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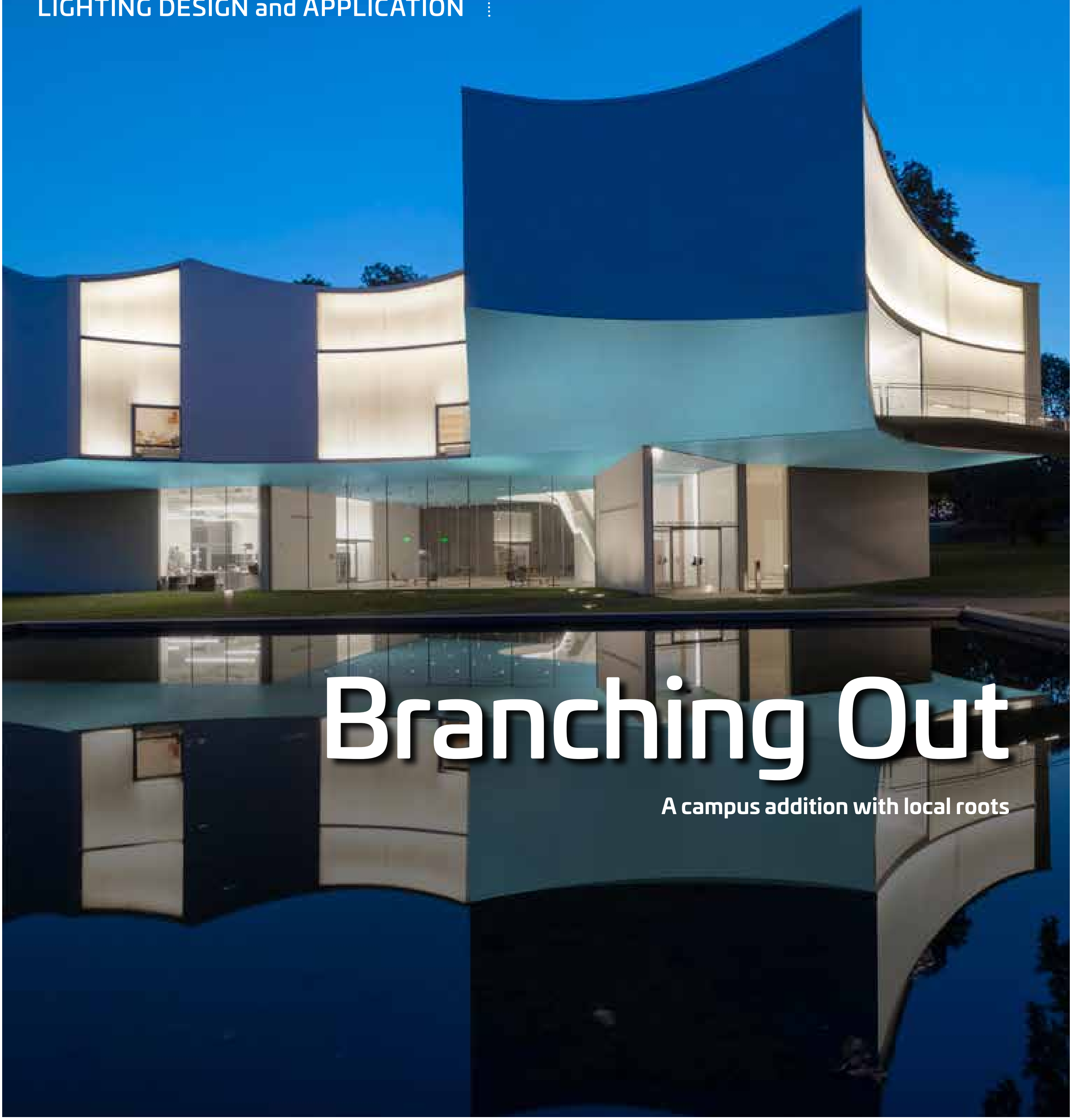

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Improving Airport Safety: New Research on Drone-based Photometry

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Airport and airfield lighting systems around the world have received major overhauls in the past two decades as a result of the transition to LED lighting and new research in vision science. Because of safety requirements and the highly specialized nature of aviation lighting in the U.S., the Federal Aviation Administration (FAA) sets standards for airport and airfield lighting and maintenance. Any upgrades or changes to FAA lighting standards are made only after careful evaluations, which are typically conducted by the FAA's research and development division in conjunction with university research experts.

Since 2005, the Lighting Research Center at Rensselaer Polytechnic Institute has been assisting the FAA to help the nation's airfields implement advanced, energy-efficient lighting solutions through technology and human factors research (*www.lrc.rpi.edu/programs/solidstate/aviation.asp*). Some of this research has helped in identifying the visual needs of pilots for accurately distinguishing signals and signs used in airport visual guidance applications, while other studies have assessed technologies and systems to aid in the development and deployment of new, LED airport lighting systems. Results from these studies have aided FAA in revising some of its publications such as Advisory Circulars (ACs) and Engineering Briefs (EBs).

While LED lighting has now made its way into the majority of U.S. runways and airfields, the FAA continues to pursue initiatives that will increase safety. One of these initiatives is the use of unmanned aerial systems (UAS), commonly known as drones.[1]

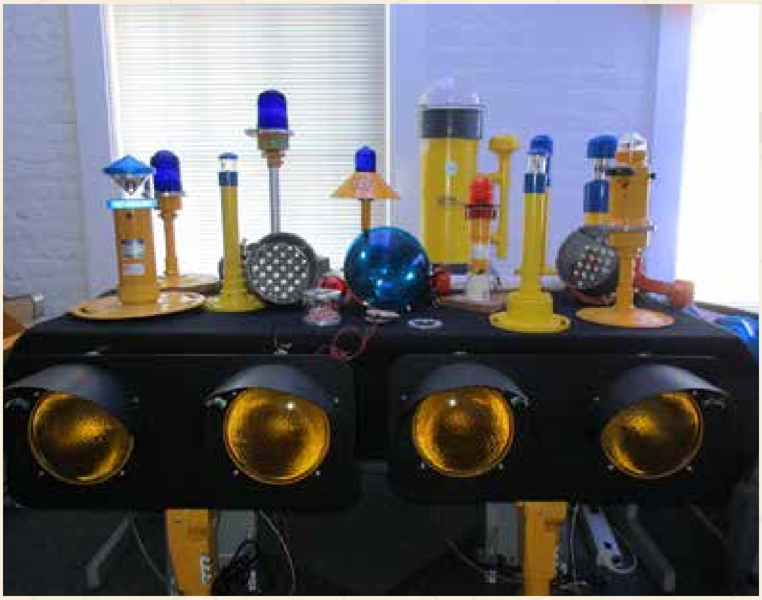
Because airfield lighting provides critical visual information to pilots, regular and timely maintenance is crucial to ensure safety. Beam intensity and chromaticity are required to stay within strict ranges that are set by FAA standards and depend upon the type of airfield fixture. Long-term LED life tests conducted by the LRC with runway edge, centerline and touchdown zone LED luminaires showed that fixtures can burn out, exhibit lumen depreciation beyond acceptable minimum values and exhibit chromaticity shifts outside of the FAA's white color boundary within a few thousand hours.[2] Under realistic applications, weather conditions (such as hot climates), dust, debris and rubber deposits on in-ground fixtures can exacerbate loss of photometric performance. A survey of airport administrators in the U.S. found that LED-based fixtures have been reported to burn out or become too dim. Despite this knowledge, the most common criterion for the replacement of an LED fixture is when the fixture emits no light.[3] One potential issue with this approach to maintenance is that even when the light is operational, its intensity may not be sufficient for pilots to clearly identify runway lights.

With the transition to LED lighting, airport operations personnel are tasked with regularly checking the operation of airfield fixtures. Understandably, airport maintenance is expensive, time consuming and dangerous. While maintenance crews can perform daily checks to ensure that all light fixtures are operational, there is no practical way that their intensity is within spec. For this purpose, periodic inspections are needed. In typical practice, a photometric measurement device is attached to a vehicle that is driven around the airfield to take measurements from each light fixture. The photometer's mounting position must be changed manually for each fixture type due to the range of fixture heights. This method is time consuming, expensive, and has potential for inaccurate measurements. With UAS, however, photometric measurements could be streamlined because a UAS-mounted photometer can be flown easily at any height and may not conflict with other maintenance operations or require taxiway or runway closures.[4]

Photo: Courtesy of LRC

An airfield luminaire set up in the LRC's mirror goniophotometer for intensity distribution measurement.

For the past year, the LRC has been researching the feasibility of using a UAS-based system for field photometry. The goal is to solve existing challenges to obtain accurate measurements and optimize the time it would take to characterize a light fixture in the field. Field characterization of a fixture's beam intensity distribution can be achieved by measuring the illuminance produced by the light fixture on a projected vertical plane in front of it. Paired with the distance and angular displacement between the photosensor and the light fixture, it is possible to derive intensity as a function of angle using the inverse square relationship. In a laboratory setup, it is possible to control for variables that have an impact on the accuracy of the measurements, such as fixture-to-sensor positioning, fixture thermal stabilization and inter-reflections, to name a few. In the field, these variables are more difficult to



Sample lighting systems used in airport runways and taxiways for visual guidance.

control, beginning with how to measure the distance and angular position of the light sensor with respect to the fixture.

To investigate this last point, LRC researchers have set up a Global Navigation Satellite System (GNSS) receiver as the basis to determine the location of the photosensor relative to the light fixture. As part of the study, the LRC set up a base station capable of streaming real-time kinematic (RTK) correction data to a rover antenna. The LRC has conducted several experiments to determine the uncertainty of the distances measured between the base station and the rover antenna. Results in the laboratory have shown that the standard deviation of earth-centered, earth-fixed (ECEF) coordinates can be in the ±1 cm range but up to ±10 cm. As expected, the uncertainty in the vertical direction is higher than for the horizontal axes. Additional studies are being conducted to determine the optimum test distance between the photosensor and the light fixture to minimize the errors in luminous intensity due to uncertainty in measured distance. Data from an inertial measurement unit (IMU), similar to what is used in phones, provides the orientation of the photosensor to complete all angular information needed to optimize the flight path of a drone to characterize a light fixture in airports. Field validation studies are planned as next steps.

In the future, we anticipate that there will be a considerable number of opportunities to use newer technologies, such as UAS, in conjunction with lighting science to help improve safety and operations at U.S. airports. ◎

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