

AE Illinois

***2009 Annual Report of the
Department of Aerospace Engineering
University of Illinois at Urbana-Champaign***



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Department Head's Remarks

Welcome to the 2009 Annual Report of the Illinois Aerospace Engineering Department. Despite the trying financial times that we've all experienced in the last year, the department remains quite healthy in all respects. Our State budget has held steady to date in spite of gloomy predictions of major shortfalls in revenues during the past year. Our enrollments remain strong with 382 undergraduate and 125 graduate students as of this fall. We have worked particularly hard the last several years on our graduate student enrollment, which is at an all-time high.



Craig Dutton

In terms of our curriculum, we have just completed a major revision of our undergraduate program, successfully gained approval of the revision through all levels of the university, and are now in the implementation phase. Similarly, we have completed a major revision to our M.S. degree program, including a new non-thesis option, and are now gaining approval of this revised degree program, with implementation likely to begin in the fall of 2010. Next up will be revisions to our Ph.D. program.

Our research programs are thriving as well. In FY2009 we had the highest level of research expenditures ever within the department, and the initiation of some very exciting new programs. Several of these programs will be featured in the following pages. You can read about a new MURI project led by AE Prof. John Lambros. The work of John and his colleagues aims to mitigate loads on devices by controlling their material microstructure to tailor the stress waves generated by impacts. Other featured work includes Sri Namachchivaya's mathematical modeling of multi-scale stochastic phenomena, a new bone adhesion project of Eric Loth and colleagues, and the ongoing, innovative work of Scott White and colleagues on autonomic, self-healing materials.

We are extremely proud of the honors our faculty have achieved. Some highlighted in this publication include Ioannis Chasiotis (NSF PECASE Award), Eric Loth and Philippe Geubelle (elected as ASME Fellows), Scott White (Finalist for international Bepi Colombo Prize), Jonathan Freund (APS Francois Frenkiel Award), and Harry Hilton, Ioannis Chasiotis, and Mohammad Naraghi (Fourth International Conference on Continuum Mechanics Best Paper Award). We are also pleased to introduce you to Soon-Jo Chung, who has just joined our faculty from Iowa State University. His research interests are in the areas of autonomous systems and robotics, and we are very excited to have him join us.

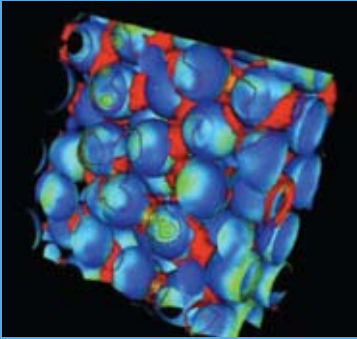
Our students and alumni also continue to achieve great things. In these pages you will read about the accomplishments of graduate students Manu Sharma, Adam Steele, Greg Busch, and Jacob Englander, as well as about our amazing undergraduate space design teams. Among our featured alumni are Earl Dowell, who recently received the prestigious Guggenheim Medal, as well as two astronauts, Lee Archambault and Scott Altman, who commanded recent Shuttle missions, and Mike Hopkins, who is in the newest class of astronaut candidates.

So, read and enjoy. We look forward to your comments; our contact information is readily available on our website at: www.ae.illinois.edu.

Sincerely,

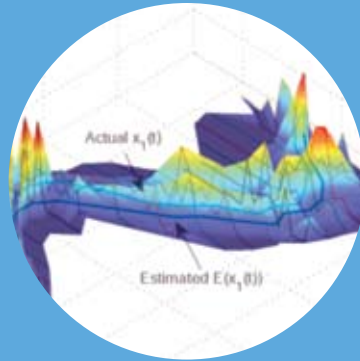
Craig Dutton
Bliss Professor and Head

Highlights



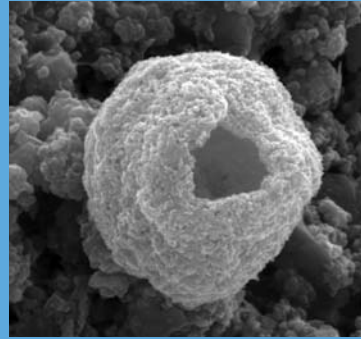
Smart Materials

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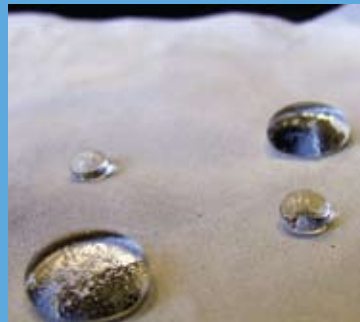
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Illinois-led Project Garners \$6.25 Million DoD Grant

“If you drop a cell phone . . . a smart casing would trap and annihilate the waves and mitigate impact effects.”

Both the electronic components of your cell phone and the explosive portions of military weaponry could be better protected by the smarter materials that scientists including AE Profs. John Lambros and Philippe H. Geubelle plan to design.

The U.S. Department of Defense has awarded a \$6.25 million grant for the University of Illinois-led project, “Design of Adaptive Load Mitigating Materials Using Nonlinear Stress Wave Tailoring.” The DoD’s Multidisciplinary University Research Initiative (MURI) will provide \$1.25 million annually for five years to support the work.

Calling the project “ambitious,” Lambros said the team wants to control the microstructure of materials that encase critical components. If the equipment is dropped or otherwise damaged, the casing material would channel resulting stress waves to desired locations and away from areas most needing protection.

“If you drop a cell phone, you don’t want the interior components damaged so you don’t want the stress waves to reach the interior. Instead, a smart casing would trap and annihilate the waves and mitigate impact effects,” Lambros said.

Likewise, such casings would result in munitions being more insensitive to impact loading, making weapons handling safer for people and equipment, he said.

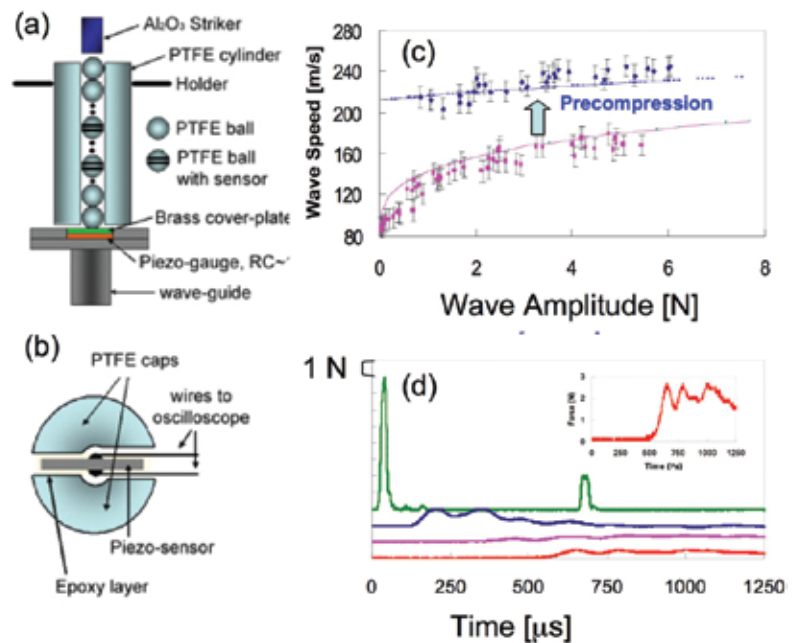
In addition to Lambros, the principal investigator of the project, and Geubelle, other Illinois researchers involved in the project are Profs. Alexander F. Vakakis and Daniel A. Tortorelli of Mechanical Science and Engineering, and Prof. Waltraud M. Kriven of Materials Science and Engineering. Joining them will be Chiara Daraio, an assistant profes-

sor of Aeronautics and Applied Physics from the California Institute of Technology.

It’s clear to the team that more than one material will be needed to achieve the desired results. “We’ll need a combination of materials in a heterogeneous composite system,” Lambros said.

Vakakis and Daraio will begin by looking at the fundamental physics resulting from model experiments on simpler systems such as granular materials that include plastic and metal components.

Using the knowledge Vakakis and Daraio gain, Totorelli and Geubelle will do design and optimization work through computer simulation. Kriven will use the simulations to develop new processing methods and new materials, including granular materials, ceramics and geopolymers—inorganic, lightweight materials that don’t have to be heated



Wave propagation in a granular bead chain (a) Polymeric PTFE beads with embedded sensors (b), record the wave propagating through the chain. Two novel wave propagation features are exhibited: (c) Tunability—adding a pre-compression changes the wave speed profile, as shown experimentally (points) and analytically (lines); (d) Energy trapping (bottom): Force measured at the wall (red line) is only a small fraction of the input force (green line). From Chiara Daraio’s work.



Geubelle



Kriven



Daraio



Lambros



Tortorelli



Vakakis

to high temperatures to be made, but that are hard and durable like ceramics.

Lambros will do experimental mechanics testing and oversee the entire project, which also will require the work of a dozen graduate students and three postdoctoral research associates.

The Army Research Office (ARO), Office of Naval Research (ONR), and the Air Force Office of Scientific Research (AFOSR) conducted the 2009 MURI competition for the DoD. ARO will oversee the Lambros team's work.

The MURI program supports research by teams of investigators that intersect more than one traditional science and engineering discipline in order to accelerate both research progress and transition of research results to application. Most MURI efforts involve researchers from multiple academic institutions and academic departments. Selection was highly competitive: a total of 152 proposals were submitted and 41 were funded.

Chasiotis Earns Presidential Early Career Award

Grant Supports Investigation of Nanoscale Polymer Behavior

Associate Prof. Ioannis Chasiotis will be traveling this fall to Washington, D.C., to receive from President Barack Obama a 2008 Presidential Early Career Award for Scientists and Engineers (PECASE).

The award is the highest honor the U.S. government bestows upon young professionals at the outset of their independent research careers. Chasiotis is among 100 individuals being honored in all fields of science and engineering.

Young scientists and engineers with PECASE awards also receive a five-year research grant to further their study in support of critical government missions. Supported by the National Science Foundation, Chasiotis' project has been the study of the mechanical behavior of polymeric materials in ultra small volumes. At the nanoscale, these materials behave very differently from the way that polymers behave when fabricated in large quantities.

Although in every day applications polymers are not used directly in such very small quantities, when they are combined with nanopowders and nanotubes to form products such as nanocomposites, polymers are compartmentalized in such small quantities that their physical behavior is radically altered.

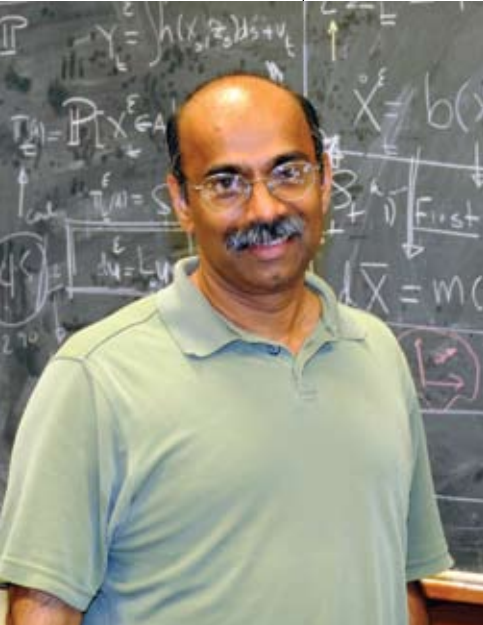
"Large fractions of the polymer molecules are either not as confined or are tightly confined when polymeric materials are limited to nanoscale sizes, forcing them to follow new deformation routes," Chasiotis said.

In recent years, aerospace firms and other sectors have explored



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Seeing the World Through Equations



When AE Prof. Navaratnam Sri Namachchivaya observes the world around him, he strives to understand fundamental features that can be modeled mathematically. In other words, he sees the world through equations.

A theoretical and applied mechanician for the past 25 years, Sri Namachchivaya sees it as his task to “develop mathematical methods so as to be able to understand the most important physical factors at play in a given problem. Interesting problems are those that lead to a new addition to our mathematical toolbox.”

By developing mathematical methods, he understands and is able to explain phenomena such as stabilization by noise and stochastic bifurcations. Bifurcations are “tipping points” where the behavior of a system changes dramatically even though the system’s control parameters have changed only slightly.

For example, a bifurcation occurs when an aircraft loses lift due to an angle of attack that is too high: a small change in the wings’ attack angle leads to a dramatic change in the aircraft’s overall lift. Stochastic bifurcations are those where noise plays an important role and therefore the use of deterministic theories does not provide a satisfactory answer.

Recently, Sri Namachchivaya has been concerned with extracting information from the plethora of data that electronic, networked sensors can provide. The steady cost reduction of computerized equipment has led to sensors that are greater in number and better in sensitivity than ever before. However, this explosion in the amount of data available has also started to overwhelm those responsible for deciphering the data and explaining what it means.

“The goal is to combine the information from sensor data with knowledge of the mathematical properties of the underlying dynamical systems to

better estimate the true state of a physical system,” he maintains. “Using our research results, we can give meaningful predictions of multi-scale stochastic phenomena that occur in space and time. We have looked at several specific large-scale problems, for example the operation of the electric power grid and the motion of eddy structures—or vortices—in the atmosphere and oceans.”

Consider the case of vortical structures in the oceans. On one hand, one could track and predict their motion using satellite imagery. This is relatively straightforward, but launching a satellite and maintaining it in orbit is a significant undertaking. An alternative means to observe and measure environmental factors such as temperature and flow rates is to equip drifters and floats with inexpensive computerized sensors, then place those devices on the oceans.

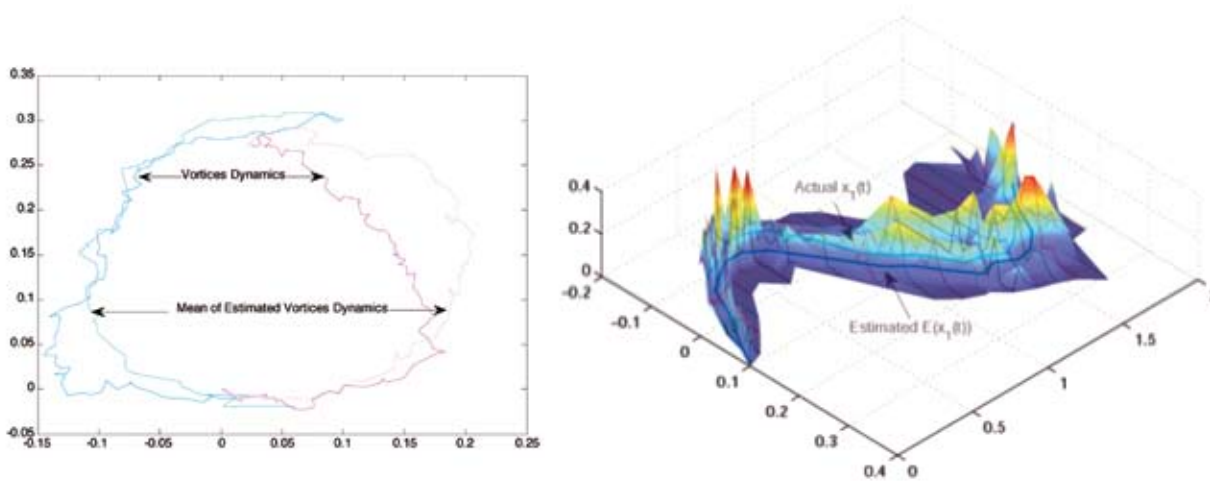
The thousands if not millions of measurements ocean-floating sensors can obtain from complicated phenomena such as a hurricane, however, are very different from the information that can be derived from satellite imagery. Sensor-derived information requires that multi-scale methods, stochasticity and data assimilation be integrated into the investigation.

Sensor-driven data can also explain the workings of biological cells. Within each cell are many tracks upon which walk protein machines known as molecular motors. The motors are enzymes that convert chemical energy into directed motion.

Since 2007, Sri Namachchivaya has been developing new signal processing methodologies and information theoretic techniques to discover and extract essential biological information from the movement of these motors to predict behavior, to build models and validate them from data. One of the jobs of the motors is to carry waste out of the cell, and bring nutrients into it. Sri Namachchivaya can observe the motors’ movement by observing their cargo.

“I may not be able to see a molecular motor, but maybe I can see the loosely attached cargo it is pulling,” he explains, in illustration. “Knowing the

Using our research results, we can give meaningful predictions of multi-scale stochastic phenomena that occur in space and time.



The left figure shows the mean value of estimated position of the vortices by tracking the single tracer. The right figure shows the conditioned pdf of the position.

position of the cargo is how I can estimate the position of the motor itself.”

Sri Namachchivaya also is using sensor-driven data to develop theories that will improve the function of electric power grids. His group uses subspace clustering, neural networks, nonlinear filters and dynamical system theory to determine the coherency pattern of the power generators from data. Critical conditions can arise very quickly in power grids, he points out.

“If engineers monitoring the operating conditions of electric utility networks could be notified of imminent blackout conditions at least 10 minutes in advance, that should be enough time for them to take corrective measures and avoid disruptions,” he believes.

In recent work in delay differential equations, he was able to demonstrate analytically the potential effectiveness of spindle speed variation to eliminate cutting-tool chatter in turning. Observations showed that constant, repetitious use caused the tool to vibrate and chatter to result. Counter-intuitively, the movement would stabilize when variable speeds were used. Sri Namachchivaya’s research showed that random patterns of variable speeds worked well in reducing the chatter.

“This is good for the manufacturer, because it’s easier to have a random pattern than to maintain a constant pattern,” he said.

The unifying theme was a study of delay differential equations with fluctuating delay. His work provided a more transparent derivation of the chatter suppression results than those previously known.



Bone Adhesion Project Gets Grainger Funding

This research can enable tissue-engineered implants for reconstructive skeletal deformities and cell-based therapies for osteoarthritis.

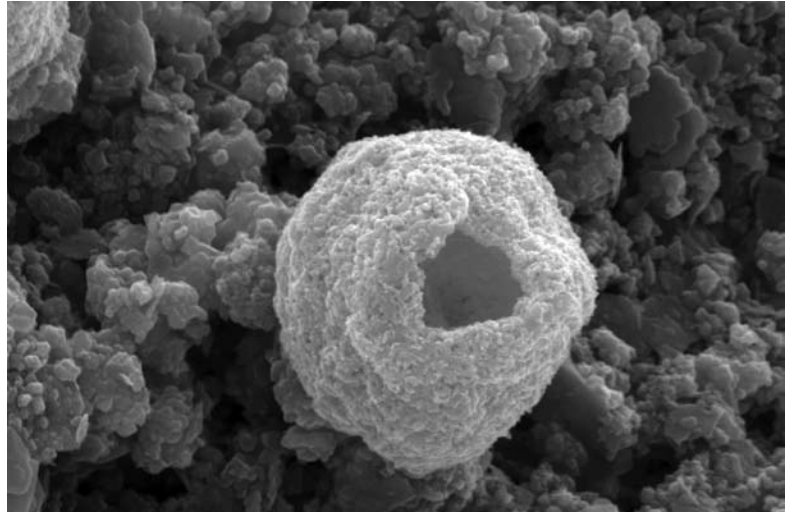
A bone adhesion project of AE Prof. Eric Loth and Dr. Ilker Bayer is being funded as part of the Grainger Program in Emerging Technologies that the University of Illinois College of Engineering administers.

Loth and Bayer have teamed with Prof. Iwona Jasiuk of Mechanical Science and Engineering on the project, "Novel Biocompatible Bone Adhesion Technology."

The researchers propose developing biocompatible adhesives and composites to bond bone to other bone, repair plates or to help make implants using an original orthopedic adhesion technology. More specifically, they propose to design bio-inspired porous nano-composite bone graft materials fortified with proteins and antibiotics, which can set and cure in moist environments while promoting new bone generation and/or healing.

Traditional approaches in bonding bone to bone or bone to metal or composite usually involve natural or synthetic polymers or cements but typically require use of other fasteners such as screws and/or chemical pre-treatments with corrosive chemicals. The researchers propose a novel approach involving new composite systems consisting of a polymeric matrix and a ceramic reinforcement to provide superior bonding and strength without pre-treatment.

In the future, this research can enable tissue-engineered implants for reconstructive skeletal



A scanning electron microscope photograph shows the nanostructured microporous surface morphology of the proposed composite adhesives.

deformities and cell-based therapies for osteoarthritis and osteoporosis Loth and his group believe. Several different polymer and ceramic combinations will be selected, synthesized to form composites and tested experimentally and theoretically to assess the quality and characteristics of the resulting adhesives.

This technology may be of great importance in orthopedics for securing scaffolds and implants as well as in dental applications involving gluing implanted teeth or other implants to bone, which is a multi-million dollar market.

The College of Engineering selected this project as one of ten proposals for the Grainger Program in Emerging Technologies funding. The Grainger Foundation created the program to promote the translation of new academic developments in engineering into commercially viable products and services. It is designed to bridge the gap between traditional funding for basic theoretical research and typical industry funding, which targets already-proven technologies.

Loth has been a faculty member since 1990 and Bayer, with expertise in polymers and nano-textured surfaces, has been a post-doctoral scientist since January 2008.



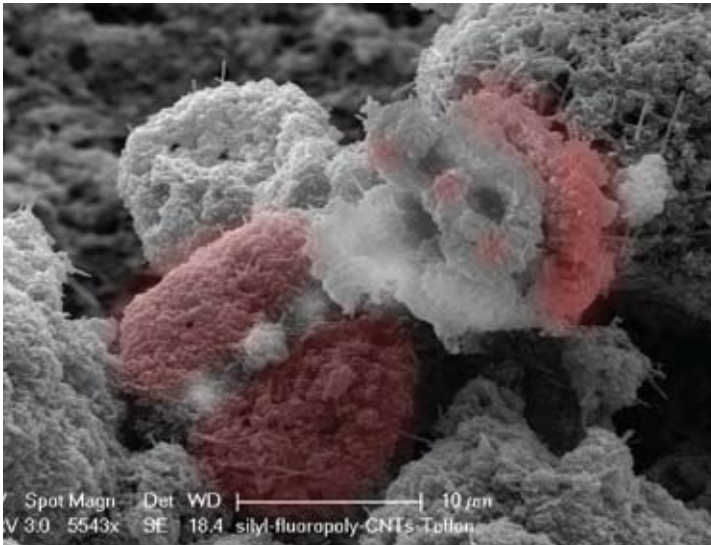
Loth



Jasiuk



Bayer



Santa Claus Comes to Town in Nanocomposite Photo

Santa Claus made an early appearance in a photo AE Prof. Eric Loth's research group produced recently.

The photo won second place among 50 finalists in the Science as Art Competition at the Materials Research Society Spring Meeting in San Francisco.

Postdoctoral research associate Ilker Bayer said the photo is a scanning electron micrograph of a nanocomposite coating surface morphology.

"It showed very interesting surface roughness features, one of which was the structure that resembles Santa amazingly," Bayer said. "We just colored the image to highlight the resemblance. No image overlaying or other image processing was applied."

"The polymer nanocomposite was composed of a dispersion of sub-micron Teflon particles and carbon nanotubes in a polymer matrix," Bayer said.

In addition to Loth and Bayer, who originally recognized Santa, AE graduate student Adam Steele added the highlight color and has also been working on the project.

Loth Named ASME Fellow

AE Professor Eric Loth has been named a Fellow of the American Society of Mechanical Engineers (ASME). Fellowship status in the 129-year-old organization is conferred upon veteran members who have contributed significant engineering achievements.

Professor Loth has distinguished himself nationally and internationally for over 20 years as an engineer and educator in the area of fluid dynamics. His major research accomplishments include development of novel simulation methods and fundamental research in aerodynamic, aeroelastic, multi-phase, and supersonic flow phenomena.

He has over 75 journal publications (including a review paper on multiphase flow with more than 90 citations), and over 100 conference papers.

Loth earned his PhD in 1988 from the University of Michigan, with a dissertation on experiments of multiphase supersonic turbulent flows. He earned a master's in 1985 from Pennsylvania State University and a bachelor's in 1983 from West Virginia University, conducting research in aerodynamic simulations and wind turbine systems, respectively.

Loth focused on computational fluid dynamics of shock waves with unstructured grids when he began his career at the Naval Research Laboratory. He joined the AE Department's faculty as an Assistant Professor in 1990, and rose to Associate and then Full Professor by 2002, when he was named a Willett Faculty Scholar of the College of Engineering. In 2008, he was appointed AE's Associate Head of Undergraduate Studies.

Founded in 1880, ASME is a not-for-profit professional organization that promotes the art, science and practice of mechanical and multidisciplinary engineering and allied sciences throughout the world. The core values of ASME are rooted in its mission to better enable mechanical engineering practitioners to contribute to the well-being of humankind.

New Developments in Autonomic Materials: New Ingredients, Self-Healing Coatings and Force-Sensitive Color Changes

AE Prof. Scott White and his collaborators in the Autonomic Healing Research group mixed up a new recipe for self-healing polymers in the past year, then pushed the materials' boundaries by developing self-healing coatings and an ability for polymers to change color in reaction to force.

lead to mechanical failure. Autonomic self-healing—a process in which the damage itself triggers the repair mechanism—can retain structural integrity and extend the lifetime of the material.

Designed to mimic the human body's ability to repair wounds, self-healing materials release a healing agent into the crack plane when damaged, and through chemical and physical processes, restore the material's initial fracture properties.

In November 2007, White and collaborators reported the use of chlorobenzene, a common but toxic organic solvent that in epoxy resins achieved a healing efficiency of up to 82 percent. In their latest work, which combined a non-toxic and Kosher-certified food additive (ethyl phenylacetate) and an unreacted epoxy monomer into microcapsules as small as 150 microns in diameter, the researchers achieved a healing efficiency of 100 percent.

"Previously, the microcapsules contained only solvent, which flowed into the crack and allowed some of the unreacted matrix material to become mobile, react and repair the damage," said graduate research assistant Mary Caruso. "By including a tiny amount of unreacted epoxy monomer with the solvent in the microcapsules, we can provide additional chemical reactivity to repair the material."

When the epoxy monomer enters the crack plane, it bonds with material in the matrix to coat the crack and regain structural properties. In tests, the solvent-epoxy monomer combination was able to recover 100 percent of a material's virgin strength after damage had occurred.

"This work helps move self-healing materials from the lab and into everyday applications," said graduate research assistant Benjamin Blaiszik. "We've only begun to scratch the surface of potential applications using encapsulated solvent and epoxy resin."

In addition to White, Caruso and Blaiszik, the other co-authors of the paper were AE affiliate and materials science and engineering professor Nancy Sottos and chemistry professor Jeffrey Moore.

The U.S. Air Force Office of Scientific Research and the U.S. Department of Defense supported



Photo by L. Brian Stauffer

Researchers: from left, Jeffrey Moore, a professor of chemistry; Nancy Sottos, a professor of materials science and engineering; Scott White, a professor of aerospace engineering; and graduate research assistants Mary Caruso and Benjamin Blaiszik.

New recipe for self-healing plastic includes dash of food additive

The scientists found adding a food additive to damaged polymers can help restore them to full strength.

The repair process, in which solvent-filled microcapsules embedded in an epoxy matrix rupture when a crack forms, presented a major improvement over the original self-healing process first described in February 2001. "While our previous solvent worked well for healing, it was also toxic," said White, also a researcher at the Beckman Institute for Advanced Science and Technology. "Our new solvent is both non-toxic and less expensive."

During normal use, epoxy-based materials experience stresses that can cause cracking, which can

the research. Some of the work was performed at the university's Center for Microanalysis of Materials, partially supported by the U.S. Department of Energy.

New polymer coatings prevent corrosion, even when scratched

Imagine tiny cracks in a patio table healing by themselves, or the first small scratch on a new car disappearing by itself. This and more may be possible with self-healing coatings White's group is developing.

The new coatings are designed to better protect materials from the effects of environmental exposure. Applications range from automotive paints and marine varnishes to the thick, rubbery coatings on patio furniture and park benches.

"Starting from our earlier work on self-healing materials at the U. of I., we have now created self-healing coatings that automatically repair themselves and prevent corrosion of the underlying substrate," said Paul Braun, a self-healing group member and a University Scholar and professor of materials science and engineering.

To make self-repairing coatings, the researchers first encapsulate a catalyst into spheres less than 100 microns in diameter (a micron is 1 millionth of a meter). They also encapsulate a healing agent into similarly sized microcapsules. The microcapsules are then dispersed within the desired coating material and applied to the substrate.

"By encapsulating both the catalyst and the healing agent, we have created a dual capsule system that can be added to virtually any liquid coating material," said Braun, who also is affiliated with Beckman Institute, Frederick Seitz Materials Research Laboratory, department of chemistry, and Micro and Nanotechnology Laboratory.

When the coating is scratched, some of the capsules break open, spilling their contents into the damaged region. The catalyst and healing agent react, repairing the damage within minutes or hours, depending upon environmental conditions.

The performance of the self-healing coating system was evaluated through corrosion testing of damaged and healed coated steel samples compared to control samples that contained no healing agents in the coating. Reproducible damage was induced by scratching through the 100-micron-thick

polymer coating and into the steel substrate using a razor blade. The samples were then immersed in a salt solution and compared over time.

The control samples corroded within 24 hours and exhibited extensive rust formation, most prevalently within the groove of the scratched regions, but also extending across the substrate surface, the researchers reported. In dramatic contrast, the self-healing samples showed no visual evidence of corrosion even after 120 hours of exposure.

"Our dual capsule healing system offers a general approach to self-healing coatings that operates across a broad spectrum of coating chemistries," Braun said. "The microcapsule motif also provides a delivery mechanism for corrosion inhibitors, antimicrobial agents, and other functional chemicals."

With Braun, the paper's co-authors are White and former Beckman Institute and materials science graduate student Soo Hyoun Cho. A company Braun, White and other U. of I. researchers formed is exploring commercialization of the self-healing coatings technology.

Northrop Grumman Ship Systems, the U.S. Air Force Office of Scientific Research, and Beckman Institute funded the work.

Mechanical stress leads to self-sensing in solid polymers

Parachute cords, climbing ropes, and smart coatings for bridges that change color when overstressed are several possible uses for force-sensitive polymers the group is developing.

The polymers contain mechanically active molecules called mechanophores. Specific chemical reactions

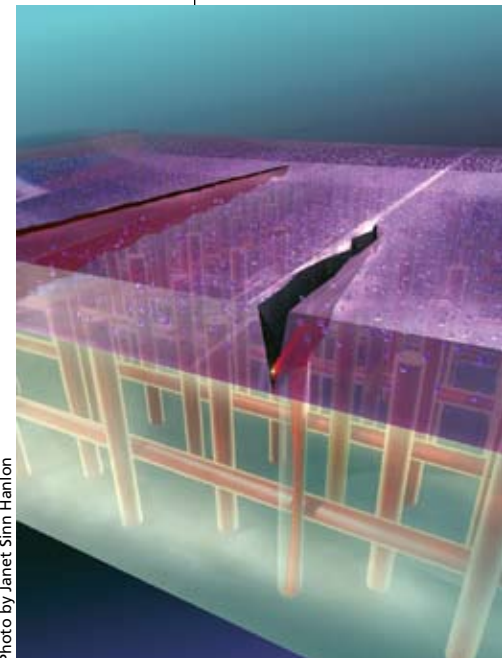


Photo by Janet Sinn-Hamilton

Cracks in a brittle coating are healed autonomously via a three-dimensional microvascular network embedded in the underlying substrate. The network contains a healing agent (red) which polymerizes after contacting the catalyst (purple) in the damaged regions.

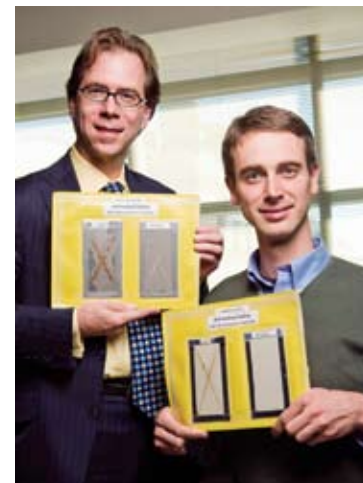


Photo by L. Brian Stauffer

Illinois researchers Paul Braun, right, and Scott White have created self-healing coatings that automatically repair themselves and prevent corrosion of the underlying substrate.

Autonomic Healing Research, continued

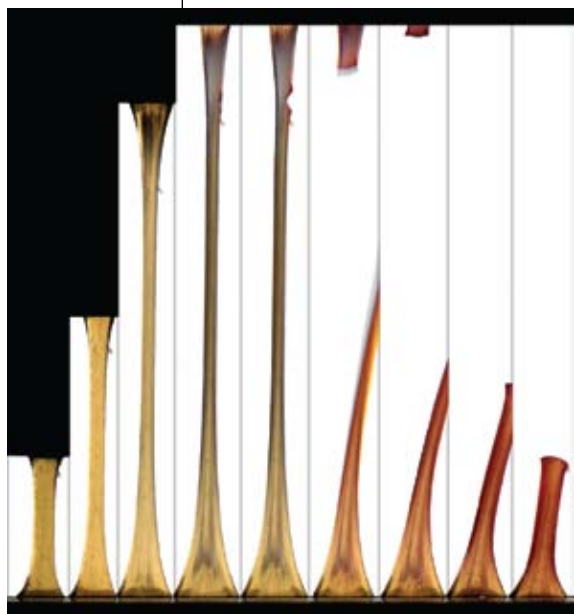


Photo by Beckman Institute ITG, Darren Stevenson and Alex Jerez

Progressive images of a mechanophore linked elastomer during tensile loading. After the polymer reaches a critical strain, a force-induced red color results from selective covalent bond cleavage in the mechanophore just prior to failure.

are triggered in the mechanophores when pushed or pulled with a certain force.

"This offers a new way to build function directly into synthetic materials," said Nancy Sottos, a Willett Professor of materials science and engineering and an affiliate of the Beckman Institute. "And it opens the door to creating mechanophores that can

perform different responsive functions, including self-sensing and self-reinforcing, when stressed."

In previous work, the group showed they could use mechanical force to induce a reaction in mechanophore-linked polymers that were in solution. Now the researchers show they can perform a similar feat in a solid polymer.

Mechanically induced chemical activation (also known as mechanochemical transduction) enables an extraordinary range of physiological processes, including the senses of touch, hearing and balance, as well as growth and remodeling of tissue and bone. Analogous to the responsive behavior of biological systems, the channeling of mechanical energy to selectively trigger a reaction that alters or enhances a material's properties is being harnessed by the researchers.

In critical material systems, such as polymers used in aircraft components, self-sensing and self-reinforcing capabilities could be used to report damage and warn of potential component failure, slow the spread of damage to extend a material's lifetime, or even repair damage in early stages to avoid catastrophic failure.

"By coupling mechanical energy directly to structural response, the desired functionality could be

precisely linked to the triggering stimulus," said Sottos.

In their work, the researchers used molecules called spiropyran, a promising class of molecular probes that serve as color-generating mechanophores, capable of vivid color changes when they undergo mechanochemical change. Normally colorless, the spiropyran used in the experiments turns red or purple when exposed to certain levels of mechanical stress.

"Mechanical stress induces a ring-opening reaction of the spiropyran that changes the color of the material," said Douglas Davis, a graduate research assistant and the paper's lead author. "The reaction is reversible, so we can repeat the opening and closing of the mechanophore."

"Spiropyran can serve as molecular probes to aid in understanding the effects of stress and accumulated damage in polymeric materials, thereby providing an opportunity for assessment, modification and improvement prior to failure," Davis said.

To demonstrate the mechanochemical response, the researchers prepared two different mechanophore-linked polymers and subjected them to different levels of mechanical stress. In one polymer, an elastomer, the material was stretched until it broke in two. A vivid color change in the polymer occurred just before it snapped. The second polymer was formed into rigid beads several hundred microns in diameter. When the beads were squeezed, they changed from colorless to purple.

The color change that took place within both polymers could serve as a good indicator of how much stress a mechanical part or structural component made of the material had undergone.

"We've moved very seamlessly from chemistry to materials, and from materials we are now moving into engineering applications," Sottos said. "With a deeper understanding of mechanophore design rules and efficient chemical response pathways, we envision new classes of dynamically responsive polymers that locally remodel, reorganize or even regenerate via mechanical regulation."

The paper's co-authors are Sottos, Davis, White, Braun, Moore, chemistry professor Todd Martinez and members of their research groups. The U.S. Army Research Office MURI program funds the work.

A vivid color change in the polymer occurred just before it snapped.

White is Finalist for Bepi Colombo Prize

AE Prof. Scott R. White was one of five finalists for the 2008 Bepi Colombo Prize, an international award named in honor of Italian scientist Giuseppe Colombo, famous for his contributions to aerospace technology and exploration.

White was considered for his pioneering work in developing self-healing polymers, materials that mimic the autonomic healing response natural to living systems. White's research team reported their initial breakthrough in 2001 with an epoxy polymer containing a microencapsulated healing agent and a catalytic chemical trigger. Cracks in the polymer rupture the embedded microcapsules, releasing the healing agent into the crack, healing it.

In subsequent research White's team has developed a second generation of the polymers incorporating a vascular network akin to biological systems, so that the healing agent supply can be replenished indefinitely, extending the materials' lifetime greatly.



From left, Roger-Maurice Bonnet, Executive Director of the International Space Science Institute in Bern, Switzerland, and Chairman of the International Jury for the Bepi Colombo Prize; Flavio Manzolini, Councillor for Economic Activities of the Province of Padova, Italy; and AE Prof. Scott R. White.

The research has gained worldwide attention and has resulted in White founding a company, Autonomic Materials Incorporated, in the University of Illinois Research Park. Applications for the self-healing polymers are far-reaching, ranging from aerospace structures, to sporting goods, to microelectronics to coatings and paint.

Candidates for the biannual Bepi Colombo Prize must have produced research that has contributed to a meaningful advance in a field related to Prof. Colombo's research activity, and/or has produced results that impact consumers' daily lives.

Colombo built his career at the University of Padova, Italy, lecturing on mechanical vibrations and celestial mechanics, as well as space vehicles and rockets. He participated in research at the Harvard Smithsonian Center for Astrophysics, then at Caltech and Jet Propulsion Laboratory.

Colombo is known for his discovery of the spin-orbital coupling of Mercury, the planning of multiple fly-by of Mercury in 1972-1973, the conceptual design of the Solar Probe mission, the promotion of the Skyhook concept applications, a new type of orbiting gravity gradiometer, and the interpretation of the azimuthal brightness variation of ring A of Saturn as a spiral structure. He studied new concepts concerning space transportation, large space structures and evolution of space technology for space sciences and applications. He also was one of the pioneers of many tethered satellite applications.

Geubelle Named ASME Fellow

AE Professor Philippe Geubelle has been named a Fellow of the American Society of Mechanical Engineers (ASME). Fellowship status in the 129-year-old organization is conferred upon veteran members who have contributed significant engineering achievements.

Over his 15-year professional career, Geubelle has distinguished himself nationally and internationally as an engineer and educator in computational mechanics. His key research accomplishments include development of novel numerical methods for fracture mechanics, computational design and modeling of biomimetic self-healing and cooling materials, multiscale modeling of heterogeneous materials and computational aeroelasticity.

Geubelle is the AE Associate Head for graduate programs and directs the Illinois Space Grant Consortium. He has supervised over 30 graduate students, and has obtained multiple awards for his research, teaching and advising work.

Among his honors have been the 1998 and 2009 American Institute of Aeronautics and Astronautics Illinois Chapter's Teacher of the Year Award; the 2007 Best Fatigue and Fracture paper published in the *Journal of Engineering Materials and Technology*; the 1999 and 2006 University of Illinois College of Engineering Xerox Research Award; the 2000 University of



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New AE Professor Developing Bat-Like Aircraft Flight



Chung

The successful reverse-engineering of flapping flight will potentially lead to an innovation in aircraft design

Equipped with a vision to develop aircraft that mimic the autonomy and agility of bats, Soon-Jo Chung began this fall semester as a new assistant professor in Aerospace Engineering.

Coming to Illinois from Iowa State University, the biomimeticist brings with him a three-year, \$300,000 Air Force Young Investigator research grant he received this year for his project, "Bio-Inspired Integrated Sensing and Control of Flapping Flight for Micro Aerial Vehicles."

According to Chung, "Bat-inspired flapping flight holds promise for creating micro-aerial vehicles (MAVs) where rigid fixed wings drop substantially in aerodynamic performance. The successful

reverse-engineering of flapping flight will potentially lead to an innovation in aircraft design, and push the frontier of our understanding of neurobiological mechanisms underlying animal flight and locomotion."

"There's a lot to learn from bio systems," Chung said. "Bats can fly with damaged wings. They are so agile and highly maneuverable; they can make rapid 180-degree turns autonomously and they can fly indoors without colliding with obstacles."

Bats' wings are designed to allow the animals to move acrobatically. Thousands of tiny hairs on the wing membranes provide sensory information that controls the shape and pitch of the wings. This enables bats to adjust their flight in response to wind gusts and obstacles.

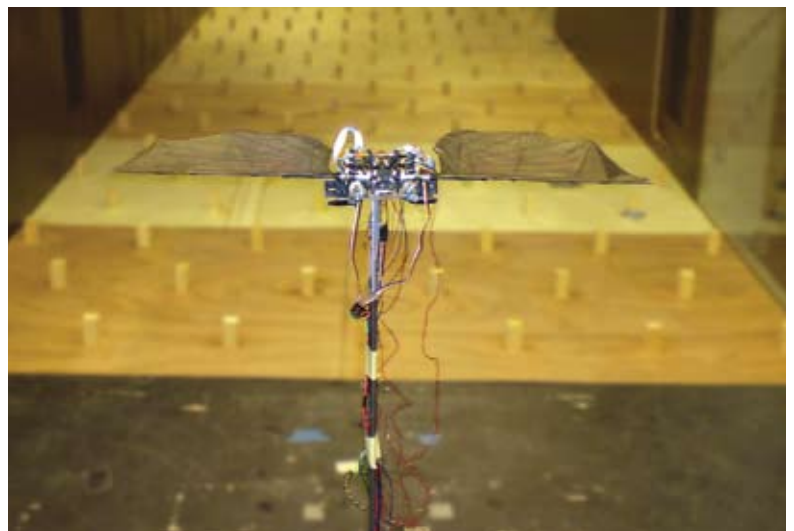
These qualities are desirable for small aircraft that could be used

in surveillance, particularly in urban settings where obstacles hamper movement and satellite control is blocked.

Chung is working on a MAV with an engineered neural control system that mimics bats' ability to synchronize their wings' flapping and joint movements, allowing them to respond to changes in environment. Meanwhile, his ongoing research on vision-based navigation is expected to make a break-through with a superior information-to-weight ratio. A small camera allows the vehicle to see obstacles while an onboard computer generates a map for navigation.

So far, Chung has successfully developed a small indoor helicopter that can autonomously navigate a path. He also has produced a robotic bat that, docked on a test bed, has a range of eight independent movements in flapping its wings. The next step is to combine the two advances in a vehicle light enough to fly.

While expanding this research, Chung will continue developing new theories and methods to coordinate the movements of individual space or aerial vehicles in formation, a project that comprised his doctoral work at Massachusetts Institute of Technology.



Chung is working on a MAV with an engineered neural control system that mimics bats' ability to synchronize their wings' flapping and joint movements, allowing them to respond to changes in environment.

Chung earned that degree in estimation and control in 2007, and earned his master's, also at MIT, in 2002 in aeronautics and astronautics. He was summa cum laude in earning his bachelor's in aerospace engineering in 1998 from the Korea Advanced Institute of Science and Technology (KAIST), a leading science and engineering school in Asia.

Chung came to Iowa State in 2007, spending two years as Assistant Professor of Aerospace Engineering. Prior to that, he spent six years as a research assistant in the MIT Space Systems Laboratory and half a year as a research engineer in the New Initiative Office of the National Optical Astronomical Observatories in Tucson, Arizona. He was also a consultant for NASA's Lunar Reconnaissance Orbiter during 2007.

In addition to the 2008 AFOSR Young Investigator Award, Chung's honors include Iowa State's Aerospace Engineering's Most Inspiring Professor Award, Fall 2008 and Spring 2009; Iowa State's Aerospace Engineering's Most Interesting Line of Research Award, Fall 2008 and Spring 2009; Outstanding Faculty Award from Iowa State's VEISHEA celebration in 2009; the 2008 IEEE International Conference on Electro/Information Technology Best Paper Award; a finalist for the 2006 American Institute of Aeronautics and Astronautics Guidance, Navigation and Control Conference Best Student Paper; an AT&T Asia/Pacific 2000 Leadership Award; and a 1998 KAIST Action Committee Presidential Award.

Chung is a Senior Member of AIAA and has been nominated as Technical Area Co-Chair of the 2010 AIAA Guidance, Navigation, and Control Conference.

Freund Chosen for APS Frenkiel Award

Jonathan B. Freund, associate professor in Aerospace Engineering, has been selected as the 2008 winner of the Francois Frenkiel Award, a prestigious honor given by the American Physical Society's Division of Fluid Dynamics.

Freund was chosen for his paper, "Leukocyte margination in a model microvessel," published in the February 20, 2007, online edition of *Physics of Fluids*. The Frenkiel Award recognizes significant contributions to fluid mechanics that have been published by young investigators in *Physics of Fluids* during the preceding year.

Freund's research concerned the fluid mechanics of white blood cells when a body responds to physiological inflammation. Said Freund, "As part of inflammation, the white cells somehow get preferentially pushed toward the walls of vessels. There have been lots of ideas about why this happens. My simulation model suggests that it just involves the interaction with the red cells."

Continuing, he said, "I was also able to look at the detailed flow when a white cell is near the wall and explain, in part, why, once there, it is in a relatively stable configuration. I developed a sophisticated simulation tool to study these mechanisms."

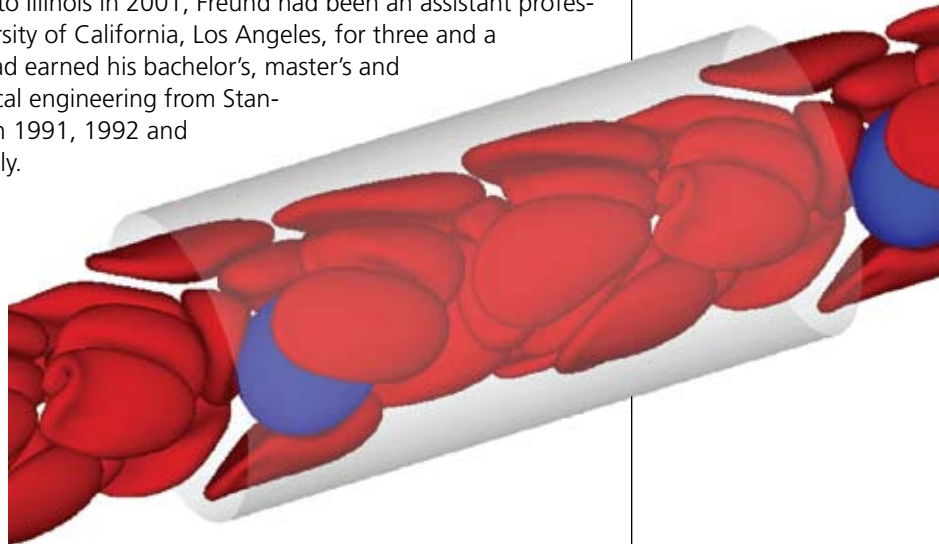
Freund has appointments in Aerospace Engineering and in Mechanical Science and Engineering at Illinois. His research areas include aerodynamic sound, compressible turbulence, numerical methods, large-scale parallel computing, molecular dynamics simulation of nanometer scale flows and heat transfer in solids.

Prior to coming to Illinois in 2001, Freund had been an assistant professor at the University of California, Los Angeles, for three and a half years. He had earned his bachelor's, master's and PhD in mechanical engineering from Stanford University in 1991, 1992 and 1998, respectively.

Freund's work had been selected in 2000 for the APS Division of Fluid Dynamics Gallery of Fluid Motion.



This simulation shows 23 red cells and one white cell flowing in a periodic model of a microvessel.



Boeing Recognizes AE Graduate Student in International Competition



Sharma

AE graduate student Manu Sharma was honored in the Boeing 2008 Student of the Year Awards.

Sharma received an honorable mention for his project involving the experimental investigation of compressible hypersonic flow using the recently constructed Hypervelocity Expansion Tube (HET) facility. He was heavily involved in the installation of the tube itself, the test section, data acquisition system, vacuum pump, gas lines and pressure instrumentation.

"I was responsible for the design of a novel primary diaphragm cutting mechanism and the test section sting and model mounts. Specifically, the long-term goal of my Ph.D. is to examine the high-temperature effects that are a defining hallmark of hypersonic flow. Thermochemical processes such as dissociation and vibrational excitation can have a substantial impact upon hypersonic aerodynamics. Towards investigating these high-temperature effects, we have selected a Mach reflection as a canonical flowfield and have used schlieren visualization, pitot pressure and wavespeed measurements and imaging spectroscopy to characterize the flowfield," Sharma said.

According to the company, the competition attracted a record number of qualified entries from around the world, including Australia, India, Singapore, South Africa and the United Kingdom, as well as the United States.

Boeing's sponsorship is one of its many efforts aimed at encouraging students to pursue careers in aerospace-related engineering fields. The worldwide competition is open to any full- or part-time engineering student pursuing a recognized degree. The winning student's work must be judged as likely to impact the future of aerospace engineering in areas such as new or enhanced capabilities, systems, processes or tools; new levels of performance; and improved life cycle costs.

AE Grad Student Wins NASA/GSRP Fellowship

AE graduate student Jacob A. Englander has been chosen for a National Aeronautics and Space Administration fellowship for his work on developing an autonomous design tool for interplanetary spacecraft missions.

The NASA/Goddard Space Flight Center Graduate Student Researchers Program Fellowship will support Englander's PhD work for the next three years.

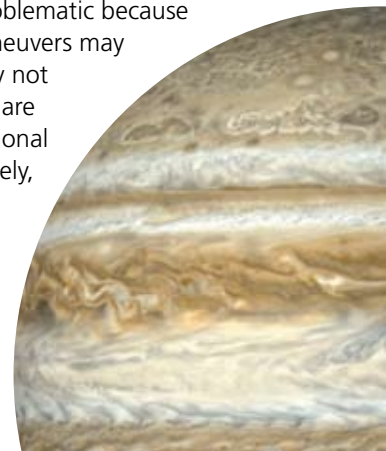
Typically, according to Englander, when NASA decides to send a probe to a planet that is difficult to reach, such as Jupiter, Saturn, or Mercury,



Englander

analysts manually design a sequence of rocket burns and gravity assist maneuvers to get the spacecraft there efficiently. Numerical methods are used to optimize each maneuver in the sequence.

This method becomes problematic because the best sequence of maneuvers may be non-intuitive, so it may not occur to designers if they are doing the work the traditional way, by hand. Unfortunately, the significant amount of time it would take to run all possible sequences on



a computer makes the process prohibitive to simulate.

Englander's goal for the project is to develop an autonomous method for choosing an optimal sequence of maneuvers and events, and then optimize each maneuver in the sequence.

"The method has to be fast and robust because we don't want our program to crash in the middle and have to start over, wasting hours or even days of computer time," Englander said.

The method also has to be adaptable to handle many different types of missions. Finally, any code developed would be integrated into NASA Goddard's GMAT (General Mission Analysis Toolkit) so that Goddard engineers could use it to design real missions.

Englander said Bradley Wall, MS 2004, PhD 2007, and now an assistant professor at Embry Riddle Aeronautical University, and Christian Chilan, MS 2002 Computer Science, did previous work on this concept. AE Prof. Bruce Conway advises Englander.



Conway

AE Researchers' Paper Chosen as Best from Continuum Mechanics Conference

A group of AE researchers has earned the Best Paper Award from a major continuum mechanics conference held in February in Cambridge, the United Kingdom.

The International Association of Mechanical Engineers/World Scientific and Engineering Academy and Society (IAME/WSEA) chose the paper, "Theory of designer nano-viscoelastic composites," from the Proceedings of the Fourth International Conference on Continuum Mechanics.

Sharing in the honor are Emeritus Prof. Harry H. Hilton, Associate Prof. Ioannis Chasiotis and Mohammad Naraghi, who completed his doctoral degree in AE in May. Naraghi is now a post-doctoral research associate at Northwestern University.

The paper resulted from the group's new approach in analyzing potential structural materials. Instead of designing structures around standard materials' properties, Hilton and his collaborators attempt to determine the properties of ideal materials that would best suit the structure's uses.

This way of looking at structural analysis and design is unique because it defines materials that do not yet exist. The work determines what attributes the materials should have to produce optimum results.

The formulas produced through the research also allow materials designers to input variables like cost, performance and weight.

The award winning paper is an application to nano-viscoelastic composites of the general theory of designer materials developed previously by Hilton, Daniel H. Lee and Abdoul A. El Fouly.

Currently Hilton, Lee and Craig G. Merrett are conducting research to generalize the fundamental paper still further to encompass entire flight vehicles (aerodynamics, control, stability, propulsion, structures). They estimate that for a large transport aircraft this would entail solving some 800,000,000 simultaneous equations and will necessitate the use of the IBM-NCSA peta-scale computing system, which will become operational in 2011.

Lee and Merrett are PhD candidates in AE.

Instead of designing structures around standard materials' properties, Hilton and his collaborators attempt to determine the properties of ideal materials that would best suit the structure's uses.



Hilton



Naraghi



Chasiotis



Dowell Receives Prestigious Guggenheim Medal

AE Alumnus Earl H. Dowell, BS 1959, William Holland Hall Professor at Duke University in Durham, North Carolina, is the 2008 recipient of the Daniel Guggenheim Medal.

The award was presented during the AIAA Aerospace Spotlight Awards Gala on May 13, 2009, at the Ronald Reagan Building and International Trade Center, Washington D.C. The Medal recognizes Dowell for pioneering contributions to nonlinear aeroelasticity, structural dynamics and unsteady aerodynamics that had a significant influence on

aeronautics, and for contributions to education and public service in aerospace engineering.

With this award, Dowell has amassed all the major honors in his field, including the Walter J. and Angelina H. Crichlow Trust Prize and the Spirit of St.

Louis Medal. He is also a member of the National Academy of Engineering and an Honorary Fellow of the American Institute of Aeronautics and Astronautics.

Since 1983, Dowell has been the William Holland Hall Professor, Mechanical Engineering at Duke University. Prior to this he was Professor at Princeton University and Assistant Professor at the Massachusetts Institute of Technology. Throughout his career, Dowell continued vibrant research activities and made outstanding and lasting seminal contributions providing solutions to some of the most important problems in aeroelasticity, unsteady aerodynamics and structural dynamics. These endeavors led to

major contributions to the flight safety of fighter aircraft and have also had a major impact on the design of both military and civilian aircraft.

In addition to his research, Dowell made extraordinary contributions to engineering education especially as a former Dean of Engineering at Duke University where he had major impact on not only the development of the school's unprecedented prominence but also on countless graduate students.

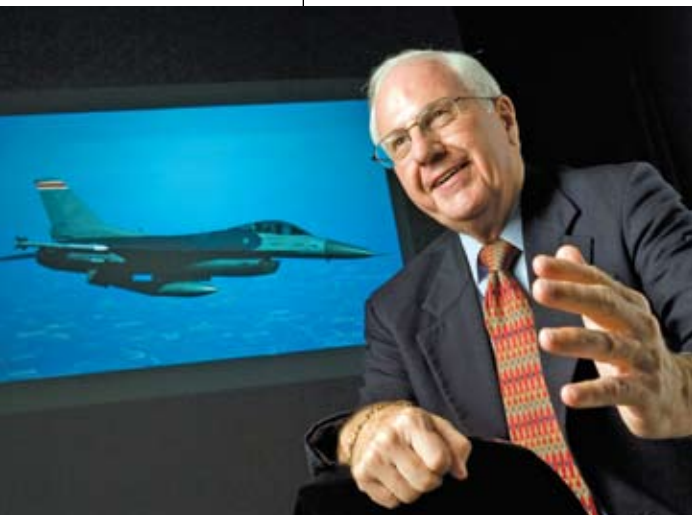
Throughout his distinguished career, Dowell also participated generously with professional service and service on high-level advisory panels including the Air Force and NASA.

Dowell is the principal author of the leading textbook in aeroelasticity, *A Modern Course in Aeroelasticity*, now in its 4th edition, and also a co-author of the now classic *Aeroelasticity of Plates and Shells*, and of the most recent *Dynamics of Very High Dimensional Systems*. Additionally, he is the author or co-author of over 250 technical papers.

Dowell's other honors include Fellow of the American Society of Mechanical Engineers, Fellow of the American Academy of Mechanics, past president of the American Academy of Mechanics, current service on the National Research Council, and others.

His accomplishments have been recognized with the AIAA Theodore von Kármán Lectureship in Astronautics, AIAA Structures, Structural Dynamics and Materials Award, and the American Academy of Mechanics Distinguished Service Award.

The Daniel Guggenheim Medal, jointly sponsored by the American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers, American Helicopter Society, and Society of Automotive Engineers, was established in 1929 for the purpose of honoring persons who make notable achievements in the advancements of aeronautics.



Please credit Duke University Photography for the photo.

AE Alumni Command Space Shuttle Flights, Join 2009 Astronaut Class

Two AE alumni commanded space shuttle flights in 2009, while a third alumnus joined the ranks of the 2009 astronaut candidate class.

Veteran space flier Lee "Bru" Archambault, BS 1982, MS 1984, commanded the shuttle Discovery's February mission to the International Space Station. Scott Altman, BS 1981, another veteran in space, commanded Atlantis' mission to service the Hubble Space Telescope in May. In July, Lt. Col. Michael S. Hopkins, BS 1992, brought to four the number of astronauts produced by the Aerospace Engineering Department at Illinois (the fourth is Col. Steven R. Nagel, BS 1969).

Archambault, a U.S. Air Force colonel, led a mission to deliver the space station's fourth and final set of solar array wings, completing the station's backbone, or truss.

The arrays were designed to provide the electricity to power science experiments and increase the crew size to six in May. During the servicing mission to Hubble, Altman's crew installed two new instruments, repaired two inactive ones, and performed the component replacements that will keep the telescope functioning into at least 2014.

Archambault joined the U.S. Air Force in 1985 and has logged over 4,250 flight hours in more than 30 different aircraft, including the F-117A Stealth Fighter. He guided that craft through 22 combat missions in the Gulf War between 1990 and 1991. Later he served as an instructor pilot and test pilot to aid aircraft weapons development before joining NASA in June 1998. He and other members of the STS-119 crew were honored on May 1 with a White House visit with President Barack Obama.



Leading NASA's STS-119 space shuttle crew, Commander Lee Archambault presented President Barack Obama with a montage in the Oval Office of the White House, Friday, May 1, 2009, in Washington, D.C.



AP Photo by John Raoux

Space shuttle Atlantis crew, from right, commander Scott D. Altman, pilot Gregory C. Johnson, mission specialist, K. Megan McArthur, mission specialist John Grunsfeld and mission specialist Andrew Feustel, mission specialist Michael Good and mission specialist Michael Massimino, leave the Operations and Checkout building enroute to board the shuttle at Kennedy Space Center in Cape Canaveral, Fla., Monday, May 11, 2009.

The Atlantis mission was Altman's fourth shuttle flight since joining the space program in 1995. He has previously flown to the International Space Station and on an earlier Hubble Space Telescope servicing mission.

Hopkins was one of nine men and women selected from among 3,500 applicants for the 2009 astronaut class. Relocating to NASA's Johnson Space Center in Houston in August, Hopkins had been working as special assistant to the Vice Chairman (Joint Chiefs of Staff) at the Pentagon.



Michael Hopkins

Photo by NASA/Bill Ingalls

AE Grad Student is Finalist for Lemelson Prize; Wins Cozad Venture Competition



Steele

AE graduate student Adam Steele was named among eight finalists across the University of Illinois at Urbana-Champaign campus for the \$30,000 Lemelson-Illinois Student Prize.

The prestigious award is an extension of the \$30,000 Lemelson-MIT Student Prize that has recognized outstanding student inventors at the Massachusetts Institute of Technology since 1995.

In addition, SongAlive, a company that Steele helped form, has won First Prize for being the Most Fundable Venture in the 2009 V. Dale Cozad New Venture Competition. With a team of programmers and web designers, Steele created a social music website aimed at harnessing the creative power of individuals around the world.

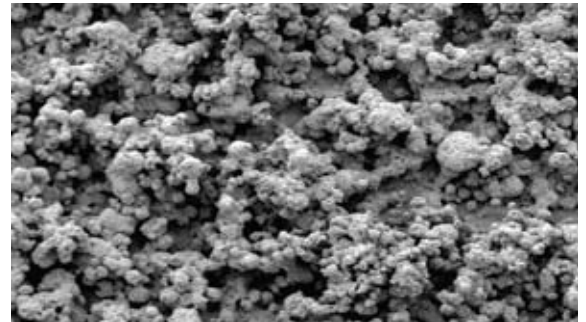
AE Prof. Eric Loth and Dr. Ilker Bayer, a postdoctoral research associate, advise Steele, who has created a biomimetic nanocomposite paint that exhibits extremely low friction to liquids, making it self-cleaning and non-wetting. This paint is both environmentally friendly and incredibly tough, enabling it to be used in a variety of applications.

Steele is also developing products to assist visually-impaired individuals in the avoidance of eye-level

This is an image of Steele in the cleanroom where he does some of his nanocomposite surface analysis. This particular instrument is a sputter coater.



This is an image of water droplets resting on a superhydrophobic nanocomposite coating. Water rolls freely with very low surface friction on the coating due to its suitably designed surface morphology and surface chemistry.



This is a scanning electron microscope (SEM) image showing the micro surface morphology of a superhydrophobic nanocomposite. The spherical agglomerations that can be observed are composed of nanoparticles and polymer, giving the surface nano-texture as well, which is critical for stable superhydrophobicity.

collisions and in extending their current outdoor navigation technology to large indoor spaces.

Steele earned his bachelor's in aerospace engineering from Penn State University, and his master's in AE at Illinois in 2008.

AE Teams Sweep Space Design Competition

Aerospace Engineering teams from the University of Illinois swept all awards in the 2007–2008 Undergraduate Team Space Design Competition, sponsored by the American Institute of Aeronautics and Astronautics Foundation.

The competition required teams to design a space vehicle to complete a specified task, focusing both on mission completion and on the total costs. The competition asked entrants to design a vehicle to retrieve various artifacts from Apollo moon missions and return them from the moon to the Earth. Eligible Apollo mission artifacts were those from Apollo 12 through Apollo 17; artifacts from Apollo 11 were off-limits.

Advised by AE Prof. Victoria Coverstone, five Illinois teams competed, doing the work as their senior design projects. Three teams took home prizes. “Each team conceptualized a unique approach to completing the mission,” Coverstone said. “Our students are innovative and technically savvy. It comes as no surprise that they swept the national competition.”

AIAA set up the contest as though a mysterious entrepreneur was offering a \$1 billion prize for teams to recover items ranging in value from 100 to 500 points. The first team to return items worth 250 points would be the winners. Among the items were a U.S. flag, a moon buggy antenna, Alan Shepard’s golf ball, and other discarded items.

Brianna Aubin, a member of Team Lunatics that took home first prize, said her team’s goal was to recover Shepard’s golf ball because it was worth the most points at 500. Aubin’s team designed a landing craft that would get to the moon to release a rover to search for the artifacts. The rover was



Members of AE’s First Place 2007–2008 Undergraduate Space Design Competition Team: (back row, from left) Abdul Rahman El Fouly, Charles Spellman, William Andrewski, Michael Larsen; (front row, from left) Joel Nordness, Brianna Aubin, Josh Birnbaum, Seth Baynar.

designed to then come back to a return capsule, also carried on the landing craft. The capsule would then fire and make the trip back to Earth.

The technical side of the mission involved designing a lander, rover and return capsule, planning orbital trajectories and propulsion, and determining how to bring the capsule back and recover it. Teams also had to plan the business end of the project and find the means to pay for it. Aubin said her team cited grants, advertising, loans, investors and payments to use the rover for public outreach and experiments.

The competition required teams to design a space vehicle to complete a specified task, focusing both on mission completion and on the total costs.

AE Group Worked to Improve Athletes' Results in Paralympics



Photos by L. Brian Stauffer

Greg Busch said the engineering team hopes to be able to test their theories using human racers on the track this fall. Such tests might include measuring the total power needed to propel a chair around a track.

A group of aerospace engineering students worked to improve the racing speeds of athletes who competed in Beijing in the September 2008 Paralympic Games that took place in China's capital city.

The students—under the tutelage of former department head Mike Bragg (now an associate dean in the College of Engineering) and research scientist Andy Broeren (now with NASA)—conducted a series of experiments with half-scale and smaller models of racing wheelchairs and their own mini-sized version of a crash-test dummy in the department's wind tunnel. Some of the students began working on the project in Broeren's senior design course in Fall 2007 and later formed a registered student organization called the Racing Wheelchair Aerodynamics Design Team.

The team's goal was to figure out how the U. of I. racers—and other competitive racers—can make aerodynamic improvements that would ultimately enhance performance speeds.

"There are very few examples in the literature on wheelchair aerodynamics," said research team member Greg Busch. "There is a lot of intuitive thought on how to do it. For instance, to keep the frontal area of the chair small, or for the racers to tuck their heads."

Bleakney said some racers have tried other tricks, including taping contact paper to the undercarriage of the chair. As it turns out, "that doesn't do anything measurable," said Busch, noting that

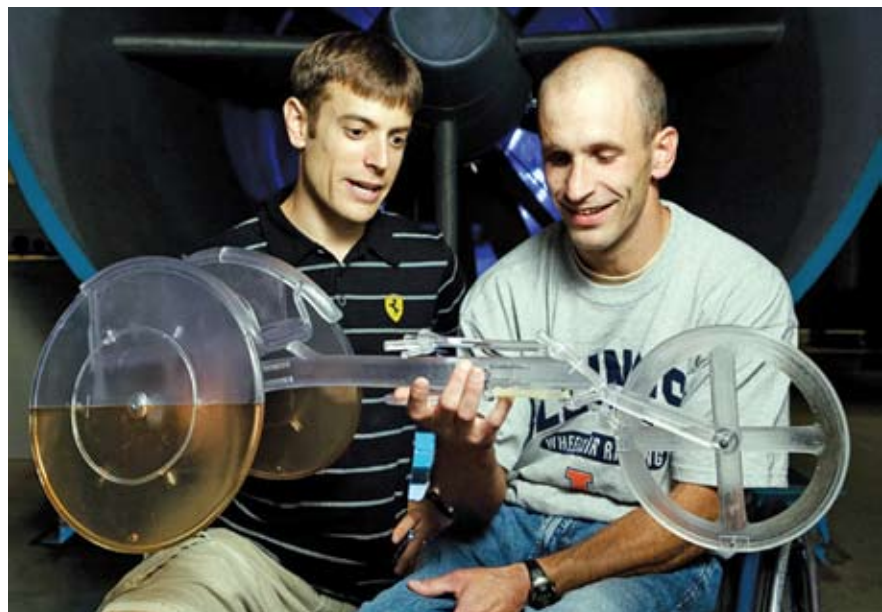
undercarriage taping was one of several theories put to the test.

A couple of the other ideas did yield noticeable, measurable results. For instance, the research team found that athletes who position their heads and torsos in a tucked, rather than upright, position, realize a 10 percent reduction in drag.

The students also studied the effect of attaching various sizes of fairings to the scale models they tested. Similar in function to the windshield on some motorcycles (also known as a fairing), the bullet-shaped attachment "smoothes airflow around riders, reducing aerodynamic drag," Busch said.

Their most successful attempt on that front yielded a 12 percent drag reduction.

The best overall benefit, however, appeared to be combining a fairing with the racer in the tucked position. With that configuration, drag was reduced by 25 percent. "We figured we would have a few



Greg Busch, aerospace engineering graduate student, left, and Adam Bleakney, UI wheelchair track coach hold a racing wheelchair model that was tested in the wind tunnel on campus. Photo by L. Brian Stauffer

percentage-point differences," Busch said, "but 25 percent was a big surprise."

Other variables the engineering students investigated included the design of the chairs' front wheel—spoked or solid—and positioning the rider's feet tucked under the body versus feet dangling.

U. of I. coach and Paralympics competitor Bleakney said he and the student athletes were excited about the initial findings of the engineering team because prior to this, ideas about what worked and what didn't were largely unproven.

"Because we had no scientific data, everything was ad hoc," he said. "That's what's exciting about the work and the data we've got now. It gives us a base to work off of, for starting testing on the field to see if the data in the wind tunnel correlates to the real world."

Chasiotis, continued from page 5

the use of polymer-based composites for large-scale structures, such as the Boeing 787. Although the main structural material to fabricate the fuselage of a Boeing 787 will be a carbon fiber composite, nanocomposite materials are becoming the means to impart multifunctionality and improve upon the durability of existing laminate and woven carbon and glass fiber composites. The use of different forms of composites reduces the structure's weight, providing obvious savings in energy, and, potentially, in maintenance costs.

However, to this point, the mechanical behavior of such materials has not been scientifically investigated, so their design is often being done in a trial and error manner. "The design of nanostructured materials proceeds with using properties for the polymer constituents that are not correct, and, consequently, computations and predictions do not agree with the experimental measurements for nanostructured composites," Chasiotis said.

His research group has the expertise to measure the mechanical behavior of polymeric nanofibers at different time and size scales by developing advanced experimental methods that hinge upon the technology of micro-electro mechanical devices.

"When this research is realized," Chasiotis maintains, "we envision being able to identify the limits and the potential of nanostructured polymeric materials, therefore gaining the ability to design and fabricate composite materials with advanced properties that will improve, and, potentially, revolutionize the way aerospace and other structures are built in the future."

Geubelle, continued from page 13

Illinois College of Engineering Everitt Teaching Award; the 2001 American Society for Composites Best Paper Award, 16th Technical Conference, Polymer Matrix Composite Division; a 1998 National Science Foundation CAREER Award; and a 1994 NATO postdoctoral fellowship.

A Bliss Faculty Scholar in the College of Engineering since 2005, Geubelle also is a faculty member of the Computational Science and Engineering program, and has joint appointments in Mechanical Science and Engineering, Civil and Environmental Engineering and the Beckman Institute for Advanced Science and Technology.

He has played key leadership roles in various engineering societies by chairing technical committees and co-organizing conferences and symposia.

Geubelle earned a bachelor's in mechanical engineering from Catholic University of Louvain, Louvain-la-Neuve in Belgium in 1988. He earned a master's and PhD in aeronautics from the California Institute of Technology in 1989 and 1993, respectively.

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