MAE NEWS

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

COLLEGE OF ENGINEERING
NORTH CAROLINA STATE UNIVERSITY
SPRING 2015

HARDWOOD HEROES

MAE faculty members applying engineering to basketball have studied everything from rims to free throws.

NC STATE UNIVERSITY
College of Engineering

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The High Powered Rocketry Club and Space Senior Design Team 1 took first place in the NASA Mars Ascent Vehicle Centennial Challenge during the spring semester. Only two of 19 teams were able to successfully complete all portions of the challenge. The MAE team won $25,000 for the club.

	BS	MS	PhD
Aerospace Engineering	51	25	6
Mechanical Engineering	226	74	21

Total 2013-2014 MAE Graduates

403

2013-2014 Research Expenditures

$10,823,000

Research Proposals in 2013-2014

136 submitted valued at **$47.5 M**

67 new awards valued at **$7.2 M**

MAE Hall of Fame Alumni

66

UPDATE **FROM THE DEPARTMENT HEAD**

Richard D. Gould

DEAR FRIENDS AND ALUMNI,

Greetings from your home department at NC State!

This has been another exciting year with a number of firsts. We held our first MAE alumni event in Charlotte NC this past February. More than 60 were in attendance and Dr. Klang was presented with the inaugural MAE Outstanding Faculty Advisor Award. We plan to host MAE alumni events at other locations in the future. We have also created a Student Professional Development program. As part of this program, GE hosted an interviewing and resume workshop this past January. A student/alumni mentor lunch event was also piloted, which we hope to expand so that our alumni can share their wisdom and experiences with our students. Finally, we kicked off our bi-monthly MAE E-Brief that will help you stay informed of what is happening in the department throughout the year.

We continue to be very active in student education and research initiatives. In 2013 –14, we graduated 403 students — the breakdown is provided in a new quick facts section of our newsletter. Additionally, we approved a new BSAE curriculum last year and just approved a new BSME curriculum — both allow our students to take more departmental electives. Our distance-delivered MS programs continue to grow and now have higher enrollments than our on-campus MS programs. In 2013-14, the MAE department had research expenditures of more than $10.8 M.

As part of the on-going effort to continuously improve NC State engineering research and education, we hired one new faculty member this past year; Dr. Marie Muller's brief biography is presented in this newsletter. Several faculty members have new appointments: Drs. Mark Pankow and Venkat Narayanaswamy were reappointed as second term assistant professors while Drs. Ashok Gopalarathnam and Xiaoning Jiang were promoted to professor. We also hired Michael Walsh as the department's director of development.

We have included biographies of two of our outstanding faculty, Drs. Hassan and Zorowski, that we hope will bring back fond memories. Dr. Hassan Hassan, who led the department in developing a nationally recognized program in aerospace research, among many other noteworthy accomplishments, is retiring in June after 53 years of service in the MAE department. He will continue to work part-time in the phased retirement program. Over the years, Dr. Carl Zorowski served a number of roles in the MAE department and the College of Engineering. Even though he retired in 1997, he has been active as a part-time teacher and mentor. He will retire, once again, after the spring semester is completed.

In this newsletter you will learn about many exciting things happening in the department, including our 2014 Hall of Fame ceremony; how the department has been involved in NC State basketball; stories on groundbreaking research; and honors received by our students, faculty and staff. You will also learn more about Dr. Lane Miller, a featured MAE alumnus.

We continue to be focused on enhancing alumni relations. Specifically, we held our 2nd MAE Hall of Fame ceremony and our MAE pancake breakfast during homecoming weekend. We plan to make these annual events. We are holding our second alumni golf tournament on May 2nd. The objective is to be better connected to our alumni, as all strong departments have strong ties to their alumni. Our alumni have been and will continue to be extremely important to our future. We sincerely hope that you join our efforts to improve our educational programs and student experiences. Your donations support critical activities that are not supported by state funds, including student scholarships and fellowships, endowed professorships, student clubs and organizations, student travel to conferences and senior design.

I hope you enjoy this edition of our newsletter. If you have any questions or suggestions, or just want to know how you can get involved, please contact me at gould@ncsu.edu.

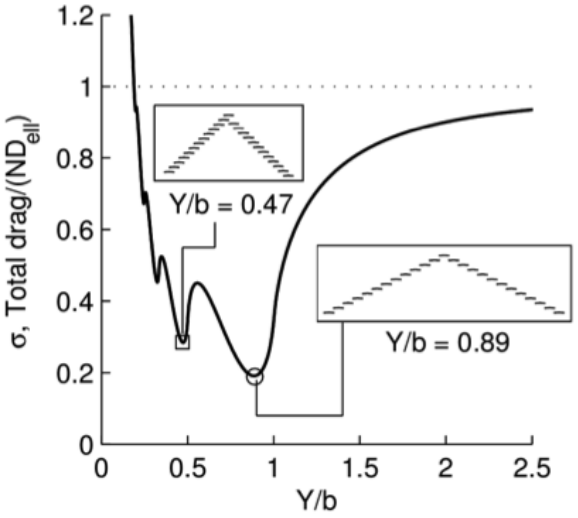
Best regards,

Richard D. Gould
RJ Reynolds Professor and Head

RESEARCH HIGHLIGHTS

Aerodynamics in nature as inspiration for engineering

Faculty: Ashok Gopalarathnam
Students: Applied Aerodynamics Group (www.mae.ncsu.edu/apa)



Drag of 25 birds in formation compared to drag of 25 birds flying separately as a function of sideways spacing. Primary and secondary optima shown in insets.

Flock of birds in flight. Photograph by Titus image from public-domain-image.com.

With the onset of the fall season, it is not uncommon to see large flocks of birds flying in V-shaped formations. It is well known that a bird flying slightly outboard of a lead bird experiences lower induced drag than if it were flying alone. The result is that the entire flock saves energy compared to the birds flying separately. Bird formations are seen to exhibit large variations in the V shapes, sometimes even within a single formation. MAE researchers have studied the effects of formation shapes. Their research shows that, although the maximum benefit (a dramatic 81 percent energy savings for a 25-bird flock) is obtained when each pair of birds is spaced side-to-side at approximately 89 percent of a single wing span, large flocks can benefit from a secondary optimum (approximately 70 percent energy savings), that is achieved with a side-to-side spacing of approximately 47 percent of a wing span. This secondary optimum spacing puts the body of the following bird almost directly behind the wing tip of the bird immediately in front, which could presumably provide a good reference for easy position keeping. While the primary optimum results from favorable aerodynamic interaction between each bird and its immediate neighbor, the secondary optimum results from favorable interaction between each bird and its next-to-immediate neighbor.

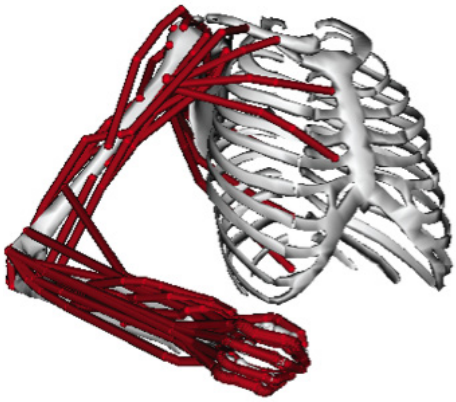
Naturally, formation flight has been proposed for aircraft. Large savings in fuel consumption can be expected if, for example, transport aircraft originating from different airports in the Eastern U.S. could rendezvous off the coast and fly in formation over the Atlantic. Forget the image of large passenger aircraft flying close to each other as done by formation aerobatic teams in airshows. Although the aircraft need to be precisely positioned relative to each other in the spanwise (sideways) sense, they can be located several miles apart in the fore-and-aft direction without loss of the drag-reduction benefits. Modern developments in precision measurement and automatic control of relative position of aircraft should certainly help. Issues related to increased unsteady loads on the wings, control deflections and demands on the flight crew need to be solved before such ideas can take flight.

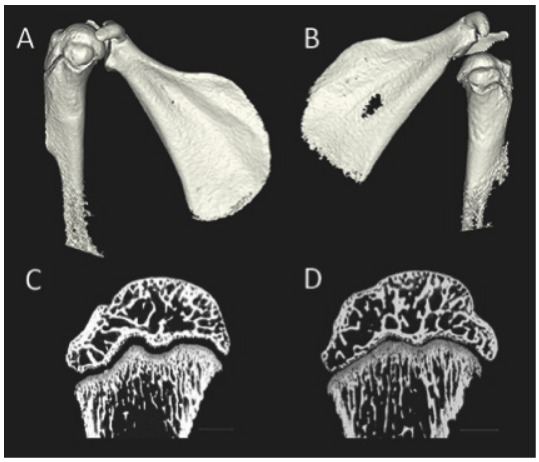
The group is also studying the aerodynamics of pop-up actuators on wings inspired by bird feathers for stall control, leading-edge vortex shedding inspired by insect flight and variable-geometry adaptive wings such as those seen in nature. They are also intrigued by whiffling geese (search for some mind-blowing slow-motion videos on YouTube) and wing tucks by eagles (search on nytimes.com/video/sciencetake) and whether they can yield solutions for flight of UAVs (drones) in turbulent atmospheric conditions. •

Dynamics and control of musculoskeletal systems in the Movement Biomechanics Laboratory

Faculty: Katherine Saul
Students: Anthony Santago, Wei Cheng, Xiaotong Li, Carolyn Stolfi, Daniel McFarland

Clinical movement dysfunction and rehabilitation of the upper limb can be challenging to both clinicians and researchers; patients frequently have multiple concomitant injuries or disabilities and several treatments may be applied concurrently. This can result in a lack of clear guidelines for clinicians regarding treatment choices and highly variable functional outcomes following treatment. Better understanding of the roles of muscle structure, limb dynamics and neuromuscular control in the production of functional movement provides a foundation for clinical practitioners to optimize rehabilitation for their patients.





Left: Figure 1. Computational musculoskeletal model of human upper limb. Mathematical models of the anatomy, muscle mechanical properties, joint function, neuromuscular control algorithms and dynamic behavior are integrated into this graphical model for use in surgical simulation and neuromuscular control analyses.

Right: Figure 2. Micro-CT images of a normal shoulder (A, C) and deformed shoulder following nerve injury (B, D). Altered articulating surface shapes and reduced bone trabecular thickness and mineral density are present after injury.

Saul's Movement Biomechanics Laboratory (MoBL) applies mechanical engineering techniques to improve treatment outcomes for neuromusculoskeletal disorders of the upper limb, using both computational simulation and experimental methods (including magnetic resonance imaging, motion capture and functional assessments of upper limb performance). Her approach uses computational simulation of muscle's nonlinear mechanical behavior and the dynamics of functional movement to compare treatment options and predict functional outcomes (Figure 1). In addition, her group explores muscle coordination and movement compensations exhibited by impaired patients using physiologically relevant control algorithms and experimental measures of movement strategies.

Recently, the MoBL has focused on two important clinical applications: 1) degenerative rotator cuff injury and 2) traumatic peripheral nerve injury to the upper limb. Approximately 20-50 percent of older adults live with rotator cuff tears, which can accompany decreased shoulder strength and range of motion and which may exacerbate age-related changes to muscle. Saul's work has focused on characterizing shoulder movement, image-based measures of muscle structure and neuromuscular control and compensations due to rotator cuff impairment to identify clinical targets for treatment (such as strength training or surgical repair). Paralysis of upper limb muscles due to neuromuscular impairment, such as spinal cord injury, peripheral nerve injury or stroke leads to loss of upper limb strength and dexterity. Neuromuscular injuries that occur at or near birth, such as cerebral palsy, spina bifida and peripheral nerve injuries, can also cause dramatic changes to the affected muscles that can alter loads on the developing bones and cause deformity. Saul's group uses computational dynamics to simulate surgical treatment options and to provide evidence for clinicians to select appropriate treatments. She also uses anatomical experiments (e.g. Figure 2), musculoskeletal modeling (Figure 1), and finite element modeling to explore muscle-bone interactions after injury to identify the mechanical mechanisms leading to bone deformity. Through interdisciplinary collaborations with clinicians, the MoBL is able to translate this research into the clinic for improved patient care.

Saul's research program has been supported from sources including the NSF, Office of Naval Research and NIH-supported collaborations. Her work has also been recognized with several awards, including the American Society of Biomechanics Pre-doctoral Young Scientist Award in 2005. •

MAE faculty members have worked with the NC State men's basketball team on free-throw shooting technique.

Building a better game

The Department of Mechanical and Aerospace Engineering hired a new faculty member named Frank Hart in 1964. Hart went on to found the Center for Acoustical Studies. In his spare time, he applied basic engineering principles to the improvement of the game of basketball.

Hart began working with Sorensen Christian Industries, a company based in his hometown of Angier, NC. Graduate student David King focused on developing Sorensen's HydraRib lift system (this was during the period before the basketball goals were being lowered). The company's sales manager was a tall, young basketball player by the name of Bobby Etheridge who was just beginning a political career, serving as a county commissioner and then state legislator. Working with Etheridge, Hart began to bring together a team to look into the basketball problems of the day.

They first considered the problem of the frequent breaking of backboards and the bending of playground rims. In the late 1970s, Noral Stewart, a full-time faculty research assistant in MAE, proposed a rim-forming solution that used high strength steel. Sorensen marketed it as the Gorilla Goal, the rights to which are today owned by Spalding, and high strength steel became the standard (See photo on page 5).

In the early 1980s, another MAE faculty member named Al Eberhardt looked at the problem of breaking backboards and discovered that their frames were being warped during installation, causing the glass to be pre-stressed and highly susceptible to breakage. He developed an installation procedure that assured that the frame remained flat during installation, which solved the problem by eliminating pre-stressing. Hart then developed a Bellville spring approach to relieve the tension between the backboard and the rim — the precursor to the break-away rim. Later, Hart served as associate dean for research and became the university provost and vice chancellor for research and extension before leaving NC State in 1994 to become president of the Microelectronics Center of North Carolina (MCNC). Hart retired in 1998 and is now back home in Angier.

At about the time that Hart left NC State, independent of

Backboard V (Dail Basketball Center, 2014)

Gorilla Goal (Spalding, 2014)

those efforts, two more MAE faculty members continued the tradition of applying engineering to the game of basketball. Larry M. Silverberg and Chau M. Tran began to study basketball trajectories. They published a paper entitled "Numerical Analysis of the Basketball Shot." It showed how to simulate millions of shots very accurately, taking into account the rim-backboard interactions, which made it easier to study best practices in shooting and a player's shooting percentages. In the early 2000s, they applied their work to best practices in the free throw. At the suggestion of Larry Hunter, an NC State assistant coach under men's basketball coach Herb Sendek, Silverberg and Tran began to focus on the bank shot. By early 2010, they had discovered that the best bank shots coalesce on a V-shaped line on the backboard (the backboard rectangle proved not to be particularly useful) and share a common focal line behind the backboard. This formed the basis of a training tool for the bank shot. Student Chris Laue designed and fabricated the training tool (a photo of the tool in NC State's Dail Basketball Center practice facility appears above). •

Krystal Barrett drives for a basket during a women's basketball game versus the University of Virginia.

FEATURED ALUMNUS

Graduate degree drives alumnus' success

by Lane Miller, Ph.D.

In this issue, we spotlight another of our outstanding alumni, Lane Ross Miller (Ph.D. ME 1988), whose success after graduation makes him an exceptional representative of the MAE Department. Miller was an inaugural inductee into the MAE Hall of Fame and is a leader in technology and innovation in his professional career. Today, Miller serves as vice president of global technology at the LORD Corporation, overseeing the company's continuing innovation in adhesives, coatings, vibration attenuation and motion control. LORD is also one of the major corporate supporters of the MAE Department. Since 2013, the LORD Corporation Doctoral Fellowship has sponsored first year doctoral students to increase the participation of domestic and underrepresented doctoral students in research areas relevant to the work of the LORD Corporation. This generous and competitive award is an attractive recruitment opportunity for the best graduate student candidates, strengthening MAE's graduate and research programs. Further, LORD has supported MAE students through the MAE Bridge Program, which hires our students in the summer after completing their undergraduate degree and before beginning their graduate degree.

Miller's own story highlights the ongoing influence of his MAE graduate education at NC State and the strong connection between NC State and the LORD Corporation.

Lane Miller

I grew up on a small dairy farm in Pennsylvania, developing a strong work ethic and mechanical aptitude. Somewhere in my gene pool I was given a modest ability for mathematics and more importantly a fascination that the physical world can be described with equations. With this interest, I completed my B.S. in mechanical engineering at the University of Pittsburgh at Johnstown, Pa. in 1979 and my M.S. at Penn State in Erie, Pa. in 1982. One of the best decisions in my life (besides marrying my wife Louise!) was to work for LORD Corporation. After starting my career in Erie in 1979, LORD gave me the opportunity to transfer to Cary, NC to a newly created research and development center. I was excited to transfer to work on cutting-edge technology and pursue a Ph.D. in mechanical engineering at NC State.

When I joined LORD, the company had a mechanical division that produced components to reduce vibration and a chemical division that produced adhesives. Truly committed to be the technology leader, LORD had embryonic ideas that someday vibration could be controlled electro-mechanically. These ideas were quite avant-garde, given that this predated 8-bit microprocessors! Active vibration control captured my

imagination and satisfied my math-predicting-nature fascination. Graduating in 1988, I am grateful for LORD supporting my Ph.D. and allowing my dissertation topic to be active vibration control. Also, I am grateful that mechanical engineering at NC State accommodated me as a student who had a job, mortgage and family.

While I was focusing on new technologies, others at LORD saw a quality in me that I didn't fully appreciate — leadership. As a result, in 1986 I became an R&D manager, leading a team of engineers. Today, I am vice president of global technology with an organization of 350 scientists, engineers and technicians, and LORD continues to be a world-wide leader with annual sales approaching one billion dollars. While my days are filled with non-technical activities, I have never stopped being an engineer and never disengaged from the technology.

LORD dynamic components react loads and allow motion to enable helicopters to fly.

One of my chief responsibilities is to champion innovation. At LORD, innovation means transforming technology to create value. Neat ideas and fancy technology alone do not qualify as innovation. Creating value means that somebody is willing to buy your technology at a profit. An example is active vibration control for helicopters. While reducing vibration is critical, the value of active vibration control is that it eliminates heavy all-mechanical vibration treatments, reducing the weight of the helicopter by up to 200 lbs. This translates into an extra passenger, more fuel and a greater range. Providing clear economic advantage to our customers, LORD is today the world's leader in this technology. In addition to mechanical and chemical businesses, LORD now has a rapidly growing electro-mechanical business with a portfolio of active technologies. I am proud to have played a small part in creating this new business.

I have never forgotten that my engineering education is the basis for what success I have had. Today, I am a champion within LORD to maintain a close relationship with mechanical and aerospace engineering at NC State. LORD has financially supported a number of graduate students and today funds the LORD Fellowship that allows the department to recruit top students into the graduate program. Through the years, LORD has hired many interns and full-time NC State engineers, and numerous LORD engineers have benefitted, like I did, in earning graduate degrees. This relationship is a true win-win for NC State and LORD.

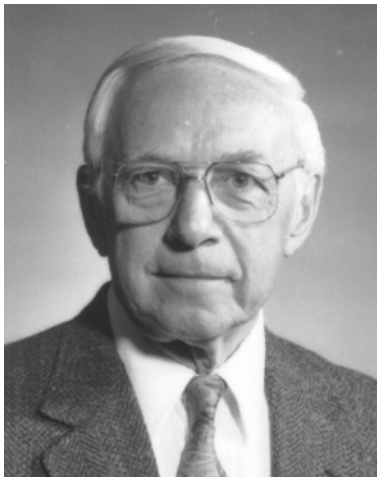
> "I have never forgotten that my engineering education is the basis for what success I have had."
> — *Lane Miller*

After 35 years at LORD, I am starting to think about what is next for me. I keep being pulled back to my fascination that math can describe nature. I actually plan to take graduate physics courses, or maybe teach a few engineering classes. Remaining connected to NC State not only feels like the right thing to do, but also the fun thing to do! •

Carl Zorowski: a top-speed educator

Born in 1930, the third son of Eastern European immigrant parents, Carl Zorowski grew up in Pittsburgh, Pa. His early childhood and teen years coincided with the Great Depression and World War II. In 1948, he attended Carnegie Institute of Technology (CIT), now Carnegie Mellon University (CMU), earning baccalaureate, master's and doctoral degrees in mechanical engineering. He began teaching as a graduate student at CIT in 1953. The experience set him on a lifelong academic career. In 1956, he was appointed an assistant professor in the Mechanical Engineering Department at CIT teaching engineering mechanics and mechanical design.

In 1962, he left CIT to take on updating the mechanical engineering program at NC State. One of his early program reform initiatives was the creation of the current MAE 415 Analysis for Mechanical Engineering Design and MAE 416 Mechanical Engineering Design classes. These courses provide students with opportunities to apply their engineering knowledge to the solution of real engineering problems. With a grant from the National Science Foundation (NSF), he established the first design project laboratory in Broughton Hall in the mid-1960's. The design project concept provided students with not only the challenge of coming up with a practical engineering solution concept but the experience of physically prototyping and testing their design solutions in the laboratory. This design project experience is still ongoing in the undergraduate program with industrial support in expanded shop and laboratory facilities.



His academic career at NC State included time as the head of the Department of Mechanical and Aerospace Engineering, associate dean for academic affairs in the College of Engineering and co-founder and director of the Integrated Manufacturing Systems Engineering Institute. Established in 1985, the Institute was one of the earliest self-sustaining interdisciplinary master's degree programs on campus that involved multiple engineering departments with participation and support from industry. It remains a continuing and viable program today providing practical student internships with local manufacturing firms.

His early research at CIT centered on metal forming mechanics but switched at NC State to deformable textile structure mechanics (there were no steel mills in NC) with an emphasis on automotive tire deformation mechanics. He served as an associate faculty member of the College of Textiles as it developed a Ph.D. graduate program and was a consultant to Chemstrand in RTP in tire cord mechanics. As time progressed, his research interests turned more to engineering education reform. Publications in these three areas number over a hundred. He also served as thesis advisor for 125 master's and Ph.D. candidates over the years.

Zorowski began participating in amateur motorsports in 1969.

Although his career included academic administration, discipline research, industrial outreach and consulting, it was classroom teaching, student interaction and educational program development that provided the greatest satisfaction and joy. His passion was to help students develop their creative and innovative capabilities and to apply engineering fundamentals to the modeling and solving of real engineering design problems.

For five years, he served as director of the South East University and College Coalition for Engineering Education (SUCCEED), an NSF-funded engineering education reform program led by NC State involving the engineering programs at VPI, NC A&T, UNC Charlotte, Clemson, Georgia Tech, University of Florida and Florida State University. He retired from NC State in 1997 after 35 years of faculty service and is currently Reynolds Professor Emeritus of Mechanical and Aerospace Engineering. He has continued teaching part time at the graduate level for the College's Engineering Online distance education program. In 2010, he developed and directed a summer study-abroad design program for NC State engineering students with students from Zhejiang University and involving the Caterpillar Corporation in Hangzhou, China.

He is the recipient of many awards for academic and professional service and achievement. Among these are: RJ Reynolds Professor of Mechanical Engineering in 1969, the Charles Russ Richards Memorial Award by Pi Tau Sigma and American Society of Mechanical Engineers (ASME) in 1975, a Fellow of ASME in 1987, the RJ Reynolds Tobacco Company Award for Excellence in 1989, a Fellow of the American Society of Engineering Education (ASEE) in 1997, and the Alexander Quarles Holladay Medal for Excellence awarded by the NC State University Board of Trustees in 1999.

For extra curricular enjoyment and pleasure, Zorowski has participated in amateur motorsports since 1969 as a licensed driver with Sports Car Club of America and currently the Vintage Drivers Club of America. Beginning in small European sports cars, he now competes in classic Formula Vee. •

AWARDS & HONORS

FACULTY HONORS

Dr. Scott Ferguson awarded ASME Design Automation Young Investigator Award

The ASME Design Automation Young Investigator Award recognizes an outstanding young investigator who is making noteworthy contributions in the area of design automation, including research in design representation, design optimization, design evaluation and/or design integration. Ferguson was recognized for his contributions in the areas of market-based product design and the design of complex engineered systems.

Dr. Yong Zhu – Recipient of 2015 Alcoa Foundation Engineering Research Achievement Award

Dr. Chih-Hao Chang – Inducted into NC State Academy of Outstanding Teachers

Dr. Eric Klang – Recipient of 2015 George H. Blessis Undergraduate Advisor Award

Dr. Jack Edwards – Named Angel Family Distinguished Professor

STUDENT HONORS

MAE team takes first place in NASA competition

The HPRC and Space Senior Design Team 1 competed in the NASA Student Launch competition, an eight-month design challenge, and this year the team combined with the NASA Mars Ascent Vehicle Centennial Challenge for a greater challenge for the teams that chose to compete. The Student Launch project requires teams to provide a proposal, PDR, CDR, FRR, and PLAR to NASA. Teams were able to pick between a mini-MAV (Mars Ascent Vehicle) and a maxi-MAV. The mini-MAV required teams to find a sample on the ground and place it into their rocket autonomously. The maxi-MAV required teams to find the sample, place it into the rocket, raise the rocket to 85 degrees and insert an igniter autonomously. During the launch, the vehicle needed to reach an apogee as close to 3,000 feet as possible and then eject the payload section at 1,000 feet. The MAE team competed in the maxi-MAV and was also entered in the NASA Mars Ascent Vehicle Centennial Challenge and took first place in that competition.

Aerial Robotics Club takes first place

The ARC took first place at the 2014 Association for Unmanned Vehicle Systems International Unmanned Air Systems competition.

PHOTO | HENDRICK MOTORSPORTS

Keith Rodden (left) is the crew chief for driver Kasey Kahne (right).

Wolfpack in Motorsports

MAE alumni make race teams go

A version of this article originally appeared in NC State magazine, the magazine of the NC State Alumni Association. The magazine is a benefit of membership. To join, go to alumni.ncsu.edu.

Brian Wilson '03 works from his cubicle at a NASCAR garage in Mooresville, NC, looking for an edge in the next race.

Wilson is not a driver or a mechanic, but his work will go a long way toward determining what sort of success 2012 Sprint Cup champ Brad Keselowski will have in the #2 Miller Lite car during the rest of the season. Wilson is Keselowski's race engineer and much of his work is done at a desk that looks out onto the Penske Racing Facility's garage floor.

Wilson seldom touches the cars. Instead, he helps design those high-priced race cars so that they cut through air and stick to the track, roaring at speeds of 190 miles per hour with a 700-horsepower V-8 engine pulsing for a heart. Mechanics use sockets and wrenches and other tools to work on the cars and engines, and Keselowski relies on his skill with brakes and the steering wheel to navigate the racetracks. But Wilson draws up the dimensions for the next car using his computer and textbooks.

In the last 15 years, Wilson and other MAE graduates have become a force in NASCAR, the home of American professional stock-car racing. Engineers like Bobby Hutchens '82, who was NASCAR's first full-time engineer with a college education, have helped change the sport with the fundamental understanding of mechanical engineering they received in NC State's engineering classrooms and in the garage of Wolfpack Motorsports, a student-run organization in the MAE department that allows participants the chance to apply their skills to designing, building and racing cars.

The introduction of engineers into the sport came about in the

late 1990s after NASCAR heavily restricted what mechanics could physically do to cars. NASCAR's first engineers soon found they weren't just competing against other race teams. They fought an old-guard group of racing insiders resistant to change and wary of "college boys" coming into a sport where knowledge had predominantly come from mechanics and drivers' instincts.

NASCAR Sprint Cup veteran Jeff Burton says the transition was rocky for engineers. "One of the things I've always raced on is seat-of-the-pants engineering. I call it redneck engineering. You take what you know and you see what your competitors are doing," he says.

"There was a fear that these engineers weren't racers. 'All they know is numbers.' There was a bit of resistance," says Dr. Eric Warren '91 B.S., '93 M.S., '97 Ph.D., director of competition at Richard Childress Racing.

He remembers that resistance when he came into racing as an engineer in the late '90s, recounting how he was tested by an older teammate who asked him to take a tire off a car at the Indianapolis Motor Speedway his first day on the job despite having no automotive experience. But he stuck with it because he saw the possibility of what science could do on Sundays and recognized that the key to an engineer's success in racing was to look past what the car was doing and study why it was doing it.

PHOTO | RICHARD CHILDRESS RACING

Luke Lambert

"At the end of the day, we're going with what works...when your information doesn't line up with your experience, you have to respond with your experience."

— Luke Lambert, '05
Ryan Newman's crew chief

Burton says engineers' influence has run deep throughout NASCAR, making the use of computers an everyday part of racing. One example is simulation, or "sim" to engineers, a mathematical model using scans of all of a car's parts and dimensions. Add to that a gumbo of other data, including the physics involved at a particular racetrack, and the engineers can see how the car will react to different variables. They also take into account factors such as when the driver hits the brakes or gives the car gas.

"Simulation is a tool that we didn't have 10 years ago," Burton says. "That's a huge part of the success you're able to have. It has engineering fingerprints all over it."

Sim allows Kyle McArver '06, a race and simulation engineer at Roush Fenway Racing, to see what happens to the car when a certain type of spring compresses under different track conditions or when a tire has different amounts of force bearing down on it when it goes into and comes out of a turn. And it helps race engineers with one of their primary tasks — coming up with the car's setup for a particular race.

"It's picking your four springs," says McArver, who adds he owes his skills to the MAE Wolfpack Motorsports program. "Your four shocks. Picking your front sway bars. Suspension geometry. Some tire settings."

The sim helps teams predict how cars will react to those changes. Race engineers also have borrowed advancements in automotive manufacturing technology and transferred them to racing garages. Daniel Knost '01 came to Stewart-Haas in 2008 after working on his Ph.D. at Virginia Tech studying jet engine cooling. He started as a race engineer for the number 39 Quicken Loans Chevrolet driven by Ryan Newman. That engineering background and his scientific approach helped him find a spot working on a seven-post rig that hooks up to the car to simulate track conditions. Four hook-ups connected to the car's wheels simulate all the bumps in a particular track's surface, and three hydraulic hook-ups attached to the car's body simulate downforce on the car and different banking.

Also called the "shaker rig," it's an investment of about $2 million for a race team and was developed for car manufacturers that wanted to test noise and vibration in the 1980s and 1990s to reduce motion sickness in passengers.

"So race teams came along," Knost says, "and said, 'We don't necessarily care about comfort, but we care about what the car does.' . . . We come in here and run all night, run all weekend. And we can fire all these different things at the car so we can get an idea of how each part works."

For the race engineer, learning about each part means bouncing from the assembly room floor into the humming of the shop where all the parts and tools are built, to the fabrication room in the back where the chassis, the cars' steel skeletons, are built.

Knost is now crew chief for the #10 GoDaddy Chevrolet driven by Danica Patrick with Stewart Haas Racing as of January this year.

A recent trend engineers like Knost are taking to the helm of NASCAR teams is switching gears from being a race engineer to crew chief.

Keith Rodden '03 took his mechanical engineering degree from NC State to the track, and caught on in NASCAR as a race

Brian Wilson (left) is shown talking to Brad Keselowski and Paul Wolfe; Wolfpack Motorsports is a student-run organization within MAE that gives students a chance to design, build and race cars (right).

engineer. That's a hat he wore for much of his 12-year career in NASCAR before becoming a crew chief for the first time in 2014 for the #1 team at Chip Ganassi Racing. He was named crew chief for driver Kasey Kahne and the #5 team at Hendrick Motorsports in November 2014. The 2015 Sprint Cup Series season marks his second year as a crew chief.

It's a move that Rodden has come to love despite the challenges that come with it. "It's different when you have the final say on everything," he says. "Things like when the car is going to pit. What you are going to do for adjustments."

Rodden says there are three basic components to being an effective crew chief. He cites the problem-solving involved, the psychological aspect of leading the team and the competitive fire that drives him to want to win every race. Add to that the fact that every condition at every track is variable, and a crew chief gets a very low percentage of time that things happen as he expects. "About one percent," Rodden says, laughing. "Things never seem to go to plan."

And then there's Luke Lambert '05, who proves that all the science, sim and data are no substitute for the instinct that kicks in on race day. Lambert was a long-time race engineer at Richard Childress Racing, but made the change to crew chief in 2011 as interim crew chief for Jeff Burton. He is currently the crew chief for the #31 car driven by Ryan Newman.

Lambert spends the week in the garage, looking at data on the upcoming tracks. But on race day, when he wears the pressures of a head coach in football and has the final say in the decisions for the team, he realizes that science only gets him so far. He fuses his experience with the cars to his knowledge of engineering, and in the end, relies on his instinct.

"I try to understand why we make the decisions we make," he says. "But at the end of the day, we're going with what works and I don't care to understand it, in a sense. When your information doesn't line up with your experience, you have to respond with your experience."

For Lambert, the bottom line is the finish line, leading even the most technically trained mechanical engineer to forsake the scientific method for what actually works. "And at the end of the day," he says, "How you finish is what matters." •

MAE Speedway Alumni Event

More than 60 MAE alumni and friends got together on Thursday, Feb. 5, from 6 to 8 p.m. in the Speedway Club at Charlotte Motor Speedway for the inaugural MAE alumni event. Food and drink were provided and Dr. Richard Gould, MAE department head, gave a talk about the current state of the department. Some of the notable alumni present at the event were Keith Rodden, BSME 2003, who is crew chief for Kasey Kahne at Hendrick Motorsports; Luke Lambert, BSME 2005, who is crew chief for Ryan Newman at Richard Childress Racing; and Dr. Eric Warren, BSAE 1991, MSAE 1993, PhD AE 1997, who is director of competition at Richard Childress Racing.

Five current MAE students and members of Wolfpack Motorsports were also in attendance, as well as six MAE faculty members: Drs. Jeffrey Eischen, Rich Gould, Richard Johnson, Eric Klang, Bob Nagel and Larry Silverberg. In a surprise recognition, Dr. Eric Klang received the Outstanding Faculty Advisor Award for his work with the MAE Department and Wolfpack Motorsports.

The department is planning future MAE alumni events at other locations.

Dr. Hassan A. Hassan – passion for all that is aerospace

Hassan A. Hassan

Dr. Hassan A. Hassan was born on February 26, 1931, is married with two children, and has three grandchildren – one of them is a freshman at N.C. State. He received his B.S. in mathematics from the University of London in 1952, and his M.S. and Ph.D. in aeronautical engineering from the University of Illinois in 1953 and 1956, respectively. He was a faculty member at University of Baghdad, Iraq, from 1956 to 1959 and at Virginia Tech from 1959 to 1962, rising to the rank of full professor. In 1962, he joined NC State University as a full professor and spent 53 years at NC State until beginning his phased retirement this summer of 2015.

Hassan has seen a lot of change since arriving at NC State. In 1962, the total student enrollment at NC State was about 7,500 and today it is about 36,000. The different programs in diesel engineering, aeronautical engineering and mechanical engineering were combined and the Department of Mechanical and Aerospace Engineering was formed. In 1964, the Bachelor of Science in aerospace engineering was created and Hassan was the central figure in aerospace research. Hassan spent every summer at NASA Langley Research Center together with an entourage of students working on research problems side by side with NASA researchers. He continued this practice for more than 30 years until the early 1990s — playing a critical role in the development of NASA's in-house computational fluid dynamics codes with the special focus on predicting transition and separation — the features of aerodynamic flow that continue to challenge engineers today. He was the major advisor to 34 doctoral students, authored more than 200 publications and has been recognized with numerous research awards including the Alcoa Foundation Distinguished Engineering Research Award (1987); the Alumni Distinguished Graduate Professor (1991); the NASA Public Service Medal (1992); the RJ Reynolds Co. Award for Excellence in Teaching, Research, and Extension (1993); the AIAA Thermophysics Award (1999); and the Alexander Holladay Medal For Excellence, 2004 – the highest honor bestowed on a faculty member by the NC State trustees.

Hassan led the aerospace faculty in developing a national reputation in aerospace research that is second to none. He was among a distinguished group of faculty who formed the program's CFD center and the Mars Mission Research Center in the late 1980s — the largest research center in the University of North Carolina System at that time. The center trained the next generation of aerospace researchers and engineers.

In phased-retirement, Hassan plans to teach and continue to focus on his research. •

MIKE BREEDLOVE IN MEMORY

Mr. Michael (Mike) Breedlove served 31 years at NC State with his last 28 years in the MAE department. He retired as MAE 416 lab manager in December 2014. Breedlove loved his many students he so proudly guided at NC State. He was an avid fisherman who loved the beach and spending time with family and friends. •

DONOR LIST

The Department of Mechanical & Aerospace Engineering at NC State is grateful to our donors for their generous support. This list represents donations between January 2014 and December 2014. While we make every effort to be accurate and thorough, it is possible to accidentally omit or misspell a name. Please contact 919.515.3241 with any additions or corrections.

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MAE 2014 HALL OF FAME INDUCTEES

The MAE Hall of Fame was established to inspire our current students and to celebrate accomplishments of those extraordinary graduates who have used their education to excel in a profession, career or service. The nomination is based on professional and service achievement, entrepreneurship and contributions to professional societies. **Congratulations to the MAE Hall of Fame inductees for 2014 listed below!**

William F. Morris, Jr.
BSME 1941
Charles E. Branscomb
BSME 1949, MSME 1950
James A. (Ott) Jones
BSME 1951
Marcus B. Crotts
BSME 1953
Edward I. Weisiger, Sr.
BSME 1954
James M. Davis, Jr.
BSME 1958
Franklin D. Hart
BSME 1959, MSME 1961,
Ph.D. ME 1965

Joseph P. Archie
BSME 1960, MSME 1962,
Ph.D. ME 1968
James A. Hackney, III
BSME 1961
Robert Transou
BSME 1962
Van D. Sherrill
BSME 1962
Jerry S. Lee
BSME 1963,
Ph.D. ME 1967
Herbert A. Fishel
BSME 1963

Claud A. Verbal
BSAE 1964
Harry L. Beach, Jr.
BSME 1966, MSME 1968,
Ph.D. ME 1970
James D. Mobley
BSME 1970
James A. Stewart
BSME 1970
Fred N. Hunter
BSME 1984
Robert B. Womack
BSME 1985

Charles E. Sykes
BSME 1985
Basil Hassan
BSAE 1988, MSAE 1990,
Ph.D. 1993
Montie W. Roland
BSME 1990
Ann B. Carlson
Ph.D. AE 1990
Lin H. Chambers
Ph.D. AE 1991
David F. Robinson
BSAE 1992, MSAE 1994,
Ph.D. AE 1994

NEW FACULTY AND STAFF

Michael Walsh is the director of development for the MAE Department. He is responsible for managing major gift programs for the department. This includes working with the department head to develop and market private fundraising opportunities for alumni and managing major gift prospects for the department. Walsh received a B.S. in geography from Radford University. He received an M.A. in organizational leadership from Mansfield University and an associate's degree in environmental studies from Keystone College. Walsh and his wife, Emily, have a daughter and a son who hopefully will be NC State engineers one day!

Dr. Marie Muller received an M.S. in physics and a Ph.D. in physical acoustics from the University Paris Diderot. Prior to joining the MAE faculty, she was an assistant professor with the Institut Langevin at the University Paris Diderot since 2008. The focus of her research is on the development of new contrasts for medical imaging that provide additional information relevant to diagnosis. Her approach is based on understanding the propagation of ultrasound and elastic waves in biological tissue and establishing quantitative relationships between ultrasound parameters and the mechanical properties of tissue. Recent applications include bone modeling and assessment and elastography for obstetrics. Muller has received multiple awards, including the Ph.D. Thesis award from the French Society of Biological and Medical Engineering, IEEE France Section; and the Young Researcher Award from the French Society of Acoustics.

JOHN PERKINS IN MEMORY

Dr. John Perkins served as a faculty member in the MAE department from 1965 to 1999. He was active in the department's aerospace engineering programs and served in a number of administrative capacities. His research focused on aircraft design, working closely with a number of aerospace companies. In 1981, he introduced a "hands-on" capstone senior design class in which student teams spend a year designing, building and flight testing an unmanned aircraft. It was the first such experience in an undergraduate aerospace engineering program in the country. Perkins set up a special airfield for this course, which NC State later named Perkins Field and which continues to be actively used. Perkins' contributions and our memories of him in the department continue to live on. •

QUICK FACTS

A look at some of the figures that shape the Department of Mechanical and Aerospace Engineering at NC State.

1

The High Powered Rocketry Club and Space Senior Design Team 1 took first place in the NASA Mars Ascent Vehicle Centennial Challenge during the spring semester. Only two of 19 teams were able to successfully complete all portions of the challenge. The MAE team won $25,000 for the club.

	BS	MS	PhD
Aerospace Engineering	51	25	6
Mechanical Engineering	226	74	21

Total 2013-2014 MAE Graduates

403

2013-2014 Research Expenditures

$10,823,000

Research Proposals in 2013-2014

136 submitted valued at **$47.5 M**

67 new awards valued at **$7.2 M**

MAE Hall of Fame Alumni

66

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To learn more about supporting the Department, contact Michael Walsh.

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