Purdue SAFE-RWSL surveillance system built to prevent airport runway incursions

Patent-pending, solar-powered system activates lights using widely available ADS-B data and computer vision modeling

A prototype camera module was installed as part of the SAFE-RWSL — or Simple, Affordable, Flexible and Expandable Runway Status Lights — system at the approach end of a runway at Purdue University Airport. Purdue researchers John Mott and Luigi Dy developed SAFE-RWSL as a low-cost, easy-to-integrate option for airports of varying capacities to improve runway safety and reduce risks of incursions. (Purdue University photo/Luigi Dy)

DECEMBER 16, 2024 | STEVE MARTIN SHARE

WEST LAFAYETTE, Ind. — Researchers in the Purdue Polytechnic Institute have developed a patent-pending, economically viable, simplified light system to automatically indicate an airport runway's status to pilots, pedestrians and vehicle operators.

The solar-powered system is called Simple, Affordable, Flexible and Expandable Runway Status Lights, or SAFE-RWSL. It uses automatic dependent surveillance-broadcast (ADS-B) data and computer vision to activate runway lights in real time.

John Mott is a professor and Luigi Dy is a doctoral student in Purdue University's School of Aviation and Transportation Technology. They developed SAFE-RWSL and disclosed it to the Purdue Innovates Office of Technology Commercialization, which has applied for a patent to protect the intellectual property.

The research will be presented Jan. 8 at the 2025 Transportation Research Board Annual Meeting in Washington, D.C., during a session titled "Managing the Safety Impact of Transformational Changes on Aviation."

A six-minute presentation about SAFE-RWSL in its earliest prototype form is available on Dy's YouTube channel. His dissertation that covers the human-factor issues related to the effectiveness of SAFE-RWSL is published online.

"Based on the performed study, the use of simplified runway status lights is expected to be effective at reducing runway incursion risk in nontowered, no-traffic environments when a conflicting aircraft is difficult to see," he said.

Industry partners interested in developing or commercializing SAFE-RWSL should contact Matt Halladay, senior business development manager and licensing manager — physical sciences, at mrhalladay@prf.org about track code 70016.

Limitations of traditional runway surveillance systems

Radar-based detection systems are the current standard to prevent runway incursions. The cost usually limits their use to larger airports; the current baseline system costs tens of millions of dollars.

“Small airports generally rely on simple ‘see-and-avoid’ procedures or, in limited cases, air traffic controllers to prevent these incursions,” Mott said. “Without a comprehensive approach that incorporates technology, however, even the most vigilant pilots and air traffic controllers, if available, can’t prevent all potential accidents resulting from encroachments on an active runway by pedestrians, ground vehicles or other aircraft.”

Current systems used for runway surveillance also can be complex to implement. They often require expensive infrastructure such as electrical systems, pavement reconstruction, or additional equipment installed in aircraft and vehicles.

“ADS-B technology is already mandated for aircraft in most types of U.S. airspace, making it widely available,” Dy said. “As a result, the SAFE-RWSL system is a low-cost, easy-to-integrate option for airports of varying capacities to improve runway safety and reduce risks of incursions.”

Testing and next development steps

The prototype SAFE-RWSL system has been tested at Purdue University Airport, the country’s first university-owned airport. It serves commercial airline passengers, passenger and cargo charters, and military operators.

To evaluate the effectiveness of the SAFE-RWSL’s ADS-B component, Mott and Dy observed 123 aircraft operations and compared them to detections.

Contents of the camera module prototype in the SAFE-RWSL system developed by Purdue researchers John

Mott and Luigi Dy. (Purdue University photo/Luigi Dy)

"The system accurately detected 94% of aircraft, including all operations involving ADS-B-transmitting aircraft. It also sufficiently provided timely runway status information despite being in airspace where ADS-B is not required," Dy said.

To train, develop and evaluate the effectiveness of the SAFE-RWSL's computer vision component, Mott and Dy utilized a sample of recorded images of aircraft operations. Based on almost 3,400 seconds of ground operations, the system accurately detected 94% of operations.

"Using object detection and filtering algorithms, the computer vision software designed to run on solar-powered modules was able to detect 110 out of 110 approaching aircraft, while providing sufficient time to indicate potential traffic conflicts," Dy said. "Our next step to develop the computer vision subsystem of SAFE-RWSL is to conduct live tests of aircraft on runways."

Mott and Dy have also conducted economic feasibility projections on the system.

"We estimate a production SAFE-RWSL system to cost no more than an order of magnitude less than existing systems, enabling it to be applicable to more airports than existing systems," Dy said. "Initial projections showed an expected 10-year benefit-to-cost ratio of 2.37."

Mott and Dy are developing a second-generation prototype to demonstrate to stakeholders.

"We hope to get further funding from interested parties to continue to improve and test the system in different environments," Dy said. "We hope that the system will eventually be accepted by the Federal Aviation Administration as a solution for runway incursion mitigation."

Mott, Dy and McClane Rush, an alumna who earned her master's at Purdue in 2022, won the 2021-22 University Design Competition of the Airport Cooperative Research Program (ACRP), a program of the Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine. Dy also received an ACRP Graduate Research Award for the research.

About Purdue Innovates Office of Technology Commercialization

The Purdue Innovates Office of Technology Commercialization operates one of the most comprehensive technology transfer programs among leading research universities in the U.S. Services provided by this office support the economic development initiatives of Purdue University and benefit the university's academic activities through commercializing, licensing and protecting Purdue intellectual property. In fiscal year 2024, the office reported 145 deals finalized with 224 technologies signed, 466 invention disclosures received, and 290 U.S. and international patents received. The office is managed by the Purdue Research Foundation, a private, nonprofit foundation created to advance the mission of Purdue University. Contact otcip@prf.org for more information.

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Purdue University is a public research institution demonstrating excellence at scale. Ranked among top 10 public universities and with two colleges in the top four in the United States, Purdue discovers and disseminates knowledge with a quality and at a scale second to none. More than 105,000 students study at Purdue across modalities and locations, including nearly 50,000 in person on the West Lafayette campus. Committed to affordability and accessibility, Purdue's main campus has frozen tuition 13 years in a row. See how Purdue never stops in the persistent pursuit of the next giant leap — including its first comprehensive urban campus in Indianapolis, the Mitch Daniels School of Business, Purdue Computes and the One Health initiative — at https://www.purdue.edu/president/strategic-initiatives.

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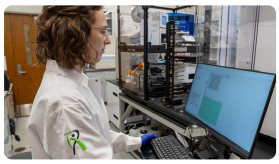

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