



RWSL Background Information

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1 BACKGROUND

The Federal Aviation Administration (FAA) has long recognized the safety hazards associated with runway incursions. As part of their ongoing efforts to explore new technologies aimed at reducing runway incursions, the FAA's Runway Incursion Reduction Program (RIRP) proposed that a method be developed to directly notify pilots when entering, crossing or departing from a runway is unsafe. The Runway Status Light System (RWSL) designed and developed by MIT Lincoln Laboratory (MIT/LL) will provide this direct notification using surveillance-driven lights located at runway intersections (Runway Entrance Lights or RELs) and just in front of where departing aircraft hold in position prior to commencing their departure roll (Take-off Hold Lights or THLs).

RWSL is designed to serve as an automated, all-weather safety backup to pilots, airport vehicle operators and air traffic controllers. Surveillance data from ASDE, multilateration, and ADS-B sources are combined with airport configuration data to estimate when a runway is occupied or about to be occupied by high-speed traffic. The runway occupancy status is indicated through illumination of status lights designed to be visible to crews about to cross or depart from a runway.

The runway status light system provides advisory information only, and never substitutes for ATC-provided clearances. It is expected that crews will use RWSL as another means of maintaining situational awareness of traffic on active runways while continuing to comply with all ATC-issued clearances.

Versions of RWSL are being tested at the Dallas-Ft. Worth, TX (DFW) and San Diego, CA (SAN) airports, where operational evaluations of the REL portions of RWSL are scheduled to be conducted within the coming year.

1.1 Runway-status lights and NTSB recommendations

Runway incursions rank near the top of both the FAA and Department of Transportation (DOT) Inspector General (IG) lists of airport safety concerns and have been included in the National Transportation Safety Board (NTSB) "top ten" list for over a decade. The NTSB recommendation that the FAA develop a means to "give immediate warnings of probable collisions/incursions directly to flight crews in the cockpit" is addressed by runway-status lights. The runway-status lights are designed to provide a direct indication to flight crews when it is unsafe to enter or cross a runway or to start a departure roll; vehicle operators also benefit from increased situational awareness associated with automated status lights.

1.2 Runway Safety Issue

In those instances where insufficient advance notice of an incident or incursion is available for a controller to correct the situation via commands to aircraft crews, direct notification to the crew or vehicle operator is essential. These situations are in contrast to slowly developing scenarios for which controller actions (e.g. in response to AMASS alerts) are an effective mitigation means. In general, a layered approach to runway safety that includes RWSL as one element can provide a more comprehensive safety improvement. Valuable elements of the runway incursion prevention process include surveillance-based situational awareness for the tower controller and surveillance-based conflict alerts for the tower controller as well as runway status information *directly presented to flight crews* whenever and wherever such conflicts may develop.

1.3 History of RWSL

The application of runway-status lights to the runway incursion problem has been studied for over a decade. Commencing in the early 1990's, MIT Lincoln Laboratory developed a preliminary operational concept of runway-status lights followed by a concept demonstration at Boston's Logan International Airport. In the mid 1990's, NASA Langley Research Center reported the results of a cockpit simulation study of pilot acceptance of runway-status lights while the Volpe National Transportation Systems Center studied the design and physical installation of runway-status lights at Logan International Airport.

All of these studies concluded that runway-status lights could be an effective means to prevent runway incursions and runway conflict accidents and would be supported by pilots and controllers, provided that the performance of the surveillance and light control logic could be optimized to be compatible with high-density airport operations. However, it was a near universal conclusion at the time that the existing surface surveillance quality was inadequate to support a RWSL system with a low enough false activation rate to be compatible with operations at a complex, busy airport.

FAA focus on improvements to surface surveillance (particularly the development of the ASDE-X system in which surface movement radar plots are fused with beacon multilateration position estimates) justified the re-examination in 2002 of RWSL for use at a complex, busy airport. MIT Lincoln Laboratory was tasked to execute a multiphase effort to integrate an ASDE-X prototype system at DFW with runway status lights installed at a limited number of busy intersections on the west side of the airport.

Following an engineering phase test at MIT Lincoln Laboratory, RWSL was successfully tested at DFW through two shadow operations in which live data drove RELs depicted on monitors in the center tower during 2003-2004; a live, operational evaluation of runway status lights is scheduled at DFW in 2005. An analogous phase of testing is in progress at SAN where the first phase of shadow operations evaluation was successfully completed in 2003. One more shadow operations test is planned, to be followed by an operational

evaluation of RELs, driven by primary surveillance and safety logic added to the Airport Movement Area Safety System (AMASS), in the spring of 2005. Both the DFW and SAN airport authorities have been strong supporters of the field site tests to date.

In conjunction with the shadow operation field site activities, testing was conducted by the Siemens Airfield Lighting Solutions Company at DFW, to demonstrate the signal and lighting control performance of standard light fixtures (currently used at other airports for the red stop bars during low visibility active Surface Movement Guidance and Control System (SMGCS) operations) for new use as Runway Status Lights. Also, the FAA William J. Hughes Technical Center provided a lighting array test bed where pilots, FAA Airports and FAA Flight Standards personnel evaluated twenty-two versions of the lighting array. The test arrays were set up (with the actual fixtures being placed on top of the pavement) near the runway area at Atlantic City Airport (ACY) to identify an REL configuration that is both unique from SMGCS and other existing lights and visible to crews during varied workloads. The result of these efforts is a prototype system that is being installed at DFW and SAN to support the upcoming RWSL operational evaluations.

Representatives from the airline and pilot communities have played essential roles in the development and evaluation of RWSL. The RWSL operational concept has been presented to pilot groups for comment in a variety of settings; American Airlines provided pilot volunteers to assist in the shadow operations evaluation at DFW, and to advise on methods to train crews prior to commencing an operational evaluation at DFW. Briefings and demonstrations have also been provided to the runway incursion working group at Delta Airlines, to groups at the Experimental Aircraft Association Air Venture Oshkosh, and the Air Line Pilots Association (ALPA) annual safety forum.

2 PURPOSE OF RWSL

The RWSL system seeks to improve airport safety by indicating to crews and vehicle operators when it is unsafe to cross or enter a runway or to commence a departure roll; it is an automatic, advisory backup system expected to prevent or reduce the severity of runway incursions. The RWSL system indicates runway occupancy via status lights at runway intersections (runway entrance lights, RELs) and on the runways just downfield of where crews start their departure roll (Take-off hold lights, THLs).

Pilots and vehicle operators are expected to realize that proceeding across a red light exposes them to a potentially hazardous situation. RWSL is advisory in nature and does not relieve crews and vehicle operators of the requirement to maintain situational awareness and comply with all ATC-issued clearances. Furthermore, lights only indicate a hazard when illuminated; lights in the off state do NOT indicate that a crew or operator is cleared to cross, enter, or depart from a runway without an ATC clearance.

2.1 Definition of RWSL

RWSL is an automatic system consisting of Surveillance Sensors, Safety Logic, and Status Lights. The first component of the status lights to be fielded is the Runway Entrance Lights (RELs). RELs advise pilots and ground vehicle operators that a runway is unsafe to enter or cross. RELs are red if unsafe; otherwise RELs are off. This is a visual advisory only. Normal operations require no controller action, although a means is provided for Air Traffic to disable the RWSL evaluation system at any time.

3 RWSL SYSTEM ARCHITECTURE

3.1 How it works

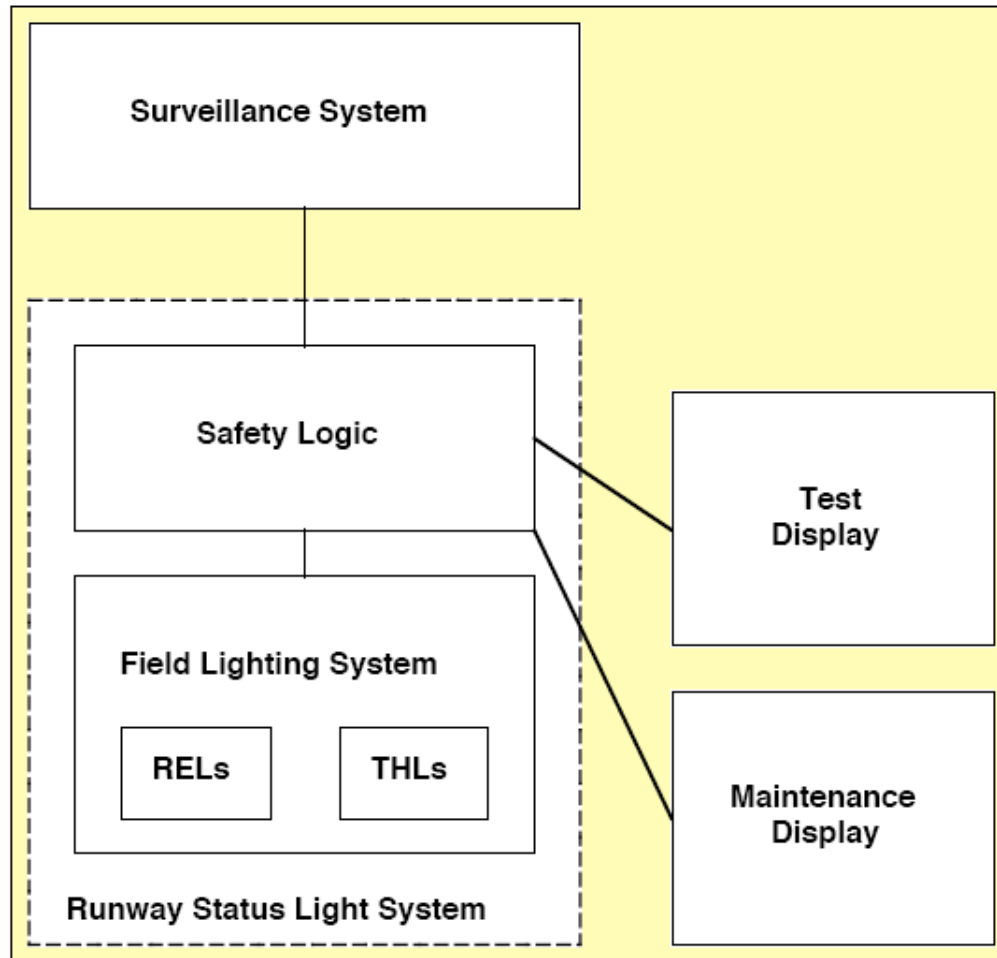


Figure 1 RWSL high-level architecture

RWSL, as shown in Figure 1, is driven by an external surveillance system that provides position and other information for all aircraft and vehicles on and near the airport surface. RWSL contains safety logic that processes the surveillance and commands the field lighting system to turn the lights on and off in accordance with the motion of the detected traffic and the geometry of the airport.

Red icons on an appropriate display in the control tower will eventually represent RELs and THLs. At the present phase of research and development, only RELs are being tested at DFW and SAN. The SAN system plans to use only RELs for the foreseeable future

because it employs only AMASS (ASDE-3 radar) traffic information (not fused with multilateration of beacon returns as in DFW). At SAN, the AMASS ASDE-3 tower display will show hold bars timed to agree with the illumination of lights on the field.

For the operational evaluation at the SAN tower, the REL style hold bars will be displayed as green thick lines on the existing monochrome ASDE-3 monitor screen. For the operational evaluation at the DFW west tower, the RELs will be displayed separately from AMASS and shown only to the test director. RWSL will provide a color screen either on a laptop computer or on one of the two color ASDE-X flat panel monitors that supported shadow operations in the center tower.

At SAN, the AMASS ASDE-3 tower display will show hold bars timed to agree with the illumination of lights on the field. For the operational evaluation at the SAN tower, the REL style hold bars will be displayed as green thick lines on the existing monochrome ASDE-3 monitor screen. For the operational evaluation at the DFW west tower, the RELs will be displayed separately from AMASS and shown only to the test director. RWSL will provide a color screen either on a laptop computer or on one of the two color ASDE-X flat panel monitors that supported shadow operations in the center tower.

The lights are driven automatically using computer processing of integrated surface and approach-space surveillance. RWSL software detects the presence and motion of aircraft and surface vehicles on or near the runways, assesses any possible conflicts with other surface traffic, illuminates runway-entrance lights (RELs) if the runway is unsafe for entry or crossing, and illuminates takeoff-hold lights (THLs) if the runway is unsafe for departure.

RWSL does not include any alerts with respect to runway conflicts or controller clearances, only lights that indicate runway status. There is no link between the lights and the voice communications and RWSL does not provide any voice communications. It is important that all users understand that the RELs and THLs indicate status only, never clearance. The lights are only a visual status indication meant to reinforce pilot situational awareness, not to supplant controller clearances.

Since the runway-status lights are shown directly to pilots and vehicle operators on the airport surface, the reliability of their operation is critical to acceptability. Previous studies using primary radar as the source of surface surveillance have concluded that surveillance quality must be very good to ensure acceptable operation of runway-status lights. Recent improvements in surface surveillance, e.g., fusion with transponder multilateration, promise to provide the necessary surveillance quality. The upcoming operational evaluation of RWSL at DFW will be an opportunity to demonstrate reliable, automatically controlled runway-status lights to crews and vehicle operators on the airport surface.

In the current version of RWSL, no status lights will be shown to arrival aircraft although different indications are under consideration in other FAA programs; e.g. flashing Precision Approach Path Indicators (PAPIs). It is technically feasible to incorporate

additional lights to indicate the status of the landing runway to pilots on approach. Such a feature may be investigated in the future in hopes of providing timely warning to pilots on approach in certain time-critical landing scenarios where it may be desirable to augment tower-cab alerts with a direct conflict indication to the cockpit.

Figure 2 shows a notional operational conceptual diagram of runway-status lights at DFW and SAN, with DFW using both primary and secondary multilateration surveillance and SAN using only primary radar surveillance. The landing aircraft has caused the RELs to turn on along the landing runway. The THLs are not illuminated in this situation. At DFW, surveillance is provided by a combination of ASDE-3 and ASR-9 radars, and transponder multilateration. Surveillance and safety logic processing is performed in a central processing facility.

RWSL Operational Concept Figure



Figure 2 Conceptual diagram of the Runway-Status Light System at DFW and SAN with surveillance sources driving red RELs. (note SAN does not have multilateration)

4 OPERATIONAL CONCEPT OF RWSL

The RWSL concept is as follows:

- 1) RWSL provides prompt and unambiguous indication of runway status to pilots and vehicle operators to indicate clearly when it is unsafe to enter a runway or to commence take-off.
- 2) RWSL provides this information automatically and at all times, without controller or other human input.
- 3) RWSL acts as an automatic and independent safety backup. It does not enforce procedures. It will not significantly increase controller workload. It will not interfere with the normal flow of airport traffic.
- 4) RWSL does not convey an ATC clearance. Runway-status lights indicate runway status only. Clearance is provided by air traffic control, verbally, as under current procedures. If a runway status light is illuminated, it indicates that a particular operation (e.g., entering the runway) is unsafe. If clearance has been issued and a status light illuminates red, the pilot or vehicle operator must stop and contact the tower controller before proceeding. A pilot or vehicle operator who sees a status light turn off must still await clearance from the tower before proceeding.

An example of a manual input that a test team member or supervisor might make to RWSL is to change airport configuration, but no input to the status information shown by the lights is ever given by controllers.

4.1 Runway Entrance Lights (RELs) configuration and location

Figure 3 is a photograph of the REL fixture. As shown in the figures 4 and 5, RELs consist of several red, in-pavement lights spaced evenly along the taxiway centerline commencing ahead of the hold line to the runway edge, plus one additional light on the runway centerline. All RELs are directed toward the taxiway hold line and are oriented to be visible only to pilots and vehicle operators entering or crossing the runway from that location.



Figure 3 Photograph of L861-S fixture

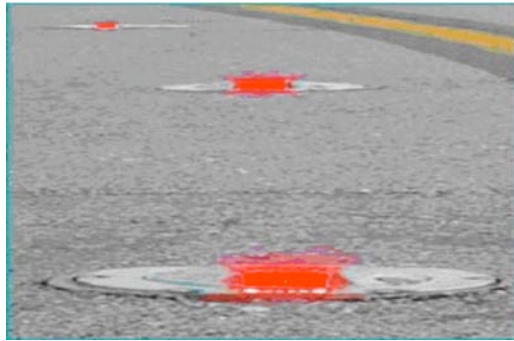


Figure 4 RELs along a curved taxiway centerline

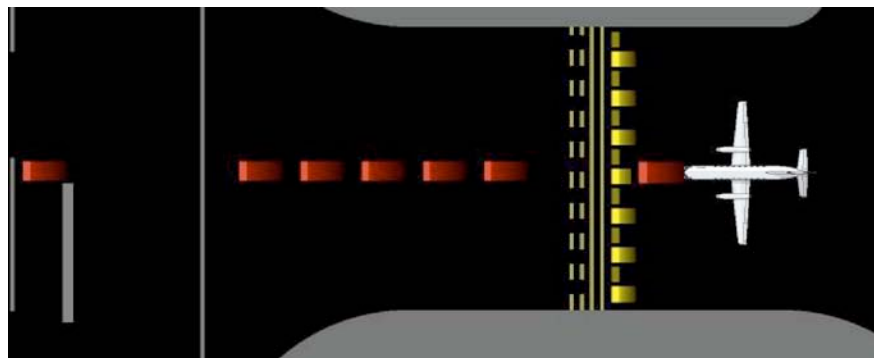


Figure 5 RELs along a straight taxiway centerline

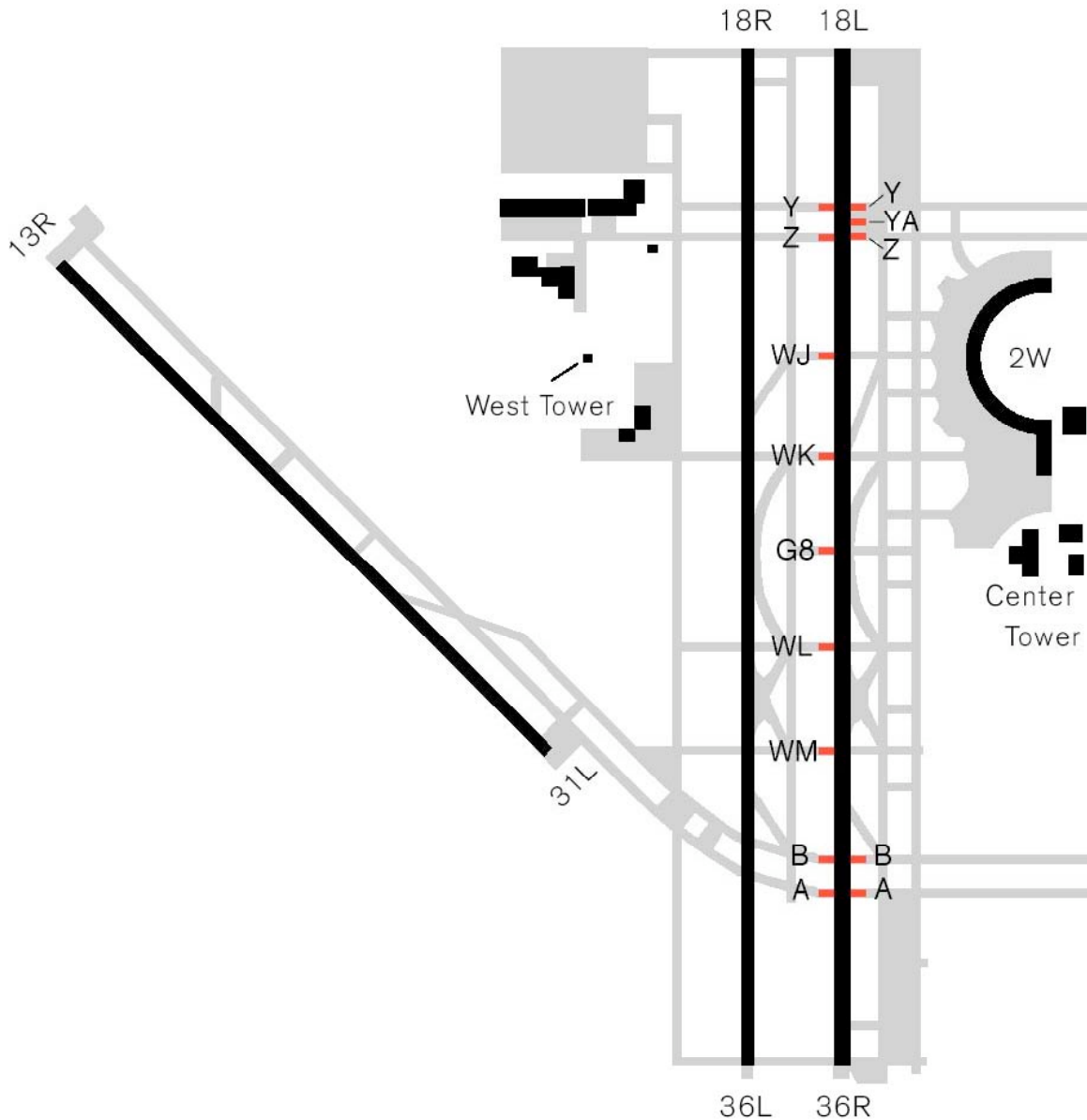


Figure 6 DFW west side with REL alignment and locations on 18L/36R taxiway intersections. (note YA RELs have been removed)

Figure 6 illustrates the RELs currently installed at DFW. Only runway 18L/36R is part of the test at this time. RELs are installed on the west side of DFW, on runway 18L/36R at selected intersections as follows:

Inboard side: Y, Z, B, and A

Outboard side: Y, Z, WJ, WK, G8, WL, WM, B, and A

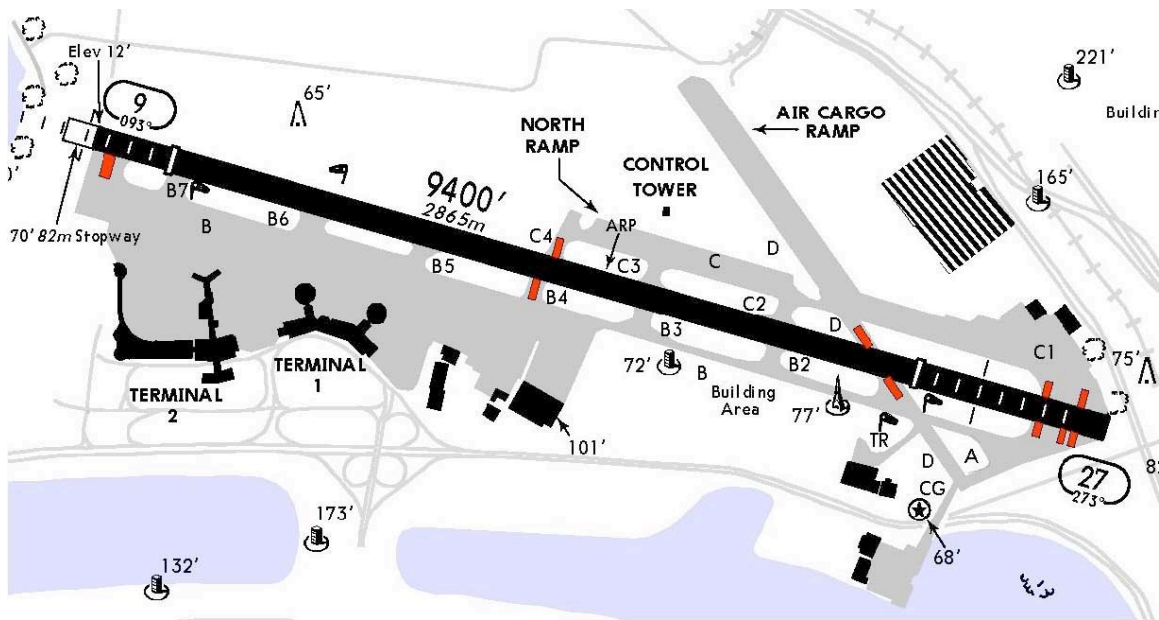


Figure 7 SAN with REL alignment and locations on 9/27 taxiway intersections

Figure 7 illustrates the RELs currently installed on the single runway at SAN. RELs have been installed and tested on RWY 09/27

North side: TWYs C1, D, C4

South side: TWYs B1, D, B4, B8

In summary, Runway Entrance Lights indicate that the runway is unsafe to enter. They are illuminated red if the runway is not safe to enter; otherwise they are off. For future deployment of RWSL at NAS airports, RELs are to be located at taxiway entrances to active and inactive runways, oriented to face the taxiways. At present, there is no direct indication of runway status to pilots and vehicle operators preparing to cross or enter into position on runways in the National Airspace System (NAS). Existing FAA surveillance systems depend on air traffic control (ATC) communications to advise aircrews about potential runway conflicts at high density controlled airports via use of the Airport Movement Area Safety System (AMASS), which alerts the controller to then advise the pilot. Uncontrolled airports have no technology or system to address this issue. The RWSL concept provides a visual indication of runway occupancy status directly to pilots. By augmenting the controller-pilot communication with direct pilot notification, valuable reaction time is gained and high-energy collisions are averted in critical occupied runway situations.

5 OPERATIONAL EVALUATION

5.1 Operational Evaluation Process

In September 2003, the DFW RWSL system was evaluated utilizing a “shadow operations” approach. The entire RWSL system except for the field lighting system was assembled, optimized, and operated just as it would in normal operations. Instead of causing runway intersection lights to illuminate, light commands from the RWLS system controlled illumination of symbols on a plan-view display of the airport surface, located in the center tower at DFW. The system was configured to demonstrate light activation for selected intersections along runway 18L/36R on the west side of the DFW airport. Tower supervisors evaluated the correctness of the runway entrance light timing by comparing the out-the-window view of traffic, the clearances issued on the VHF communications channel, and the illumination of the runway entrance lights on the shadow operations display. Feedback from the September, 2003 evaluation led to improvements in the test system and a repeat of the shadow operations test in June 2004 at DFW. The most notable improvements implemented post-September 2003 were fusion of the ASDE-3 primary radar data with multilateration and increased altitude interrogation rate (to every half second) of the multilateration data to drive the RWSL light command logic.

Nineteen pilots from the Allied Pilots Association also voluntarily participated in the two shadowing tests. They each spent approximately two hours observing from the tower and interacting with the test team. Their feedback, via a written survey developed by MIT Lincoln Laboratory, was highly positive indicating strong support for the RWSL system. Their view is that RWSL will add another layer of safety by providing them with an automatic and independent direct warning of an unsafe runway. The successful results from the second shadow operations evaluation justified a decision to proceed with preparations for the DFW operational evaluation.

5.2 Operational Evaluation

A test team consisting of The Federal Aviation Administration, Massachusetts Institute of Technology Lincoln Laboratory, and the Dallas Fort Worth Airport Authority, with support from the local air traffic controllers and ATC supervisors will be conducting an assessment of Runway Status Lights (RWSL) on Runway 18L/36R at Dallas Fort Worth International Airport (DFW) in early 2005. DFW ATC supervisors, MIT Lincoln Laboratory researchers and FAA Technical Center researchers will be members of the test team. A test team member will be present in the West control tower at DFW whenever RWSL is turned on and Runway Entrance Lights are operational during the assessment period. RWSL will only be active when the test team is present.

Figures 8 and 9 depict the RWSL system components to be used during the Operational Evaluations at DFW and SAN, respectively. The operational evaluation phase will test the operational suitability of the runway status light system. A field lighting system has been installed on the airport. The lights have been thoroughly checked out prior to operational evaluation. Pilots and vehicle operators will view lights, which will be driven dynamically by the RWSL safety logic software in response to live surveillance. A hard kill switch will be available in the tower to disable the system if deemed operationally necessary by tower personnel. Controller, pilot, and vehicle operator feedback will be elicited to determine the operational suitability of the concept. Technical performance data will be collected and summary performance statistics will be generated by automated test software.

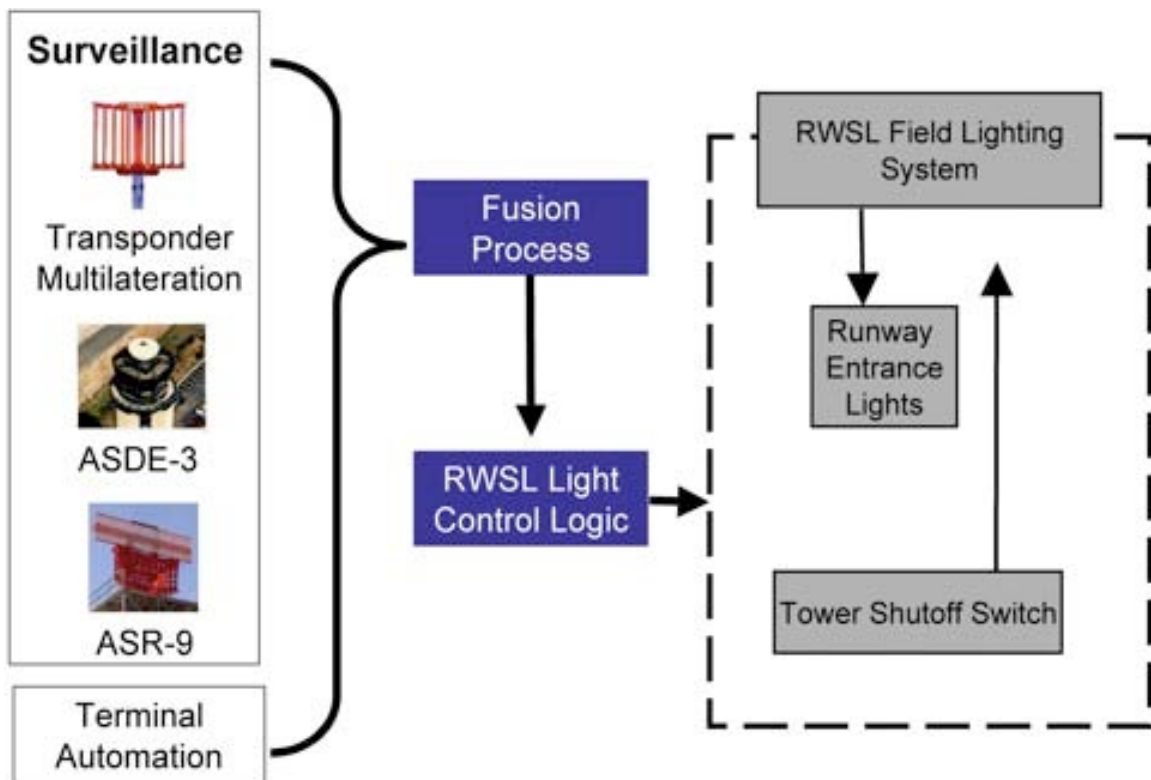


Figure 8 DFW RWSL System Components

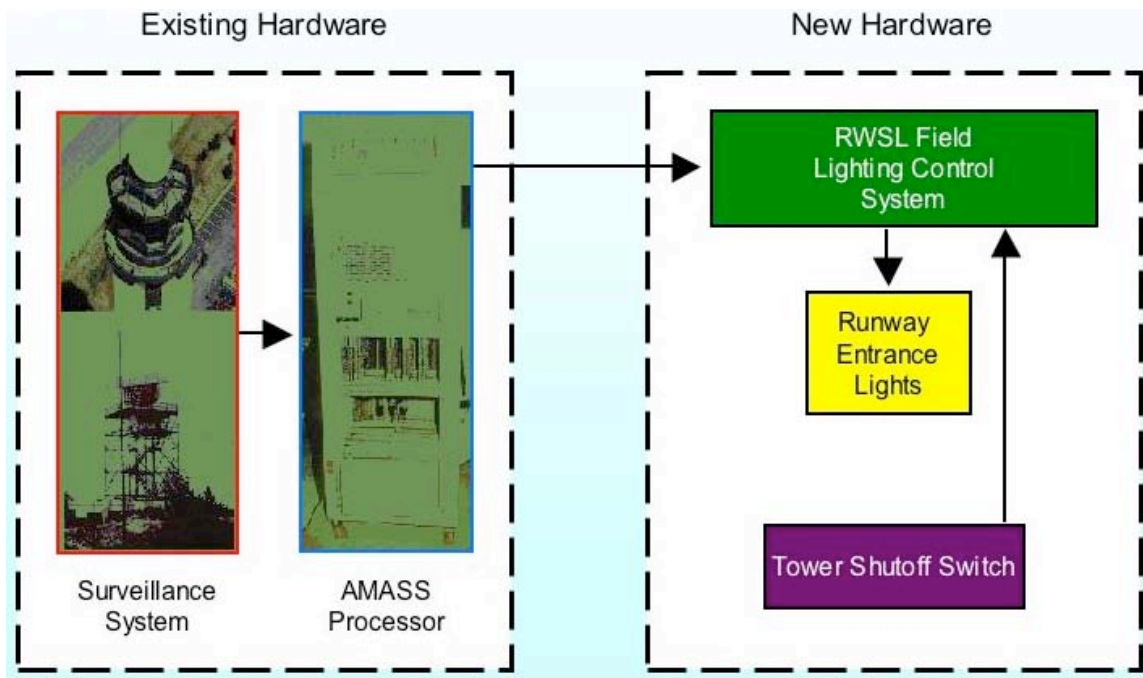


Figure 9 SAN RWSL System Components

The operational evaluation will be performed in the west tower and on runway 18L/36R at Dallas-Fort Worth International Airport (DFW). Computer, networking, and light control hardware will be installed in the west tower cab and on the floor below, in the center tower junction level, and in the Southwest lighting vault as needed for display, control, surveillance, lighting, and networking. The system will use surveillance covering the west side of the airport and approach areas.

The RWSL system at DFW will provide two types of displays during operational evaluation: a traffic and status display and a lighting control display. RWSL test team members using a laptop computer will view these displays.

The traffic and status display will be available to the test director on a laptop computer that will travel with that person during the operational evaluation. The test director will typically be stationed in the West Tower cab and bring the laptop there. The test director is a team member. Typically the test director will be a test team member from MIT/LL, however the assignment of test team director will change based on which test team members are present during specific test periods. For practicality in conducting the operational evaluation, the test director may choose an acting test director including one of the West Tower supervisors.

The two monitors used for the Shadow Operations may also be used to display status and traffic in the Center Tower for observation by the test team during the operational evaluation.

The RWSL traffic and status display shows the states of the runway-status lights, runway and taxiway outlines, and the traffic in plan view, as shown in Figure 10 where all RELs are on due to departing aircraft. Aircraft and surface vehicles are shown as icons. Data tags show aircraft identification (ACID) and equipment type if available, otherwise a tail number and equipment type if available.

The data tags can also optionally show altitude in feet above ground level and speed in knots. Aircraft on final approach are depicted on an approach bar near the arrival end of the runway (to compress the approach course for a manageable display). The approach bar represents five nautical miles of approach space.

The capability to inform the RWSL system of changes in runway configuration for north or south flow; to turn the system off via a soft off button; to select the operational mode for normal or limited as may result from heavy rain conditions; and to set the light intensity to one of five levels (to adjust for night, day, or limited visibility operations) will be provided to the test director on the same laptop computer (via electronic keys on the touch screen or keyboard entries) and/or by using hardware switches in the West Tower cab.

For the SAN operational evaluation, the existing AMASS ASDE-3 monochrome monitor will be modified to display the thick green lines as hold bars consistent with the timing of RELs turning on and off while the traffic will be shown as targets marked by a small filled circle without tags or aircraft identification call signs.

Prior to the upcoming operational evaluation of RWSL at DFW, an Operational Characteristics Test (OCT) will be conducted to establish that the field lights are operated in a manner acceptable to ATC, Flight Standards, and/or other appropriate organizations. OCT will be conducted from the Center Tower, using the Light Control Computer (LCC) as the system controller. The field lighting fixtures will be uncovered and, initially, the lights for one selected intersection (i.e., taxiway) will be “enabled” (capable of being turned on and off). The lights for all other intersections will be “disabled” (always off, independent of standard on/off commands). The enable/disable capability is a feature of the LCC.

During the operational evaluation at DFW, scheduled to last approximately three months, the following wording will be added to the current Airport Traffic Information Service (ATIS) message: “Runway Status Light operational evaluation in progress on runway one eight left (or three six right). Do not cross illuminated red lights at selected taxiway intersections. Transponders should remain on while evaluation is in effect.” The ATIS message will be changed whenever the airport switches between north and south flow. The ATIS message addition for RWSL Operational Evaluation at SAN is: "Runway Status Light operational evaluation in progress. Do not cross illuminated red lights at selected taxiway intersections."

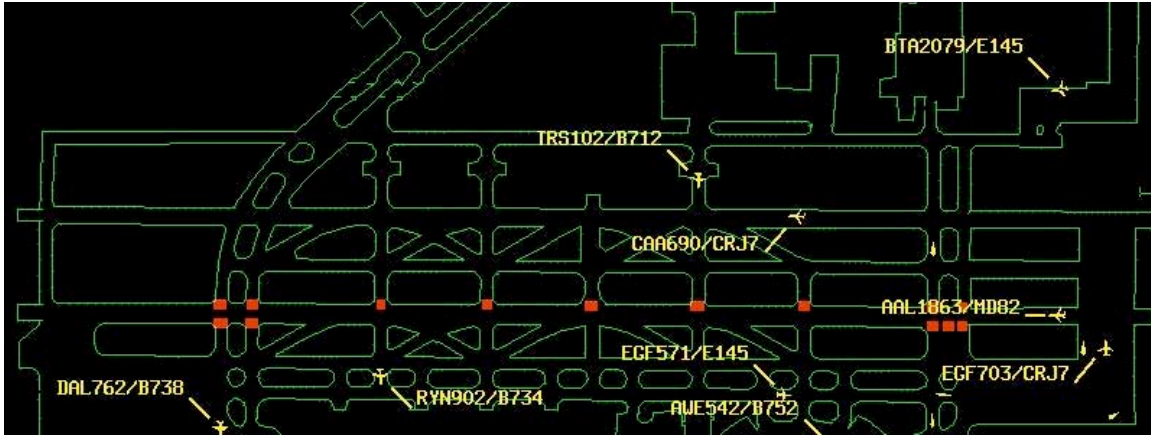


Figure 10 RWSL Display snapshot of DFW traffic with one line ACID/Type tags and RELs depicted as red rectangles at selected intersections

When RWSL operations are not active, this message shall be taken off the ATIS.

During the Operational Evaluation period, feedback and opinions will be collected from the pilot community. Pilots who view RELs will be asked to complete a questionnaire. Paper copies of the questionnaire will be available as tear off sheets printed on the release notes given to flight crews and at local DFW and SAN FBO offices and online copies will be at posted on www.rwsl.net and www.rwsl.ll.mit.edu. Pilots should also be alert for local seminars, mailings, NOTAMS and other information resources about the RWSL Operational Evaluation activities and schedule.

5.3 Operational protocol

Operating independently of Air Traffic Control, RWSL has two states, **ON**: lights are illuminated **red**, indicating the runway is not safe to enter or cross, **RED MEANS STOP!** And **OFF**: lights are **EXTINGUISHED**, conveying no meaning. — **THE SYSTEM NEVER CONVEYS APPROVAL OR CLEARANCE TO PROCEED ONTO A RUNWAY.**

Pilots remain obligated to comply with all ATC clearances, except when compliance would require crossing an illuminated red REL. In such a case, the crew should **hold** short of the runway (if possible), contact ATC, and await further instructions. However, if the pilots notice an illuminated red REL and remaining clear of the runway is impractical for safety reasons, then crews should proceed according to their best judgment of safety (understanding that the illuminated REL indicates the runway is unsafe to cross or enter) and contact ATC at the earliest opportunity. ATC may disable RWSL at any time if in their judgment the system is interfering with normal, safe operations. ***ALSO, TRANSPONDERS MUST REMAIN ON WHILE OPERATING ON THE AIRPORT SURFACE TO PROVIDE RWSL WITH POSITION AND AIRCRAFT IDENTIFICATION DATA.***

The pilot operational protocol for RWSL includes:

- When cleared to either “takeoff, cross the runway, position and hold, or immediate takeoff”, and RELs are illuminated; stop the aircraft, advise Air Traffic of the situation (for example: “TransAir 123 stopped with red lights”), and await further clearance.
- When RELs illuminate without any associated hazard, the flight crew should stop the aircraft and should remain clear of the runway or stopped short of the runway and wait for further clearance.
- When the aircraft continues across the hold line and flight crews observe illuminated red lights, the flight crew should stop and tell Air Traffic “TransAir 123 is stopped past the hold line because of red lights.”

At SAN the traffic information is derived from the AMASS system only, and transponders are not required to be ‘on’ throughout the movement area.

6 CONCLUSION

The primary goal of the Runway Status Light System (RWSL) is to reduce the number of runway incursions and thus prevent runway accidents while not interfering with normal, safe and efficient airport operations. RWSL improves crew and vehicle operator situational awareness through accurate and timely indication of runway occupancy. The RWSL implementation is divided into two relatively independent categories. Runway Entrance Lights (RELs) indicate to crews about to cross a runway when high-speed traffic on that runway constitutes an immediate hazard. Similarly, Takeoff Hold Lights (THLs) indicate to crews about to commence a departure roll when traffic crossing downfield would constitute an immediate hazard. In all situations, RWSL provides advisory information that may never be construed as an ATC clearance.

RWSL has successfully passed through initial evaluation phases in preparation for field-testing of the REL subsystem. The engineering phase conducted at MIT Lincoln Laboratory and two shadow operation phases conducted at DFW in the Center Tower all have contributed to refinements in the configuration of the surveillance and light illumination logic deemed necessary by the RWSL Research Project Management Team, who maintain oversight on the technical suitability of the prototype system for operational evaluation. Meanwhile, the RWSL testing at SAN has successfully passed shadow operations and is proceeding toward an operational evaluation pending completion of system modifications and regression testing.

The Operational Evaluation will address the following key requirements set forth for the RWSL development program:

- Involve controllers and pilots in all phases of development
- Require acceptable progress be demonstrated
- Determine operational suitability for combined use of RWSL and AMASS
- Explore integration of RWSL with ASDE-3/AMASS and ASDE-X

Since the opportunity now exists to exploit improved surface surveillance, runway-status lights offer a cost effective means to mitigate runway incursions and prevent surface accidents. The technical challenges center on assuring that RWSL correctly indicates hazards to assure an incursion-prevention benefit, while avoiding interference with normal, safe operations.

The human factors challenges include:

- Training pilots and vehicle operators to understand that illuminated lights indicate a hazard, but lights turning off never imply a clearance
- Assuring that the status lights are visible to crews and vehicle operators under all weather conditions, and independent of workload
- Determining the temporal and spectral characteristics of the status lights
- Locating the lights for optimum usability and effectiveness at reducing runway incursions

- Insuring no increase to controller workload
- Integrating the use of RWSL with other related systems currently used in the surface environment such as AMASS controller alerts and LAHSO
- Measuring response times of controllers, pilots, and vehicle operators and judging acceptable thresholds of reliability to insure operational suitability.

RWSL was successfully demonstrated to air traffic control supervisors and airline pilots at DFW in September 2003 and June 2004. Plans call for an operational evaluation of the system to begin next fiscal year, 2005.¹

¹ **Points of Contact:**

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