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Tech Notes

Runway Status Lights

To prevent incursions on airport runways, MIT Lincoln Laboratory developed a status lights system that uses existing airport surveillance technology in conjunction with advanced data-fusion techniques and state logic.

The National Air Traffic Controllers Association estimates that 87,000 flights—commercial carriers, private planes, air taxis, air cargo carriers, and military aircraft—are in U.S. airspace each day. As each of those flights must take off and land, the potential for runway collisions is great. Although the domestic aviation system in the United States is one of the safest man-made transportation systems ever implemented, accidents still occur.

Preventing runway incursions that lead to accidents has been on the National Transportation Safety Board's "Most Wanted List" for nearly two decades, and it is a priority for the Federal Aviation Administration (FAA) and the Department of Transportation as well. To help prevent impending incursions, MIT Lincoln Laboratory developed the Runway Status Lights (RWSL) system, a highly automated system that directly alerts pilots and vehicle operators of potential risks.

The RWSL system, developed for the FAA, alerts pilots when a runway is unsafe by turning on special red lights, embedded in the runway pavement, that are fully visible to pilots and nearby personnel (Figure 1). The lights are controlled by safety logic that automatically processes surveillance information from a preexisting surveillance system. The system serves as an independent backup to the clearances issued by air traffic controllers, issuing alerts rapidly to all aircraft approaching an intersection at which a collision may be imminent.

RWSL Operational Concept

RWSL comprises three types of lights to maximize effectiveness in preventing accidents arising from runway incursions (Figure 2):

Runway Entrance Lights (RELs), placed at runway/taxiway intersections, signal the pilot that it is unsafe to enter or cross a runway because it is currently or will soon be occupied by high-speed traffic such as an aircraft taking off or landing.

Takeoff Hold Lights (THLs), placed on runways at departure positions, indicate that it is unsafe to take off because the runway ahead is occupied by another aircraft.

Runway Intersection Lights (RILs), placed on runways approaching an intersection, signal a pilot in a takeoff or landing roll to stop because the intersection ahead is unsafe to enter or cross.

RWSL determines the locations of aircraft and vehicles on the airfield, as well as of planes arriving or departing, on the basis of

Figure 1. The RWSL warning signals illuminate red when a runway or intersection is unsafe for an aircraft to enter.

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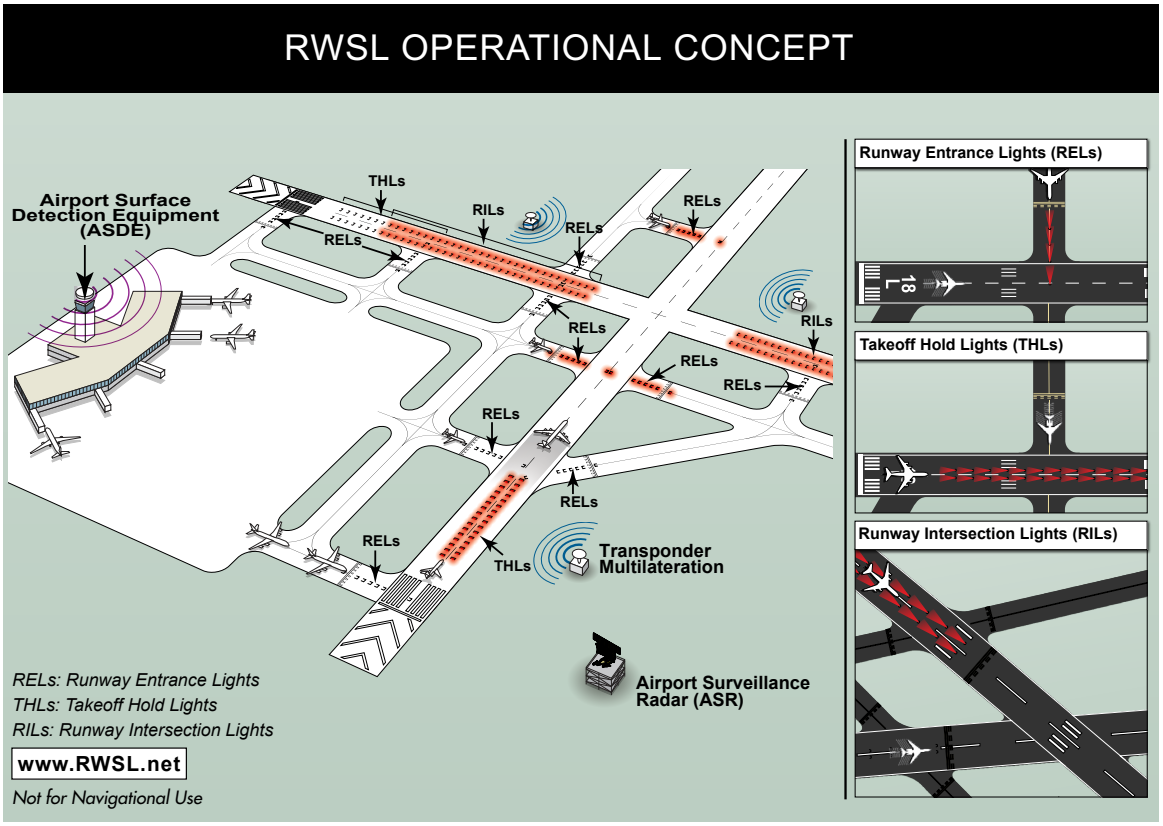

Figure 2. Illustration of the RWSL concept of operations.

data from three surveillance sources:

- Surface primary radar returns from the Airport Surface Detection Equipment
- Multilateration calculated from the differences of time of arrival of transponder signals from aircraft and vehicles; data from several multilateration receiver locations are used
- Airport Surveillance Radars for aircraft operating in the vicintiy of the airport

Fusing the large amount of data from these diverse sources presents challenges, such as avoiding the generation of potentially confusing multiple tracks for the same aircraft and compensating for the occasional unresponsive transponder. RWSL fusion uses all available inputs to create "clean" system tracks. The system can generate tracks from single or multiple surveillance sources in case of malfunction or nonexistence of sensors or equipment. This flexibility is desirable because service vehicles operating on runways and taxiways are not always equipped with transponders that respond to multilateration interrogations. In cases of sensor outages or maintenance, RWSL can also use multilateration data without radar returns, thus increasing the system's adaptability to uncommon situations.

A safety-logic process accepts the fused surveillance information, determines the operational state of a track (whether an aircraft is stopped, taxiing, landing, or departing), predicts likely future behavior, and determines which lights should be turned on and when. Then, a light-control computer communicates with a field lighting system to activate and deactivate the status lights, indicating to pilots the status of runways and intersections. RWSL also supports a visual display in the ATC tower, showing light status as well as aircraft call sign, equipment type, and location. A separate user interface allows supervisors in the tower to modify certain RWSL settings, such as light intensity and runway configuration.

Training personnel in the system and its protocols is necessary for the effectiveness of RWSL. Education is done through publications, such as the Notices to Airmen, briefings, and a web site, www.RWSL.net. Equally important is feedback from pilots, air traffic controllers, and ground-vehicle operators, as well as analysis of information recorded during tests of the system, all of which provide data to inform future modifications or enhancements.

Lincoln Laboratory has documented several instances in which RWSL has effectively warned the pilot not to continue takeoff because another aircraft had inadvertently entered the pilot's assigned runway. At the FAA's request, Lincoln Laboratory reviewed U.S. runway incursions that occurred between 1997 and 2000 at 100 of the busiest airports and that involved at least one large passenger jet and were classified as "high hazard" (had a miss distance less than 100 feet). The study determined that RWSL might have prevented or mitigated 75% of the 167 identified incursions.

In 2007, the FAA announced it will install RWSL at 22 major airports in the U.S. National Airspace System by 2011. Successful operational evaluations of prototype RWSL systems at Dallas/Fort Worth and San Diego International airports led to the 2009 delivery of a Lincoln Laboratory–designed RWSL system, built by the ARCON Corporation, to Los Angeles International Airport. The same system is planned for deployment in 2010 at Boston's Logan International Airport. Lincoln Laboratory is currently working with ARCON, Sensis, and the FAA to complete the technology transfer of RWSL. ■

Additional Reading

J. Eggert, B. Howes, M. Kuffner, H. Wilhelmsen, J. Bernays, "Operational Evaluation of Runway Status Lights," *Lincoln Laboratory Journal,* vol. 16, no. 1, pp. 123–146, 2006.