

Bulletin

of the

CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING



Volume 33,2 / Summer-Fall 2018

Soaring into the Future: A New Age of Autonomous Flight

Flying can be exhausting. Not just for harried passengers racing to make connecting flights, but also for pilots who do not have the benefit of an autopilot to control many key functions of flight. In a keynote address on “Autonomy in Aviation: Past, Present and Future,” presented at the 43rd Annual Meeting and Dinner of the Connecticut Academy of Science and Engineering in May, CASE member Michael Francis, former Chief, Advanced Programs and Senior Fellow at the United Technologies Research Center (UTRC), reviewed the history of autonomous flight and offered a glimpse into the future of this technology.

According to Francis, in the earliest days of flight, at the start of the 20th century, the pilot alone manually controlled every detail including altitude, direction, and speed and even assured stability. “Pilots could literally wear themselves out in a short period of time,” he noted. However, new inventions like the “gyrocompass” developed in 1908 by the prolific American inventor Elmer Sperry, paved the way for the first autopilot for aircraft, developed by his son Lawrence. Since Lawrence Sperry’s invention, there have been vast technological developments providing new capabilities, reducing pilot workload, and allowing for sophisticated operations unimaginable to early pilots. Now, the start of another technological era is underway. Today, we are rapidly advancing towards autonomous aircraft—planes that largely fly themselves. However, Francis points out that, before these new technologies can fully take flight, we “must find a way to trust the machine’s intelligence.”

During the 1990s, Francis worked for the Defense Advanced Research Projects Agency (DARPA) which, he notes, was “created in the aftermath of Sputnik so the United States wouldn’t ever again be technologically surprised.” Over the years, DARPA’s high risk-high payoff research led to many familiar advances: creating the first computer network, ARPANET, which formed the basis of the Internet; introducing the Defense Department to stealth technology; and exploring unmanned aircraft technology. Although early unmanned aerial vehicles (UAVs) were essentially sophisticated radio controlled airplanes, operated by a pilot on the ground, these machines have evolved to incorporate a high level of autonomous functionality.

As Francis points out, people tend to think of autonomous aircraft as something absolute—either there is a pilot in charge or a computer in charge. In fact, autonomy is a progressive condition; its level of influence and control increases with every technology breakthrough. Autonomous flight has not yet reached its absolute end state but has a long and deep history beginning with Sperry’s autopilot. For example, in 1933, legendary pilot Wiley Post flew solo around-the-world, accompanied only by “Mechanical Mike,” a then state-of-the-art autopilot that incorporated a radio compass. He completed his flight in eight days, one less than his prior circumnavigation accomplished three years earlier with co-pilot Fred Noonan. Later, with the advent of World War II, an autopilot was used to improve bombing accuracy

(See Flight, page 2)

From the National Academies

The following is excerpted from press releases and other news reports from the National Academies of Sciences, Engineering and Medicine (www.national-academies.org).

◆ ‘Vital Directions for Health and Health Care’

This initiative of the National Academy of Medicine began with a symposium in September 2016, to identify “the most promising opportunities for improving health and health care.” Created explicitly as a guide for the incoming Administration, this special publication, released in March 2018, includes an overall synthesis by a steering committee together with 19 discussion papers organized around three overarching goals: Better Health and Well-Being; High-Value Health Care; and Strong Science and Technology. Among the 19 topics addressed are: Systems Strategies for Better Health Throughout the Life Course; Addressing Social Determinants of Health and Health Disparities; Preparing for Better Health and Health Care for an Aging Population; Payment Reform for Better Value and Medical Innovation; Workforce for 21st Century Health and Health Care; Information Technology Interoperability and Use for Better Care and Evidence, and Training the Workforce for 21st Century Science.

nam.edu/initiatives/vital-directions-for-health-and-health-care/

◆ Securing the Vote: Protecting American Democracy

To protect the integrity and security of US elections, all local, state, and federal elections should be conducted using human-readable paper ballots by the 2020 presidential election, says a

(See NAS, page 7)

At Talcott Mountain Science Center: Inspiring Love of Learning for 50 Years

For fifty years, the Talcott Mountain Science Center has been inspiring students with a love of learning through hands-on discovery and engagement. Perched atop Talcott Ridge, the Talcott Mountain Science Center is an educational icon that has become known for its unique approach to engaging students in the classroom.

Saturday, summer and vacation programs attract children in kindergarten through eighth grade from all corners of Connecticut and beyond. Talcott’s science educators also bring hands-on, dynamic, authentic science activities into area schools and classrooms.

Connecticut’s premier independent school for gifted and talented students in grades K through 8, Talcott Mountain Academy, focuses on hands-on learning and offers an innovative curriculum that weaves together all aspects of education into an integrated learning experience.

(See Talcott Mountain, page 7)

and minimize collateral damage to civilians. According to Francis, “the auto-pilot enabled sustained precision for control and navigation. The technology continued to improve and worked its way into commercial aircraft and even general aviation aircraft by the early 1970s.”

Francis points out that “aircraft instruments in the 1940s and ‘50s were based on an analog electronics technology, since early digital computers were too cumbersome, heavy and unsuitable for use in aircraft of that day.” With the onset of the Information Age, programmable computer-based electronics were developed and the number of functions that could be performed dramatically increased. This technology was added incrementally to improve auto pilot control and navigation, increasing precision while further reducing pilot workload.

The introduction of the digital computer also enabled new capabilities, such as Fly-by-Wire (FBW) flight control systems. FBW provides a control capability whereby the “pilot tells the computer what he wants to do through cockpit control movements, and the computer decides how to do it.” In essence, Francis explains, the computer functions like a “translator between pilot and plane. The pilot might say I want the plane to turn to the right and the computer makes the judgement about how to accomplish the turn.” The 1964 Apollo Lunar Landing Research Vehicle is considered by many to be the first FBW flight vehicle. In the late 1980s, Airbus developed the first commercial aircraft to employ FBW technology.

FBW technology allowed for blended controls useful in military

aircraft like the General Dynamics F-16 Fighting Falcon, as it permitted greater maneuverability and agility. DARPA’s experimental X-31 fighter demonstrator used FBW to integrate vectored thrust and conventional controls, enabling the aircraft to break the aerodynamic stall barrier and permitting a level of maneuvering agility not before seen in a combat aircraft. Francis emphasizes that “the over-arching message with FBW is that the computer adds a level of precision and flexibility not possible with earlier technologies. These attributes underscore the dominant role that the digital computer now plays in a large range of functions that enable flight.”

Today, digital computers are pervasive in modern military and commercial aircraft, where they are used for functions ranging from flight control and navigation to the detection and mitigation of problems that can occur in flight. A complex machine like an aircraft has many variables to consider, and with current technology, computers can be used to automate functions such as avoiding terrain, optimizing maneuver performance, or conducting contingency route planning due to weather conditions.

With today’s unmanned aircraft used in military operations, autonomy is not optional, but required. The remote crew in charge of the aircraft may be a long distance away, connected by radio communications through a satellite link, and unable to control the aircraft in real time. Therefore, the UAV must be capable of managing itself – using pre-programmed instructions to turn, climb, descend and auto-navigate the flight route. The DARPA-Boeing X-45A, an early unmanned combat air vehicle (UCAV) demonstrator, was able to virtually conduct an entire mission autonomously, with minimal guidance from its remote human crew. UCAVs have successfully demonstrated autonomous in-flight refueling and takeoffs and landings on aircraft carriers.

Another class of aircraft motivating the revolution in autonomy encompasses those aircraft designed to operate at low altitudes, such as helicopters and the more recently introduced small unmanned air systems (sUAS) – perhaps the fastest growing segment of aviation today. The closer to earth a vehicle flies, the more complex the environment becomes, as low altitude atmospheric conditions and obstacles must be considered. While many of the rules that govern safety at high altitudes are time tested, this is not the case for low altitude operations, especially in dense, obstacle-rich environments such as those found in urban areas. High traffic operations around airports are also particularly challenging.

For helicopters, which do not require runways, urban centers and other constrained environments offer valuable market venues. The ability to avoid obstacles of all types, launch and land on a pitching, heaving small ship deck, and identify a safe landing zone in the event of an in-flight emergency are challenging tasks for the most seasoned pilots. Autonomous technologies are on the verge of being able to accomplish these tasks with greater confidence and precision. From 2011 to 2015, Francis initiated and guided Connecticut-based Sikorsky Aircraft’s autonomy research and development program that ultimately led to the MATRIX™ autonomous technology suite and Sikorsky’s Autonomy Research Aircraft (SARA). MATRIX technology enables autonomous tasks such as those noted previously. SARA functions as a flying test bed to develop and prove autonomous capabilities that can augment piloted aircraft or enable unmanned variants of these machines. One of Sikorsky’s goals is to exploit these technologies to develop a simple, intuitive controller so a non-pilot operator with minimal training could guide an unmanned helicopter to a safe landing using, for example, an iPad “app.”

The recent explosion in the use of sUAS, often referred to as drones in the media, is a powerful catalyst for advances in autonomy. In a few short years, entrepreneurs have spearheaded diverse civil and

(See Flight, page 8)

The Connecticut Academy of Science and Engineering

The purpose of the Academy is to “provide guidance to the people and the government of the State of Connecticut ... in the application of science and engineering to the economic and social welfare.”

OFFICERS OF THE ACADEMY

Baki Cetegen, President
UConn

Joann Sweasy, Vice President/President Elect
Yale School of Medicine

Regis A. Matzie, Secretary
Westinghouse Electric Company (ret.)

Edmond Murphy, Treasurer
Lumentum (ret.)

EXECUTIVE DIRECTOR

Richard H. Strauss

ASSOCIATE DIRECTOR

Terri Clark

EDITORS

Leon Pintsov, Executive Editor – Engineering
Pitney Bowes, Inc.

Mike Genel, Executive Editor – Medicine
Professor Emeritus of Pediatrics
Yale University School of Medicine
CASE President, 2008-2010

Amy R. Howell, Executive Editor – Science
Department of Chemistry
University of Connecticut

MANAGING EDITOR

Martha Sherman

The *BULLETIN* of the Connecticut Academy of Science and Engineering is published by the Connecticut Academy of Science and Engineering, Inc., 805 Brook Street, Building 4-CERC, Rocky Hill, CT 06067-3405. (860) 571-7143. acad@ctcase.org. www.ctcase.org. To subscribe, contact us by phone or email or subscribe on our web site. The Connecticut Academy of Science and Engineering is a private, nonprofit public-service organization established by Special Act No. 76-53 of the Connecticut General Assembly.

COPYING PERMITTED, WITH ATTRIBUTION

IN BRIEF

Science and Engineering Notes from Around Connecticut



Biomedical Research

HIV RESEARCH FIRM GETS STATE FUNDING. The **State Bond Commission** in February approved \$1 million in funding for Branford-based **ViiV Healthcare**, a bioscience company performing HIV research and medicine development. The company expects this expansion will allow it to retain 425 jobs and add 45 new jobs within five years. ViiV Healthcare supports science and research for development of new medications for people living with HIV.

CT ORGAN IMPLANT BIOTECH FIRM RECEIVES SBIR GRANT. **Biostage, Inc.**, a biotechnology company developing bioengineered organ implants to treat life-threatening conditions of the esophagus, bronchus and trachea, has been awarded a Fast-Track Small Business Innovation Research (SBIR) grant by the Eunice Kennedy National Institute of Child Health and Human Development (NICHD). The grant, to be released in two phases with potential total funding of \$1.7M, was announced this spring and will support Biostage's development and preclinical testing of its Cellspan™ Esophageal Implant (CEI) for treatment of pediatric esophageal atresia. Biostage's **Sumati Sundaram** and **Christine Finck**, Surgeon-In-Chief at **Connecticut Children's Medical Center**, are the principal investigators.

FARMINGTON FIRM SECURES \$2M IN FUNDING. **Azitra Inc.**, a Farmington-based company started in 2014 by **Yale University** scientists, secured \$2.15 million from a combination of sources including **Connecticut Innovations**, Bios Partners, a Texas-based venture capital firm specializing in early-stage biotechnology and medical device companies, and North Carolina-based KdT Ventures. Azitra uses genetic engineering to develop topical dermatological and skin care treatments, with human testing beginning later this year. The company's drug candidates include a treatment for eczema and ichthyosis vulgaris, a disorder that causes dead skin cells to accumulate in patches on the skin's surface.

NEW WCHN INSTITUTE ESTABLISHED WITH GIFT. This spring, **Western Connecticut Health Network (WCHN)** announced receipt of a significant gift from Ridgefield resident **Rudy L. Ruggles, Jr.**, to advance research at the **WCHN Biomedical Research Institute**. The Institute, founded in 2009, will be named **The Rudy L. Ruggles Biomedical Research Institute**. The facility features a 17,000-square-foot open-bench laboratory for developing therapies, medical procedures, and diagnostics including techniques to identify people at risk or likely to resist certain treatment regimens. Ruggles is on the board of trustees for the J. Craig Venter Institute and serves as an adjunct professor in its genomic medicine division.



Business & Industry

INFOSYS TO DEVELOP HARTFORD HUB. The **State Bond Commission** approved \$14 million in financing for **Infosys**, an India-based information technology company, to develop a new training and innovation hub in **Hartford** as part of a major expansion in the United States. In return for the state's investment, the company will create an estimated 1,000 jobs in Hartford by 2022. A global provider of information-technology and training services, Infosys is in the midst of shifting much of its training from India to the United States, where it is planning to open four or five hubs. The **Connecticut**

Technology and Innovation Hub will have a special focus on insurance, healthcare and manufacturing, focusing on smart underwriting, claims fraud, Internet of Things technology and the Cloud.

P&W ENGINE HONORED WITH ASME AWARD. The American Society of Mechanical Engineers (ASME) has designated **Pratt & Whitney's** Single Crystal Turbine Blade as a historic mechanical engineering landmark, recognized for its progression in mechanical engineering and aviation. The creation of the single crystal turbine blade began in the 1960s, when engineers **Maurice (Bud) Shank** and **Frank VerSnyder** at Pratt & Whitney worked to develop a new turbine blade with higher strength and heat resistance. This single crystal turbine blade became one of 260 ASME landmarks around the world, ten of them being in Connecticut.

GENERAL DYNAMICS TO INVEST IN ELECTRIC BOAT. **General Dynamics Electric Boat** announced this spring that it will invest \$850 million in its operations with up to \$83 million in assistance from the state. General Dynamics plans to add nearly 1,900 workers in Groton and New London over the next 17 years, bringing the workforce to more than 13,000. Production will increase to three new vessels a year by 2021, requiring a new dry dock in Groton for the construction of the new Columbia class of ballistic missile subs.

UTC TO BOOST HIRING, INVESTMENTS. In May, **United Technologies Corporation (UTC)** announced plans to hire 35,000 people and make investments of more than \$15 billion in research and development over the next five years. It launched a dedicated site, www.utcinvestingintheusa.com, to highlight investments in the United States. Employment opportunities will be available across all 50 states with the greatest hiring needs in Connecticut, Florida, and Georgia. Half of UTC's hiring will be in production and maintenance and half dedicated to professional and managerial positions, including engineering and technology development roles.

SEMA4 TO EXPAND CT PRESENCE. **Sema4**, a health information company providing advanced genomic testing, recently announced it would move its primary diagnostic testing laboratory from New York City to **Stamford**. Currently, Sema4 has two Connecticut locations including headquarters in **Stamford** and a laboratory in **Branford**. The **Connecticut Department of Economic and Community Development** will provide a \$6 million loan to support expansion of Sema4's Connecticut facilities, including relocation of its New York lab. The move is expected to create 408 jobs in Connecticut, bringing the company's job presence in Connecticut to more than 550 employees.



Communication

NET NEUTRALITY BILL DIES IN CT HOUSE. On May 4, by a single tie-breaking vote cast by **Lt. Gov. Nancy Wyman**, the **Connecticut State Senate** passed a bill intended to restore Connecticut's ability to prohibit internet service providers from blocking websites or charging them for faster delivery of their content, sending the measure to the **House** for consideration. The bill, which died after being neither debated nor voted on before the end of the legislative session, was a response to action by the Federal Communications Commission (FCC) scrapping former President Barack Obama's net neutrality regulations last year. More than two dozen states, including California, New York, Connecticut and

Items that appear in the In Brief section are compiled from previously published sources including newspaper accounts and press releases. For more information about any In Brief item, please call the Academy at (860) 571-7143, or contact us at acad@ctcase.org.

IN BRIEF

Science and Engineering Notes from Around Connecticut

Maryland, are considering legislation to reinstate net neutrality rules within their borders. Earlier this year, Washington became the first state to sign such legislation into law.

CLARITY NAMED AMONG BEST WORKPLACES. Earlier this year, the *Hartford Business Journal* and **Best Companies Group** named **Clarity Software Solutions, Inc.**, a healthcare communications company, as one of the Best Places to Work in Connecticut. This is the fourth time the company has been recognized for this award. Eligibility includes having at least fifteen employees and being in business for at least a year. Rankings look at workplace policies, practices, philosophy, systems, and demographics as well as the employee experience. Clarity is headquartered in **Madison** and serves various healthcare organizations throughout the country.



Education & Cognition

UTC SPONSORS NICEE EXPO. **United Technologies Corporation** was named the presenting sponsor of this year's **National Invention Convention and Entrepreneurship Expo (NICEE)**, which was held at the Henry Ford Museum of American Innovation in Dearborn, Michigan this spring. NICEE, founded by The STEMIE Coalition, an organization of youth invention and entrepreneurship programs, is in its third year of recognizing K-12 inventors and entrepreneurs.

UCONN RECEIVES FUNDING FOR TECHNOLOGY TRAINING PROGRAM. Earlier this year, the US Office of Energy Efficiency and Renewable Energy announced awards totaling nearly \$4 million to **UConn** at Storrs and the Georgia Tech Research Corporation to initiate traineeship programs for early-stage technology training in the area of advanced materials and process technologies for energy-related manufacturing. UConn will receive \$1.25 million over five years to implement a masters-level training program to fill workforce needs across industry, national labs, and universities, focusing on advancing critical science, technology, engineering, and math disciplines and competencies specifically relevant to the federal Advanced Manufacturing Office's mission to provide competitive, merit-reviewed funding opportunities designed to investigate new manufacturing technologies.

CT STUDENTS CONTINUE TO LAG IN MATH. The results of the 2017 National Assessment of Educational Progress (NAEP) indicate that Connecticut students do better in reading than math. "Math continues to be a challenge for us as a state," remarked **Ajit Gopalakrishnan**, chief of the **Connecticut State Department of Education's** performance office. He added that Connecticut has begun a program to improve math, but the new program did not impact testing results as it began after the 2017 NEAP testing.

NSF GRANT WILL FUND EFFORT TO CLOSE GENDER GAP IN ENGINEERING. In April, **Norwalk Community College (NCC)** was awarded approximately \$225K from the National Science Foundation (NSF) to close the gender gap in engineering occupations and encourage more women to study engineering in college. The three-year grant will fund an NCC initiative titled, Recruitment and Retention of Women in Engineering and Engineering Technology. NCC will use the funding to prepare a gender-diverse population of technicians for local industries and prepare more graduates to transfer to four-year colleges and universities for further education in engineering.

STEM LEADERSHIP AWARDS ANNOUNCED. This spring, the **Connecticut Science Center** recognized individuals and organizations in STEM (science, technology, engineering, and math)

who promote lifelong learning through science. Along with these **STEM Achievement Awards**, the **Petit Family Foundation Women in Science Leadership Award** is presented to a female leader who makes a significant effort to support other women and encourage girls' interests in STEM. This year's honorees were **Michele Dischino**, professor at **Central Connecticut State University**, who received the Petit Foundation award; **Sharon Gusky**, professor at **Northwestern Connecticut Community College**, who received the Science Center's Individual award; and the **Girl Scouts of Connecticut**, honored with the award for organizations.

UB NAMES NEW DEANS. CASE member **Tarek Sobh** is one of three new deans named to lead three new colleges as part of the **University of Bridgeport's** academic and administrative restructuring plan. Sobh was named dean of the **College of Engineering, Business and Education**, which includes the School of Engineering, the Ernest C. Trefz School of Business and the School of Education. He is also executive vice president for the university. **Manyul Im** will serve as dean of the **College of Arts and Sciences**, and **Carol Papp** will lead the **College of Health Sciences**, which includes the Fones School of Dental Hygiene, School of Nursing, College of Chiropractic, Physician Assistant Institute, Nutrition Institute, College of Naturopathic Medicine and the Acupuncture Institute.

GOODWIN COLLEGE MOBILE LAB TAKES TO THE ROAD.

Goodwin College began traveling with a 44-foot-long, 12-foot-wide trailer equipped with workstations and high-tech gear to visit schools and provide students with opportunities to explore jobs in manufacturing. In addition to visiting schools, the portable classroom also teaches new skills to workers or enhances knowledge. The lab includes storage boxes, 13 workstations, soldering equipment, a borescope that can identify defects in pipes, 3D printing equipment and devices that measure material fatigue.



Energy

ECONOMIC BENEFITS OF ENERGY EFFICIENCY MEASURES

CITED. According to the 2017 *Programs and Operations Report* from the **Connecticut Energy Efficiency Board**, every dollar invested in energy efficiency in Connecticut generates \$7 for the state's economy. The report, issued in March, concludes that energy efficiency improvements in 2017 will save Connecticut homeowners, renters, cities and towns, and businesses more than \$841 million over the life of those measures. In 2017, the program, marketed under the brand "Energize Connecticut" and financed by a small charge on customer's electric and natural gas bills, generated 34,000 jobs, added \$1.4 billion to the gross state product, completed more than 94,000 residential energy efficiency projects and rebates, performed energy-efficient improvements to nearly 27,000 multifamily units, partnered with businesses, non-profits and public sector customers to improve building efficiency, and delivered lifetime energy savings of 4.2 billion kWh of electricity, 97.8 million cubic feet of natural gas, and 29.3 million gallons of fuel oil and propane.

BETHEL CELEBRATES COMPLETION OF SOLAR FACILITY. The town of **Bethel** completed a solar photovoltaic ("PV") facility in June. Town officials worked with Massachusetts-based Ameresco to develop the project under a 20-year Power Purchase Agreement. Ameresco will operate and maintain the system to ensure optimal energy production. Bethel's solar farm includes 2,900 PV panels totaling 947.7 kW direct current, designed to generate over 1.2 million kWh of renewable electricity each year. It is connected to the local utility distribution system, reducing annual CO₂ emissions by 934 metric tons.

IN BRIEF

Science and Engineering Notes from Around Connecticut

CT VW SETTLEMENT TO FUND CLEAN AIR PROJECTS. On June 4, **Governor Dannel P. Malloy** announced that Connecticut would make the \$7.5 million the state receives from the national legal settlement in the Volkswagen emissions scandal available to fund clean air projects. The funds will reimburse projects that replace, repower or retrofit an array of aging diesel mobile sources and/or non-road equipment. Both non-government and government entities were eligible to apply for funding to implement the projects; eligible projects must reduce nitrogen oxide (NOx) emissions across the state. The **Connecticut Department of Energy and Environmental Protection** is administering the program.

CT COMMITS TO FUEL CELL PROJECTS, OFFSHORE WIND. Connecticut recently made a commitment to fund four major fuel cell projects in **Colchester, Derby, Hartford** and **New Britain**, doubling the capacity of fuel cells in Connecticut. In the state's first procurement of offshore wind, the **Connecticut Department of Energy and Environmental Protection** also purchased 200 MW of offshore wind from the Deepwater Wind project off the coast of New London that can power about 100,000 homes.

20 MW FUEL CELL IN NEW BRITAIN. **Governor Dannel P. Malloy** announced plans to build a 20 MW fuel cell at the **Energy and Innovation Park** housed at the vacant **Stanley Black & Decker** industrial site in **New Britain**. **Mark Wick**, a partner with the park, said the \$1 billion project will support a new data center, infrastructure and IT equipment. In addition to creating 3,000 jobs, the project is expected to generate more than \$45 million for New Britain and \$200 million for the state over the next 20 years in tax revenue. The project is a joint venture of Stanley Black & Decker, Energy and Innovation Park, and Connecticut fuel cell maker **Doosan**.

NEW LAWS FOCUS ON RENEWABLE RESOURCES. 2018 legislation designed to reduce greenhouse gas emissions to 45% below 2001 levels by 2030, increase clean energy coming into the state and restrict certain coastal projects in consideration of projected sea rises were signed into law by **Governor Dannel P. Malloy**. The new laws mandate that 40% of the state's electricity come from renewable sources by 2030 and creates a new flat rate for solar power. **Robert Klee**, commissioner of the **Connecticut Department of Energy and Environmental Protection**, said the intent of these laws is to combat climate change and create clean energy jobs.



Environment

CLIMATE CHANGE EDUCATION BILL PASSES. **Governor Dannel P. Malloy** signed Public Act No. 18-181 that allows school districts to include "climate change consistent with the Next Generation Science Standards" as part of the science curriculum in Connecticut public schools. The act directs the **Connecticut Department of Energy and Environmental Protection** to be available to local and regional boards of education for development of climate change curriculum.

AQUARIUM REDUCES SINGLE-USE PLASTICS. The **Maritime Aquarium at Norwalk** has significantly reduced single-use plastics, including eliminating drinking straws and plastic bottles. Plastic silverware, coffee lids and food containers have been replaced with biodegradable substitutes. In the gift shop, plush animals are no longer stuffed with plastic beads, toys no longer have cellophane wrapping, and purchases no longer go in plastic shopping bags.

SPOTTED LANTERNFLY ALERT. **Deputy State Entomologist Victoria Smith** of **The Connecticut Agricultural Experiment Station** in New Haven expressed concern this spring about Spotted Lanternflies, an invasive insect originally from Asia. This insect has

been destroying apple and grape crops in other northeastern states over the past few years. Although not yet sighted in Connecticut, scientists are concerned that they will eventually arrive. The insects were first identified in the United States in 2014 in shipments of stones from Korea. They appear as fast-moving ticks when first born, then morph into adults resembling a yellow and red butterfly. Aside from weakening the host plant through feeding, their droppings and the secretions from feeding wounds attract bees, wasps and hornets, and encourage mold growth. They do not sting or bite.

HARTFORD TUNNEL PROJECT WILL ADDRESS FLOODING. A four-mile tunnel construction project that will provide for the separation of sewage wastewater and stormwater through the South End of **Hartford**, ending in **West Hartford** near New Park Avenue, is considered the largest single infrastructure project in Connecticut. The South End of Hartford, near Franklin Avenue and Wethersfield Avenue, has been prone to flooding for decades due to stormwater; the tunnel is designed to alleviate this problem. Costing more than \$250 million, the tunnel itself is the most expensive phase of a seven-year project. The tunnel will be funded by the **Connecticut Department of Energy and Environmental Protection** and **Metropolitan District** ratepayers.

NEW TICK, WEST NILE VIRUS WARNINGS. In August, **The Connecticut Agricultural Experiment Station** in New Haven warned that a new species of tick recently found in Westchester County, New York, could have made its way to Connecticut, posing a threat to the state's livestock. The "longhorned tick" is native to east Asia and was discovered in New Jersey last year. This year it was also confirmed in areas of Arkansas, New Jersey, North Carolina, Virginia, and West Virginia. Additionally, the **State Mosquito Management Program**, administered by the Station, reported "exceptionally high" numbers of mosquitoes carrying West Nile virus, noting that mosquitoes in 40 Connecticut towns had tested positive for the virus. "August and September are the months when people are at greatest risk of West Nile infection," said CASE member **Theodore Andreadis**, director of the Experiment Station, adding "We strongly encourage people in affected communities to take simple steps to prevent mosquito bites, such as using insect repellent and covering bare skin, especially during dusk and dawn when biting mosquitoes are most active."

WARMING CLIMATE FAVORS SPREAD OF ASIAN TIGER MOSQUITO. A recent report from the US Council on Environmental Quality reported the invasive and aggressive Asian Tiger mosquito, capable of infecting people with rare diseases like the Zika virus and dengue fever is expected to spread through almost all of **Connecticut** by 2040. The report further states, "Infection rates of West Nile Virus and other mosquito-borne diseases are likely to rise as a warming climate creates more favorable habitats for mosquitoes." The mosquito, *Aedes albopictus*, was first discovered in Connecticut in 2006, then not seen again until 2010, with rising numbers since then. It thrives in urban and suburban environments, readily feeds on humans, and can survive the winter in Connecticut.



Food & Agriculture

CT LEGAL FOOD HUB LAUNCHED. Two **Yale Law School** clinics—the **Ludwig Center for Community and Economic Development** and the **Environmental Protection Clinic**—helped launch the **Connecticut Legal Food Hub** this spring. The Hub, a collaboration between the two clinics and the Boston-based Conservation Law Foundation, is one of four such initiatives in the nation. It will serve as "a free legal services clearinghouse" to help

IN BRIEF

Science and Engineering Notes from Around Connecticut

low-income farmers, nonprofit organizations and food entrepreneurs navigate legal issues associated with food production and distribution.

CT KELP INDUSTRY GROWING. The **Connecticut Department of Agriculture** has licensed five new kelp farms in 2018. In 2013, **Bren Smith** established the nonprofit organization **GreenWave** to train new kelp farmers and provide them with two years of support. Kelp is low in calories yet high in iron, protein, and vitamins A, B and C. Demand from restaurants and food wholesalers is helping drive the industry. CASE member and **UConn** Professor **Charles Yarish**, one of the nation's leading kelp researchers, believes once the market is fully established, seaweed-derived biofuel could be produced for as little as \$80 a ton, considerably less expensive than corn- and wheat-derived biofuels, which trade at \$160 to \$190 per ton.



Health

LAST FLU SEASON DEADLIEST IN YEARS FOR CT. Connecticut's 2017-2018 flu season was the deadliest in years, with a total of 112 deaths from the flu, more than in the two previous seasons combined. The **Connecticut State Department of Public Health** reported that deaths associated with the flu totaled 57 in 2012-13, 46 in 2013-14, 48 in 2014-15, 37 in 2015-16 and 65 in 2016-17. The most recent national statistics show Connecticut is among 45 states where flu was considered widespread this past flu season.

YALE TEAM FINDS ANTI-BACTERIAL VIRUS. A team of **Yale** scientists and doctors identified an anti-bacterial virus, found in a Connecticut lake, that was used to successfully treat an 80-year-old doctor with a life-threatening antibiotic-resistant bacterial infection in his heart. The patient's physician, **Deepak Narayan**, was contacted by researcher **Benjamin Chan**, whose work focuses on bacteriophages and their effectiveness against drug-resistant infections. A bacteriophage known as OMKO1, found at **Dodge Pond** in East Lyme, destroyed the bacteria, *Pseudomonas aeruginosa*. Narayan is senior author of the paper, with co-author **Paul Turner**, Yale's Elihu Professor of Ecology and Evolutionary Biology. The findings appeared in the March 1 issue of *Evolution, Medicine, and Public Health*.

STUDY FINDS COMMUNITY TRAITS AND WELL-BEING LINKED.

A **Yale** study on health and wellness found that racially diverse neighborhoods, access to preventive care, and public transportation are all factors linked to well-being and quality of life. The study, which looked at more than 300,000 adults and examined data on 77 characteristics of counties across the United States related to demographics, clinical care, social and economic factors, and the physical environment, found significant correlations. The study, led by **Brita Roy**, assistant professor of medicine at the **Yale School of Medicine**, was published May 23 in *PLOS ONE*. CASE member **Harlan M. Krumholz** was senior author on the study.



High Technology

CTC HONORS WOMEN OF INNOVATION. The **Connecticut Technology Council** announced the winners of its **Women of Innovation** awards at its 14th annual Connecticut Technology Council Women of Innovation® Awards presentation in March. The winners included students, mentors, scientists and chief executives. CASE member **Susan J. Baserga**, professor of Molecular Biophysics & Biochemistry, Genetics and Therapeutic Radiology at **Yale University**, was recognized in the area of Research Innovation and Leadership as a pioneer in molecular biology for her research

on the formation of ribosomes and their relationship with certain diseases and cancers. Other winners included: **Margaret Steinbugler**, manager of materials analysis and mechanics at **Pratt & Whitney**; **Rishika Maitra**, a senior at the **Academy of Aerospace and Engineering** in Windsor; **Susan Meabh Kelly**, who won the Academic Innovation and Leadership Award; **Sarah E. Kelly**, vice president of Pharmaceutical Sciences at **Pfizer**; **Honey Reddi**, clinical laboratory director at **The Jackson Laboratory for Genomic Medicine**; **Marcia LaFemina**, president of the **Pennsylvania Globe Gaslight Company**; **Candace Freedenberg**, founder and president of **Untapped Potential Inc.** and **Ashley Kalinauskas**, founder and CEO of **Torigen Pharmaceuticals Inc.**

UConn LAB SPURS TECHNOLOGY INNOVATION. This spring, **UConn** announced that its **OPIM Innovate Lab** is open to all students, faculty and staff to provide hands-on experience with emerging technologies in business, including virtual reality, 3D printing, Internet of Things, microcontrollers, and data analytics devices. OPIM Innovate is located in the **Gladstein Research Laboratory** at the **School of Business**. Future technologies to be researched include drones, artificial intelligence, and blockchain. The lab has attracted private high schools, UConn's **Connecticut Transportation Institute**, and other external partners to visit and learn about emerging technology and how to teach it.

FIRST ENGINEERING-FOCUSED ENTREPRENEURIAL DEGREE PROGRAM ANNOUNCED. **UConn** announced a new Master's of Engineering in Global Entrepreneurship degree, the first engineering-focused entrepreneurial graduate degree in the state. The new master's degree program, a partnership between the **UConn Schools of Engineering and Business**, **Trinity College**, and the **University of New Haven**, is designed to help create a supportive environment for startups. Novice entrepreneurs will learn best practices and receive mentorship from veteran entrepreneurs. CASE member **Kazem Kazerounian**, dean of the School of Engineering, notes the importance of spreading a wide recruitment net to bring in the most talented students, regardless of their state or country of origin, much the way student-athletes are recruited.



Transportation

WATERBURY I-84 PROJECT TO FINISH AHEAD OF SCHEDULE.

On August 20, **Governor Dannel P. Malloy** announced the imminent completion of the I-84 widening project in **Waterbury**, with three eastbound lanes opening this week, and the three westbound lanes opening by mid-September—one year early. The \$330 million project involves the addition of a third travel lane and full width shoulders in each direction and safety improvements to a 2.7-mile segment of I-84 from Washington Street, east to Pierpont Road in Waterbury. "We are grateful to the City of Waterbury for working with us to develop and implement the detour at Harpers Ferry Road over the past eight weeks," **Connecticut Department of Transportation Commissioner James P. Redeker** said. "This allowed us to complete the necessary work in this vicinity in eight weeks rather than in eight months, as was originally planned."

CTDOT COMPLETES BRIDGE REPLACEMENT PROJECT. In June, the **Connecticut Department of Transportation** reopened the northbound lanes of the **West River Bridge** on Interstate 95 between New Haven and West Haven to traffic after a \$141 million replacement project. The southbound lanes reopened in April. The project began in 2014 and included three traffic lanes in each direction. Officials said full shoulders were added to help reduce

(See In Briefs, page 8)

Talcott Mountain *(from page 1)*

In addition to children's programs, Talcott has a number of learning opportunities that are open to the public and appropriate for all ages. Talcott Mountain Science Center has trained thousands of teachers in subjects like STEM/STEAM, computers and technology, elementary science, astronomy, meteorology, geology, field ecology and more.

With numerous telescopes and the largest teaching planetarium in Connecticut, Talcott hosts hundreds of people each year for their monthly Skygazing programs. Also popular is On the Shoulders of Giants—a forum for the general public to interact with and learn from Nobel Laureates, MacArthur Fellows and other award-winning experts. Past presenters include primatologist Jane Goodall; forensic pathologist Henry Lee; oceanographer Sylvia Earle; Nobel physicist Sheldon Glashow; and the first woman to walk in space, Kathryn Sullivan, to name but a few.

For more information about the Talcott Mountain Science Center's upcoming programs and events, visit tmsc.org.



Hands-on science is fun at Talcott Mountain! [Photo: Talcott Mountain Science Center]

From the National Academies *(from page 1)*

new report, *Securing the Vote: Protecting American Democracy*, from the National Academies. In addition, every effort should be made to use paper ballots in the 2018 federal election. Ballots that have been marked by voters should not be returned over the Internet or any network connected to it, because no current technology can guarantee their secrecy, security, and verifiability.

www.nap.edu/catalog/25120/

◆ Integrating Simulation Science and Data Science

Convergence has been a key topic of discussion about the future of cyberinfrastructure for science and engineering research. Convergence refers both to the combined use of simulation and data-centric techniques in science and engineering research and the possibilities for a single type of cyberinfrastructure to support both techniques. The National Academies of Science, Engineering, and Medicine convened a Workshop on Converging Simulation and Data-Driven Science on May 10, 2018, in Washington, DC. Speakers addressed the potential benefits and limitations of convergence as they relate to scientific needs, technological capabilities, funding structures, and system design requirements. This publication summarizes the presentations and discussions from the workshop.

www.nap.edu/catalog/25199/

◆ 'Open Science by Design'

According to a new report from the National Academies, *Open Science by Design: Realizing a Vision for 21st Century Research*, significant progress has been made in providing open access to scientific research, but a range of challenges—including the economics of scientific publication and cultural barriers in the research enterprise—must be overcome to further advance the openness of science. The report recommends coordinated action from the academic community and other research stakeholders, and the use of an "open science by design" framework to foster openness throughout the research process.

www.nap.edu/catalog/25116/

◆ Returning Individual Research Results to Participants

Current regulations prohibit return of laboratory results to individuals from laboratories other than those that are federally certified, which precludes sharing results from noncertified research labora-

tories. This consensus report recommends that, when conducting research involving testing of human specimens, investigators and their institutions should consider whether and how to return results on a study-specific basis and that relevant regulations be revised to respect the interest of research participants while balancing competing considerations of safety, quality and burdens of the research. To minimize the burden on research laboratories with constrained resources, sponsors, funding agencies and research institutions should facilitate access to resources, support training and development of laboratory infrastructure.

www.nap.edu/catalog/25094/

◆ Programs and Services for Children with Disabilities

Although there are a variety of services and programs to support children with disabilities and their families, achieving specific goals to prepare for adulthood and coordination of care within and across service sectors are essential to healthy growth and development. A new report from the National Academies outlines some of the limitations which create barriers to access and to the quality of services, including socio-economic and demographic disparities, state variation in implementation of federal programs, fragmentation of services, insufficient workforce capacity and development, inadequate transitioning to adult services and gaps in continuity of care, and makes a number of recommendations to improve services.

www.nap.edu/catalog/25028/

◆ New Report Identifies Promising Potential Breakthroughs in Food and Agriculture Science

A new report from the National Academies, *Science Breakthroughs to Advance Food and Agricultural Research by 2030*, identifies the most promising scientific breakthroughs that could have the greatest positive impact on food and agriculture, and that are possible to achieve by 2030 to increase the US food and agriculture system's sustainability, competitiveness, and resilience. The urgent progress needed today, given challenges such as water scarcity, increased weather variability, floods, and droughts, requires a convergent research approach that harnesses advances in data science, materials science, information technology, behavioral sciences, economics, and many other fields, according to the report.

www.nap.edu/catalog/25059/

commercial applications that range from a fixed wing drone that can deliver urgently needed medical supplies and devices to hard-to-reach locations such as Rwanda, to small quadrotor aircraft that can hover in close proximity to aging bridges, identifying structural flaws. Drones are being built to inspect windmills, power lines, railroad tracks, and in some cases may eventually perform repairs or take corrective action more quickly and safely than a human. Francis points out that “Yamaha developed an unmanned helicopter that can “nurture vineyards located in mountainous terrain not accessible to conventional farm equipment—dispensing pesticides and nutrients, enabling ‘precision agriculture’.”

These small machines, which typically weigh anywhere from a few ounces to over 50 pounds, pose a special challenge due to their limited payload weight, size and power. This limits the number and type of sensors and the amount of on-board computing power needed for operations in complex environments. The smallest of these, so-called micro air vehicles (MAVs), take this problem to another level. Designed to be agile, they are intended to interrogate the inside of structures and confined spaces. These environments often preclude the ability to communicate with a remote operator, necessitating a high level of machine autonomy; yet these MAVs are the least capable of hosting the equipment needed to operate effectively.

On a larger scale, unmanned vehicle concepts reaching the size of a Boeing 747, intended to fly freight more economically across transoceanic distances, are in early development. Significant potential savings are in operating costs, including training and proficiency that results from eliminating an onboard crew. Most recently, the concept of airborne commuter vehicles or taxis have garnered considerable interest and investment. Francis observes that “these pilotless airplanes, the flying equivalent of driverless cars, are being advocated by people who tend to be overly optimistic with respect to their introduction into operational use.” The technology required for safe, trusted autonomous flight operations needed for human transport in complex urban environments is not yet mature, although rapidly advancing artificial intelligence (AI) tools such as high level reasoning and machine learning provide optimism for the future. Those working in this field are generally young, creative,

technology-savvy people who see possibilities but are not yet biased by past experiences or failures.

Perhaps the greatest impediment to further increasing the level of aircraft operational autonomy lies in the limitations imposed by the current regulatory framework. Aside from the cumbersome nature of the testing-intensive approach in use since the earliest days of software systems, the fundamental regulatory philosophy and structure that persists appears to be incompatible with intelligent software. As Francis states, “Certifying human intelligence is different from certifying computer intelligence. We are at a place in the information revolution where machines can operate at high levels, but they cannot yet replicate the levels of judgment and decision making needed to cope with unforeseen contingencies.” Machines are not yet able to recognize unpredictable circumstances and pursue logic that allows adaptation to the arbitrary problem at hand. But even when intelligent software is able to achieve these levels, today’s software verification and validation (V&V) philosophy will likely prove to be inadequate. Current software V&V approaches assume that execution of a software program has a precise, a priori predictable outcome. A system capable of learning violates this assumption, since the learning process may lead to unpredictable outcomes, even if they turn out to be acceptable. “The approach to certification will likely have to change as a new alternative to trust machine intelligence is found,” Francis said.

And finally, cultural considerations need to be addressed. New technologies bring changes in costs and benefits. Consequently, conflict will arise between those that will benefit from the innovation and others that will be adversely affected by the loss of competitiveness and jobs, privacy issues, and other effects that accompany changes in the status quo. Perhaps the next generation will have access to flying “commuter cars.” These machines are not yet in our airspace, not entirely because of the technology involved, but because of the trust factor. Despite the limitations of current technology, progress in key areas such as sensors, algorithms and miniaturization has been phenomenal, and the prospects for achieving an acceptable level of autonomous capability for many diverse airborne applications are bright. Now it is time to soar into the future—and a new age of autonomous flight. — **Wendy Swift, freelance science writer**

In Briefs *(from page 6)*



Transportation (continued)

lane closures in the event of an accident or police activity. The 1,000-foot bridge first opened in 1958 and is one of the longest and most traveled in the state. More than 136,000 vehicles cross it every day.

CTRAIL HARTFORD LINE BEGINS SERVICE. The **CTrail Hartford Line** opened for service between **New Haven** and **Hartford**, and between **Hartford** and **Springfield** this spring. The \$755 million train line offers 17 round trips per day. The double-tracking is not complete in some areas, but **Connecticut Department of Transportation (CTDOT) Commissioner James Redeker** said the work is being scheduled as “positive train control” is delivered. Money for the completion of the rail line north of Hartford is in CTDOT’s five-year capital budget.

SOUTHWEST ADDS NONSTOP SERVICE FROM BRADLEY. Southwest Airlines began daily nonstop service between **Bradley International Airport** and St. Louis Lambert International Airport in August. This route is part of a larger trend for Bradley, which has seen an increase in its number of travelers for the fifth consecutive year.

AUTONOMOUS VEHICLE TESTING PILOT PROGRAM

LAUNCHES. In April, **Governor Dannel P. Malloy** announced the launch of a Fully Autonomous Vehicle Testing Pilot Program designed to bring autonomous vehicle developers to Connecticut. The program, created through legislation passed in 2017, requires any Connecticut town or city interested in participating in the program by allowing fully autonomous vehicles to be tested on its roadways to submit an application. Up to four municipalities will be selected for participation under the program, which is being administered by the **Office of Policy and Management** in consultation with the **Connecticut Departments of Motor Vehicles, Transportation, the Emergency Services and Public Protection, and Insurance.** Prior to completing an application, interested municipalities are encouraged to search for and partner with interested autonomous vehicle testers and to describe what they hope to achieve, why specific locations were selected, and “the municipality’s ability to safely oversee fully autonomous vehicle testing.” In addition, municipalities are required to conduct a public outreach campaign to notify local officials, first responders, the general public and local media outlets prior to testing. As of late June, the cities of **Stamford** and **Windsor Locks** had submitted formal applications, with officials in **Bridgeport, Manchester** and **New Haven** also expressing interest.

—Compiled and edited by Wendy Swift