technical note technical note

Human Factors Evaluation of Airfield Lighting Configuration and Intensity Control at Boston Logan International Airport

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16. Abstract

Between September 2013 and October 2016, two aircraft, parts 91 and 121 (i.e., operating under Title 14 Code of Federal Regulations Part 91 and Part 121 Flight Rules), were cleared under Visual Flight Rules to land on Runway (RWY) 4L at Boston Logan International Airport (BOS), but instead aligned their aircraft to land on parallel Taxiway (TXY) B. In both instances, air traffic controllers noticed the aircraft were not aligned with RWY 4L and directed the aircraft to perform a go-around, or an aborted landing of an aircraft on final approach. In May 2017, RWY 4R was scheduled to be closed for construction, which would require RWY 4L to handle significantly more traffic. Considering the two aforementioned aircraft incidents and the planned increase in use of RWY 4L, this was a cause for concern for airport personnel. As a result, the Federal Aviation Administration (FAA) Office of Airports requested the FAA Airport Technology Research and Development Branch (ATR) conduct a human factors evaluation of runway/taxiway lighting configurations and intensity levels between RWY 4L and TXY B at BOS.

FAA ATR personnel gathered airfield lighting information and conducted five approaches at night to assess potential visual cues that could cause a pilot to align their aircraft with TXY B instead of RWY 4L at BOS. In addition, one flight test run was conducted using a new area navigation (RNAV) procedure developed for RWY 4L that was intended for use while RWY 4R was closed for construction.

Two pilots and two visual guidance researchers were on board the aircraft to comment on visual cues presented during each approach. A video imaging staff member was also on board to capture the visual scene for each approach. Flight testing did not identify any issues with the visual cues on the airport that would cause a pilot cleared to RWY 4L at BOS to mistake TXY B as a runway. During the flight test runs, it was noted that the edge lights on RWY 4L appeared spotting and too dim.

It is recommended that maintenance be conducted and the light intensity be increased for conditions flown. In addition, the RWY 4L left side runway end identifier lights (REIL) at the 20° offset approach to TXY B were consistently not visible. It is recommended that a maintenance check of the RWY 4L left side REIL be conducted to explore the possibility that other airfield signage could be blocking the REIL light output at that angle.

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LIST OF ACRONYMS

AGL	Above ground level
ALCS	Airfield Lighting Control System
ATCT	Air traffic control tower
ATR	Airport Technology Research and Development Branch
BOS	Boston Logan International Airport
FAA	Federal Aviation Administration
GPS	Global Positioning System
ILS	Instrument landing system
KIAS	Knots indicated airspeed
LED	Light-emitting diode
MassPort	Massachusetts Port Authority
MOR	Mandatory Occurrence Report
NM	Nautical mile
PAPI	Precision approach path indicator
REIL	Runway end identifier lights
RNAV	Area navigation
RWY	Runway
TRACON	Terminal Radar Approach Control
TXY	Taxiway
VFR	Visual Flight Rules
WJHTC	William J. Hughes Technical Center

EXECUTIVE SUMMARY

Between September 2013 and October 2016, two aircraft, parts 91 and 121 (i.e., operating under Title 14 Code of Federal Regulations Part 91 and Part 121 Flight Rules), that were cleared under Visual Flight Rules (VFR) to land on Runway (RWY) 4L at Boston Logan International Airport (BOS) but instead aligned their aircraft to land on parallel Taxiway (TXY) B. In both instances, air traffic controllers noticed the aircraft were not aligned with RWY 4L and directed the aircraft to perform a go-around. In May 2017, RWY 4R was scheduled to be closed for construction, requiring RWY 4L to handle significantly more traffic. Given the two aforementioned aircraft incidents and the planned increase in use of RWY 4L, this was cause for concern for airport personnel. As a result, the Federal Aviation Administration (FAA) Office of Airports requested the FAA Airport Technology Research and Development Branch (ATR) conducted a human factors evaluation of runway/taxiway lighting configurations and intensity levels between RWY 4L and TXY B at BOS.

FAA ATR personnel documented the airfield centerline and edge lighting for RWY 4L-22R, TXY B, TXY N, and TXY M as either light-emitting diode (LED) or incandescent. In addition, the light step settings on the runways and taxiways were documented for both day and night and at the various predefined visibility levels. Researchers conducted five approaches at night to assess potential visual cues that could cause a pilot to confuse TXY B with RWY 4L at BOS. In addition, one flight test run was made using a temporary area navigation (RNAV) procedure developed for RWY 4L intended for use while RWY 4R is closed for construction.

The FAA New England Region collected the requisite airfield lighting and configuration information for BOS in December 2016. The Massachusetts Port Authority (MassPort) identified the type of lighting on RWY 4L and TXYs B, N, and M. MassPort confirmed that all runway and taxiway regulators actuate to the configured brightness levels using the Airfield Lighting Control System (ALCS). The response times of the ALCS touchscreens in the air traffic control tower (ATCT) were also tested and verified.

A test plan was coordinated with the FAA New England Region, MassPort, William J. Hughes Technical Center (WJHTC) Flight Operations, WJHTC Imaging Technologies Branch, BOS ATCT, BOS Terminal Radar Approach Control (TRACON), and the FAA Office of Airports over a period of six weeks. Progressive buy-in was achieved, and the final six flight test runs represented a consensus opinion for how to proceed. The flight test runs were conducted on May 10, 2017.

Two pilots and two visual guidance researchers were on board the aircraft to comment on visual cues presented during each approach. A video imaging staff member was also onboard to capture the visual scene for each approach. Flight testing did not identify any issues with the visual cues on the airport that would cause a pilot cleared to RWY 4L at BOS to mistake TXY B for a runway.

During the flight test runs, the edge lights on RWY 4L appeared spotting and too dim. It is recommended that maintenance be conducted and the light intensity be increased for conditions flown. In addition, the RWY 4L left side runway end identifier lights (REIL) at the 20° offset approach to TXY B was consistently not visible. It is recommended that a maintenance check of the RWY 4L left-side REIL be conducted to explore the possibility that other airfield signage could be blocking the REIL light output at that angle.

INTRODUCTION

PURPOSE.

The Federal Aviation Administration (FAA) Airport Technology Research and Development Branch personnel evaluated the lighting system configurations and the intensity level settings on Runway (RWY) 4L and parallel Taxiway (TXY) B at Boston Logan International Airport (BOS) to assess if there were any visual cues that could cause a pilot to mistake TXY B for a runway. In addition, a temporary area navigation (RNAV) procedure developed for RWY 4L to be implemented when RWY 4R is closed for construction was assessed for safety at the request of the FAA New England Region.

BACKGROUND.

Between September 2013 and October 2016, two aircraft that were cleared Visual Flight Rules (VFR) to land on RWY 4L at BOS instead aligned their aircraft to land on parallel TXY B. In both instances, air traffic controllers noticed the aircraft were not aligned with RWY 4L and directed the aircraft to perform a go-around, or an aborted landing of an aircraft on final approach. In December 2016, light-emitting diode (LED) runway centerline lights were installed on RWY 4L to help pilots better identify the runway. In May 2017, RWY 4R was scheduled to be closed for construction, and RWY 4L would have to handle significantly more traffic. This was cause for concern among airport personnel given the aforementioned aircraft incidents and the planned increase in use of RWY 4L. As a result, the FAA Office of Airports requested the FAA Airport Technology Research and Development Branch conduct a human factors evaluation of runway/taxiway lighting configurations and intensity levels between RWY 4L and TXY B at BOS. Figure 1 shows the BOS airport diagram.

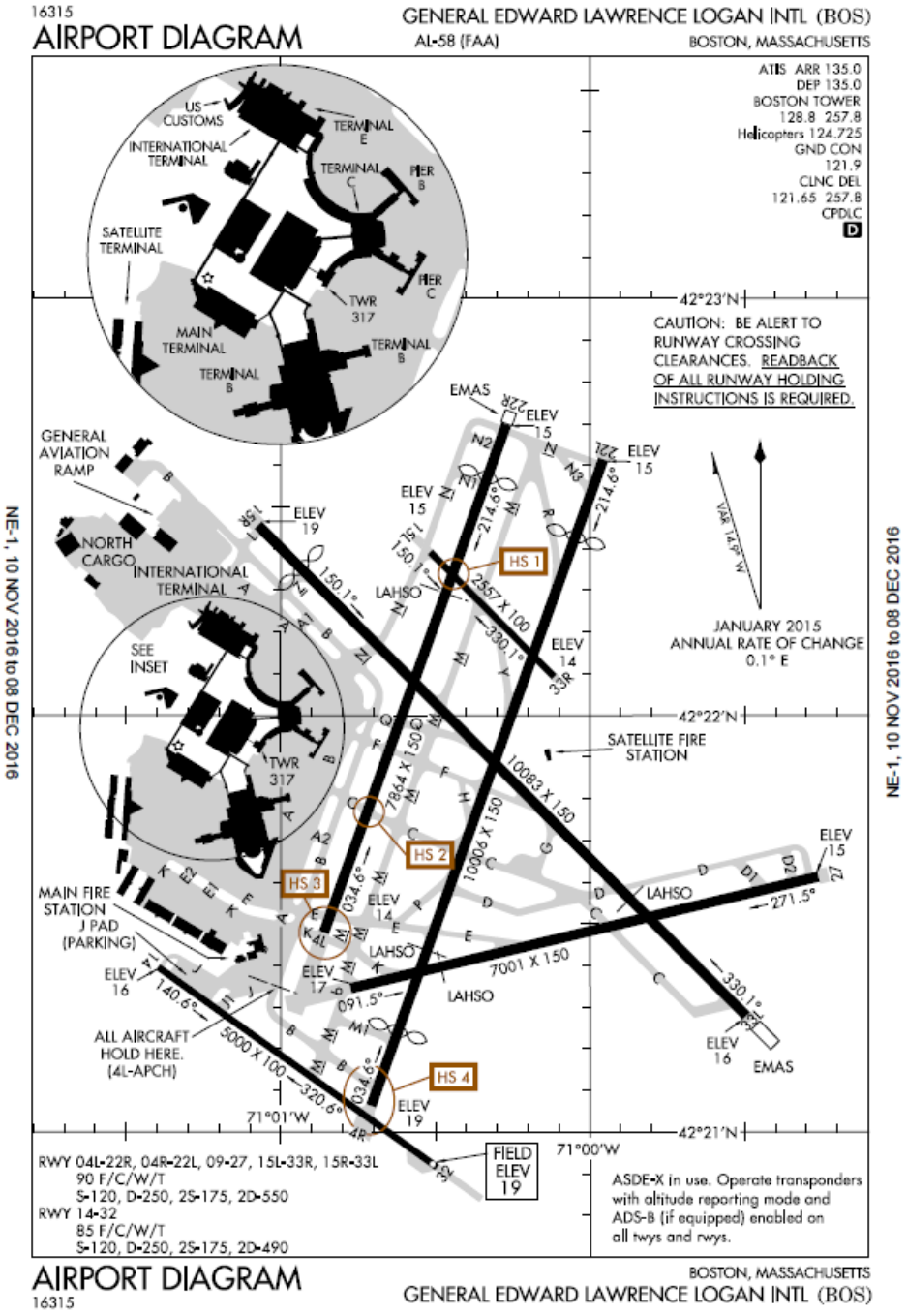


Figure 1. The BOS Airport Diagram

INCIDENT 1. The first incident occurred on September 27, 2013, at 19:16 local. Sunset was at 18:32 local or about 45 minutes prior. The aircraft was a Cirrus® SR22 flown by a part 91 operator (i.e., operating under Title 14 Code of Federal Regulations Part 91 Flight Rules). A generic Cirrus SR22 is shown in figure 2; it is considered a four-seat general aviation (GA) aircraft.

Figure 2. Cirrus SR22 Aircraft

Figure 3 shows the Mandatory Occurrence Report (MOR), which indicates the aircraft was on a straight-in visual approach to RWY 4L. The pilot reported, "the RWY 4L lights were not bright enough." Researchers understood that the runway lights were likely set to step 2 and the taxiway lights to step 1.

Incident Date & Time: 9/27/13 @ 23:16 UTC
Call Sign(s): [redacted] (SR22)
Incident Summary: AIRCRAFT ON A VISUAL APPROACH TO RWY 4L. AS AIRCRAFT CROSSED THE AIRPORT BOUNDARY, LCW NOTICED ON THE ASDE-X THAT THE AIRCRAFT APPEARED TO BE ALIGNED WITH TXY B, INSTEAD OF RWY 4L. CONTROLLER INITIATED GO-AROUND. UPON CLIMB OUT BY THE AIRCRAFT, IT WAS OBVIOUS THAT THE AIRCRAFT WAS INDEED ALIGNED WITH TXY B. THERE WAS TRAFFIC TAXIING ON TXY B OPPOSITE DIRECTION TO THE POTENTIAL LANDER. BOS FLM SPOKE TO THE PILOT VIA TELEPHONE AND PILOT STATED THAT HE WAS SORRY BUT THE RUNWAY LIGHTS WERE NOT BRIGHT ENOUGH ALTHOUGH PILOT DID NOT ASK FOR THE LIGHTS TO BE TURNED UP. I EMPHASIZED THAT THE PILOT SHOULD HAVE ASKED FOR BRIGHTER INTENSITY IF THERE WAS SOME CONFUSION. NO PILOT DEVIATION FILED AS THERE WAS NO APPARENT VIOLATION THANKS TO THE CONTROLLER'S IMMEDIATE ACTION. THERE WAS NO LOSS OF SEPARATION.

Figure 3. Incident 1 MOR

INCIDENT 2. The second incident occurred on October 20, 2016, at 19:30 local. Sunset was at 18:45 local or about 45 minutes prior. The aircraft was a Bombardier Dash 8 flown by a part 121 operator. A generic Bombardier Dash 8 is shown in figure 4; it is a twin-engine, medium-range, turboprop airliner.

Figure 4. Bombardier Dash 8 Aircraft

Figure 5 shows the incident report, which indicates the aircraft was on a BOS procedure to fly the RWY 15R instrument landing system (ILS) with a visual transition to RWY 4L. The transition required the aircraft to follow the channel and then bank through a 90° turn to align with RWY 4L at a distance of about 1 mile from the RWY 4L threshold. In this particular incident, the aircraft made a gradual turn and was not aligned parallel with RWY 4L until 0.25 mile from the threshold, as shown in figure 6. The aircraft descended to an altitude of 0 feet and then entered a missed approach procedure. Finally, the aircraft circled around the runway and landed on RWY 4R. Researchers understood that the runway and taxiway lights were likely set to step 3.

Date/Time: Oct 20, 2016 - 2330Z

A/C: PDT4872 (DH8/A)

Summary: [redacted], A DH8A, FLYING THE 15RVA4L APPROACH. [redacted] TURNED FINAL LINING UP WITH B TXWY INSTEAD OF RY 4L. LCE, LCW, TMC, 5AND CIC NOTICED IT NOT LOOKING CORRECT AND LCW SENT [redacted] AROUND OVER THE TOP OF JBU865, AN A320, HOLDING ON B TXWY SHORT OF RY4L. CLOSEST PROXITY 20 FEET VERTICAL.

Figure 5. Incident 2 MOR

Figure 6 shows the ground track of the incident 2 aircraft. Airport Technology R&D Branch personnel used this ground track to calculate an approach for the FAA test aircraft to fly, essentially a straight-in visual approach to RWY 4L with a 20° offset from the threshold instead of flying the channel to avoid creating noise for Boston residents. This information was then used for several test runs described later in the document.

Figure 6. Incident 2 Ground Track [1]

DATA COLLECTION

The FAA New England Region composed pertinent information on airfield lighting configuration and intensity at BOS in December 2016. This information was important to document prior to flight test runs and analysis.

AIRFIELD LIGHTING.

The Massachusetts Port Authority (MassPort) identified the type of lighting on RWY 4L and TXYs B, N, and M in December 2016. The type of lighting is shown in table 1.

Table 1. The BOS Lighting Types

Surface	Centerline Lights	Edge Lights
RWY 4L-22R	LED	Incandescent
TXY B	Incandescent	LED
TXY N	Incandescent	LED
TXY M	Incandescent	LED

AIRFIELD LIGHTING CONFIGURATION.

MassPort confirmed that the runway (steps 1 through 5) and taxiway (steps 1 through 3) regulators actuate to the configured brightness levels of the Airfield Lighting Control System (ALCS). The response times of ALCS touchscreens in the air traffic control tower

(ATCT) were tested and verified. One of the keyboard, video monitor, and mouse (KVM) extenders was beginning to fail and was replaced. It was also confirmed that the ATCT lighting control panel could properly adjust all step settings on all taxiways and runways.

Tables 2 and 3 show ATCT procedures for runway and taxiway step settings at BOS based upon the prevailing meteorological visibility.

Table 2. The BOS Light Settings for Day Operations

Visibility (miles)	Day
10 to 3	RWY-0 TXY-0
2.5 to 2	RWY-3 TXY-0
1-3/4 to 1	RWY-4 TXY-0
3/4 to <1/4	RWY-5 TXY-3

Table 3. The BOS Light Settings for Night Operations

Visibility (miles)	Night
10 to 3	RWY-2 TXY-1
2.5 to 1	RWY-3 TXY-1
3/4 to <1/4	RWY-4 TXY-2

Runway centerline lights on RWY 4L-22R were successfully commissioned in December 2016.

TEST PLAN

The test plan was coordinated with the FAA New England Region, MassPort, WJHTC Flight Operations, WJHTC Imaging Technologies Branch, BOS ATCT, BOS Terminal Radar Approach Control (TRACON), and the Office of Airport Safety and Standards Airport Engineering Division (AAS-100) over a period of six weeks. Progressive buy-in was achieved, and the final six flight test runs represented a consensus opinion for how to proceed.

The first test objective was to recreate the two incidents at BOS at approximately the same number of minutes after dark that the two incidents occurred, which coincidentally, both incidents occurred 45 minutes after dark. The first test objective was to determine if lighting was adequate for a pilot to identify TXY B as a taxiway. The second test objective was to vary the runway and taxiway light settings to observe the visual difference from a pilot's perspective for the two incident flight paths and determine if the varied light settings improved a pilot's ability to identify TXY B as a taxiway. The third objective was to fly the temporary RWY 4R RNAV approach with side-step to RWY 4L that was to be implemented by BOS while RWY 4R was closed for construction and to provide feedback on a pilot's visual ability to correctly identify RWY 4L.

INCIDENT 1 FLIGHT TEST RUNS.

Two flight test runs were conducted in FAA Aircraft N47 starting at approximately 20:38 local time by flying straight in toward TXY B. The centerline lights on RWY 4L were turned off during the first run and turned on during the second run. Table 4 shows the flight test run configuration information that was used by BOS ATCT and the flight crew to coordinate during testing. Figure 7 shows the approach to TXY B at BOS.

Table 4. Incident 1 Flight Test Runs

RNAV (GPS) 4L Then Straight Toward TXY B						
Run	RWY 4L Centerline Lights	Indicated Airspeed Within 5 NM	Protect TXY B	RWY 4L Intensity (Step) Setting	TXYs: A, B, M, J Intensity (Step) Setting	Missed Approach Point
1	OFF	140 KIAS	Yes	2	1	~0.25 NM from TXY B
2	ON	140 KIAS	Yes	2	1	~0.25 NM from TXY B

GPS = Global positioning system
KIAS = Knots indicated airspeed
NM = Nautical mile

Figure 7. Incident 1 Flight Approach to BOS

INCIDENT 2 FLIGHT TEST RUNS.

Three flight test runs were conducted from a coordination point 5 miles from TXY B with a 20° offset (magnetic bearing of 055.70°) to TXY B. Although this flight path did not recreate the exact flight path of the aircraft in Incident 2, it did recreate the aircraft path during Incident 2 once the aircraft turned toward RWY 4L on the visual approach. Hence, all video analysis is valid from the spatial point where the aircraft turned toward RWY 4L.

Figure 8 shows the coordination point for the Incident 2 approaches. Table 5 contains the flight test run configuration information that was used by BOS ATCT and the flight crew to coordinate during testing. Flight Test Run 3 recreated the runway and taxiway conditions during Incident 2. The taxiway and runway lighting was set to step 3, and the centerline lights on RWY 4L were off. Flight Test Run 4 used standard taxiway and runway light settings, and the centerline lights on RWY 4L remained off. Flight Test Run 5 used standard taxiway and runway light settings with the RWY 4L centerline lights turned on.

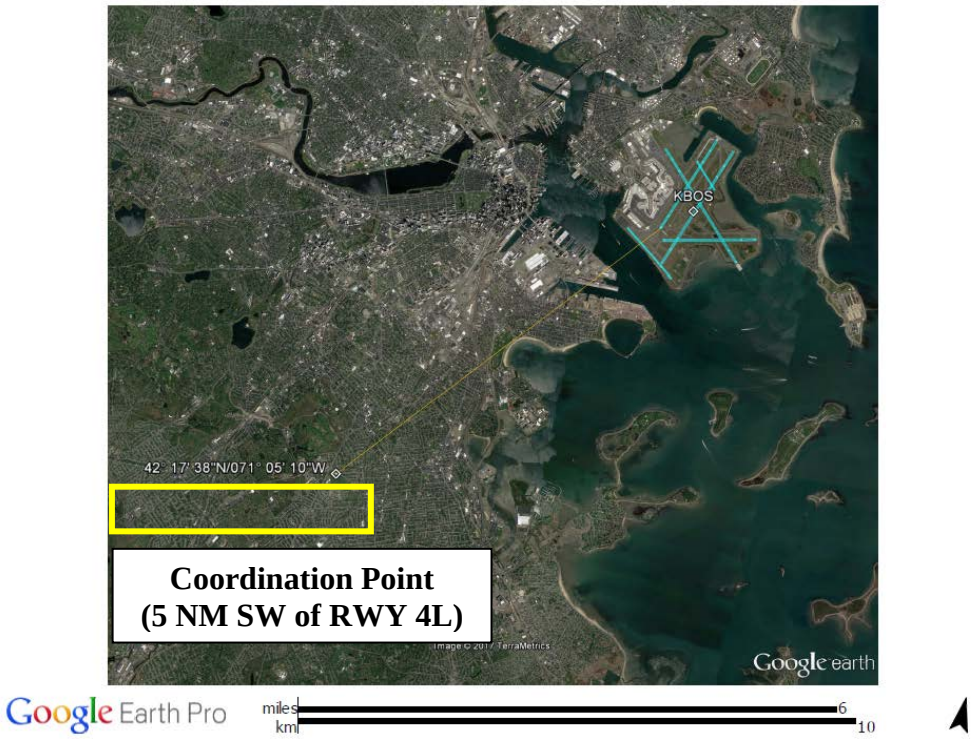


Figure 8. Coordination Point for Incident 2 Flight Test Runs

Table 5. Incident 2 Flight Test Runs

Coordination Point With 20° Offset to TXY B (magnetic bearing of 055.70°)						
Run	RWY 4L Centerline Lights	Indicated Airspeed Within 5 NM	Protect TXY B	RWY 4L Intensity (Step) Setting	TXYs: A, B, M, J Intensity (Step) Setting	Missed Approach Point
3	OFF	140 KIAS	Yes	3	3	~0.25 NM from TXY B
4	OFF	140 KIAS	Yes	2	1	~0.25 NM from TXY B
5	ON	140 KIAS	Yes	2	1	~0.25 NM from TXY B

Note: RWY 4L REILs are "ON" for all runs

Figure 9 shows the Incident 2 20° offset approach to RWL 4L along with the missed approach point 0.25 NM from the taxiway end.

Figure 9. Incident 2 Flight Approach to BOS

TEMPORARY RNAV PROCEDURE FOR RWY 4L FLIGHT TEST RUN.

In May 2017, RWY 4R was closed for construction, and RWY 4L handled significantly more traffic. A temporary RNAV procedure, i.e., an RNAV 4R approach with a site step to RWY 4L at 800′ above ground level (AGL), was approved for the construction period. The FAA New England Region expressed concern about this approach, so ANG-E261 agreed to conduct one flight test run using the temporary RNAV approach.

All RWY 4R lights were turned off before the start of Flight Test Run 6, as BOS ATCT planned to have the RWY 4R lights off during construction. Flight Test Run 6 was to follow the RWY 4R RNAV approach and then perform a side-step maneuver to RWY 4L at 800′ AGL. Table 6 contains the flight test run configuration information that was used by BOS ATCT and the flight crew for coordination during testing. Figure 10 shows the RWY 4L approach to BOS.

Table 6. Temporary RNAV Flight Test Run

RNAV (GPS) 4R Followed by Side-Step to RWY 4L						
Run	RWY 4L Centerline Lights	Indicated Airspeed Within 5 NM	All Runway Lights and Approach Lights	RWY 4L Intensity (Step) Setting	TXYs: A, B, M, J Intensity (Step) Setting	Missed Approach Point
6	ON	140 KIAS	OFF	2	1	~0.25 NM from RWY 4L

Note: RWY 4L REILs are “ON”

Figure 10. Temporary RNAV Flight Run Approach to BOS

RESULTS AND DISCUSSION

Flight test runs were conducted on May 10, 2017, using the WJHTC Bombardier Global 5000 aircraft. Two pilots and two visual guidance researchers were on board the aircraft to offer comments on visual cues presented during each approach. A video imaging staff member was also on board to capture the visual scene for each approach. A "go decision" was made by BOS ATCT at 6:30 PM based upon the wind direction and traffic flow, as well as the good visibility at BOS. The Global 5000 started the first flight test run at 8:32 PM, approximately 45 minutes after sunset.

FLIGHT TEST RUN 1: INCIDENT 1.

The first two fight test runs were designed to recreate Incident 1 conditions, which included a straight-in visual approach. During Flight Test Run 1, the airfield lighting configuration on the night of the incident was recreated. In particular, the RWY 4L centerline lights were turned off, as they were not installed when the incident occurred. Figure 11 shows the aircraft view of BOS on the approach for Flight Test Run 1. RWY 4L is clearly visible with the precision approach path indicators (PAPI) on the left side of the runway. TXY B is also clearly identified by the green centerline lights.

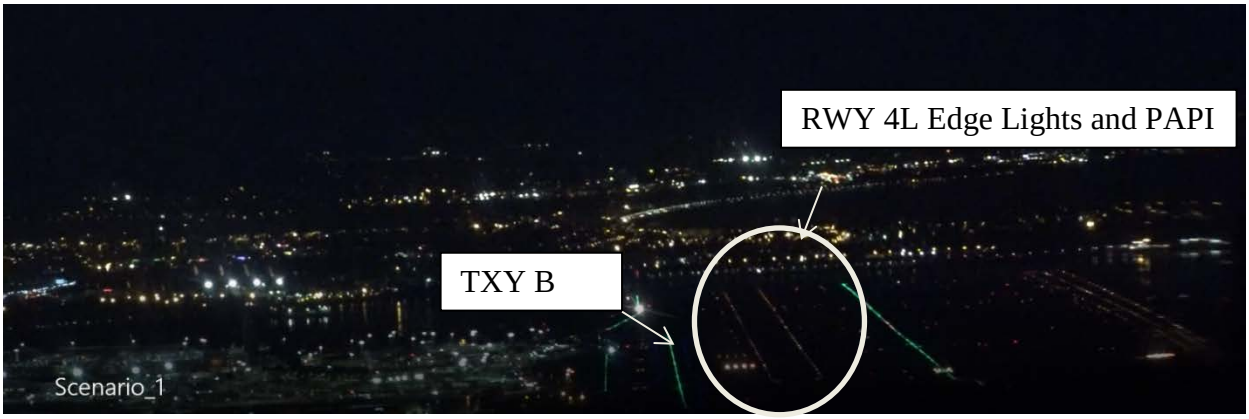


Figure 11. Flight Test Run 1 Aircraft Site View

As the aircraft began the approach, PAPIs on RWY 4L and 4R first; then, the pilots identified the white runway lights on RWY 4L and noted that RWY 4R runway lights were visible but slightly dimmer (normal for viewing the runway lights from over the taxiway). Researchers noted that the green centerline lights of TXYs B and M were clearly visible and perceived to be brighter than RWY 4L. When the aircraft got closer to the runway, both REILs on RWY 4L were visible; the green taxiway centerline lights still appeared green, and RWY 4R was more visible than 4L because of the centerline and approach lights. RWY 4L's edge lighting was observed to be not uniform (i.e., "spotty"). Given the angle of approach and background illuminance, visibility would likely have improved if the edge lights on RWY 4L were set to step 3 instead of step 2. Blue taxiway edge lights on TXYs B and M were visible. Researchers determined there was no mistaking the taxiway for a runway during approach.

FLIGHT TEST RUN 2: INCIDENT 1.

Flight Test Run 2 was the same as Flight Test Run 1, except the new RWY 4L centerline lights were activated. The aircraft site for Flight Test Run 2 is shown in figure 12.

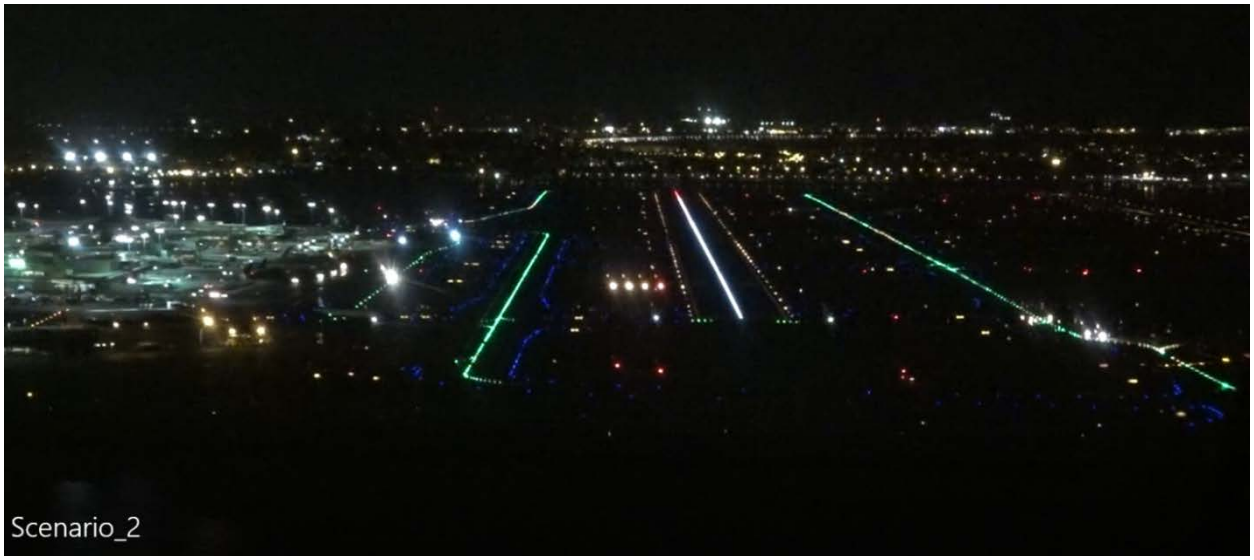


Figure 12. Flight Test Run 2 Aircraft Site View

As the aircraft began the approach, researchers identified the PAPIs on RWY 4L and RWY 4R first; then, they identified the white lights of RWY 4L, and noted that RWY 4R's lights were visible but slightly dimmer. After initial identification, it was noted that the RWY 4L centerline lights definitely appeared whiter than any other white lights in view. RWY 4L edge lights looked more yellow, dimmer, and still spotty. RWY 4L centerline lights were noticeably brighter than RWY 4L edge lights. All lights on RWY 4R, where visible, appeared yellow and dimmer than the RWY 4L centerline lights. When the aircraft was closer to the runway, both REILS on RWY 4L were visible, and the green centerline lights on TXY B appeared green. Blue taxiway edge lights were visible for TXYs B and M. Researchers determined there was no mistaking TXY B for a runway during the approach.

FLIGHT TEST RUN 3: INCIDENT 2.

Flight Test Runs 3, 4, and 5 addressed the conditions present of the second incident in 2016, when a Dash 8 transitioned from the RWY 15R approach to the RWY 4L visual and overflew the area between TXYs A and B. The aircraft site for Flight Test Run 3 is shown in figure 13.

As the aircraft began the approach, PAPIs on RWYs 4L and 4R were not visible. However, green centerline lights for both TXYs B and M were clearly visible. At about 3 miles, only one REIL (later identified as the right REIL) on RWY 4L was visible, and RWY 4L runway lights were identified. Green taxiway centerline lights appeared green. The green centerline lights of TXYs B and M were clearly visible. As the aircraft came closer to the edge of TXY B, RWY 4L's left REIL and edge lights became visible. TXY B lights were noticeably brighter than RWY 4L lights. With the angle of approach and background illuminance, visibility could have

been improved if RWY 4L edge lights had been set on step 4 instead of step 3. The green centerline lights of TXY A were visible. Blue edge lights of TXY B and M were visible. Researchers determined there was no mistaking TXY B for a runway during the approach.

Figure 13. Flight Test Run 3 Aircraft Site View

FLIGHT TEST RUN 4: INCIDENT 2.

Flight Test Run 4 was setup to recreate conditions comparable to the second incident in 2016. The approach was at a 20° offset to TXY B, RWY 4L lights were set to step 2, RWY 4L centerline lights were off, and TXY B and M lights were set to step 1. The aircraft site for Flight Test Run 4 is shown in figure 14.

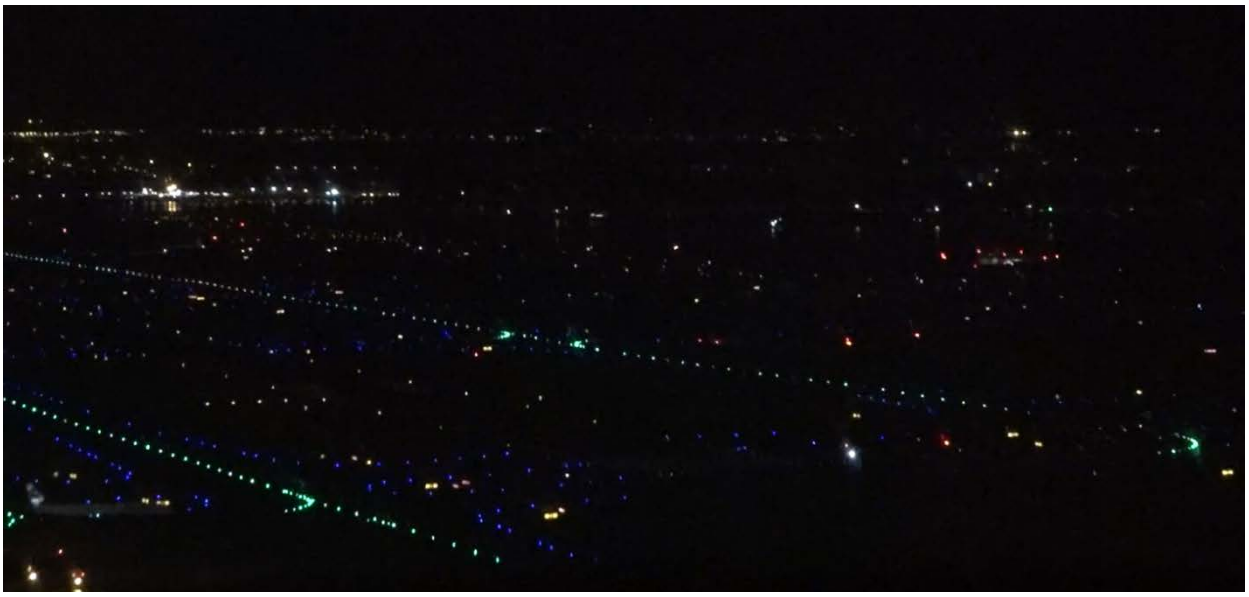


Figure 14. Flight Test Run 4 Aircraft Site View

As the aircraft began the approach, PAPIs on RWY 4L and RWY 4R were not visible. However, as in all previous flight test runs, the green centerline lights of both TXYs B and M were clearly visible. The researchers could still not see the runway lights; and as a result, one pilot commented that "the runway must be between the two long green lines, so let's keep going."

At about 3 miles, only one REIL (later identified as the right REIL) on RWY 4L was visible, RWY 4L runway lights were identified, TXY B and M green centerline lights were clearly visible and appeared unmistakably green. RWY 4L edge lights came into view.

When closer to the edge of TXY B, RWY 4L's left REIL became visible. TXY B lights were noticeably brighter than the RWY 4L lights. With the angle of approach and background illuminance, better visibility would likely be achieved if the RWY 4L lights were set to step 3. The blue TXY B and M edge lights were visible. Researchers determined there was no mistaking TXY B for a runway during the approach.

FLIGHT TEST RUN 5: INCIDENT 2.

Flight Test Run 5 was setup to recreate conditions comparable to the second incident in 2016. The approach was at a 20° offset to TXY B, RWY 4L lights were set to step 2, RWY 4L centerline lights were activated, and TXY B and M lights were set to step 1. The aircraft site view for Flight Test Run 5 is shown in figures 15 and 16.

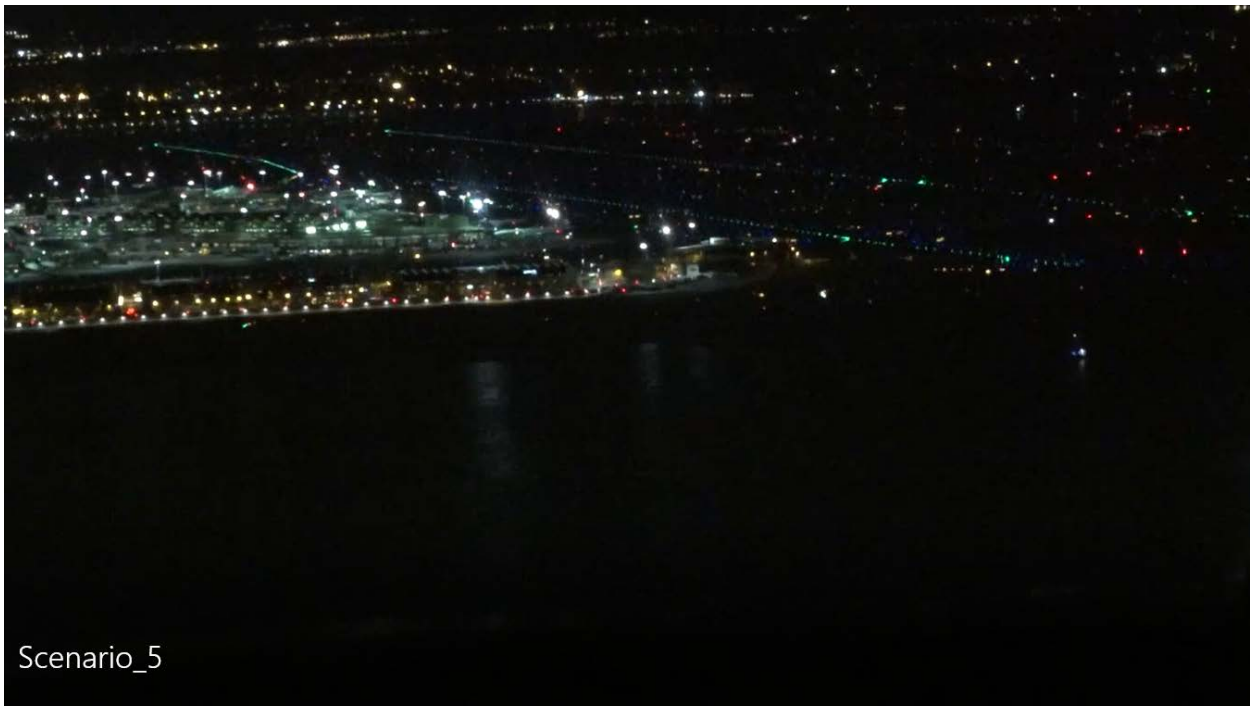


Figure 15. Flight Run 5 Aircraft Site View—Over Channel

Initially, from a distance, RWY 4L and RWY 4R PAPIs were not visible. However, as in all previous flight test runs, both TXY B and M green centerline lights were clearly visible. Having flown the previous approaches, the test aircraft pilots knew that the runway was between the two long green lines, as shown in figure 16.

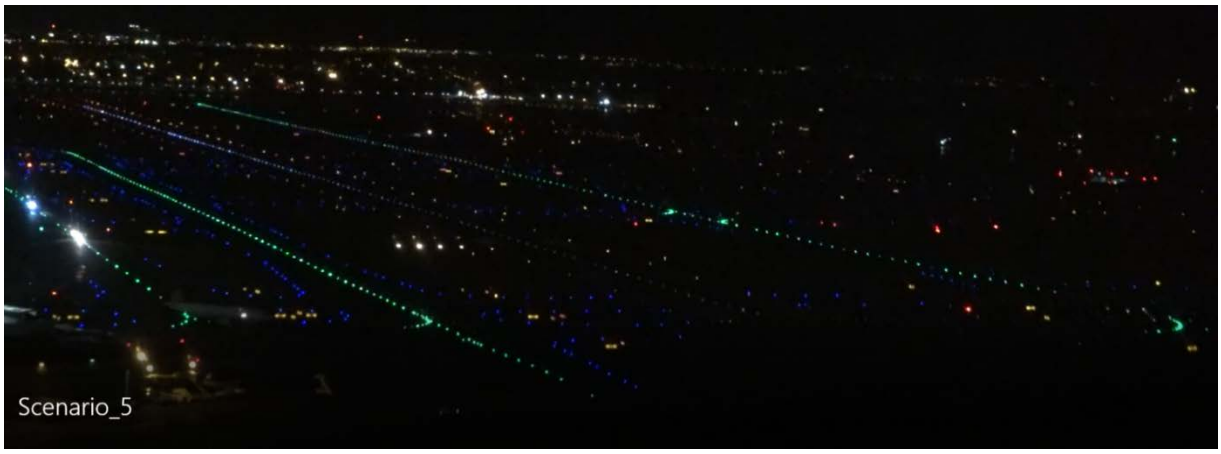


Figure 16. Flight Test Run 5 Aircraft Site View

At about 3 miles, only one REIL (later identified as the right REIL) on RWY 4L was visible; RWY 4L lights were identified, and TXY B and M green centerline lights were visible and appeared unmistakably green. RWY 4L edge lights became visible. TXY B lights were noticeably brighter than RWY 4L lights. From this angle, having RWY 4L centerline lights activated did not aid in identifying the runway.

As the aircraft approached the edge of TXY B, RWY 4L's left REIL became visible. With angle of approach and background illuminance, better visibility would probably be achieved if RWY 4L lights were set to step 3. The blue TXY B and M edge lights were visible. There was no mistaking TXY B for a runway during the approach.

FLIGHT TEST RUN 6: RNAV SIDESTEP TO RWY 4L.

Flight Test Run 6 was designed to fly the temporary RWY 4R RNAV approach with a side-step maneuver to RWY 4L that was to be implemented during the week of May 15, 2016. The aircraft site view for Flight Test Run 6 is shown in figure 17.

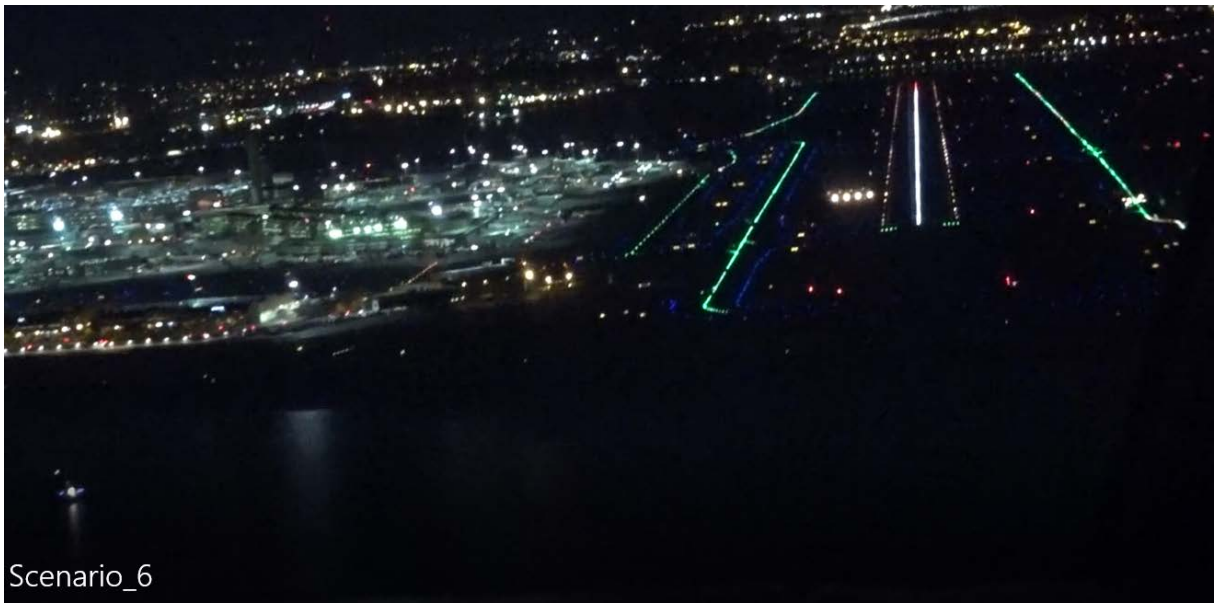


Figure 17. Flight Test Run 6 Aircraft Site View

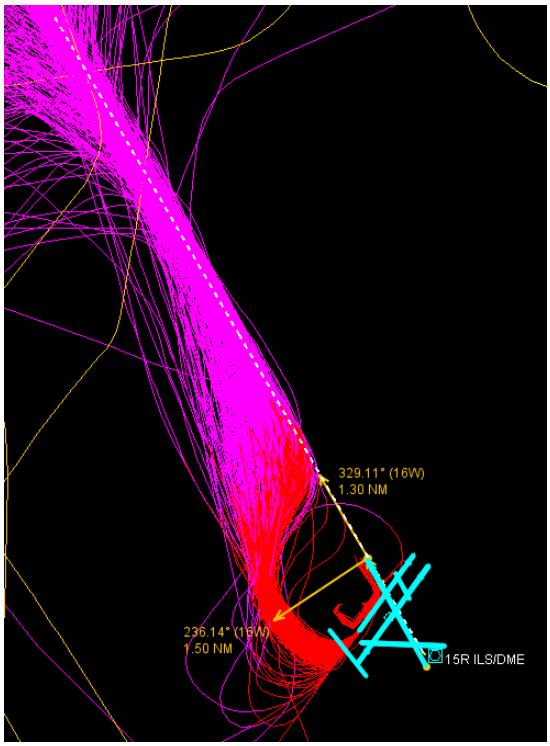
Initially, from a distance, PAPIs on Runways 4R and 4L were identified, RWY 4R's yellow-white runway edge lights were identified, and RWY 4L's centerline light was clearly visible. The RWY 4L white centerline lights appeared brighter than any other white lights on the airfield. The green lights on TXY B and M were visible.

At a closer distance, the TXY B green centerline lights and the RWY 4L lights became visible, and both REILs were visible. Although all RWY 4L lights were visible, the runway edge lights appeared yellow and dimmer compared to the RWY 4L centerline lights. The blue TXY B and M edge lights were visible. Researchers determined that there was no mistaking TXY B for a runway during the approach.

The pilots noted there were mechanical construction cranes located across the water between RWYs 4R and 4L and about 2 miles from the RWY 4L threshold. The pilots suggested that the side-step height from RWY 4R to RWY 4L be increased by 100′ from the current 800′ AGL to provide more clearance.

ANALYSIS OF INCIDENT 2.

In October 2016, an analysis was performed of the aircraft approaches into BOS RWY 4L using the 15R ILS transition procedure from January 2015 through July 2016. Researchers determined that 2480 aircraft used the 15R ILS visual transition to RWY 4L procedure within this time period, of which there were four missed approaches and zero aircraft that lined up on TXY B. Figure 18 is a mapping of the approach routes by altitude and shows the majority of aircraft flew the route at under 2000′ AGL.



DME = Distance measuring equipment

Figure 18. Analysis of Aircraft Arrivals on 15R ILS Visual Transition to RWY 4L (January 2015-July 2016) [1]

CONCLUSIONS

Flight testing did not identify any visual cue issues that could mistakenly cause a pilot at Boston Logan International Airport to mistake Taxiway B for a runway.

The temporary Runway 4L RNAV approach was assessed to be safe.

REFERENCES

1. Hare, V., “Approaches Into BOS 04L Using 15R ILS,” Microsoft® PowerPoint® presentation, The Mitre Corporation, October 24, 2016.