University (PSU) in August 2009 as an assistant professor in the department of Civil and Environmental Engineering (CEE). Her ongoing research focuses on the identification of bridge fragility parameters from its vibration response, assessment of risk and reliability of various civil infrastructure components under multihazard scenarios, time dependent reliability analysis of concrete bridges in chloride environment, and the use of fiber reinforced polymer composites for structural retrofit and rehabilitation. Her research interests also include the application of stochastic processes and fields in civil engineering, structural health monitoring and damage detection, and the analysis of different soil-structure interaction problems at bridge abutments and foundations.

Brian R. Elbing has been a research faculty member at the Applied Research Laboratory at Pennsylvania State University since November of 2010. His research focus is in the area of multiphase, high Reynolds number experimental fluid mechanics and flow-induced noise. He has spent the past six years at the University of Michigan as a graduate student and postdoctoral research fellow studying drag reduction technologies for surface ship applications. While at the University of Michigan, Brian received his PhD and MSE degrees in mechanical engineering. He also has his BS in mechanical engineering from Western Michigan University.

COL (ret.) Samuel S. Evans joined the Vertical Lift Research Center of Excellence (VLRCOE), in the Aerospace Engineering Department 3 years ago after a 27 year career in the U.S. Army, where he served as an aviation logistician, and helicopter pilot, specializing in aviation maintenance. He flew both UH-1 and UH-60 aircraft and culminated his career as the Chief of Aviation Logistics at the Pentagon. He brings decades of hands-on rotary wing experience to the faculty and students at PSU. COL Evans received his B.S. from the USMA in1985, his M.S. from the Army command and Staff College in 1996, and his M.A. Army War College in 2006.

Dr. Reginald F. Hamilton is an Assistant Professor of Engineering Science and Mechanics at Penn State and a member of the Active Structures interest group of CAV. Dr. Hamilton earned his B.S. in mechanical engineering from Southern University and M.S. and Ph.D. in mechanical engineering from University of Illinois, Urbana-Champaign. Dr. Hamilton's research group characterizes different classes of Shape Memory Alloys utilizing advanced experimental mechanics and microstructure characterization techniques. The research elucidates the atomic-/micro-structure and physical behavior relationships in order to advance the application, as well as improve the performance, of SMAs in smart material systems and adaptive structures.

Zoubeida Ounaies joined the Pennsylvania State University in January 2011 as an associate professor of Mechanical Engineering. Previous to that, Zoubeida was an associate professor in Aerospace Engineering and Material Science and Engineering at TAMU, where she was the inaugural holder of the Aldridge Career Development Professorship. She has been awarded the NSF CAREER Award (2007), the TEES Select Young Faculty Award (2008) and the Montague Teaching Scholar award (2008). Her research has been supported by NSF, AFOSR, NASA and DARPA.

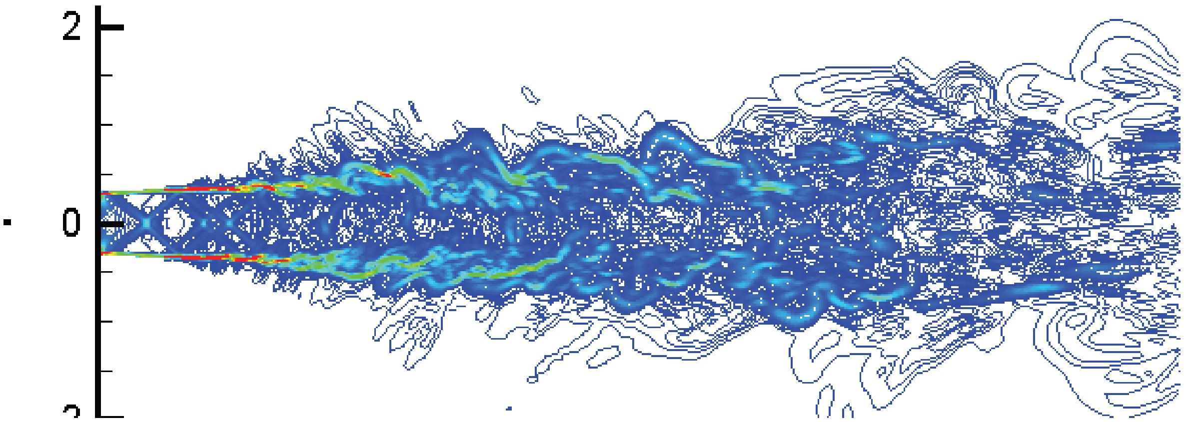
Dr. Sven Schmitz is an Assistant Professor of Aerospace Engineering at Penn State University focusing in the area of Wind Energy. Following his Ph.D. in 2006 he was awarded several research grants from the U.S. Army Aeroflight Dynamics Directorate (AFDD) and worked as a CFD consultant for the General Electric (GE) Wind company. In 2010, Dr. Schmitz joined the faculty in Aerospace Engineering at Penn State University. Dr. Schmitz's expertise is in vortical wake flows around wind turbines and helicopters. His background in Hybrid CFD/Vortex methods make him an expert of the complex nature of vortex sheets emanating from rotating blades and their roll-up and convection process downstream of the rotor. His past work on 'Vorticity Embedding' concerned the physically correct representation of vortex sheets within a CFD flow solver domain that intrinsically satisfies the conservation of sheet circulation and vorticity.

Jonathan Pitt joined the Computational Mechanics division of the Applied Research Laboratory in June 2010, after spending a year at the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory. He received his BS in Physics and Mathematics from Lebanon Valley College, and earned both his MS and PhD in Engineering Science and Mechanics at PSU. His research expertise is in computational solid and fluid mechanics. Past and current projects have focused on nuclear reactor coolant modeling, damage mechanics in thermoelastic materials, outdoor acoustic propagation, and flow evolution in open seas. In his spare time, he volunteers with the Boy Scouts and enjoys traveling.

Featured Research

Rather than generating a grid that follows the details of the surfaces of the chevrons, an immersed boundary method is being used to simulate them. In this approach, the effect of the chevrons is simulated with a distribution of forces that brings the flow to rest inside the chevrons. This approach saves significant computer time, and initial results from it are very promising.

Morris' research in jet engine noise is being supported by the Naval Air Systems Command (NAVAIR), Pratt & Whitney, the Boeing Company and NASA.



Instantaneous density gradient contours in an underexpended superconic jet.

Students do research for ESPN the Magazine

A recent ESPN magazine article ("These go to 11," ESPN the Magazine 15 Nov 2010) ranked the top collegiate basketball arenas according to "noise potential." The top five arenas were listed as Kansas University, Duke University, New Mexico University, Kentucky University and Florida University. The rankings were established by a team of Penn State Acoustics students using the theory for sound build up in large rooms, since actual measurements were infeasible. Both diffuse field and direct field contributions of the sound pressure were estimated at center court for octave band frequencies from 125 Hz to 4 kHz. Seating geometries, materials and other relevant information were collected for each arena and used with estimated absorption coefficients to determine the room constant and critical distance. The diffuse field contributions were then combined with approximate sources terms based on the seating capacity of the arena, the proximity of the fans to the court and whether they were students. The sound pressures were then combined into a total A-weighted sound pressure level and used to determine the ranking. The direct and reverberant contributions of each arena were then compared to establish the positive and negative aspects of each arena in terms of noise potential. This comparison reveals how Kansas and Duke reached the top of the ranking, despite having drastically different arena geometry and capacity.

Researcher (from left) Andrew Bernard, and students participating on the project are Andrew Christian, Brian Cranage, Micah Shepherd, Kieran Poulain, Neal Evans, Andrew Orr, and Dan Domme. Dr. Steve Hambric (at far right) is the advisor.

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.

Brian Reinhardt, earned his Masters Degree in Engineering Science and Mechanics in May 2010 and he is now pursuing a Ph.D. in Engineering Science. Brian completed an internship with Hitachi in Japan furing Fall 2011. He continues his study of nonlinear ultrasonics on tensile specimens. Brain can be reached at btr5016@psu.edu) .

Xiaoning Xi earned her Masters Degree in Engineering Science and Mechanics in May 2010 and she is now pursuing a PhD in Engineering Science. She is studying biological cells via atomic force microscopy as a part of the group's Department of Engineering-funded cellulose research project. Xiaoning can be reached at xzx104@psu.edu.

Christian Gross, a graduate student at the Swiss Federal Institute of Technology Zurich, did research in acoustics, ultrasound and non-destructive evaluation of materials with the group for two months during 2010.

Yihan Tian, a graduate student at the University of Windsor (Canada), did research in acoustic microscopy on biological samples with the group for two months during 2010.

Mohan Basnet, an undergraduate student at Southeastern Louisiana University, did research in optical nondestructive evaluation on thin films with the group for three months during 2010.

Post doc Matthew Kropf (mmk230@psu.edu) received a $100,000 Ben Franklin Technology Partners award to fund biodiesel research.

Adaptive 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 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: 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: Samantha Cirone, M.S. expected 2011

Title: Actuation of Miniature Trailing Edge Effectors (MiTEs) for Rotorcraft Applications
Sponsor: NASA / Army Vertical Lift Research Center of Excellence (VLRCOE)
Summary: This research deals with the development and testing of an actuator for a Miniature Trailing- Edge Effector (MiTE). MiTEs can be used to address stall alleviation, flight control, and vibration reduction. The optimal deployment schedule for MiTEs is an on/off type deployment as opposed to a single-frequency harmonic deployment. In this work, the desired on/off square-wave deployment is approximated by a five-term Fourier series. A piezoelectric bimorph was designed to minimize the required drive voltage and integrated into an airfoil section for verification of the design under aerodynamic loading. The MiTE had a height of 1% of the chord and was located approximately 10% of the chord upstream of the trailing edge. A bench test was conducted to verify the actuator dynamics and the required deflections were obtained without exceeding the limits of the piezoelectric material. Results showed that the flap deflection approximated a square-wave for angles of attack of 0.84° and 12° and wind speeds up to 40 m/s.
Student: Michael Thiel, Ph.D. expected December 2011

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 December, 2011

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. The initial bench testing and CFD study verify the validity of the bypass damper concept, and prove the device ready for the next stage of development and testing.
Collaborator: Dr. Edward Smith (Aerospace)
Student: Conor Marr, Ph.D. expected December 2011

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 2012

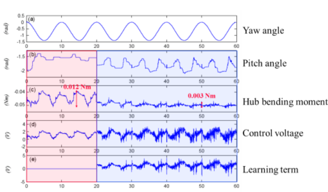
MECHATRONICS RESEARCH LAB

C. Rahn - Director

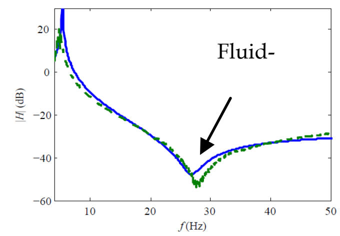
The Mechatronics Research Lab specializes in a multi-physics model-based approach to control and design of mechatronic systems. The research has been supported by funding from NSF, NIH, AFOSR, ONR, Army, DOE, DOC, and industry. Research in the MRL is currently concentrated in three areas: Smart structures,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

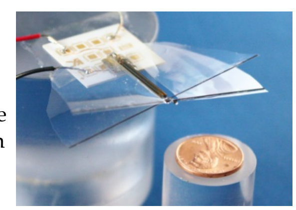
Using Lyapunov-based approaches that do not require discretization, we design controllers that asymptotically stabilize the distributed model. This mathematically elegant method eliminates the spillover instabilities associated with traditional control approaches, produces simple, low order, physically 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.



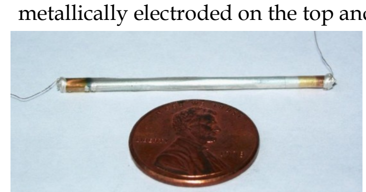
NSF is currently supporting an EFRI project in smart structures with Prof. Kon-Well Wang and two other PIs from Michigan and Prof. Chuck Bakis here at Penn State. The overall goal of this research is to create a transformative multifunctional adaptive structure concept through investigating the unique 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.



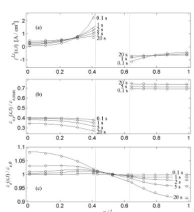
EAP Actuators for Braille displays are being developed under funding from NIH. Prof. Qiming Zhang provides the materials that are then cast into films, stretched to the desired thickness using a zone heating machine, placed on frames, sprayed with conductive polymer electrodes, laminated to form a bi-layer, 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



Technical Group Research Highlights

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: Vipul Mehta (PhD August 2010, presently at Intel Corp.), Greg Hayes (PhD May 2011), and Samantha Cirone (MS expected August 2011)

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 work has also been directed at testing prototype instruments in surgical simulation to quantify and compare their performance to commercially available instruments.
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. Recent efforts have been aimed at developing optimization methods for the compliant spine including dynamic effects, and at testing the compliant spine in bench top experiments to quantify the lift and thrust achieved. Ongoing work includes expanding the design method to provide morphing in bending, sweep, and twist simultaneously.
Collaborators: James Hubbard (University of Maryland)
Students: Yashwanth Tummala

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. Dean Capone and Dr. Bill Bonness are continuing to work with two graduate students in flow-induced noise. Ms. Alexandria Salton is investigating the use of rings of accelerometers for non-intrusively determining the acoustic pressure inside a water filled piping system. Mr. Neal Evans, following on the work of Dr. Bill Bonness, is examining the effect of roughness on the low wavenumber portion of a turbulent boundary layer. The work will use the facilities developed by Dr. Bonness during his Ph.D work. Both students are expected to graduate in Summer 2011.
Dr. Timothy A. Brungart, Mr. Steven D. Young and Dr. Dean E. Capone recently completed an effort to identify means of reducing the cooling fan noise from a chassis housing electronic components for a major electronics manufacturer. Replacement fans and mounting modifications were identified that provided equivalent cooling airflow rates and predicted sound power reductions of up to 20 dB in level. The electronics manufacturer intends to implement the alternative fans and mounting arrangement into their next generation chassis.
Drs. Dennis McLaughlin his work in supersonic jet noise. During the past year he work has found that beveled exits for subsonic nozzles rotate the jet plume and primarily reduce noise through the subsequent rotation of the acoustic field. Until recently, this was believed to be the case for beveled exits on supersonic converging-diverging nozzles. The jet plume from such nozzles was examined and shown to deflect less than 6 degrees for both over-expanded and under-expanded flows. Therefore any measured noise reduction is due to the alteration of the noise generation mechanisms and not the deflection of the jet plume.

Machinery Prognostics and Condition Monitoring

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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.

Wind Turbine Health Monitoring

Researchers from the Applied Research Laboratory and the Aerospace Engineering Department are working with the Penn State Center for Sustainability (CfS) to demonstrate health monitoring concepts on a CfS wind turbine at Penn State. The CfS wind turbine is a Southwest Windpower Whisper 500 with two blades and a peak capacity of three kilowatts of power.

Figure 1: Whisper 500 wind turbine at the Penn State Center for Sustainability.

Brenton Forshey, a graduate student in Aerospace Engineering, is working to implement health monitor on the turbine blades and the electrical generator. The wind turbine is currently instrumented with voltage and current sensors to each of the generator's three output phases and a 3-axis accelerometer on the mast supporting the turbine nacelle. Additional sensors monitor the meteorological conditions at the site and the energy storage system.

Blade and gearbox failures are two of the most critical failures in full-scale commercial wind turbines. Previous studies have shown that gearbox faults are initiated by unsteady loads on the generator shaft bearings. One goal of the present measurements is to characterize unsteady wind loads on the turbine. Failure modes being studied include mass and aerodynamic blade imbalance, power electronic failures and battery energy storage system failures. Recent measurements also included the use of a wireless accelerometer mounted on the turbine nacelle. Additional drive train testing will be conducted on the ARL mechanical diagnostic test bed using load conditions measured on the wind turbine.

Participants in the project include Dr. Karl Reichard, Mr. Mark Turner, and Mr. Nate Lasut from ARL, and Dr. Dennis McLaughlin Brenton Forshey (student) and Dr. Susan Stewart, from the Department of Aerospace Engineering.

Tactical Wheeled Vehicle Health Monitoring

ARL Penn State conducted testing for the US Army Material Systems Analysis Activity (AMSAA) to develop a health monitoring for alternators on Army heavy trucks. The primary objective of this work was to leverage laboratory based power generation device health management research and technology development results and apply them to a field system as an embedded solution. This technology development effort, though focused on ground platform alternators, was intended to provide solutions that can be applied to various types of power generation devices. It project investigated methods to reliably detect various alternator faults with a minimum number of sensors and which required minimal additional processing of the sensor signals.

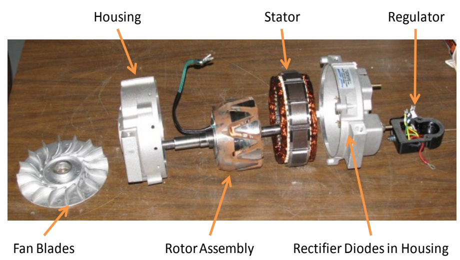

Figure 2: Main alternator components.

The ARL project used a combination of laboratory and field testing of alternators with seeded faults. The faults include bearing (mechanical) faults and winding (electrical) faults. The vehicle was used as the test bed for this program was a Freightliner 915 truck heavy truck, similar to heavy commercial trucks. The alternator was instrumented with voltage, current, temperature and vibration sensors, as shown in Figure 3. We were able to successfully detect both the mechanical and electrical faults in the alternator.

A key finding from the study was the requirements for doing prognostic health assessment of the alternator electrical faults. Simple fault detection and diagnosis (alternator has a fault and is no longer providing current) is possible using typical low sample rate sensing and minimal embedded signal processing. Detection of early indicators of the electrical (and mechanical) faults requires higher sample rates and the ability to perform frequency analysis and signal demodulation. These results are being used to develop performance specifications for next generation vehicle health management systems.

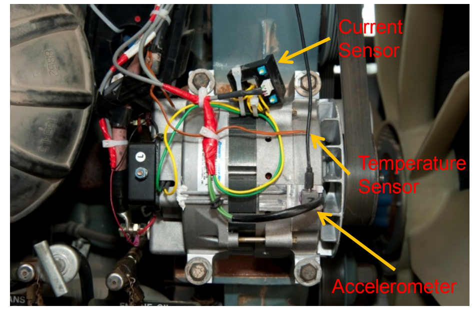

Figure 3: Alternator instrumented for health monitoring testing.

The project was led by Jeff Banks, Jason Estep and Mark Brought from ARL.

Helicopter Electrical System Health Monitoring

The OH-58D Kiowa Warrior helicopter has been a workhorse for the U.S. Army for decades and is projected to continue to accrue flight hours for years to come as a highly capable platform applied against various mission profiles. The U.S. Army is interested in the implementation of condition based maintenance (CBM) for this platform to increase operational availability of the aircraft, reduce the required number of maintenance activities and increase the inspection interval period. The CBM methodology and these objectives are directly dependent upon the capability of the health and usage monitoring system and its ability to detect diagnose and provide an estimate of remaining useful life (RUL).

The Applied Research Laboratory at The Pennsylvania State University (ARL Penn State) has developed prognostic technologies for helicopter electrical power systems that can be integrated into an existing on-board Health and Usage Monitoring System (HUMS). The goal of the program was to develop a capability to monitor, detect and provide an estimated remaining useful life RUL for the starter/generator, battery and power inverter. The focus of this effort was to develop technologies that provide actionable prognostic information for forecasting part replacement and to extend existing time and usage -based maintenance intervals.

In order to provide a focus for the technology development effort, a FMEA was conducted for each power system component. The activities performed for this analysis included:

- Acquired maintenance data and conducted interviews with the OH-58D contract maintenance personnel at the Aviation Center Logistics Command at Fort Rucker.
- Conducted interviews with Kiowa Warrior Maintenance Test Flight Examiner (United Stated Army Safety and Standardization Directorate (USASSD)) tasked to inspect maintenance

Technical Group Research Highlights

operations in all U.S. Army OH-58D units.

- Conducted interviews with Army employee who repairs Kiowa Warrior inverters at Tobyhanna Army Depot.

Based on the FMEA results for each power system component, each health management technology development team focused their development on the most critical failure modes. The primary failure mode for the starter-generator is brush wear. For the battery, there is no single dominant failure mode, but instead the process indicated that general monitoring of the battery state of charge and state of health could reduce overall maintenance costs. The primary failure mode for the power inverter is failure of the current source indicator and transistors. Diagnostic and prognostic systems were developed for each of these three electrical subsystems.

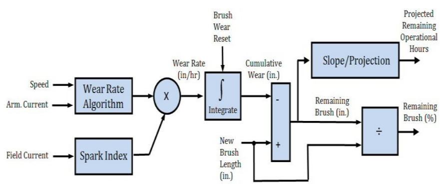

Figure 4: Starter-generator brush wear prognostic algorithm.

The project was led by Jeff Banks, Todd Batzel, Robert Keolian, Matt Poese, Terrance Lovell (student), Mitch Lebold, and Karl Reichard of the Applied Research Laboratory.

Structural Health Monitoring

Mitch Lebold and Martin Trethewey recently completed a multi-year project for the Electric Power Research Institute (EPRI) which investigated the development of a torsional line shaft health monitoring system that can be applied to any system containing a rotating shaft, such as: reactor coolant pumps, centrifugal charging pumps, condensate and feed water pumps. Laboratory and field tests have demonstrated that torsional vibration features are particularly sensitive to shaft cracking detection and growth trending. Although the failure of some of these pumps in power plant applications due to shaft cracking does not generally result in unit trips or reduced power operation, the unexpected failure can create maintenance scheduling problems and increased safety risk.

The prototype torsional vibration measurement system consists of a combination of off-the-shelf and specially designed components, along with specialized data collection programs. Essentially for these experiments laser transducers are used to detect each encoder strip of a passing reflective encoder tape. The encoder tape can be mounted directly on the rotating shaft or placed on a larger diameter hub to increase the pulse per revolution count of the tape. Transducers are mounted around the shaft on specially designed brackets at increments of 120°. A sample torsional vibration frequency spectrum for a reactor coolant pump is shown in Figure 5.

The system was tested in the laboratory using scaled shafts with seeded faults and in a seeded fault test conducted at the Jeumont Industrie IRIS 41% RCP impeller test loop in France. The worked conducted on the Jeumont IRIS pump test loop showed that ARL's torsional processing approach proved viable in detecting and tracking changes in natural frequency due to cut depth. A medium scale torsional test rig was designed and developed using an existing platform at ARL. The enhancements made to the existing platform allowed the additional capabilities of providing torsional and lateral load to a rotating shaft. The test bed used for experimentation consists of a 30 horsepower DC electric drive motor, a 75 horsepower DC electric load motor, and a 12 ton capacity hydraulic ram. Torsional load can be applied using the 75HP load motor, and a lateral load can be applied at the shaft's midpoint using the hydraulic ram. The results of torsional vibration measurements made over several incremental crack depths are shown in Figure 6.

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 PARTNER 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 2010. 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:

Amanda Lind, M.S. spring 2011, Ph.D. expected spring 2013
Thesis topic: Terrain reflection and post-boom noise for low-boom sonic booms
Sponsor: FAA
Advisor: V. Sparrow

Kieran Poulain, M.S. expected fall 2011
Thesis topic: Atmospheric profile effects on the propagation of aircraft en-route noise
Sponsors: FAA and Volpe National Transportation Systems Center
Advisor: V. Sparrow

Alexandre Jolibois, Ph.D. expected summer 2013
Thesis topic: Optimization of high-speed rail 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

Joyce Rosenbaum, Ph.D. spring 2011
Thesis topic: Advanced acoustic propagation models for predicting aviation noise.
Sponsor: FAA and Volpe National Transportation Systems Center
Advisors: A. Atchley, V. Sparrow

Kimberly Lefkowitz Riegel, Ph.D. expected fall 2011
Thesis topic: Ray-trace/radiosity methods for

the propagation of sonic booms in urban canyons
Sponsor: NASA
Advisor: V. Sparrow

Sang Cho, Ph.D. expected fall 2011
Thesis topic: Sonic boom diffraction around buildings and hybrid model implementations
Sponsor: NASA
Advisor: V. Sparrow

Brian Tuttle, Ph.D. expected summer 2011
Thesis topic: Nonlinear acoustic streaming in conical thermoacoustic devices
Sponsor: Office of Naval Research

Rotorcraft Acoustics and Dynamics

Ed Smith, group leader
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The Penn State's CAV Rotorcraft Acoustics and Dynamics Group continues to be at the core of our Vertical Lift Research Center. State is home to one of only two Vertical Lift Research Centers of Excellence (VLRCOE) in the country.
This Center currently supports nearly 60 full-time graduate students and involves more than 25 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 noises signatures is a high priority. We have experienced particular growth in programs focused on structural health monitoring, and ultrasonic ice protection systems. These areas have "increased the frequency range of interest" amongst our CAV Group members. Acoustics and dynamics issues associated with ducted fan air vehicles, 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, ducted fan 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, rotor loads monitoring, and interior noise control. This year, we were awarded new research programs from NASA (partnered with Bell Helicopters), GE (wind turbine ice protection), and the US Army (airframe crack detection). We continue to work with Boeing, Sikorsky, Lord Corp, Goodrich. Timken, and several small high-tech companies in the development of new rotorcraft technologies.

Structural Vibration and Acoustics

Steve Hambric, Group Leader
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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.

This year, we were visited by Dr. Liang-Wu Cai, on sabbatical from Kansas State University, who is teaming with us on a NASA project to use band-gap materials – structures with arrays of embedded discontinuities – to minimize transmission noise tones. Liang-Wu gave a talk on his band-gap material research, which is available on our CAV lunch seminar online archive.

We were also pleased to welcome our first exchange student from our international liaison – INSA de Lyon. Roch Scherrer completed his Masters degree working in our CAV reverberation and anechoic rooms, characterizing the sound transmission loss of a composite panel computationally, and experimentally.

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

Title: Phononic Crystals and Acoustic Bandgaps and Mirages
PI: Tony Jun Huang
Student: Sz-Chin Steven Lin (PhD – Engineering Science and Mechanics)

Title: Vibration of coated multilayered plates and shells
Sponsor: NUWC/ONR
PIs: Sabih Hayek and J.E. Boisvert (NUWC)

Title: Nuclear Reactor Vibro-Acoustics
Sponsor: Westinghouse
PI: Peter Lysak and John Fahnline

Title: Rotorcraft structural health monitoring using structural intensities
Sponsor: US Army
PI: Stephen Conlon
Student: Peter Romano (MS – Aerospace Engineering)

Title: Energy harvesting for rotorcraft structural health monitoring applications
Sponsor: ARL/Penn State
PI: Stephen Conlon
Student: Mike Quintingeli (MS – Mechanical Engineering)

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

Title: Implementation of a fatigue life protocol
Sponsor: US Navy
PI: Kevin Koudela

Title: Actuator noise characterization calculations
Sponsor: Moog
PI: Rob Campbell

Title: Wind-turbine blade vibration calculations
Sponsor: Sandia National Lab
PIs: Mike Jonson and John Fahnline

Title: Characterization of the CAV Reverberant Room
Sponsor: CAV
PIs: Steve Hambric, Chris Barber, and Steve Conlon
Student: Andrew Orr (M.S. candidate)

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

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. candidate)

Title: Acoustics of Shaftless Propulsors
Sponsor: DARPA and US Navy
PI: Steve Hambric

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

Technical Group Research Highlights

Underwater Acoustics

Chris Barber, group leader
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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.

Daniel Park is studying Low Probability of Intercept for Sonar applications with an emphasis on Covert Detection and Range Estimation. He is also trying to understand covertness itself as characteristic of a system. He is using noise-like signals and investigating different types of detection schemes.

Alex Sell is working on understanding how certain shallow water environment features affect performance of a model-based Bayesian localization routine. Also, he is developing a range-dependent waveguide invariant distribution, which utilizes a priori knowledge of the underwater environment and has applications to localization and event recreation. He will present two papers at the ASA meeting in May.

Chris Applegate is studying various models for predicting attenuation through bubbly liquids. He is comparing their accuracy and attempting to determine the appropriate model to use for a variety of scenarios.

Dale McElhone is modeling acoustic backscatter from bubble distributions. A new effective medium approach is being applied for frequencies well below the resonant frequency of the bubbles.

Sushma Chandran is studying the literature on cognitive RADAR and looking at how to apply the ideas to SONA/R. She also is analyzing the classification data from an in-water sonar trial and comparing the results to ground truth (i.e. what really happened).

Andrew Pyzdek is looking at how SNR affects the performance of a passive sonar Bayesian localization algorithm. He is using real ocean data from a 1996 measurement. He has prepared a paper for the Seattle ASA meeting in May.

Lee Culver is working on the problem of acoustic propagation through bubbly water, and in particular, how bubble scattering degrades array and the characteristics of bubbles left behind after an underwater explosion. He also is developing an approach to extending the Bayesian localizer to sequential batch processing.

Chris Barber is continuing work on ship radiated noise investigations, including field tests and data analysis to support development of noise models for maneuvering ships. He is preparing for a June 2011 return to the Navy's Acoustic Research Detachment in Bayview, ID, to conduct a follow-up test to last year's nearfield radiated noise experiment, and is also organizing a special session on radiated noise of unmanned underwater vehicles for the Nov 2011 ASA meeting in Seattle.

Brian Fowler (MS Candidate in Acoustics) is working on analysis of nearfield radiated noise data acquired during experiments in 2009 and 2010 to investigate the effectiveness of beamformed line arrays for nearfield radiated noise measurements in shallow water environments.

Sam Denes (PhD candidate in Acoustics) is starting his field work in the Bering Sea examining multi-media sound propagation (water, ice and air) to develop accurate sonar equation parameters for the propagation of Pacific walrus vocalizations. This information will be directly related to determining the effective range of communication between walrus and for management and mitigation methodologies of this species using passive acoustic monitoring.

Jennifer Miksis-Olds received funding from ONR to commence a long-term ambient ocean sound study. This work will use over a decade of data recorded by the Comprehensive Test Ban Treaty Organization (CTBTO) to investigate patterns of ambient noise level, variability, and its impacts/implications on ecosystem dynamics in the Pacific and Indian Oceans.

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