Mechanical Engineering

Autumn 2007

the MEssenger

UNIVERSITY OF WASHINGTON
COLLEGE of ENGINEERING
A Community of Innovators

Photos © Boeing

Boeing Rolls Out New Era With 787 Dreamliner

The Puget Sound—not to mention the entire aviation industry—is abuzz with excitement generated by the new 787 Dreamliner. Already the most successful launch of a new commercial airplane in the history of the company, Boeing wowed the world with a dramatic rollout on July 8, and anticipates the first test flight in spring 2008.

Roughly 50 percent of the primary structure of the 787 is made using polymeric composites. While thousands of engineers and scientists from around the world have contributed to the development of composites and related technologies, the faculty, students, and alumni of the ME Department have contributed directly to development of the 787.

Here are a few examples. Beginning in 1989, ME Professor Mark Tuttle and Professor Zelda Zabinsky (of the Industrial Engineering Department) began developing a structural design approach to identify the optimal design of a composite fuselage. Their work culminated in a major software tool now known as COSTADE ('C'omposite 'O'ptimization 'S'oftware for 'T'ransport 'A'ircraft 'D'esign and 'E'valuation). Delivered to Boeing engineers in 1998, COSTADE was heavily used during design of the 787 fuselage structure. In addition, since 2003 Prof. Tuttle has led the Center on Advanced Materials for Transport Aircraft Structures, which involves faculty and students from around the College of Engineering working on research projects directly related to the 787 (details at http://depts.washington.edu/amtas/).

The 787 will feature large electrochromic windows. Passengers will be able to adjust the transparency of their windows electronically by pushing a button, eliminating the need for a separate window screen. Much of the technology that has made these windows a reality was developed by ME Professors Chunye Xu and Minoru Taya of the Center for Intelligent Materials and Systems (http://depts.washington.edu/cims/).

Although the composite structures in the 787 are manufactured to near net-shape, some machining (such as drilling rivet holes or final trimming around door or window openings, for example), is inevitably required. Composites are difficult to machine using traditional methods. Therefore, over the past decade Prof. Mamidala Ramulu has worked

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Chair's Corner

ME Chair

Mark Tuttle

Greetings from the University of Washington campus! Autumn Quarter 2007 is well under way, and we have welcomed 100 new undergraduate and 53 new graduate students to our department, bringing our total combined enrollment to 390 students.

I would like to personally welcome Prof. Nate Sniadecki to the department (see pg 7), and to congratulate Prof. Savio Woo (MSME '66, PhD '71) on his election to the Mechanical Engineering Hall of Fame (see pg 6).

Our research programs can be roughly grouped into four main categories:

- Health Systems and Biotechnologies
- Advanced Materials and Manufacturing
- Environmentally Sensitive Energy Conversion
- Controls and Mechatronics

Our studies related to Health Systems and Biotechnologies were summarized in the spring '07 issue of *The MEssenger*. In this issue we highlight our work in Advanced Materials and Manufacturing. We plan to provide an overview of the remaining two focus areas in future issues.

The need for improved materials and manufacturing processes has never been greater. Dwindling energy reserves and increasing greenhouse gas emissions require that current transportation systems (land, air, and sea) become more energy efficient and environmentally benign. Improved materials and manufacturing processes are a fundamental requirement to achieve these goals. The new Boeing 787 Dreamliner (see lead story, pg 1) is a perfect illustration. The 787 will be about 20% more fuel-efficient, yet will fly faster and have a longer range than do current aircraft of comparable size. These improvements are primarily due to the use of advanced lightweight composites, which only became possible after the development of new manufacturing processes that can be used to produce large composite structures. Look for an increased use of composites or advanced materials in all transportation vehicles (autos, trucks, trains, ships) in the years to come.

As always, I hope you will visit the Mechanical Engineering Department if you find yourself on or near the UW campus!

Boeing Dreamliner

Continued from page 1.

extensively with Boeing and others to develop state-of-the art machining processes suitable for use with composites, ranging from various polycrystalline diamond cutting tools to abrasive water-jet cutting technologies. His studies (http://faculty.washington.edu/ramulum) led directly to many of the machining operations now used to produce composite parts for the 787.

Of course, the most important "products" of the ME Department are our graduates. Many have played major roles in the 787 program, either as Boeing engineers or as engineers working with its partners and suppliers, and many received their first exposure to composite materials during their studies at the UW.

Over the 100-year history of the department many hundreds of our graduates have enjoyed successful careers at the Boeing Company. ME graduates now involved in the 787 program carry on this proud tradition.

From faculty, staff, and students of the ME Department: Congratulations to the Boeing Company on the landmark 787 Dreamliner!

2007 ENGINEERING LECTURE SERIES

Join us! Tuesday, November 13 • 7 pm ~ Kane Hall 130, UW Seattle • FREE

Building the Future of Commercial Aviation: Boeing's 787 Dreamliner

Al Miller, '71, '77, Director, 787 Technology Integration, The Boeing Company
Mark Tuttle, Chair, UW Mechanical Engineering

Boeing is preparing for the first flight of the 787, a light-weight, super-efficient plane with a structure that incorporates an innovative shift from metals to composite materials. Before you take your first flight on the Dreamliner, get the inside story on the making of the plane and how it will change your flying experience. Also hear about next-generation advanced materials being developed in UW labs that will alter the future of planes, cars, energy, and more.

Seating is limited. REGISTRATION REQUIRED. Register online at UWalum.com or by calling 206-543-0540.
Sponsored by the College of Engineering and the UW Alumni Association

Crowds admire the 787 at the July 8 rollout.

© Boeing

The Department honored its 102nd graduating class at a graduation ceremony held on June 10. This year's graduates, including 8 PhD, 40 MSME and 103 BSME degree recipients, joined over 10,000 alumni who have received ME degrees since the first class of six BSME students graduated in 1905. Mark Tuttle presented opening and closing remarks. Bryan Speare spoke on behalf of his classmates. Martin Snoey delivered the keynote address.

Martin Snoey Speaks at Graduation

Martin R. Snoey (MSME'66), delivered an inspiring speech to over 400 students, family members, friends, and faculty at this year's commencement. Among other themes, Snoey discussed his passions and how balancing the pursuit of those passions has been an exhilarating life goal.

Snoey's roots in ME run deep through his impressive career. At the Naval Civil Engineering Laboratory he was one of few civilians to receive US Navy training and certification as operator of naval undersea research submersibles, and he made a world-record dive. While at the laboratory, he co-authored 11 technical publications. Snoey is a registered professional engineer in four states including Washington. His long career in the transportation industry concluded with retirement from Harley-Davidson as corporate vice president and COO of Transportation Vehicles Division. Earlier in his career he was president and CEO of Geostar Corporation, assistant general manager of PACCAR's Kenworth Division, and vice president of Mercedes-Benz Freightliner.

Snoey has seemingly unlimited passion for adventure and has traveled around the world with explorations ranging from riding camels in Egypt to riding elephants in Nepal; from hiking in Bhutan to safaris in Kenya; from diving on the Australian Great Barrier Reef to rafting the Grand Canyon. Mountaineering is a special pursuit, as he has climbed over 50 mountains around the world including Mt. McKinley, Alpamayo, Kilimanjaro, Orizaba, and Mont Blanc. An avid Harley owner, he has ridden 80,000 plus miles including a USA Four Corners Ride, Lewis & Clark Trail Ride, Trans-Canada Ride, and to Harley Davidson's 100th anniversary celebration in Milwaukee.

Snoey is a fourth-generation Washingtonian, as his pioneer ancestors lived in Washington in the territorial era. He earned a BSME ('65) from WSU and holds an MBA ('72) from Harvard Business School.

In retirement, Snoey devotes considerable time to his community and serves on several boards of directors. Snoey also shares a rich personal life with his wife of 42 years, Barbara. He is the proud father of three grown children, Andrew, John (MBA '01), and Gretchen (MPA '06), and father-in-law of Kelly (MPA '03) and the grandfather of two.

Bryan Speare Awarded Dean's Medal

This spring mechanical engineering student Bryan Speare was honored with the 2007 College of Engineering Dean's Medal for academic excellence, research, and his industrial experience and campus and community involvement. Bryan received his BSME summa cum laude at the June commencement and gave the student graduation address at ME's graduation ceremony. His primary interest is in ship design, manufacturing, and testing, and he plans a career in the maritime industry. While an ME student Bryan designed and manufactured propulsion components for the Human Powered Submarine project and worked on a capstone project team that redesigned an ultraviolet water treatment system. After graduation he headed for Newport News, Virginia, where he accepted an engineering position with Northrup Grumman, which designs and builds nuclear-powered aircraft carriers and submarines. In addition to designing and building things, Bryan enjoys playing and composing music, kayaking, bicycling, and hiking.

Mark Tuttle (L), Bryan Speare (C), and Martin Snoey at the 2007 Mechanical Engineering Graduation Ceremony.

Advanced Materials and Manufacturing Research

Chunye Xu (C) demonstrates the switchable window to Chao Ma (L) and Sooyeun Kim (R).

Smart Materials and their Devices
Chunye Xu

A chemist and engineer, Prof. Chunye Xu works on electroactive polymers (EAPs), electrochromic polymers (ECPs), and their devices. Prof. Xu is co-director of CIMS. Her studies of EAPs are focused on electrically driven property-deformations, and studies of ECPs focus on electrically induced color changes. These materials have applications as actuators, sensors, switchable windows, sunglasses, and more. Xu's team also works on development of new solar cells and rechargeable batteries.

- www.depts.washington.edu/cims/research/electroactive.htm

The mechanical response of advanced materials and structures and the development of associated manufacturing processes have been core activities within ME since the department was founded in 1906. For example, in the 1940s Prof. Gus Schaller developed a metal casting process based on the use of olivine sand, a process still in worldwide use today. Starting in the 1950s Prof. Emmett Day pioneered the use of strain gauges, brittle coatings, and other techniques to measure strains induced in load-bearing structures. In the 1960s Prof. Raymond Taggart began his studies of yielding processes in titanium alloys, while Prof. Albert Kobayashi began his studies of crack growth in metals and ceramics, which have since formed the basis of what we now call "fracture mechanics."

Today our faculty are working on the advanced materials and manufacturing processes of the early 21st century. This section provides an overview of our work in this critical area. Please visit the websites indicated for a more detailed explanation of our exciting research!

Polymer Optics and Processing Laboratory
Ann Mescher

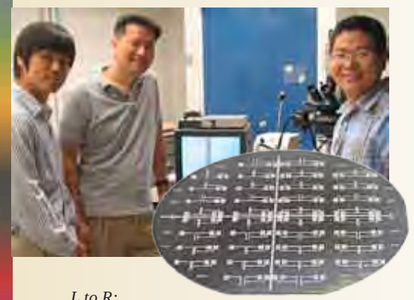
L to R: Andrew Eidinger, Greg Winchell, and Ann Mescher.

Drawing process used to create a holey fiber.

Design and manufacture of polymer optical fibers is among the interests of Prof. Mescher. Most optical fibers are made of glass, since light attenuation is much lower in glass than in plastics. However, glass is brittle, has a limited range of refractive indices, and requires expensive connections. Polymer fibers are superior in these areas, and are attractive for use in residential or automotive applications. Prof. Mescher has developed a process to produce photonic crystal fibers (known as "holey fibers"). By incorporating axial holes in optical fiber it is possible to achieve properties not available in solid fibers. These holes can be arranged to maintain polarization, to create single-mode fibers, or for high numerical aperture fibers.

- www.depts.washington.edu/polylab/home.html

Nanomanufacturing Laboratory Jae-Hyun Chung



L to R:
Woonhong Yeo, Jae-Hyun Chung, and John Bai
Inset: Si nanowire devices on a 4-inch wafer.

Professor Chung's group is working on nanomanufacturing methods, nanoscale devices, nanostructured composite systems, biosensors, and biomimetic actuators. These studies will allow use of nanoscale structures in practical applications.

- www.faculty.washington.edu/jae71/

Jiangyu Li

Multifunctional Materials Laboratory Jiangyu Li

Prof. Jiangyu Li heads the Multifunctional Materials Laboratory (MML). Established in 2006, the MML is devoted to the development of multifunctional materials based on tightly coupled theoretical, numerical, and experimental investigations carried out at multiple length scales. Current emphasis is on ferroelectric, ferromagnetic and multiferroic materials, and on electroactive polymers and their composites. Basic objectives are to understand formation and evolution of microstructures in these materials, to clarify how these microstructures relate to macroscopic properties, and to develop processing techniques necessary to control formation of desirable microstructures. This will allow the engineer to produce materials that have any desired combination of macroscopic properties.

- http://mfml.me.washington.edu/

Manufacturing Science and Technology Laboratory Mamidala Ramulu

Timothy Briggs inspects water-jet cutting nozzle.

Mamidala Ramulu

Prof. Ramulu leads the Manufacturing Science and Technology Laboratory (MSTL). He and his students work to provide a fundamental understanding of the basic physics of existing manufacturing processes. The effects of manufacturing processes on static and fatigue properties and on surface quality and structural integrity of engineered materials are studied in detail. A recent project of special importance has been the combination of friction stir welding of the titanium 6Al-4V alloy to produce extremely large sheet metal pieces that can withstand superplastic forming processes involving elongations in excess of 200%. Prof. Ramulu has also contributed to the development of abrasive high-pressure water-jet processes used to machine aerospace materials.

- http://faculty.washington.edu/ramulum/

Center for Intelligent Materials and Systems (CIMS)
Minoru Taya

L to R: Joyce Zhang and Minoru Taya.

Prof. Taya is director of CIMS, which was established in 2000. Prof. Taya and his colleagues are developing devices made from advanced "smart" materials. These include electroactive or conducting polymers, piezoelectric composites, metal matrix composites, and thermomechanical or ferroelectric shape memory alloys (SMAs). For example, CIMS researchers developed an actuator that is extended or retracted by means of a magnetic field rather than a mechanical linkage or pneumatic/hydraulic pressure. In 2006 Prof. Taya and CIMS received a prestigious MURI award from the Air Force Office of Scientific Research to study energy harvesting and storage systems for use in future aerospace vehicles.

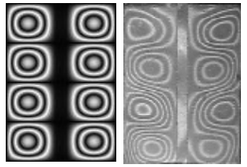
- http://depts.washington.edu/cims/

Center of Excellence for Advanced Materials in Transport Aircraft Structures (AMTAS) Mark Tuttle

Keith Brofsky

L to R: Tim Lee, Elisabetta Valenti, and Mark Tuttle.

Below: Buckling mode shape for a stiffened composite panel



Predicted *Measured*

Prof. Tuttle's research program is devoted to polymeric composite materials and structures. His studies have involved prediction and measurement of long-term composite creep behavior, optimal design of composite aircraft structures, buckling response of reinforced composite panels, and hygrothermal response of sandwich composites. Since 2003 Prof. Tuttle has been the director of AMTAS, a Center of Excellence supported by the Federal Aviation Administration. AMTAS involves faculty and students from several departments within the College of Engineering as well as faculty and students from Washington State University, Oregon State University, and Edmonds Community College.

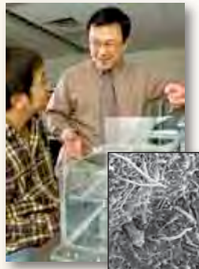
- www.depts.washington.edu/amtas/

Computational Design and Manufacturing Laboratory
Duane Storti
Mark Ganter

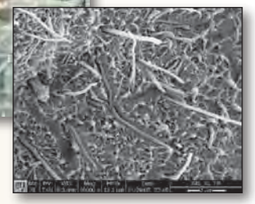
L to R: Duane Storti, Bryn Miyahara, Rhonda Anderson, Beth Taber, and Mark Ganter.

The Computational Design and Manufacturing Lab was co-founded by Profs. Duane Storti and Mark Ganter. They have collaborated in development of implicit solid modeling algorithms, in geometry characterization using shape skeletons, and in development of surface-surface intersection algorithms. Their work is immediately applicable to rapid prototyping (also called "rapid manufacturing"), in which a virtual design, developed by an engineer using a CAD package for example, is transformed into a solid 3-D prototype in minutes.

Advanced Materials Processing and Manufacturing Laboratory
Wei (Wayne) Li



L to R: Hai Wang, and Wei Li.



SEM image (x10,000) showing carbon nano fibers embedded in polyethylene (PE).

Prof. Li's research interests are in the area of materials processing and manufacturing. He conducts research on machining, welding, soldering, and on-line monitoring of manufacturing processes. He also develops environmentally benign processing techniques for bio and nanomaterials. He recently began a study of multifunctional nanocomposite foams. These foams are expected to have ultra-high strength-to-weight ratio, high thermal and electrical conductivities, and thus can be used to improve energy efficiency in many engineering applications. The figure at right shows an example from a preliminary study.

- http://faculty.washington.edu/weiwli/

ME's Man of Gold

Dr. Savio Woo to be inducted into ME Hall of Fame

Whenever Savio (Lau-Yuen) Woo or one of his childhood playmates in Hong Kong made an amazing throw of a basketball into the hoop or an improbable soccer goal, they bragged for weeks about their "Olympic shot."

At the 1998 Winter Olympics in Nagano, Woo achieved a real moment of Olympic glory when he received the first gold medal of the games, not for athletic prowess but for his extraordinary contributions to the science of sports medicine. He is the second of only four scientists so honored with this special medal by the International Olympic Committee.

His landmark research on the biomechanics of the knee and healing of ligament injuries prompted orthopaedic surgeons to abandon the weeks or months of cast immobilization that traditionally followed surgery. Woo showed that rehabilitation with controlled movement and exercise speeds healing from devastating injuries, and he used robotics to develop better surgical procedures for both world-class athletes and all sports lovers so they can return more quickly to the slopes or playing fields.

Skier Picabo Street should know. A little over a year after tearing her anterior cruciate ligament to shreds, Woo watched her win gold in the Super G in Nagano. She later gave him a copy of her autobiography inscribed to "The Golden Boy."

Woo directs the University of Pittsburgh Musculoskeletal Research Center (MSRC; www.pitt.edu/~msrc) and also holds the prestigious title University Professor of Bioengineering. He is the rare scientist who is a member of both the Institute of Medicine and the National Academy of Engineering. He has received a long list of highest honors bestowed by many orthopaedic and biomechanics societies including the Bioengineering Division of ASME.

"UW ME launched Savio Woo into a stellar career in biomechanics and bioengineering. We will be proud to induct him into the ME Hall of Fame next June," says chair Mark Tuttle.

As a new graduate student at the UW in 1965, Woo landed a research assistantship with Professor Albert Kobayashi, who put him to work on an NIH-funded project studying the structure and material of the cornea and sclera of the eye. "He was a go-getter," Kobayashi recalls.

Kobayashi also admired Woo's willingness to take on bioengineeing research during the birthing of the discipline, long before it gained credibility, status, and popularity as a "hot" area of work. Woo says it was an exciting time, but also remembers "just trying to survive" in a field that was then something of the orphan between two disciplines and considered "not rigorous enough" by traditional engineers.

After earning his PhD in 1971, Woo secured a faculty position in the Department of Orthopaedic Surgery at UC–San Diego. There he dove into the biomechanics of joint and fracture healing. It's the perfect specialty for a man who so enjoys sports that he's sure he is the only Chinese student from Hong Kong who already loved baseball before he came to the U.S. in 1960. In fact, after earning his BS at Chico State, he chose the UW for graduate school in part for our Rose Bowl bound football team!

Woo and his Pitt research team are now tackling ligament healing on the molecular and cellular levels through functional tissue engineering. But he feels that to be known only for his research accomplishments would be extremely disappointing as he aspires to be an outstanding teacher and mentor for his 700 plus students and fellows who go out and do great work all over the world. In accepting every honor that comes his way, Woo always shares credit with his wife (Pattie) and family, colleagues, and students.

It may be hard to top Olympic gold, but Woo says induction into the ME Hall of Fame will be a much-appreciated honor. "I'm just glad that Professor Kobayashi won this before me," Woo adds. "I would not accept it otherwise. He gave me the opportunity and showed me how to work hard and work smart." Be it in sports or research, that's what it takes to earn gold.

Woo at Vail.

Education Key to Good Life for "Just Plain Folks"

Eileen and Harlyn Prouty

Harlyn Prouty's comfortable retirement life in Southern California is light years removed from his childhood growing up poor on a South Dakota farm during the Depression and World War II. No electricity. No running water. No indoor toilet. "I still remember digging a new hole for the outhouse," Prouty says.

His family moved to Vancouver, WA, when he was 16. Military service followed high school, then he returned to Vancouver, met and married Eileen, and eventually landed a job making beer at Lucky Lager Brewery. The birth of a son led him to the state employment office to figure out what to do with his life. An aptitude test pointed to engineering as a possible career. After he completed prerequisite courses at Clark College, the UW admitted him. Making ends meet during engineering school meant working as a night shift manager at a hardware store, and on some weekends, taking a train to Vancouver (studying all the way), working a night shift at the brewery (at double the minimum wage), and catching the train back to Seattle on Sunday.

ME degree ('64) in hand, at age 29 he secured a position at Ampex Corp., which developed the first magnetic audio tape recorder, with $500,000 in backing from Bing Crosby! Prouty's own life song just grew sweeter. In 1972 he joined a start-up in the San Francisco Bay area, Petersen Precision Engineering, which manufactures parts for computer disk drives for companies such as IBM and Hewlett Packard. As his career path clearly pointed to management, he attended graduate school at night to earn a general management degree from the University of Santa Clara.

Retired since 1989, the Proutys now enjoy golf, traveling, and visits from their grandchildren. They also take great satisfaction in establishing the Harlyn and Eileen Prouty Endowed Scholarship in Engineering to assist financially needy students who wish to transfer from Clark College to the UW ME program.

"Eileen and I are just plain folks and we don't have a pile of money, but we did well in life," Prouty says. "Education was the key and we want to do what we can to pass the key along to others."

Honors & Awards

Jae-Hyun Chung was awarded a UW Technology Gap Innovation Fund award to demonstrate Shadow Edge Lithography in fabricating nano-sized structures on semiconductors and biochips.

Emmett E. Day, Emeritus, received the Society for Experimental Mechanics 2008 Tatnall Award for dedicated and outstanding service to SEM.

Ashley F. Emery was named a Fellow of the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Albert S. Kobayashi, Emeritus, was awarded the ASME Daniel C. Drucker Medal for seminal contributions to the fields of experimental and fracture mechanics.

Mamidala Ramulu was elected a Fellow of the Society of Manufacturing Engineers and received the US Waterjet Technology Assn. Technology Award.

James J. Riley will be an invited lecturer for academic year 2007-08, for the Midwest Mechanics Seminar Tour, at ten top Midwestern universities.

Duane Storti was named Mechanical Engineering Faculty of the Year for 2006-07. Students cited his energy and enthusiasm during class, and for pushing students to think and expand their learning experience.

Nathan Sniadecki Joins ME Faculty

Nathan Sniadecki

This September Assistant Professor Nathan J. Sniadecki joined ME from a post-doctoral fellowship with Prof. Christopher S. Chen, PhD, MD, in the Department of Bioengineering at the University of Pennsylvania. He was at Penn from 2003 to 2007. Prior to that, Nate was a post-doc with Dr. Chen in the Department of Biomedical Engineering at The Johns Hopkins School of Medicine. He earned his PhD and MS in mechanical engineering from the University of Maryland in 2003, and his BS in mechanical engineering from the University of Notre Dame in 2000.

His research is in mechanobiology, bioinstrumentation, and bioMEMS (micro-electromechanical systems for biological studies). His specialty is the engineering of micro- and nanofabricated measurement tools for the understanding of cell mechanics and mechanotransduction, which is the biological conversion of mechanical signals into biochemical changes in cells. His long-term research goals include working toward fundamental advancements in the areas of tissue engineering, developmental biology, and the mechano-progression of disease in the cardiovascular, connective, and muscle tissues.

He is eager to collaborate with researchers in the medical, bioengineering, and biology fields. He says that "UW is an ideal fit for me because it is renowned for both its medical and engineering research so the opportunities here are outstanding." Nate is a long-time sailor so he is excited about calling Seattle home and living around so much water.

ME Students Participate in National Competitions

SAE car on competition course.

UW's FSAE team placed 4th in the Autocross event and 5th in the design event at the 2007 Formula SAE competition at the California Speedway in Fontana, California, this past June. The team was well on the way to another top-five finish when a coolant leak occurred midway through the endurance event, resulting in disqualification in that event. Among numerous lessons learned during the year, the coolant leak reinforced the lesson that every detail, even a seemingly innocuous one, is critical to the entire project. Even with disqualification, the team finished 20th overall in a very competitive field of over 60 vehicles. For more information, see http://students.washington.edu/auto.

The second major student competition sponsored by the ME Department is the Human Powered Submarine competition, held in late June at the David Taylor Model Basin in Washington, DC. The Mechanical Engineering team, led by Adam Huxtable, earned first place awards for technical presentation and for best use of composites. The team also earned honorable mention for best overall performance and 7th place overall in the single-person, propeller-driven category. For more information see http://courses.washington.edu/uwsub.

Lowering the sub into the basin for the competition.

ME department
would like to hear from alumni.

We invite news of professional appointments, promotions, awards, honors, patents, grants, life experiences, etc.

Go to http://www.me.washington.edu/people/alumni

ME Website: www.me.washington.edu / ME Main Office: 206.543.5090

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COLLEGE of ENGINEERING *Mechanical Engineering*

the MEssenger

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