Air Traffic Controller Training for Operational Evaluation of Final Approach Runway Occupancy Signal (FAROS) at DFW

Maria Picardi Kuffner
MIT Lincoln Laboratory

September 2008
• **Goal of training**
  – Learn features of the FAROS system and display, safety logic and adaptation

• **Purpose of training**
  – Become familiar with the FAROS visual and aural advisories

• **Objective of FAROS Operational Evaluation**
  – Identification and mitigation of status light anomalies
  – More thorough evaluation of FAROS operational suitability
Overview of RWSL and FAROS

• Runway Status Lights at DFW consists of *existing* Runway Entrance Lights (RELs) and Takeoff Hold Lights (THLs) and *new* Final Approach Runway Occupancy Signal (FAROS)

• Runway Status Lights Purpose
  - Reduce frequency and severity of runway incursions
  - Prevent runway accidents

• How do Runway Status Lights do this? By increasing pilots’ and ground vehicle operators’ situational awareness
  - RELs give a *direct warning* to pilots and ground vehicle operators that it is unsafe to enter or cross a runway
  - THLs give a *direct warning* to pilots that it is unsafe to depart from a runway
  - FAROS gives a *direct warning* to pilots that it is unsafe to land on a runway
    - By flashing existing Precision Approach Path Indicators (PAPIs)
Most runway incursions result from pilot deviations.

“Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take off of aircraft.”
Objective of RWSL and FAROS

- **Per NTSB’s MOST WANTED:**
  - “Give immediate warnings of probable collisions/incursions directly to flight crews in the cockpit.”
- RELs warn unsafe to enter/cross RWY
- THLs warn unsafe to depart from RWY
- RILs warn unsafe to cross RWY intersection
- FAROS warns unsafe to land
Timeline of Selected Runway Accidents

- **8 Fatalities**
  - Detroit: 1990

- **14 Fatalities**
  - Quincy, IL: 1996

- **122 Fatalities**
  - Milan: 2001

- **49 Fatalities**
  - Kentucky: 2006

- **583 Fatalities**
  - Tenerife: 1977

- **34 Fatalities**
  - Los Angeles: 1991

- **2 Serious Injuries**
  - North Las Vegas: 2003

- **3 Fatalities**
  - Titusville, FL: March 2008

“Land Over”
Goal of FAROS:
Prevent Runway Accidents and Incursions

- **Example:** LAX 1991 “landover” accident
  - “Forgetting is a human factor routinely found in operational errors by air traffic controllers that cause incidents virtually every day in our nation's air traffic system. This type of human error has also been identified in past accidents. For example, on February 1, 1991, a USAir Boeing 737 collided with a Skywest Metroliner at the Los Angeles International Airport, killing 34 passengers and crew. This accident occurred, in part, because the air traffic controller cleared the USAir airplane to land about 3 minutes after she had cleared the Skywest airplane onto the same runway to hold for departure…”
    - Quote Reference: Testimony of Jim Hall, Chairman NTSB, April 16, 1997

- **Accidents with aircraft not exiting the runway after landing while a subsequent landing is in progress (aka “tail chase”)**
  - FAROS would warn landers

- **Accidents with aircraft or vehicle crossing the runway while landing is in progress**
  - FAROS would warn landers; RELs designed to prevent such events by warning crossers
FAROS and RWSL
High Level Block Diagram

Surveillance
- ASDE-3
- ASR-9

MIT/LL Light Control Logic

Field Lighting System
- PAPIs

FAROS
RELs
THLs

RWSL Test Display with FAROS, RELs and THLs on (red) due to traffic
Drawings of RWSL & FAROS

- Runway Entrance Lights (RELs)
- Flashing PAPIs indicate the runway is occupied!
- Final Approach Runway Occupancy Signal (FAROS)
- Not to scale

- Takeoff Hold Lights (THLs)
- Runway Intersection Lights (RILs)

Note: Assessment of RWSL double-row THLs and RILs and FAROS flashing PAPIs is TBD.
Illustration of FAROS: Pilots’ View

- Indicates runway unsafe for landing
- **Flashing** PAPIs if runway not safe for landing
- Otherwise steady (glide path indication only)
• FAROS is a pilot notification system of runway status for pilots on final approach to landing
  - When runway is occupied and approaching aircraft has reached the arming distance (default is 1.5 nmi)
    - PAPIs begin flashing to pilots
    - Red bar shown on RWSL display in tower
  - When aircraft is within approximately .5 nmi of landing threshold and runway is occupied
    - PAPIs begin or continue flashing to pilots
    - Red bar shown on RWSL display in tower flashes red and white
    - Audible advisory sounds in tower “FAROS (RWY designator)”
• When FAROS acquisition point is reached
  – Attempt to see traffic on runway
    ❖ If seen, evaluate the situation then proceed with caution
    ❖ If not seen, then prepare to contact ATC at contact point
• When FAROS contact point is reached after passing acquisition point
  – Attempt to see traffic on runway
    ❖ If seen, evaluate the situation then proceed with caution
    ❖ If not seen, then contact ATC to verify landing clearance and
      prepare for an immediate go-around
    ❖ If ATC does not verify landing clearance promptly, go around
    ❖ If ATC cancels the landing clearance, go around
• LAHSO-capable A/C defined by DFW AT as
  – Not on type exclusion list (for example 747s)
  – Not a foreign carrier (operating at DFW w/in past two years)
• For LAHSO-capable landing A/C only, when LAHSO is in effect
  – RELs will not turn on downfield of LAHSO line
  – FAROS will not signal if traffic on RWY is crossing downfield of LAHSO line
  – FAROS will signal for all other scenarios such as
    ❖ A/C stopped on RWY, A/C opposite direction on RWY, slow taxi on runway, previous lander still on RWY, and if crossing traffic slows down on RWY
• If arrival is to RWY 18L/36R without FAROS
  – Inform crew that landing RWY is not equipped with FAROS, per Notice N DFW ATCT 7110.243:
    ❖ When an aircraft is given a landing clearance on a Runway 18L or 36R, advise the pilot that the runway is a non-FAROS runway
    ❖ Phraseology: “Runway 18L/36R cleared to land, non-FAROS runway”
FAROS “Arming” and “Activation” Regions Defined

- There is one **arming region** on each FAROS-instrumented runway
  - Arming regions for 17R/35L and 17C/35C shown in light blue
  - Start of region is 3 nmi from r/w threshold
  - Arming distance for FAROS
    - Default is 1.5 nmi from RWY threshold

- There are multiple **activation regions** that cover runway in both directions
  - Example activation regions for 17R/35L and 17C/35C shown in green (overruns not included)
  - When LAHSO is used, activation region ends at the LAHSO line

- Shape of activation region bumps out in all areas where high-speed taxiways meet the runway
  - To address issue of aircraft re-entering the runway after having started to exit at an angled taxiway
  - Also to allow for imprecision in aircraft or vehicle position data

*Illustration of FAROS arming and activation regions on DFW-East (not to scale)*
High Level Operational Requirements

• FAROS must have aircraft in position for landing (in arming region) and aircraft or vehicle “on” runway (in activation region) in order to turn on
• FAROS must turn off once either condition is no longer met
• FAROS must not interfere with normal safe operations
• FAROS must operate automatically for each operation
  – No controller action required
• FAROS must accurately depict that it is unsafe to land
DFW RWSL OPERATIONAL CONCEPT

- Runway Status Lights (RWSL) turn on and off automatically; RWSL driven by surface radar surveillance
- RELs turn ON when it is unsafe to enter or cross a runway; RELs are visible from taxi hold position
- THLs turn ON when it is unsafe to depart from the runway; THLs are visible from takeoff hold position (and final approach)
- FAROS turns ON when it is unsafe to land; FAROS is visible from final approach to runway

FAROS: Final Approach Runway Occupancy Signal
PAPI: Precision Approach Path Indicator
REL: Runway Entrance Lights
THL: Takeoff Hold Lights

www.RWSL.net
• FAROS deployment planned for 18R/36L, 17R/35L, and 17C/35C

• Need for FAROS noted in FAA Runway Safety Blueprint 2004
  - “When pilots are on final approach for landing, in certain conditions such as periods of reduced visibility, it is difficult to distinguish an aircraft that is already on the runway and pointing directly away from an arriving aircraft. A visual method to warn pilots (operating in sufficient visibility) that the runway is occupied would reduce the opportunity for collision.”
• **AMASS alert** is currently male voice
  – Mandatory go around issued by ATC
    ❖ “Warning, runway 18L go around”
• New visual **FAROS advisory** on RWSL displays
  – Red bar or flashing red/white bar adjacent to the runway
• New audible **FAROS alarm and advisory** from small speaker
  – Brief tone for audible alarm, default is 1 second sine wave
  – Tone followed by *female* voice advisory
    ❖ “FAROS runway 18L”
    ❖ Presented once
  – New visual indication of FAROS not in service
  – “No FAROS” to be displayed on the RWSL display
  – Similar to current “No RWSL” display
• One small speaker was added to the RWSL hardware to sound
  **FAROS audible advisory**
  – Other equipment is same as used for RWSL Operational Evaluation of
    RELs and THLs at DFW
• Adaptation parameters were adjusted to meet tempo of DFW operations while providing direct warning to pilots
• Default adaptation parameters have been tuned to
  – Arming distance is 1.5 nmi from runway threshold
  – Acquisition point is 500 ft AGL or about 1.5 nmi from landing threshold
  – Contact point is 300 ft AGL or about .75 nmi from landing threshold
FAROS Anomalies

- **Definition of runway status light anomalies:**
  - **False Activation (FA)**
    - Light flashing when FAROS advisory should not be in effect
  - **Missed Detection (MD)**
    - Light not flashing when FAROS advisory should be in effect
  - **Interference (I)**
    - Communication interference occurs when FAROS causes crew to contact ATC *before descending to the contact point*
    - Operational interference occurs when FAROS causes crew to interrupt a normal, safe landing below the contact point
    - Increased controller and/or pilot workload
• Goal
  – Expose FAROS to real surveillance with live operations and expert observation by ATC and pilots

• Method
  – Evaluate accuracy of FAROS advisories, given ATC clearances and aircraft or vehicle movement
  – Observe and record instances of anomalous light operation

• Results
  – Assess possible interference with normal, safe operations and degradation of airport capacity
  – Estimate effectiveness of FAROS in preventing runway incursions
  – Determine operational suitability of FAROS at DFW