NEWS ADVISORY:
OSU ELECTRIC RACE CAR ON DISPLAY AT RIFFE CENTER

After shattering the track record for an electric vehicle during its most recent time trial, The Ohio State University's electric race car will be on public display at the Riffe Center, 77 S. High Street, Columbus, from noon to 8 p.m. on Tuesday (5/23), and 8 a.m. to 3 p.m. on Wednesday (5/24). The display is part of Electric Expo, an exhibit designed to showcase innovations in Ohio's electric industry.

The electric race car is the result of an innovative design project for engineering students at Ohio State's Center for Automotive Research (CAR). OSU is one of about a dozen universities involved in designing Formula Lightning vehicles. Each university fields an entry whose chassis, tires, suspension and body are identical, but whose electric drives, battery packs and drive trains are student-designed.

Electric vehicle technology, which fuses the automotive and electric utility industries, has a bright future, according to Giorgio Rizzoni, assistant professor of mechanical engineering and head of the race car project. "Our students get to deal with the hands-on aspect of engineering, not just the theory," he said. "Their work will play a role in the advancement of electric car development."

The OSU vehicle established a new track record of 98 miles per hour during time trials at the EV (electric vehicle) competition at Richmond International Raceway on May 5. The Formula Lightning/University Spec race, showcasing university-designed electric vehicles, was the featured event.

Despite a promising time trial and first two-thirds of the race, the Ohio State vehicle finished the race in fifth place, after

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one of two battery packs failed, requiring an unscheduled pit stop. Professional race driver Craig Taylor surpassed his earlier speed record with a 100-mpk sprint on the final two laps but came in behind Case Western Reserve University and Bowling Green. Taylor drove the car to a first place win at the 1994 Indianapolis Raceway Park race.

The vehicle races again next on July 22, at the Burke Lakefront Airport in conjunction with the Cleveland Indy Grand Prix racing weekend.

Contact: Giorgio Rizzoni, Center for Automotive Research and Department of Mechanical Engineering, (614) 292-3331.
Ohio State's Center for Automotive Research (CAR) was established in 1991 to give graduate students continued education and hands-on experience in the field of automotive development and manufacturing. In addition to more than 30 faculty members who are involved with CAR, there are more than 70 graduate students studying automotive analysis, testing and design, according to the center. As well as providing opportunities for grad students and engineering faculty, CAR also donates funding, material, and technical help to many undergraduate projects which include the Formula Lightning Electric Car, SAE Formula race car, SAE Mini-Baja car, the SAE Cargo Aircraft and the Sunrayce solar car. Students involved with the projects said that the cars compete with other schools’ cars on tracks and in various timed events. Students operate all of the vehicles, except for the electric car. Among its achievements in automotive advancements is the center’s hybrid Future Car, which runs on a combination of electricity and diesel fuel. It may pave the future road of automotive efficiency. Each year, the center selects a group to give senior honors project scholarships.

Since its inception, CAR has been involved in research projects with Ford, Chrysler and General Motors. CAR is also has ties with various research laboratories in areas such as fuel efficiency, engine emissions and aerodynamics. Almost all of the center’s research is conducted off-campus at the laboratory at 930 Kinnear Road. According to CAR, the present laboratory boasts 11,000 square feet of high ceilinged garage space and 24,000 square feet of office and lab space. Inside the lab is a large, sound proof, hemi-anechoic chamber, which is used for testing external noises made by running automobiles. The building houses a water brake dynamometer and an eddy current engine dynamometer. They are used to test engine concerns, such as exhaust and running efficiency. Various pieces of brake and safety testing equipment are also located in the building.

In the near future, CAR will be moving to a renovated research area, said a student working at the center. CAR will continue to work to advance automotive technology and, most importantly, to provide students with the experience to contribute to the future of the automotive industry.
Vrrrooooooom!
Top left: Cars sit inside the laboratory/garage of the Center for Automotive Research.
Top right: Center for Automotive Research's Formula Electric car is run entirely on electricity.
Above: The engine dynamometer, used for testing fuel efficiency and exhaust, sits in an acoustically treated chamber.
Right: A look under the hood of the Center for Automotive Research's student driver SAE Formula race car.
Left: The Center for Automotive Research's hemi-anechoic chamber is used for testing noise levels on running automobiles.

Photos & story by Ben Kofron
OSU electric race car one of world's fastest

By Anthony Castillo
Lantern staff writer

Although it runs on 31 batteries, can reach speeds of at least 140 mph and has been setting or breaking records for the last three years, very few people at Ohio State have even seen or know anything about it. It's the "Smokin' Buckeyes," OSU's Formula Lightning electric race car.

Designed and built in 1993 by OSU students at the Center for Automotive Research, the car is currently one of the fastest electric cars in the world.

Each year a volunteer team of students does everything including contacting sponsors, conducting maintenance, upgrading the car and acting as a pit crew during races.

The car competes in various races, including the ABB University Spec Series, which is comprised of teams from 14 universities.

Scott Funke, a graduate student in mechanical engineering, said the main requirements are that the university have a four-year engineering degree plan, the car must be electric and the driver must be a professional.

The car is currently driven by Craig Taylor, a 55-year-old professional race car driver, who has experience as a mechanical engineer and naval fighter pilot.

This year's OSU team is comprised of 15 students, with majors varying from mechanical engineering to public relations.

Chris Maupin, a freshman team member majoring in public relations, says that anybody can get involved with the team. He points out that since his major is not along the lines of engineering, he handles the publicity for the team and the car.

"Regardless of your major, there is always something you can do on the team or for the car," Maupin said. "This is especially a great opportunity for anyone looking for a career in the professional racing field."

Maupin believes this is why the team is so successful. He said many universities only allow students with engineering degrees to join the team. He believes that while they may not know how to contact sponsors. Since 1994, the car and the various teams have been collecting trophies and records, including the 1996 ABB University Spec Series Championship, which they are favored to win again this year.

The team came one step closer to back-to-back championships when they won the 1997 APS Electric held in Arizona last quarter.

Maupin points out that not only did the team win the race with a 40-second lead over the rest of the field, but they also set a new record top speed for the track at 110 mph.

Funke said the car has the exact same components and technology as General Motors' electric car. The main difference is that the "Smokin' Buckeyes" has 31 batteries, and it is built for speed. The batteries, however, are the standard 12-volt batteries found in any car.

He said during a race, the batteries remain charged for an average of 15 to 20 minutes. When the charge gets low, the driver comes in for a pit stop.

Maupin believes this is why the team really comes together. It takes teamwork and skill to change the 31 batteries, each weighing 45 pounds. Maupin said their personal best time is 19 seconds.

Currently, there is no official record for the fastest electric race car. The OSU team hopes to change that.

The team will have a chance to set an official record at an Indianapolis race in October, where officials will be present to keep track of the fastest times.

"So far our 43 mph speed is the fastest unofficial record," said Maupin. "But for the official record, we are pretty confident we can go at least 150 mph."

The team's next race is the Cleveland Electric Formula Classic in July.
CENTER FOR AUTOMOTIVE RESEARCH RECEIVES FUNDING FROM DOE

COLUMBUS -- The Center for Automotive Research at The Ohio State University recently received an award from the Department of Energy (DOE) to sponsor graduate student research of hybrid electric vehicles -- ones that run on a combination of gasoline and battery power.

The award, coupled with funding from industry, is helping the College of Engineering establish a new graduate curriculum for the study of hybrid electric drive trains and control systems.

DOE gave Ohio State and eight other universities Graduate Automotive Technology Education (GATE) awards "to help design and develop automotive technologies that will lead to a clean and ultra fuel-efficient car of the future."

Each university will receive a maximum of $200,000 over two years to develop curriculum and laboratory projects, as well as $100,000 per year for fellowships to students who pursue an advanced engineering degree in this area.

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"GATE will help accelerate progress on the development and use of major new critical automotive technologies. It will help build a work force of skilled automotive professionals unparalleled anywhere in the world," said Secretary of Energy Bill Richardson during the announcement.

Giorgio Rizzoni, associate professor of mechanical engineering at Ohio State, said that the GATE award will "enable the university to recruit high-caliber graduate students. We will develop two new graduate courses and build two new laboratories in which they can learn about hybrid vehicles and actually build cars as they work toward a master's or Ph.D. thesis. The curriculum will also be supported by existing electrical and mechanical engineering courses in internal combustion engines and transmissions, electric machines, and the related control systems."

Rizzoni explained that engineers are now trying to develop hybrid electric vehicles because they perform better than vehicles powered by electricity alone. For instance, a fully charged electric car could cover only 40 to 50 miles, not the 200 to 300 miles most people expect from a traditional car with a full tank of gas. What's more, the infrastructure required to maintain a city full of electric vehicles simply doesn't exist.

"We'd have to build charging stations like we build gas stations," said Rizzoni.

While a typical drive train includes a gasoline engine and transmission, a hybrid drive train combines an electric motor and battery pack, or other energy storage elements, with a traditional but leaner engine.

Most people, Rizzoni said, never run their car's engine at its maximum power rating. A hybrid vehicle with a smaller engine could easily maintain the more common speeds of 60 to 70 miles per hour while cutting fuel consumption and exhaust emissions in half.

In such a scenario, an electric motor would power acceleration, and capture waste energy from the brakes during deceleration to recharge the battery.

The new graduate program will let Ohio State researchers and students investigate hybrid electric drive train design. DOE is

- more -
also encouraging the winning universities to partner with companies in the auto industry which can offer jobs or internships to GATE fellows, share research facilities and equipment with the university, and provide guest lectures.

In addition to DOE support, fellowship funds are also being solicited from (or have already been contributed by) automotive industry partners, including Ford Motor Co., General Motors Corp., DaimlerChrysler Corp., Delphi Automotive Systems and Visteon Automotive Systems. It is envisioned that as many as 15 graduate fellowships may result from the combined DOE-industry effort.

Rizzoni and six other Ohio State professors will manage the new students: Gregory Washington, assistant professor of mechanical engineering; Yann Guezenne, associate professor of mechanical engineering; Ali Keyhani, professor of electrical engineering; Steve Yurkovitch, professor of electrical engineering; Donald Houser, professor of mechanical engineering and director of the Center for Automotive Research; and Krishnaswamy Srinivasan, professor of mechanical engineering and acting associate dean of the College of Engineering.

Other winners of GATE awards included the University of California-Davis, Virginia Polytechnic Institute and State University, University of Maryland, University of Tennessee, West Virginia University, Michigan Technological University, University of Michigan at Dearborn and Pennsylvania State University. The other universities will be focusing on vehicle technologies such as fuel cells, lightweight materials, direct injection diesel engines and advanced energy storage.

Contact: Giorgio Rizzoni, (614) 292-3331; Rizzoni.1@osu.edu
Written by Pam Frost, (614) 292-9475; Frost.18@osu.edu
Solar car project revs up

By Kevin Leipow
Lantern staff writer

Ohio State's Solar Vehicle Team has begun planning the development of its next solar-powered car for a competition in the summer of 2001.

The car, Redshift IV, will be OSU's entry in the American Solar Challenge, a race running from Chicago to Los Angeles between solar-powered vehicles from universities across the country.

The American Solar Challenge of 2001 will be the fourth competition that the Solar Vehicle Team has been involved in. The team placed 11th out of 29 in their most recent competition, the 1999 Sunrayce contest from Washington, D.C., to Orlando, Fla.

The Solar Vehicle Team, based out of the Center for Automotive Research, has been engaged in developing more efficient use of solar power as well as experimenting with a number of other new technologies.

A change that is planned for the new car from last year's vehicle, called Redshift III, is switching the car's body material. The new car will use carbon fiber instead of Kevlar. Carbon fiber is heavier but stronger than Kevlar.

The team also plans to implement a new technique in designing and creating the body of the new car, where a computer guides a wire through Styrofoam to form the mold. This new technique would save a lot of time and effort from previous techniques and also make the body more perfect aerodynamically, said Annamalai.

The team is looking for graduate students in electrical and computer engineering to help program the process, said Annamalai.

Team member Jason Peterson said that the solar vehicle program develops skills employers look for and gives valuable experience in engineering, business and teamwork.

"The whole purpose of the solar vehicle is to gain experience," Peterson said. "We make our own circuit boards, build the electrical system and everything. The experience that I and other team members get is something that employers really look at."

Funding is an important element to the building of the next solar car and the team is actively seeking commercial and public sponsorship. The 1999 Redshift III was estimated to have cost approximately $100,000.

To help fund this project, team members have created the Sponsor-a-Cell program, where those interested in helping can sponsor one or more of the 800 individual solar cells for $25 per cell. The cost includes the purchase of the cell itself as well as tabbing, lamination and mounting. Sponsors receive a certificate and a map location the cell.

Those interested in sponsoring or joining the Solar Vehicle Team should e-mail the team at sunrayce@osu.edu or call 688-4084.
From: Ohio State Media Relations <osumedia@osu.edu>
To: release <release@lists.acs.ohio-state.edu>
Subject: FW: OHIO STATE: Monaco-based electric vehicle manufacturer establishes engineering headquarters in Columbus

January 13, 2011

Monaco-based Electric Vehicle Manufacturer Establishes Engineering Headquarters in Columbus

Venturi Automobiles has announced the establishment of a new company, Venturi North America, to be headquartered at The Ohio State University. Venturi plans to design, engineer and produce electric vehicles for specialty markets.

Venturi chose Columbus as its North American base of operation to be in closer proximity to The Ohio State University Center for Automotive Research, a partner on projects such as the Buckeye Bullet landspeed racing team, which recently set new international speed records for both hydrogen fuel cell and battery powered vehicles.

Media Availability: Venturi President Gildo (JILL-do) Pastor will be available on Friday, Jan. 14 from 9-10 a.m. at the Center for Automotive Research, 930 Kinnear Road, or by phone at 614-292-5990.

“The Center for Automotive Research is enthusiastic about working with Venturi’s design and engineering staff to develop new electric vehicles,” said Giorgio Rizzoni, Director of CAR. “Venturi employs some 70 people in their engineering and manufacturing operations in Monaco and in France, and we expect that in time they will establish a similar presence in Central Ohio.”

John Pohill of Livonia, Mich. has been named chief executive officer of Venturi North America.

Venturi specializes in the design, engineering, manufacturing and conversion of electric vehicles including high-performance sports cars and lightweight urban vehicles. Recently, in collaboration with French automobile manufacturer PSA Peugeot Citroën, Venturi developed an electric conversion for delivery vehicles, selected by La Poste, the French postal service.

In September 2010, the company opened its first factory, MVE (Manufacture de Véhicules Electriques), near Le Mans, France, and with an immediate order for 1,500 vehicles, became the largest active electric vehicle production line in the world.

Venturi North America plans to use manufacturing space within the Science and Technology Campus Corporation research park (SciTech) located on Ohio State’s West Campus. Company headquarters will be located within TechColumbus, adjacent to SciTech on Kinnear Road.

“We’re very pleased about Venturi’s announcement to base its North American operations in Central Ohio,” said Ted Ford, president and CEO of TechColumbus. “This adds another important advanced energy asset to the region and further demonstrates our commitment to becoming a world recognized leader in advanced energy manufacturing and energy storage.”

Central Ohio was recently designated as the Ohio Hub of Innovation and Opportunity for Advanced Energy Manufacturing and Energy Storage. A group of local partners is working to attract advanced energy enterprises to the area while supporting existing concerns. Partners include TechColumbus, Ohio State University, Battelle, Edison Welding Institute and Columbus 2020!
About Venturi Automobiles
Venturi Automobiles was founded in 1984 in France as a sports car manufacturer. Purchased in 2001 by Gildo Pallanca Pastor, it focuses on innovation in the field of electric vehicles by harnessing the most advanced technological solutions in this area. Venturi expertise extends from urban cars to high-performance vehicles.

John Pohill, chief executive officer of Venturi North America, has served in numerous engineering and manufacturing management capacities in his 30+ year career, including positions in the automotive and ship-building industries with Chrysler, General Motors and General Dynamics Electric Boat Division.

About the Ohio State Center for Automotive Research
The Ohio State University Center for Automotive Research is an interdisciplinary research center focusing on advanced electric propulsion and energy storage systems; advanced engines and alternative fuels; intelligent transportation systems and autonomous vehicles; noise, vibrations and dynamics; vehicle chassis systems and vehicle and occupant safety. CAR, along with Venturi Automobiles, battery manufacturer A123 Systems, and other industry leaders are partners on the Buckeye Bullet landspeed racing team.

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Ohio State News
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Spam
Not spam
Forget previous vote
By Dan Gearino

The earth-friendly car designed by Ohio State University students has finished third place in a national competition last night.

OSU's EcoCar 2 team is coming home from the San Diego event with a trophy, despite having some mechanical problems with the vehicle during the final testing.

"We actually feel really good," said Katherine Bovee, a mechanical engineering student and co-leader of the team. "We had a lot of obstacles to overcome."

A total of 15 teams competed, demonstrating how they had overhauled a 2013 Chevrolet Malibu to become more fuel efficient. The OSU team had a particularly complicated plan, with a battery system and a gasoline engine that runs on E-85, a fuel that is 85 percent ethanol.

Penn State University's team finished first, followed by Cal State Los Angeles and OSU.

The event, part of the long-running Advanced Vehicle Technology Competitions, is sponsored by the U.S. Department of Energy.

"The students competing in EcoCAR 2 are leading the way in designing and building the next generation of American-made automobiles that will reduce our dependence on oil and save families and businesses money at the pump," David Danielson, assistant secretary for the energy department, said in a statement.

This was the second year in a three-year cycle with the Malibu, with a competition at the end of each year. Last year, OSU finished second to Mississippi State University.

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Honda, Ohio State name co-directors for joint projects

By Dan Gearino
The Columbus Dispatch • Wednesday January 27, 2016 3:33 PM

Honda and Ohio State University have worked together on projects for years but now have appointed co-directors to oversee the partnership.

Now the collaboration will be overseen by a co-director from each: Mike Wiseman, director of the material research division at Honda R&D Americas in Raymond, and Joanna Pinkerton, former chief operating officer at Ohio State's Center for Automotive Research.

The automaker and university have a nearly 30-year working relationship, taking on projects that involve research and the sharing of resources.

"Honda is continually looking toward the future and establishing relationships with like-minded organizations that aspire to strengthen our communities while creating value for society," said Frank Faluch, president of Honda R&D Americas and an Ohio State alumnus, in a statement on Wednesday.

He said the changes "will focus and elevate our teamwork to achieve new breakthroughs in transportation research and establish a global benchmark for academia-industry partnerships in mobility."

Honda has a big presence in Union and Logan counties, with the R&D center and several assembly plants. At the same time, Ohio State has several offices and programs related to the auto industry, such as the Center for Automotive Research.

dgearino@dispatch.com
The Center for Automotive Research

Aeronautical Research

Focus areas
- Wind tunnel testing
  Scale Model:
  Complete vehicles
  Components
  Full Scale:
  Components
- Theoretical and CFD analyses of components and configurations
- Investigation of interior ducting and engine flows
- Development of analytical and specialized software
- Development of testing techniques
- 14 x 16 foot Wind Tunnel
  With or without fixed ground plane,
  Tunnel speeds up to 70 mph,
- On-line real time data acquisition utilizing
  Load cells,
  Pressure measurement systems,
  Internal force balances,
  Hot film systems,
  Survey probes,
  On-line computer reduced printout and / or plots of data
- Workshop (wood or metal) for adapting models and test facilities
- Compressed air
- Flow visualization utilizing:
  Laser sheet,
  Smoke,
  Helium bubble,
  Fluorescent oil,
  Access for photography

Research interests
- Aerodynamic evaluation of vehicle components and vehicle configurations
- Interchange of technology advancements among air, space, marine, and ground vehicles
- Evaluation of existing components with potential for redesign and / or replacement

West Research Laboratory
- 3 x 5 Wind tunnel
  Tunnel speeds up to 110 mph,
  Data acquisition and flow visualization capabilities similar to 7 x 10 and 14 x 16 tunnels,
- Transonic blowdown tunnels for component testing
  Tunnel speeds from Mach 0.2 to 1.1,
  Reynolds numbers from 2 to 40 million,
- High pressure air supply system (2500psi)
- Analytical software
- Specialized test facilities and rigs designed and developed as required

Laboratory facilities
East Research Laboratory
- 7 x 10 foot Wind Tunnel with unique 42 x 88 inch rolling road.
  Rolling road speeds up to 90 mph,
  Tunnel speeds up to 275 mph,
  Tunnel can be used without rolling road for strut or sting models,
- Workshop (wood, metal, and composite) for adaptation and / or for construction of models and test apparatus
- Extensive computer facilities including a network of Harris super minicomputers, Apollo workstations, Masscomp systems and PCs. Access to the Ohio Supercomputer Center’s Cray YMP/864

For more information contact:
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2300 West Case Rd
Columbus, OH 43235-7531
The Center for Automotive Research

Composite Materials Development

Focus areas
- New Composites for automotive components
- Near-net shape processing
- Cylinder liner applications
- Turbocharger compressor wheels
- Reinforcement for advanced diesel pistons
- Lifetime brake rotors
- Brake calipers

Composites lab facilities
- Processing laboratory with growth chambers,
- Alloy melting facilities including vacuum and inert gas arc-melting and plasma melting systems,
- Ceramic and metal powder processing facilities,
- Specimen preparation laboratory including diamond saws, electro-discharge machining (Hansveld Industries Benchmark), electropolishing systems, metallographic sample preparation,
- Thermal cycling furnace and deformation testing system,
- Ambient and high temperature mechanical testing facility including fully computer controlled Interlaken deformation simulator and other test frames,
- Transmission Electron Microscopy Laboratory with JEOL 2010 TEM with windowless EDS, PEELS, high resolution video capture, image simulation, as well as other TEMs,
- Scanning Electron Microscopy Laboratory with a JEOL 840F and Hitachi SEM, as well as other SEMs,
- Fully equipped TEM and SEM sample preparation facility including low damage saws, dimpling, ion milling, sputter and evaporation coaters,
- Finite element methods (FEM) analysis of composite behavior, access to CRAY YMP/864 for modeling purposes.

Research interests
- Development of processing - microstructure - properties relationships,
- Development of range of composites suitable for various applications,
- Microstructural design,
- Control and manipulation of microstructure,
- High thermal conductivity composites,
- Development of fracture tough composites,
- Wear resistant composites,
- High stiffness composites,
- Fatigue resistant composites,
- Assessment of thermal cycling effects,
- processing procedures for net shape manufacturing

For more information contact:
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(614) 292-2708

141 Fontana Laboratories
116 West 19th Avenue
Columbus, OH 43210
SPONSOR BENEFITS

The AEP engineers who participated with the college and high-school students in the 1997 FIRST competition believe the program to be such a positive experience that they helped convince AEP to double its commitment to FIRST for the following year.

"From the standpoint of the students, this is an extremely worthwhile endeavor, and the students will receive a paycheck greatly exceeding their efforts. FIRST offers an exciting view of applied engineering at an intense technical level that goes way beyond the typical student science project."
— Eric K. England
American Electric Power Service Corporation

AlliedSignal, Inc. sponsors Ohio State Engineering Student Project Teams through a Foundation Grant.

"As sponsors, we get to know the students and they get to know us. The students who are involved in these projects are just what we're looking for at AlliedSignal. They are getting 'real world' experience outside of the classroom and know how to function in teams. It's a rewarding partnership."
— Don Calkins
AlliedSignal, Inc.

For more about sponsorship opportunities, contact the College of Engineering:
Phone: (614) 292-7931
Fax: (614) 688-3805
119A Hitchcock Hall
2070 Neil Avenue
Columbus, Ohio 43210
You can sponsor an Ohio State team with donations of cash, materials, or expertise.

- Support students preparing for careers in industry.
- Get to know the engineers of the future.
- Advertise your company!
Engineering students work in teams to design and build electric, solar and other vehicles, concrete canoes, planes, and bridges. They test their creativity and ingenuity in friendly competition with other universities in events that draw regional and national crowds.

You can be a sponsor.

THE TEAMS

**Autonomous Robotic Transporter (ART)** [9]
A robotic vehicle carries a small payload and navigates a ground course with no human intervention. Visual sensors, ultrasonic sonar, and on-board computers combine to control the vehicle through the course's hills and turns. Distance covered and time lapsed determine the winner.

**Air Cargo Plane** [1]
Students design and build a small radio-controlled aircraft with a fixed wing size that is capable of lifting many times its weight. In competition, planes must lift off carrying the maximum weight and land safely.

**Concrete Canoe** [1]
Students design and build concrete canoes that compete in sprint and distance races. Teams are also judged on design and project presentations.

**FIRST** [8]
College students team up with corporate sponsors and high school students to create a robot in a contest known as FIRST: For Inspiration and Recognition of Science and Technology. Greenview Heights High School and Ohio State entered the competition for the first time in 1997.

**Formula Lightning Electric Race Car** [5]
This synergy of mechanical and electrical engineering is the hallmark of this team. Students design, construct, and operate an electric drive system for a specially built Indy-style racing chassis.

**Formula SAE Race Car** [6]
A short track formula-style racing vehicle, powered by a 100 HP motorcycle engine, competes in acceleration, braking and aerodynamic events. Judging criteria include cost and design report, as well as oral presentation.

**FutureCar Challenge** [2]
Ohio State is one of only 12 universities taking part in this competition to modify an existing car into one that gets three times the fuel efficiency of today's mid-size cars, while maintaining the current price, performance, and safety. Ohio State's entry uses a hybrid-electric drive system.

**Mini-Baja** [11]
The off-road Mini-Baja vehicle is built to endure a rugged, off-road track in a three-hour endurance test. The team tests its skills in events that measure safety, acceleration, braking, speed, handling, and maneuverability.

**Timber Bridge** [7]
Students are challenged to design, construct, and load wooden bridges, and then submit their designs for evaluation.

**Steel Bridge** [10]
Students use their knowledge of structural design and mechanics of materials to design and construct a steel bridge. In competition, the team loads the bridge to its ultimate limit; the most elegant and sturdy design wins.
The Center for Automotive Research

Gear Dynamics and Gear Noise Research Laboratory

Background

In 1980, the Ohio State University Department of Mechanical Engineering established the Gear Dynamics and Gear Noise Research Laboratory as a research consortium funded by industry. The Laboratory's main goal is to advance the state-of-the-art of gear design through research aimed at developing a better understanding of gear dynamics and gear noise. The scope of the research ranges from the development of computer software to the acquiring of experimental data from sophisticated test stands. Most funds received by the laboratory are used to provide financial aid for MSc. and Ph.D. students working on thesis projects related to gearing. Sponsors meet with faculty and students twice yearly to review research progress and to discuss research goals of the Laboratory. Sponsors have access to all computer codes developed by the Laboratory and are also provided reports and theses prior to their publication.

Gear Lab Sponsors:

- General Motors Gear Center
- Gleason Memorial Fund
- Harley Davidson
- Honda
- Case/IH
- John Deere
- Lexmark
- New Venture Gears
- Nissan
- Peugeot/Citroen
- Pratt and Whitney
- Reliance Electric
- Renault
- Rockwell
- Sikorsky
- Trane
- Tremec
-Measurement of root stresses at the ends of helical gear teeth.
- Coordinate measurement of worm, straight bevel and spiral bevel gears.
- The Effects of Manufacturing Errors on the Predicted Dynamic Factor of Gears.
- Strain gage and encoder measurements for the verification of the LDP program.
- Correlation of various methods of measurement of gear static and dynamic transmission error.
- Optimization procedures for topographical modification of gear teeth to minimize transmission error.
- Correlations between prediction and measurements of dynamic transmission error of spur and helical gears.
- Dynamics of High Power Density Rotorcraft Transmissions, a University Research Initiative (URI) sponsored by the US ARMY Research Office.

Project Sponsors, Grant Donors, and Affiliate Members

- Gleason Memorial Fund
- Giddings And Lewis Measurement Systems
- Sikorsky
- Navy Ship Exper. Center
- Army Research Office
- Chrysler

Current Focus Areas

- The development of a knowledge based gear design system which incorporates manufacturing sensitivities which affect gear noise.
- Development of a special purpose finite element preprocessor for the analysis of webbed and complex welded structure gears for use with the LDP program.
- Planetarv gear train dynamics.
- Development of a loaded single flank transmission error tester for right angle gearing.
- Finite element prediction of the effects of stress wave propagation on tooth dynamic stresses.
• Correlating manufacturing errors with
  the noise quality of automatic
  transmissions.

**Gearing Programs**

**LDP family**
LDP - Load Distribution Program
MULTILDP
DHLDP
GGRAPH
GSHAFT
TEOPT

**Spreadsheets**
AGMATOL
GG3
GG5

**Dynamics Programs**
GNP
DYTE
DYTEM
GRD
4DOF
VTB1

**Bevel Gears**
GRPHOCT
GRSPHIN
SPBEVL4
CAPPOCTD
CAPPSPHIN
CAPPSFB

**Miscellaneous**
CAPP

**Gear Test Stands**

• Back to Back Tester
• Gleason/Goulder Single Flank
  Measurement System
• Loaded Single Flank Tester
• Variable Center Distance Dynamic Gear
  Tester
• Gear Rattle Tester
• Housing bearing simulator.
• FZG 91.5 mm center distance back-to-
  back gear tester
• Loaded Bevel Gear Transmission Error
  Tester.
• Gleason 517 hypoid gear tester.
• Helicopter Offset Gearbox
• Planetary ring gear isolation test rig.

**Special Purpose Instrumentation for Gear Research**

• Gleason Goulder single flank transmission error optical measurement heads.
• Gleason portable encoder heads for transmission error measurement
• University of Cambridge dynamic transmission error system
• Klingelnberg gear lead, involute, and spacing inspection machine
• Tracking ratio tuners: Trig-Tek Tracking
  6 different outputs, Spectral Dynamics
  SD134), VIC, 3 Trig-Tek tracking ratio
  divider, and Caterpillar unit.
• Endevco torsional accelerometers with
  slip rings, 6 - home-made torsional
  accelerometers.
• General Motors torsigraphs.
• Trans-Era 16 channel high speed data
  acquisition system for the IBM PC.
• Ono-Sokki Transmission Error
  Measurement system.
• VIC 2-channel tracking filter.
• AE Model TV1 torsional vibration
  instrument.
• Applied Physics Acoustic Emission
  System.
• Hewlett Packard Model 35670 2 -
  channel spectrum analyzer
• Ono-Sokki 8 channel spectrum analyzer
• Flannar laser shaft alignment system
• 4 - Capacitrek capacitance displacement
  probes
• 2 - 100 lb shakers
• 2 - 7 lb shakers
• 8 channels of Electro inductive probes
• B & K laser vibrometer
• Dantec translational/torsional laser
  vibrometer
• Sony 8-channel DAT recorder
• Several PC's, Mac computers, and SGI
  computers
• 16 - channels of strain gage bridge
  balance amplifiers

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NEW RESEARCH FACILITIES AND EQUIPMENT

This has been a watershed year since two new research laboratories were developed in the C.A.R. building under the leadership of Prof. Don Houser. The Vehicle Noise Laboratory now includes an IAC hemi-anechoic chamber (35' x 25' x 15') that houses a twin-roll 150 hp Horiba chassis dynamometer, and sound quality systems based on B&K acoustic equipment and SDRC software used to assess and diagnose vehicle NVH problems. Dr. Teik Lim is enhancing this capability further by adding much needed advanced features. The Engine Breathing Systems Laboratory has just been completed under the direction of Dr. Ahmet Selamet. It includes a computer controlled engine dynamometer and various flow and acoustic silencer benches. New SGI and HP workstations have been added for FEM, BEM, CFD and dynamic system calculations. Also, an advanced machinery acoustics and vibration instrumentation grant that will create unparalleled experimental facility has been approved by the Ohio Board of Regents. This project is being directed by Prof. Raj Singh in coordination with Prof. Randy Allemang of the University of Cincinnati. The $1.85 million grant, when leveraged with gifts and discounts, may exceed $3 million over the 3 year period of the project that started in October 1996.

SPONSORED RESEARCH PROJECTS

Several new research projects were initiated in 1996. For example, the Ford Motor Co. has sponsored 4 projects with Prof. Selamet on the wave dynamics in the engine induction and exhaust systems. Dr. Lim is evaluating sound quality procedures with application to doors, latches and motors for the Chrysler Corp. Dr. Singh will be working on a brake pad-caliper system problem for the Bosch Braking Systems. Dr. T.C. Lim has brought in additional projects such as the supercharger noise analysis sponsored by Eaton.

Continuing research projects include the Gear Lab industrial consortium headed by Dr. Houser, the U.S. Army University Research Initiative on the dynamics of high power density transmissions (with D.R. Houser and R. Singh as the principal investigators of the 5 year block grant), and the ABS actuator noise study that was sponsored by Delphi Chassis with Prof. Singh. Sponsored research budget for 1996 exceeded $750,000 and a higher budget is expected for 1997. Several new proposals have been written, including 2 industrial consortium projects; the first one has been proposed by Drs. Lim and Houser that will examine bevel and hypoid gear dynamics, and the second project by Prof. Singh will develop nonlinear models for the automotive coast/drive gear rattle problem. These will start in 1997.

PEOPLE NEWS

Teik C. Lim [phone/fax: 614-688-4139/4111, e-mail: lim.5@osu.edu] joined the C.A.R. Vehicle Noise Laboratory as Research Scientist in March of 1996. Prior experience includes noise and vibration control work with automotive companies around the world. Dr. Selamet [phone/fax: 614-292-4143/3163, e-mail: selamet.1@osu.edu] moved to OSU from the University of Michigan with some of his research students in early 1996 and since then has developed new facilities at CAR. Jim Sorensen has joined C.A.R. as a Research Engineer with responsibilities to provide assistance to testing programs.

Dr. Singh received the Lumley Faculty Research Award from the College of Engineering. He was also invited to visit Korea and give invited lectures on the OSU’s NVH program. Likewise, Dr. Houser visited Europe and gave talks on CAR and the Gear Lab activities.

PUBLICATIONS & PROFESSIONAL SERVICE

More than 25 papers, including 11 journal articles, were authored by Dr. Singh, Selamet, Lim and Houser. Chief contribution include the organization and co-sponsorship of the India-US Symposium on Emerging Trends in Vibration and Noise Engineering (under an NSF grant with
NVH EDUCATION

First course in the automotive NVH sequence [ME 777-778-779] was successfully offered by Prof. Singh with an enrollment of about 75 students including 55 practicing engineers at GM. The annual Gear Noise short course again attracted more than 35 participants in Sept. 1996. That course, as taught by Drs. Houser, Singh, and Munro, has been attended by more than 800 engineers from 200 companies over the last 17 years. In 1997, this short course will be offered from September 9 to 11. A new advanced gear noise course has been added (September 16 and 17, 1997) for the regular short course alumni. Specialized and customized training or educational programs in various aspects of automotive NVH and sound quality were provided to many companies such as Honda, Ford, Cooper Tire, TRC, Samsung, LuK, etc. by Professors Lim, Selamet and Singh. We expect this activity to grow.

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Also, check the homepages at:
http://rcslgi.eng.ohio-state.edu/~houser/car.html
http://rcslgi.eng.ohio-state.edu/~s-singh
http://rcslgi.eng.ohio-state.edu/~houser/gearlab.html

Professor Singh as principal investigator) at I.I.T. Delhi India in March 1996. Professors R. Singh, A. Selamet and R. Parker were part of the U.S. delegation, and gave invited talks. A special issue of the Journal of Sound and Vibration is being prepared, based on the proceedings that were published in 1996 as a book. Yet another special edition of a journal was prepared by The Ohio State University faculty. Dr. Selamet and Dr. Lim contributed 2 papers on automotive NVH to the special issue of the Noise Control Engineering Journal (Sept.-Oct. 1996) with Prof. Singh as the guest editor. A future special issue is currently being planned with Drs. Singh, Lim and Selamet as guest editors; this will deal with advanced computer methods for noise and vibration control. Drs. Selamet, Houser and Singh have also organized and chaired several technical sessions at national and international conferences. Some typical publications are as follows.


The infrastructure at Ohio State includes the Center for Automotive Research (C.A.R.) (with major thrusts in noise, vibration & harshness (NVH), powertrain and electro-mechanics), Gear Dynamics and Gear Noise Research Laboratory and the Acoustics & Dynamics Laboratory. This communication briefly discusses current research and educational activities along with future plans in the areas of automotive noise & vibration control and machine dynamics.

RESEARCH TOPICS

1. **Powertrain/Driveline Vibration and Noise**

   Gear design, dynamics and noise; transmission rattle; driveline vibration; casing vibration; supercharger noise; nonlinear engine-block dynamics; engine mode tuning. Recent Sponsors: GM, Ford, Chrysler, Nissan, Eaton, Honda, NASA.

2. **Engine Induction/Exhaust Noise**

   Nonlinear wave dynamics and sound propagation; source coupling; design of manifolds, silencers and breathing systems; pulsations excited by accessories; fluid flow-acoustic resonance-structural dynamic interactions. Recent Sponsor: Ford

3. **Vehicle NVH and Sound Quality**

   Sound quality methods and applications to vehicle problems; airborne and structure-borne noise path analyses; in-vehicle noise and vibration simulation; interior noise modeling; coupled interactions between vehicle components and structures; near field acoustic holography. Recent Sponsors: Chrysler, Delphi-Chassis.

4. **Mounts, Damping and Path Control**

   Hydraulic and rubber mounts; idle shake control; estimation of nonlinear properties; viscoelastic damping treatments; semi-active and active isolation; structural path analysis and design optimization; brake squeal and insulators; brake groan and judder. Recent Sponsors: Teledyne, Bosch, US Army, Eagle-Picher.

5. **Structural Dynamics and Acoustics**

   Dynamic analyses of sheet metal structures, chassis elements, joints and rolling element bearings; modal analysis and synthesis; transmission casing vibration and noise; energy flow calculations over low and mid-frequency ranges; structural intensity and laser scanning techniques. Recent Sponsors: US Army, Edison Welding Institute.

NYH RESEARCH AND GRADUATE EDUCATIONAL FACILITIES

**Acoustics and Dynamics Laboratory** (ME Bldg.): This laboratory, directed by Dr. Raj Singh, is involved with teaching dedicated and industrially relevant vibration and noise control courses and is active in numerous externally sponsored projects as described in the above mentioned research areas. Major capabilities include IAC anechoic (10'x14'x 14'), Eckel anechoic (3' cube) and semi-reverberant (12'x14'x10') rooms; experimental and computational modal analyses; active vibration and noise control research equipment; B&K acoustic intensity probe system; engine mount experimental setups; visco-elastic damping evaluation and brake noise experiments; analog computer systems for nonlinear systems research; and nonlinear analysis software.

**Gear Dynamics and Gear Noise Research Laboratory** (ME Bldg.): This laboratory, directed by Dr. Donald Houser, is operated as a consortium that currently has over 25 participating companies in 5 countries out of which 18 are in the transportation industry. Major capabilities include six different gear static and dynamic transmission error measurement systems; gear rattle tester; numerous special purpose...
gear dynamics programs; and gear transmission error and load distribution codes.

**Engine Breathing Systems Laboratory (C.A.R. Bldg.):** This computer controlled modern engine dynamometer laboratory, developed by Dr. Ahmet Selamet, emphasizes model development and validation for the noise control in the induction and exhaust systems. Major capabilities include high speed data acquisition system (Concurrent); HP workstations; Emission analysis equipment; and engine and flow noise simulation codes. Facilities also include two-microphone and standing wave impedance tubes (B & K) for the evaluation of silencers and acoustical materials.

**Vehicle Noise Laboratory (C.A.R. Bldg.):** Vehicle exterior and interior noise problems are addressed in this facility. Also, advanced vehicle sound quality assessment and diagnostic systems are being developed by Dr. Lim. Major capabilities include a hemi-anechoic chamber with chassis roll dynamometer (35’x25’x15’); binaural acoustic head and DAT recorders; and sound quality systems (IDEAS, B&K).

Common research tools include the following: two acoustically treated general purpose engine test cells at C.A.R.; many FFT analyzers and variety of general purpose acoustic and vibration exciters and sensors; torsional & translational laser vibrometers; finite element codes (ANSYS, MSC/Nastar, IDEAS) and boundary element acoustic programs (SYNOISE, COMET, BEMAP, IDEAS VibroAcoustics); MATLAB, SIMULINK and related toolboxes; computational fluid dynamic codes (Star CD); numerous SGI and HP workstations, and PC computers. Additionally, OSU researchers have access to the pass-by noise measurement and in-vehicle noise evaluation capabilities of the Transportation Research Center in East Liberty (Ohio). Vehicle dynamics experiments including ride or handling performance may also be performed.

**NVH COURSES**

At Ohio State, most undergraduate and graduate courses emphasize laboratory or design work. Traditional senior elective and graduate courses include introductory and advanced machinery vibrations, engineering acoustics, mechanical measurements, vehicle dynamics, and dynamic systems modeling. The C.A.R. and the Acoustics & Dynamics Laboratory were selected by the General Motors Corp. to develop a one year graduate level course sequence on automotive noise, vibration and harshness. This sequence (ME 777, 778 and 779) is being developed and taught by Professor Raj Singh through C.A.R.’s distance learning program. The sequence is currently a part of the General Motors’ graduate program, but it will eventually be made available to other companies. A new MS degree program in Automotive Systems Engineering is also being developed.

**OHIO AUTOMOTIVE RESEARCH ALLIANCE**

An informal alliance between universities, government labs and industry, within the state of Ohio, has been formed. This is led by the Center for Automotive Research (Ohio State University) and the Structural Dynamics Research Laboratory (University of Cincinnati). A $1.85 million proposal was submitted to the Ohio Board of Regents and it has been approved via a multi-staged competitive review process. The equipment list includes near field acoustic holography equipment, a laser scanning vibrometer, a nonlinear dynamics test facility, a networked data acquisition system of high spectral bandwidth and concurrent monitoring capability, a torsional hydraulic actuator & rotational laser system, a multi-channel active noise & vibration controller, and an engine intake & exhaust noise measurement system. This new equipment would create an unmatched noise & vibration control research infrastructure.

**CONTRIBUTING FACULTY**

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