

FACULTY/STAFF NEWSPAPER

Volume 31, Number 28 • September 5, 2006

THE GEORGIA INSTITUTE OF TECHNOLOGY

Researchers use hydrogen fuel cells to power unmanned aerial vehicle

T.J. Becker Research News

eorgia Tech researchers have conducted successful test flights of a hydrogen-powered unmanned aircraft believed to be the largest to fly on a proton exchange membrane (PEM) fuel cell using compressed hydrogen.

The fuel-cell system that powers the 22-foot wingspan aircraft generates only 500 watts. "That raises a lot of eyebrows," said Adam Broughton, a research engineer who is working on the project in Georgia Tech's Aerospace Systems Design Laboratory (ASDL). "Five hundred watts is plenty of power for a light bulb, but not for the propulsion system of an aircraft this size." In fact, 500 watts represents about 1 percent of the power used in a hybrid car like a Toyota Prius.

A collaboration between ASDL and the Georgia Tech Research Institute (GTRI), the project was spearheaded by David Parekh, GTRI's deputy director and founder of Tech's Center for Innovative Fuel Cell and Battery Technologies.

Parekh wanted to develop a vehicle that would both advance fuel cell technology and galvanize industry interest. While the automotive industry has made strides with fuel cells, apart from spacecraft, little has been done to leverage fuel cell technology for aerospace applications.

"A fuel cell aircraft is more compelling than just a lab demonstration or even a fuel cell system powering a house," Parekh explained. "It's also more demanding. With an airplane, you really push the limits for durability, robustness, power density and efficiency."

In November, the researchers will present details of the project at the Society of Automotive Engineers' Power System Conference in New Orleans.

Fuel cells, which create an electrical current when they convert hydrogen and oxygen into water, are attractive as energy sources because of their high energy density. Higher energy density translates into longer endurance.

Though fuel cells don't produce enough power for the propulsion systems of commercial passenger aircraft, they could power smaller, slower vehicles like unmanned aerial vehicles (UAVs) and provide a low-cost alternative to satellites. Such UAVs could also track hurricanes, patrol borders and conduct general reconnaissance.

Breaking new ground A few other research groups have also

Hydrogen continued, page 2



Thomas Bradley and Reid Thomas start up the fuel cell aircraft during a test flight at the Atlanta Dragway.

Tech welcomes its largest freshman class in history

David Terraso Institute Communications and Public Affairs

his fall, Georgia Tech has more incoming freshmen on campus than anytime in its 111-year history. Approximately 2,607 students entered Tech this fall, while another 250 began their college career this past summer as part of Tech's first summer admissions program. At this time last year, Tech's freshman class counted 2,487. The unplanned growth in enrollment was a result of increased interest in Tech.

"This year we had more students accept our offers of admission than ever before," said Ingrid Hayes, director of Undergraduate Admission. "Typically we plan for 3 to 5 percent of the students who commit to enrolling at Tech to go elsewhere. This year, less than 1 percent chose to attend a school other than Tech."

2006 freshman	class	stats
In-state residents	1,593	(61%)
Out-of-state residents	1,014	(39%)
Female	812	(31%)
African-American	125	(5%)
Hispanic	122	(5%)
International	113	(4%)

Interest in Tech is high. This year, more than 9,600 students applied for admission to the freshman class, a 4 percent increase over last fall and a 12 percent rise since fall 2004.

The quality of Tech's new students continues to remain high. This year's average SAT score is 1,342, about the same as last year. While the average GPA is 3.71, compared to last fall's 3.74.

Class continued, page 2

Retired professor gives \$1.5M to create endowed CEE chair

Megan McRainey Institute Communications and Public Affairs

eorgia Tech Emeritus Professor Stephen L. Dickerson and his wife, Jane, have provided \$1.5 million to create the first endowed chair to reside in the School of Civil and Environmental Engineering (CEE). Pending final approval from the Board of Regents, it will be named the Frederick R. Dickerson Chair in honor of his late father.

The Dickerson Chair is intended to rve as the foundation for major CEE research and education efforts in urban transportation systems, particularly the application of advanced communications and computing to facilitate congestion reduction and energy efficiency. The Chair's research will help alleviate traffic and air pollution through real-time communications and data processing that enhances public transit, ride-sharing systems



Emeritus Professor Stephen Dickerson in a 1991 photo

and car rentals.

"A great father and mother, the benefit I received from association with Georgia Tech and the desire to contribute to resolving a significant problem all motivated our gift to Tech," Dickerson said.

Chair continued, page 3



"The next computer revolution might be the personal robot [which will] physically interact with and assist people in their daily life. It's already started in trivial applications like vacuum cleaners, pool cleaners and lawn mowers. Now we're ready to go to the next level."

—Henrik Christensen, director of the College of Computing's Robotics and Intelligent Machines Center, on the future of robots in domestic life. (McClatchy Newspapers)

Ice cream social



Undergraduate students Katie Yurman and Emma Reuter enjoy ice cream bars courtesy of Mayfield Dairy Farms President Scottie Mayfield. The visit to the Woodruff Dining Hall corresponded with a new dessert bar enabling students to make their own sundaes and milkshakes.

Mayfield is an alumnus of Georgia Tech, graduating in 1973 with a degree in management.

Hydrogen, cont'd from page 1



WHISTLE

Editor: Michael Hagearty

Photos by Rob Felt, unless noted

Published by Institute Communications and Public Affairs.

Publication is weekly throughout the academic year and biweekly throughout the summer.

Archived issues of The Whistle can be accessed electronically through the Georgia Tech Web page, or directly at www.whistle.gatech.edu.

Calendar submissions e-mailed to editor@icpa.gatech.edu, or faxed to 404-894-7214 must be sent at least 10 days prior to desired publication date. Classified submissions are on a first come, first serve basis. For more information, call 404-894-8324.

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Georgia Tech is a unit of the University System of Georgia. demonstrated hydrogen-powered UAVs, but these aircraft were either very small or used liquid hydrogen. "Compressed hydrogen, which is what the automotive industry is using, is cheaper and easier to work with," said Tom Bradley, a doctoral student in the School of Mechanical Engineering who developed the fuel cell propulsion system. "Our research will be easier to commercialize."

In contrast to the smaller UAVs, which had no landing gear and had to be hand launched, Georgia Tech's demonstrator vehicle operates like a full-sized aircraft, requiring no auxiliary batteries or boosters for takeoff.

While little information has been released about other hydrogen-powered UAVs, outreach is an important part of Georgia Tech's project. "We are laying the groundwork in design development that others can use to develop hydrogen-powered aircraft," explained Dimitri Mavris, ASDL director and a professor in the School of Aerospace Engineering. "By documenting the technical challenges we've encountered — as well as our solutions — we provide a baseline for others to follow."

The researchers hope to see many other aircraft take to the skies on power from fuel cells. "As significant as it is, we are not merely developing a one-of-a-kind airplane," added Parekh. "We're working to define a systems engineering approach for fuel-cell powered flight. We're seeking to blaze a trail that others can follow."

Difficult design game

"Hydrogen power requires a drastically different approach to aircraft design compared to conventional planes powered by fossil fuels," observed Blake Moffitt, a doctoral student in aerospace engineering who designed much of the aircraft.

To construct the fuel cell power plant, researchers bought a commercial fuel cell stack and modified it extensively, adding systems for hydrogen delivery and refueling, thermal management and air management. They also built control systems, such as data acquisition so information could be transmitted during flight.

In June, researchers tested the vehicle at the Atlanta Dragway in Commerce, Ga. Hot, humid, windy weather made testing conditions less than ideal and reduced thrust. Yet researchers were able to conduct four flights, with the aircraft traveling between 2.5 and 3.7 meters above ground for up to a minute at a time.

"Especially important, the data generated during these flights validated our design methodologies," said

Some design challenges:

• Slim performance margins. Researchers developed innovative methods to analyze performance, which enabled them to optimize the propulsion system and aircraft design.

• Weight management. Creative methods trimmed pounds, such as using carbon foam for the power plant's radiator.

• **Reducing drag**. The team used long, slender wings, a rear-mounted propeller and an inverted V-shaped tail.

• Miniaturization. Finding components small enough to fit in this space included a pump from a liquid-cooled computer and a hydrogen tank designed for a paintball gun.

Moffitt. "The data also indicated the aircraft is capable of longer, higher performance flights."

During the next few months, the team will continue to test and refine the aircraft, making it more reliable and robust. Ultimately, they plan to design and build an UAV capable of a trans-Atlantic flight — something that Parekh believes will be possible within the next five years.

Class, cont'd from page 1

Tech's incoming freshman class has a higher percentage of women than ever before — approximately 31 percent. This increase reflects a concentrated effort by Tech to bring balance to what faculty and students dub "the ratio."

"It's the result of us providing women students with greater opportunities for personal interactions with our students and alumnae," said Hayes. "Whether it was a phone call, the smaller receptions or an e-mail exchange, young women and their parents were able to have meaningful conversations with people who understand the dynamics of studying at this type of institution and have succeeded here. It is an important and effective message for us to communicate."

Students work to improve sanitation in developing countries

Megan McRainey Institute Communications and Public Affairs

When given a choice this summer between helping out with designs for environmentally friendly luxury condos less than a mile away from campus and designing and building solar latrines to improve sanitation in Bolivia, Georgia Tech undergraduate student Calvin Johnson chose the latrine project without hesitation.

"Are you sure?" pressed Kevin Caravati, a student project advisor and senior research scientist at the Georgia Tech Research Institute. "The other project is right down the street."

But Johnson, who is also an All-American wide receiver on Tech's football team, was brief and to the point. "I want to help the less fortunate," he said.

He began work the next day on designs for an inexpensive dry latrine system that could provide schoolchildren in remote areas of Bolivia with much needed basic sanitation facilities that use the sun's rays to safely transform bacteria-laden waste into fertilizer.

"You realize how fortunate you are when you see that people around the world don't have clean water and sanitation," Johnson said.

Four billion people globally suffer from chronic waterborne disease, and an estimated 13 million children die annually of diarrhea — conditions linked to a lack of adequate sanitation. In a developing country with extreme conditions like Bolivia, poor sanitation poses a serious health risk, contaminating the limited water supply and attracting disease-carrying insects.

Emory University's Center for Global Safe Water approached Tech's School of Civil and Environmental Engineering and GTRI to help remove a sanitation roadblock faced by developing countries — the design and cost flaws of current United Nations latrines.

"We wanted help with the project, but it was tough to find students enthusiastic about latrines," Caravati said.

Johnson was joined by his project partner Brad Davis, a building construction undergraduate student, and the two hammered out a final design with Caravati. The goal was to create an improved solar latrine out of the most affordable and available materials. The waste needed to be heated by the sun to a temperature that would kill pathogenic bacteria, but the design and materials had to be as simple as possible.



Georgia Tech undergraduates Calvin Johnson and Brad Davis stand with Christine Moe and Robert Dreibelbis of Emory University's Center for Global Safe Water as they build a solar latrine prototype. The lack of water and infrastructure contribute to millions of deaths annually from inadequate water supplies and poor sanitation practices.

"We focused on designing the most inexpensive and durable model, taking into account what materials would be readily available in those nations," Davis said.

The team made two prototypes from a hodgepodge of household items including a bicycle tube to insulate the waste and retain heat, a bleach bottle, Plexiglas, scrap wood and tin foil. The central idea was to "bake" the waste with an oven-like design that could reach temperatures of more than 150 degrees Fahrenheit while still keeping the inhabited area cool enough for users.

Johnson, Davis and Caravati built two very effective prototypes that would cost only \$78 per unit, compared to \$120 for existing models. In an area where families make less than \$3 per day, that cost difference could make the latrines available for schools, villages and families.

With the initial prototypes completed, the team plans to travel in January to a remote area of Bolivia's Andes Mountains to build several of the new latrines and instruct locals on how to build their own.

"It has been a great experience for Calvin and me to design and build a latrine that has the ability to vastly improve sanitation throughout the developing world," Davis said.

Chair, cont'd from page 1

Although Dickerson's research as a professor in Tech's School of Mechanical Engineering was in manufacturing automation, he has experience in the field of transportation. He served a year with the office of the Secretary for the U.S. Department of Transportation, started a successful bus and vanpool service in metro Atlanta in 1975 and once taught the graduate urban transportation course in civil engineering.

Dickerson's long history of philanthropy and service at Georgia Tech includes serving as an Alumni Association trustee. He is a member of the Phoenix Club, the President's Council and the Hill Society, and also regularly contributes to the Machine Vision Fund within the School of Mechanical Engineering. In December 2004, he was named an honorary alumnus by the Georgia Tech Alumni Association for his work as a nonalumnus on behalf of the greater good of Georgia Tech. He holds several patents that have been the basis for Georgia Tech spin-off companies in robots and machine vision for manufacturing applications.

"The establishment of the Frederick R. Dickerson Chair is a significant step for the school," states Joseph Hughes, CEE school chair. "To continue to compete at the highest levels and solve the world's largest infrastructure problems, we need to have endowments in place that allow innovative faculty to work with their students on asking new questions and creating new solutions. Steve Dickerson is a shining example of an academic who utilized creative thinking to create success through the formation of patents and companies. Whoever steps in as the Frederick R. Dickerson Chair can learn a lot from looking at Steve's experiences."

IN BRIEF:

Tech starts NCAA certification

Georgia Tech is gearing up for its 10-year NCAA certification review, a self-study and a campus site visit by the NCAA Committee on Athletics Certification.

Athletics certification is meant to ensure the NCAA's fundamental commitment to integrity in intercollegiate athletics, and consists of three subcomponents: academic integrity; equity and student-athlete welfare; and rules compliance.

President Wayne Clough has appointed Jack Lohmann, vice provost for Institutional Development, to chair Georgia Tech's executive and steering committees. The executive committee members are the three subcommittee chairs — Ivan Allen College Dean Sue Rosser (Equity and Student-Athlete Welfare); School of Mathematics Chair Tom Trotter (Academic Integrity); and Regents' Professor David McDowell (Governance and Commitment to Rules) — as well as Athletics Director Dan Radakovich and Sue Allen, executive assistant to the president.

The kick-off meeting of the steering committee and three subcommittees will be at 8:30 a.m. on Sept. 8 in the Piedmont Room of the Student Center Commons.

Board of Regents best practices competition cancelled

The Board of Regents (BOR) has announced the cancellation of their annual Best Practices competition. According to William Bowes, vice chancellor for Fiscal Affairs, "Chancellor (Erroll) Davis has decided to approach the issue of best practices within the University System of Georgia in a different manner."

The competition has been held for the past three years, and Georgia Tech has received one first place and two second place awards.

"Although we are disappointed that the BOR contest has been discontinued, this decision increases the importance of our annual Georgia Tech Best Practices Challenge," said Hal Irvin, executive director of Organizational Development. "Tech's contest focuses on identifying departmental best practices in four areas: people strategies, research, finance and Institute operations, academic and student services and information technology and provides a great way to showcase the innovation that is occurring everywhere on campus."

The 2006–07 Georgia Tech Best Practices Challenge will kick off in November, For additional information, including all of Tech's BOR entries, visit **www.orgdev.gatech.edu/bp**.

Panel discussion on avian flu

The Georgia Tech Pandemic Influenza Task Force and Student Government Association sponsoring an avian influenza briefing to provide Georgia Tech faculty and students with an overview of the potential threat posed by a flu pandemic and to provide information on preparation efforts being made by Georgia Tech, local hospitals and county, state and federal authorities.

The briefing, to be held Monday, Sept. 18 at 6 p.m. in the Student Center Theater, will include participants representing the Georgia Emergency Management Agency, the Fulton County Department of Public Health and Wellness, the Emory University School of Medicine and Georgia Tech Health Services. For more information, e-mail

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