JAA Airport Lighting System Requirements Simulator Evaluation

Eric S. Katz

April 1996

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16. Abstract

The European Joint Aviation Authority (JAA) introduced its Joint Airworthiness Requirements for Operations (JAR-OPS1) in April 1995. In general the airport lighting system requirements and associated operating minima authorized by the JAA for use during low-visibility takeoff and landing operations are lower than that used by the United States (U.S.) and American air carrier operators. The rationale for JAA's lower operating minima is based primarily on several years of operating experience by various European ICAO member states. In an effort to standardize aircrew procedures, training, and charting requirements, both the Federal Aviation Administration (FAA) and the JAA would like to harmonize low-visibility operating requirements and minima to the maximum extent possible.

This report describes a simulator evaluation to determine the feasibility of adopting the JAA lighting system requirements and operating minima as the FAA standard for low-visibility operations. The data results from this evaluation will be used by FAA Headquarters to formulate the U.S. position on adopting the JAA operational requirements for low-visibility operations.

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EXECUTIVE SUMMARY

When American air carriers operate outside the United States, they will encounter reduced airport lighting system requirements that have been adopted by the European Joint Aviation Authority (JAA). The JAA introduced its Joint Airworthiness Requirements for Operations (JAR-OPS1) in April of 1995. In general the airport lighting system requirements and associated operating minima authorized by the JAA for use during low-visibility takeoff and landing operations is lower than that used by the United States and American air carrier operators. The rational for the JAA's lower operating minima is based primarily on several years of operating experience by various European International Civil Aviation Organization (ICAO) member states. In an effort to standardize aircrew procedures, training, and charting requirements, both the FAA and JAA would like to harmonize low-visibility operating requirements and minima to the maximum extent possible.

This report describes a simulator evaluation to determine the feasibility of adopting the JAA lighting system requirements and operating minima as the FAA standard for low-visibility operations. The evaluation was conducted using the FAA B727 flight simulator with enhanced visual presentations and employed the services of experienced air carrier pilots as volunteer subjects.

This report presents the data results of this evaluation, which will be used by FAA Headquarters to formulate the U.S. position on adopting the JAA operational requirements for low-visibility operations.

INTRODUCTION

PURPOSE.

This evaluation effort was undertaken in response to a memorandum request from the Director, Flight Standards Service, AFS-1, dated March 2, 1994. The memorandum requested that the Airport Technology Research and Development Branch, AAR-410, at the Federal Aviation Administration Technical Center perform the testing and evaluation necessary to support FAA efforts to harmonize lighting requirements with the Joint Aviation Authority (JAA).

This report describes the methods by which proposed JAA reductions in requirements for airport lighting systems were evaluated and details the results of the testing effort.

BACKGROUND.

The JAA introduced its Joint Airworthiness Requirements for Operations (JAR-OPS1) in April of 1995. In general the airport lighting system requirements and associated operating minima authorized by the JAA for use during low-visibility takeoff and landing operations are lower than that used by the United States and American air carrier operators. The rational for the JAA's lower operating minima is based primarily on several years of operating experience by various European International Civil Aviation Organization (ICAO) member states. The FAA and U.S. air carriers believe it necessary to conduct a simulator evaluation to determine the feasibility of adopting the JAA lighting system requirements and operating minima as the FAA standard for low-visibility operations.

RELATED ACTIVITIES/DOCUMENTS.

The following documents relate directly to the issues addressed herein and define the nature of the lighting system differences studied in this evaluation:

- JAA document No. JAR-OPS1 (Draft), "Joint Airworthiness Requirements," contains air and ground equipment (to include lighting systems) required to support instrument operations in the European community.

- Jeppesen Sanderson Inc. Document, "JAA-FAA Harmonization Effort, Identification of Specific Differences (JAR OPS-1 and US 121 Ops Specs)," dated January 13, 1995.

- FAA Order No. 8260.3B, "U.S. Standard for Terminal Instrument Procedures (TERPS)."

- International Civil Aviation Organization (ICAO) Annex 14 to the Convention on Civil Aviation, "International Standards and Recommended Practices for Aerodromes."

DISCUSSION

Evaluation tasks accomplished within the framework of this effort included the evaluation of JAA proposed differences to runway and approach lighting requirements to determine whether they will safely support takeoff and landing operations under reduced visibility conditions.

Proposed JAA differences in required lighting that were evaluated included the following:

- Requirement for high-intensity runway edge lighting (HIRL) only to support takeoff operations in 850-foot runway visual range (RVR) conditions.
- Requirement for high-intensity runway edge lighting (HIRL) and runway centerline lighting to support takeoff operations in 500-foot RVR conditions.
- Requirement for 100-foot (rather than 50-foot) spacing of runway centerline lights to support landing operations in 500-foot RVR conditions.
- Requirement for ICAO Simple Single Source Centerline approach lighting system (ALS) (Configuration C—figure 1) to support Category I (200-ft decision height/2400-ft RVR) landing operations.
- Requirement for ICAO Simple Barrette Centerline ALS (Configuration D—figure 2) to support Category I (200-ft decision height/2400-ft RVR) landing operations.
- Requirement for standard medium-intensity approach lighting system with runway alignment indicator lights (MALSR) (Configuration A—figure 3) without runway touchdown zone (TDZ) and centerline lighting to support Category I (200-ft decision height/1800-ft RVR) landing operations.

In each instance, the JAA requirements are less stringent than the equivalent FAA lighting requirements for the given weather condition.

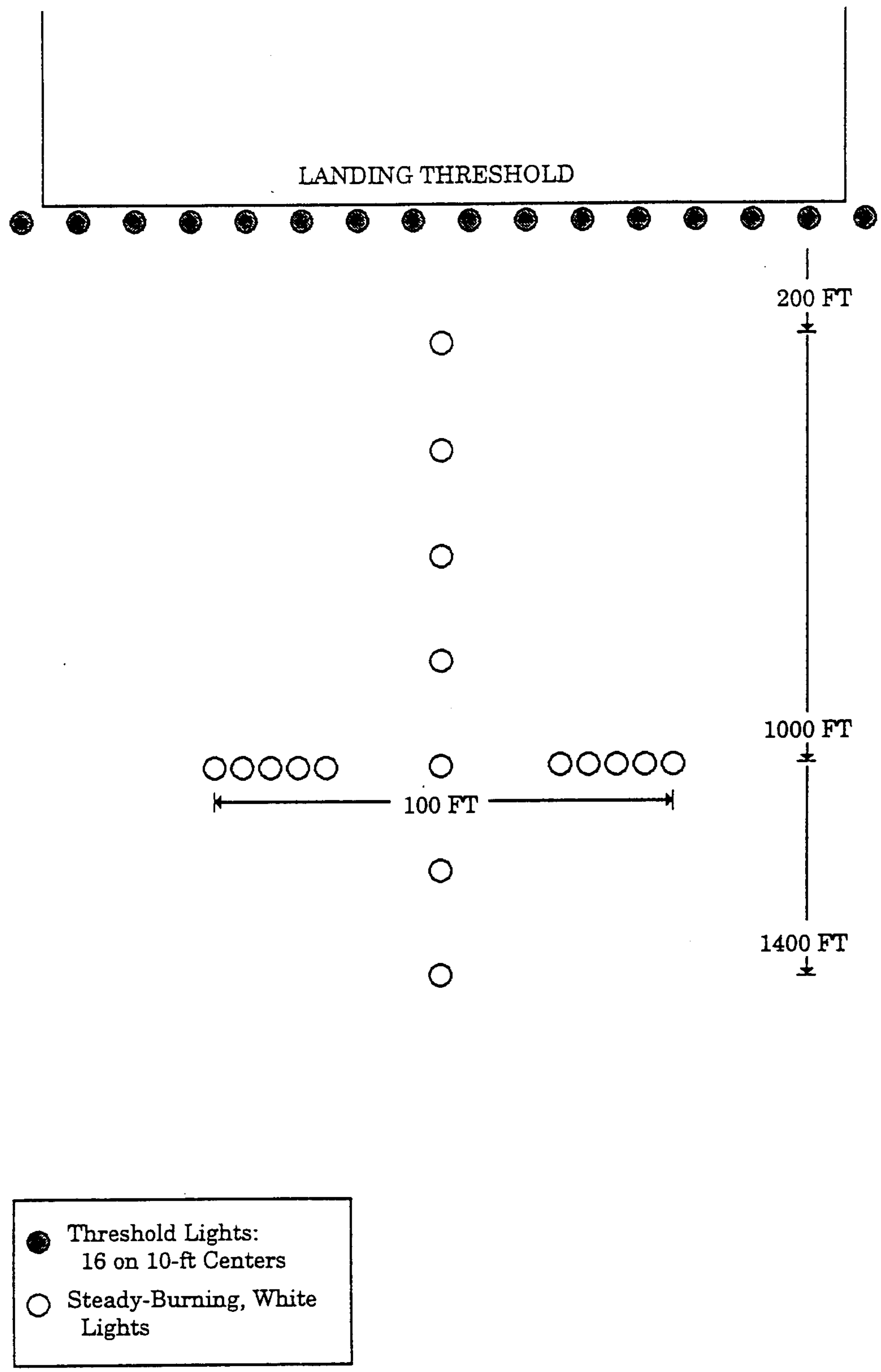

FIGURE 1. ICAO SIMPLE SINGLE SOURCE CENTERLINE ALS (CONFIGURATION C)

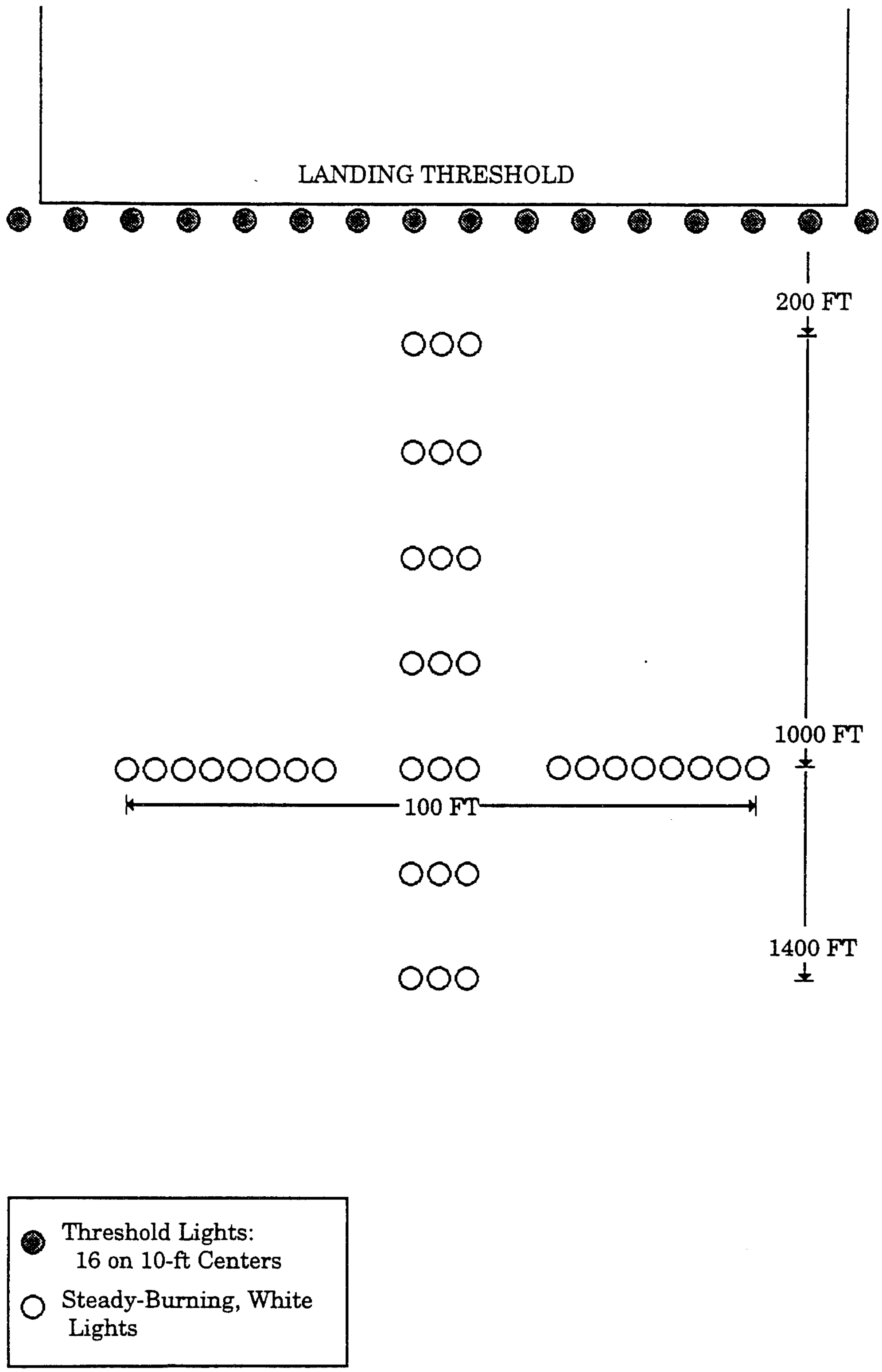

FIGURE 2. ICAO SIMPLE BARRETTE CENTERLINE ALS (CONFIGURATION D)

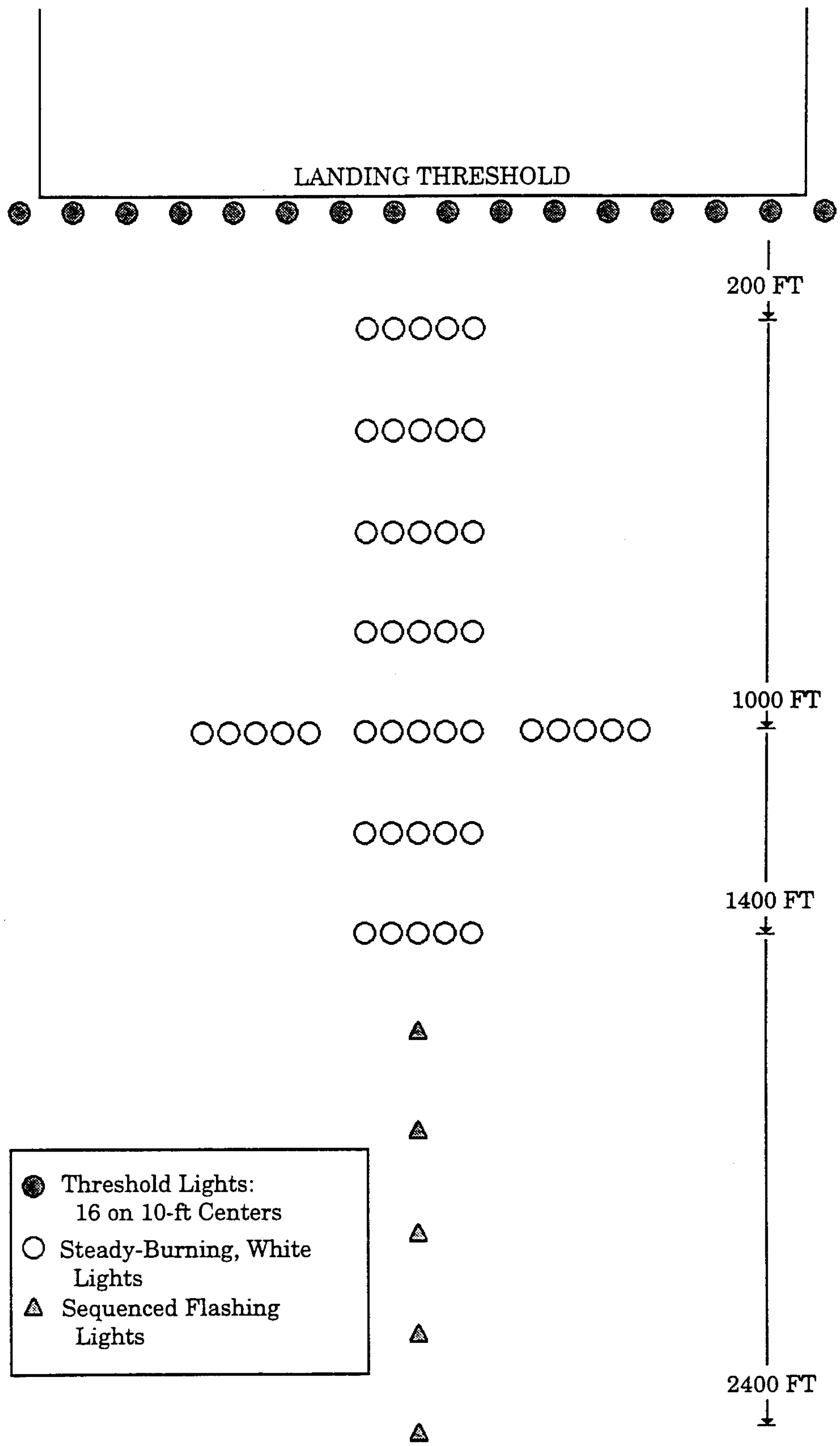

FIGURE 3. STANDARD MALSR SYSTEM (CONFIGURATION A)

EVALUATION APPROACH

EVALUATION METHOD.

In view of the fact that all of the evaluations involved testing of major lighting system configuration effectiveness/adequacy under reduced visibility conditions (Category I, II, and III), it would have been very difficult to conduct actual flight tests under existing weather conditions using modified full-scale ALS systems. Therefore, all evaluations were accomplished using the FAA Boeing 727 Flight Simulator located at the FAA Aeronautical Center in Oklahoma City. The visual display component of the flight simulator had recently been upgraded and calibrated in such a manner as to significantly enhance the lighting system presentation and to better suite it to visual aid evaluations.

The simulator is equipped with an SP-1T texturized dusk/night visual display with a full range of visual weather effects available. These include clouds (base and top selectable), scud, homogeneous fog, patchy fog, and selectable visibility and RVR. A modified RVR was also implemented for the test based on data contained in the January 1985 report by C.A. Douglas for Slant Range RVR under stable, homogeneous fog conditions.

EVALUATION PILOTS.

Twelve industry B727 type-rated pilots from various air carrier organizations (airlines, Airline Pilots Association (ALPA), and Air Transport Association (ATA)) comprised the majority of the evaluation subjects. Three rated FAA pilots also participated.

The evaluation involved fifteen subject pilots executing at least six takeoff and twelve approach/landing operations each. Scenario outlines, detailing weather and configurations tested, are provided as figure 4.

FAA RVR and Meteorological Conversion Tables are provided as table 1 and table 2 on page 9.

Simulator flight sessions lasted approximately two hours, with the subject pilot participating as Captain (Pilot-in-Command). For those evaluations that were conducted under simulated Category I conditions, all segments of the approach, to a point at or near the decision height (DH), were flown coupled with auto-throttle engaged. The captain then decoupled and at decision height either completed the landing visually or conducted a missed approach maneuver depending upon the adequacy of the visual system displayed. All Category III approaches were "Autoland" with manual rollout and deceleration. A qualified FAA pilot occupied the right seat in the simulator and performed such duties as would normally be assigned to the first officer.

JAA TAKEOFF DIFFERENCES

1. Acceptability of high-intensity runway edge lighting only (no centerline lights) to safely support takeoff operations in 850-ft RVR conditions.

Scenario	Condition	Ceiling ft	RVR ft	Wind kts	Takeoff/ Aborted
1	Normal	200	850	L@10	T**
2	Failure*≤V1	200	850	R@10	A***
14(If Req'd)	Normal	200	1000	L@10	T**
15(If Req'd)	Failure*≤V1	200	1000	R@10	A***

* Engine out   ** Takeoff Completed   *** Takeoff Aborted

2. Acceptability of high-intensity runway edge lighting and runway centerline lighting to safely support takeoff operations in 500-ft RVR conditions.

Scenario	Condition	Ceiling ft	RVR ft	Wind kts	Takeoff/ Aborted
3	Normal	200	500	L@10	T**
4	Failure*≤V1	200	500	R@10	A***
3 (Repeat)	Normal	200	500	L@10	T**
4 (Repeat)	Failure*≤V1	200	500	R@10	A***

* Engine out   ** Takeoff Completed   *** Takeoff Aborted

Simulator Conditions:

Aircraft Gross Takeoff Weight	=	172,000 lbs.
Turbulence	=	8%
Crosswind (L or R)	=	10 Knots

FIGURE 4. SCENARIO OUTLINE

JAA LANDING DIFFERENCES

3. Acceptability of 100-ft spacing of runway centerline lights to safely support landing operations in 500-ft RVR conditions.

Scenario	Approach Type	Ceiling ft	RVR ft	Wind kts	Offset ft
5	Autoland	100	500	L@10	0
6	Autoland	100	500	R@10	R@30
7	Autoland	100	500	L@10	L@30

Simulator Conditions:
Aircraft Gross Weight = 154,000 lbs
Turbulence = 8%
Crosswind (L or R) = 10 Knots (Gusts to 15 for Category I only)

4. Acceptability of ICAO Simple Single Source Centerline ALS (Configuration C) to safely support Category I landing operations.

Scenario	Approach Type	Ceiling ft	RVR ft	Wind/Gust kts	Offset ft
8	(Coupled	300	2400	R@10,G@15	0
9	with Auto Throttle (AT)	300	2400	L@10,G@15	L@60
10	to 100 ft above DH)	300	2400	R@10,G@15	R@60

5. Acceptability of ICAO Simple Barrette Centerline ALS (Configuration D) to safely support Category I landing operations.

Scenario	Approach Type	Ceiling ft	RVR ft	Wind/Gust kts	Offset ft
11	(Coupled	300	2400	L@10,G@15	0
12	with AT	300	2400	R@10,G@15	R@60
13	to 100 ft above DH)	300	2400	L@10,G@15	L@60

6. Acceptability of MALSR (Configuration A) without runway touchdown zone (TDZ) or centerline lights to safely support Category I landing operations.

Scenario	Approach Type	Ceiling ft	RVR ft	Wind/Gust kts	Offset ft
17	(Coupled	300	1800	L@10,G@15	0
18	with AT	300	1800	R@10,G@15	R@60
19	to 100 ft above DH)	300	1800	L@10,G@15	L@60

FIGURE 4. SCENARIO OUTLINE (CONTINUED)

TABLE 1. METRIC OPERATIONAL EQUIVALENT VALUES

Runway Visual Range	
Feet	Meters
300	90
400	120
500	150
600	175
700	200
1000	300
1200	350
1600	500
1800	550
2000	600
2100	630
2400	720
4000	1200
4500	1400
5000	1500
6000	1800

TABLE 2. METEOROLOGICAL VISIBILITY VERSUS RUNWAY VISUAL RANGE (RVR)

Meteorological Visibility When RVR Is Not Available		
Statute Miles	Meters	Nautical Miles
1/4	400	1/4
1/2	800	1/2
3/4	1200	7/10
1	1600	9/10
1 1/4	2000	1 1/10
1 1/2	2400	1 3/10
1 3/4	2800	1 1/2
2	3200	1 3/4
2 1/4	3600	2
2 1/2	4000	2 1/5
2 3/4	4400	2 2/5
3	4800	2 3/5

EVALUATION IMPLEMENTATION

SIMULATOR TEST PROCEDURES.

This evaluation effort was intended to determine the adequacy of visual guidance system configurations presently proposed by the JAA for use under reduced visibility conditions. It involved the testing of

- runway edge and centerline lighting supporting takeoff operations in two different Category III conditions,
- runway centerline light system extended spacing for Category III landing and rollout operations, and
- simple (reduced density/length) ALS for Category I approaches.

Design features of the simulator allowed automated insertion of defined failures during takeoff and at speeds just below V1, with selected weather conditions. The failures have been designed to duplicate actual malfunctions described by aircraft and system manufacturers and carefully implemented into the systems software so as to accurately reproduce the desired effects.

Subject pilots were briefed prior to each simulated flight session and given an opportunity to familiarize themselves with the nature of the postflight questionnaire that they would be required to complete. During the subject pilot briefing project personnel detailed such items as first officer call-outs, simulator setup, and lighting configurations to be evaluated. In addition, the subjects were informed that project personnel were in no way judging pilot ability. Postflight questionnaires were completed in the cockpit immediately after each lighting configuration was evaluated.

Questionnaires used for the evaluation of different systems or system variations were similar, but not identical, since lighting system components are intended to provide complimentary though unique guidance information. A typical questionnaire form is shown as figure 5.

Qualified observers were present in the simulator cockpit during each evaluation session to record pertinent subject pilot comments. They also noted any unique cockpit occurrences such as abrupt maneuvering.

SAMPLE

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 8 TO 10—CONFIGURATION "C"

CONFIGURATION PRESENTED: ICAO Simple Single Source Centerline ALS

REDUCED VISIBILITY CONDITION: 2400 ft

SUBJECT PILOT:______________ DATE:______

Please place a check in the appropriate square to indicate the relative usefulness of this lighting configuration in providing the following forms of guidance.

1. FINDING THE RUNWAY:

Excellent	Good	Acceptable	Almost Acceptable	Absolutely Unacceptable

2. AWARENESS OF ALTITUDE ABOVE THE GROUND:

Excellent	Good	Acceptable	Almost Acceptable	Absolutely Unacceptable

3. LATERAL ALIGNMENT WITH THE RUNWAY:

Excellent	Good	Acceptable	Almost Acceptable	Absolutely Unacceptable

4. ROLL GUIDANCE:

Excellent	Good	Acceptable	Almost Acceptable	Absolutely Unacceptable

FIGURE 5. SAMPLE POSTFLIGHT SESSION QUESTIONNAIRE

SAMPLE

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE—Page 2

5. Did the guidance that was provided by the displayed approach lighting system (ALS) configuration allow you to complete the approach and landing safely?

   Yes:_____ No:_____ Could Not Judge:_____

   Comments:____

6. What guidance information (roll, height, direction, etc.), if any, did you feel was lacking or deficient?

   None:_____ or See Comments Below:_____

   Comments:____

7. Do you feel that this ALS configuration merits further consideration as a replacement for the standard MALSR?

   Yes:_____ No:_____

   Comments:____

COCKPIT OBSERVER:____________________

   Comments:____

FIGURE 5. SAMPLE POSTFLIGHT SESSION QUESTIONNAIRE (CONTINUED)

The complete evaluation program consisted of 15 pilots flying at least six takeoffs and twelve approach/landing operations each, for a total of 270 runs. Subject pilots were B727 type-rated, Category II qualified, and were recruited from a number of different air carriers.

Every effort was made to automate the testing procedures and simulator setup as much as practicable to ensure repeatability and high-quality data collection for future analysis and evaluation.

All tests were flown using the Oklahoma City (OKC) runway 35R visual model. Certain scenario parameters had been keyed to this runway, and using a different airport would have required changes to the programs. The necessary Category III features were available on this runway, and the high quality of this particular visual model greatly enhanced test validity.

Based on the proposed weather and failure requirements provided, there were approximately 25 test scenarios available. Selection of the desired scenario automatically repositioned the aircraft, provided preselected failures at the appropriate time, and set up the proper weather conditions for that test.

INITIAL CONDITIONS.

Initial simulated aircraft conditions, as set for takeoff, were as follows:

Gross Weight	172,000 Lbs.
Fuel Freeze	Set
Visual Control	CRT
Visibility	As required
Ceiling	As required
Turbulence	8%

Initial simulated aircraft conditions, as set for approach and landing, were as follows:

Gross Weight	154,000 Lbs.
Fuel Freeze	Set
Visual Control	CRT
Visibility	As required
Ceiling	As required
Turbulence	8%

SIMULATED WEATHER CONDITIONS.

Based on the adopted test criteria, there were 10 different sets of weather conditions required. The correct set of weather conditions, with correlated visual effects, was automatically activated when a test scenario was selected.

FAILURE CONDITIONS.

The takeoff failure condition that was used is briefly described below. Failures were automatically triggered by the selected scenario at critical speeds determined during previous flight tests.

FAILURE	DESCRIPTION
Engine Seizure	Represents internal destruction of the N2 turbine on the number 3 engine. The engine seizes (N1, N2 to zero) and all accessories logic is lost with the loss in power. In addition, an engine fire warning bell was sounded concurrently as an additional pilot alert.

PILOT OPERATING PROCEDURES.

As previously discussed, the simulator test program was automated as much as possible to expedite test runs and ensure repeatability with different subject pilots.

The cockpit operator initiated each test from the pilot instructor's station. When the scenario number was entered and activated, the aircraft was repositioned to either a takeoff position at the end of the runway or to a location within the approach area. Prior to flying the actual test scenarios, each subject was given a practice session for simulator familiarization. This session typically included manually flown takeoffs, approaches, and landings and lasted approximately 15–20 minutes.

TAKEOFF SCENARIOS. After the simulator was stabilized at the takeoff position, the pilot initiated the takeoff run. Takeoffs were made at RVR's of 500, 850, and 1,000 feet under weather conditions as shown in figure 4. The fault programmed was a number 3 engine failure. If the pilot completed a successful takeoff, he continued the climb-out on the runway heading. After the subject made the request to retract the landing gear, the simulator operator ended the scenario.

During the takeoff scenarios, a set of "success criteria" was being monitored as follows:

For the takeoff rolls:

a. Lateral tracking (center of mass) less than 56 feet from the runway centerline with no undamped tracking oscillations.

b. Airborne prior to the end of the runway.

c. Bank angle within plus or minus 6 degrees while on the runway.

d. Rotation pitch angle does not cause a tail strike.

For the takeoff roll/aborted takeoffs:

a. Lateral tracking (center of mass) less than 56 feet from the runway centerline with no undamped tracking oscillations.

b. Bank angle within plus or minus 6 degrees while on the runway.

c. Full stop on the runway.

The above "success criteria" was met by all of the subject pilots.

APPROACH/LANDING SCENARIOS. After the simulator was stabilized and "frozen" at the approach position, approximately five nautical miles from the runway, the pilot was advised of the simulated weather conditions. When the subject indicated that he was ready to begin the scenario, the simulator was then "unfrozen" allowing the approach to commence.

Approaches and landings were made at RVR values of 500, 1800, and 2400 feet and with other weather conditions (wind, fog, etc.) as required by the scenario setup (see figure 4). No aircraft equipment failures were simulated during this approach and landing segment.

For some of the scenarios the simulator was programmed to track a localizer signal that had been laterally offset either 30 or 60 ft left or right of the runway centerline. In those instances, the approach lights appeared off-center, and the subject pilot was asked to manually align the simulator with the extended runway centerline for the duration of the approach and touchdown.

Prior to evaluating each new lighting configuration, the subject pilots received a detailed briefing from the test coordinators which included showing the subjects a drawing of the lighting system they were about to evaluate. The test runs, from operator initialization to run termination, averaged approximately four minutes in length.

Data variables were automatically collected by the simulator and saved to disk files. Variables that were identified for collection for this evaluation included:

1. Test/Scenario Number
2. Indicated Airspeed
3. Radio Altitude
4. On-Ground Flag
5. Pitch Angle
6. Roll Angle
7. Yaw Angle
8. Ground Distance From Threshold
9. Rate of Climb
10. Landing Warning Flag
11. Control Wheel Position
12. Control Column Position
13. Ground Speed
14. Total Thrust
15. Number 1 Engine N1
16. Number 3 Engine N1
17. Time
18. Event Marker
19. Latitude
20. Longitude
21. Glideslope Deviation
22. Centerline Deviation

There are provisions in the simulator for automatic detection if a condition is encountered which would normally result in a real-world crash and if the approach/landing profile falls outside of certain preset limits.

Crash/Hard Landing: The crash condition was triggered when any of the following were exceeded while on the ground.

1. Bank Angle greater than plus or minus 6 degrees.
2. Pitch angle greater than 8 degrees.
3. Nose gear touches first.
4. Rate of descent greater than 13.38 feet per second.

If a crash was triggered, the simulator went into a freeze momentarily until the condition causing the crash had been cleared. A red light on the instructor's panel illuminated with the condition. The hard landing portion of the warning system turned the red light on if the aircraft rate of descent was greater than 500 feet per minute at touchdown. As shown in the landing scenario incident summary pages, both hard landings and crashes did occur.

Unsuccessful Landing Warning: This feature alerts the cockpit operator if the landing profile is outside of the AC20-57A improbable box or if the airspeed is too low and a go-around is executed. The following conditions would illuminate the red warning light at the instructor's station for 20 seconds:

1. More than 2500 feet down the runway.

2. Less than 200 feet down the runway.

3. Center of mass more than 56 feet from the runway centerline with a touchdown.

4. Airspeed below VREF-5 with a takeoff.

5. If the lateral tracking deviates more than 56 feet from the runway centerline during the final 50 feet of the approach and the pilot lands.

6. If the rate of descent at touchdown is greater than 10.38 feet per second.

The unsuccessful landing warning light did not illuminate during any of the scenarios.

TEST RESULTS BY SCENARIO SEGMENT

Subject pilots were required to complete questionnaire rating forms after flying each set of scenarios designed to evaluate a single unique visual aid (lighting) configuration. The compilation of results has been organized in the same manner so as to summarize pilot opinion, reaction, commentary, and performance for each lighting configuration (see appendix).

The pilot comment summary sheets provide all of the comments received for the particular configuration evaluated, and the comments have been extracted directly from the pilot questionnaire forms.

For those configurations evaluated under approach and landing conditions, the simulator was configured so that the panel operator was able to note and record occurrences such as missed approaches, hard landings, and crashes. The occurrence of such incidents was tabulated by scenario and are provided within the results section for each landing set.

CONCLUSIONS

No interpretation of the results was conducted. Data provided will be used by FAA Headquarters to formulate the U.S. position on the acceptability of the JAA operational procedures.

APPENDIX—SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRES AND COMMENT SUMMARIES

TAKEOFF SCENARIO 1 AND 2 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 1 AND 2

CONFIGURATION PRESENTED: High-Intensity Runway Edge Lights Only.

REDUCED VISIBILITY CONDITION: 850-FT RVR

SUBJECT PILOT NUMBER:______ DATE:______

Please place a check in the appropriate square to indicate the relative effectiveness of this lighting configuration in allowing you to complete the takeoff or aborted takeoff operation safely under the visibility conditions presented.

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	**0%**	**1**	**7%**	**7**	**47%**	**6**	**40%**	**1**	**6%**

Acceptable or Above-54% **Below Acceptable-46%**
(Total of 15 Subject Pilots)

Comments:______________________

(SEE FOLLOWING SUMMARY OF COMMENTS)

COCKPIT OBSERVER:______________

Comments:______________________

(SEE FOLLOWING SUMMARY OF COMMENTS)

TAKEOFF SCENARIO 1 AND 2 COMMENT SUMMARY

Comments relating to the adequacy of high-intensity runway edge lights only to support takeoffs in 850-ft RVR conditions:

- **I strongly feel taxi [lights leading] onto the runway is important for determination of pilot orientation, i.e., three rows of white lights—which one is the centerline if all three are not visible?**
- **Used centerline markings only.**
- **Markings become worn out over time.**
- **Borderline acceptable. (Swerved to about 1/2 way to the left edge of runway on run 1—Observer)**
- **No problem.**
- **Would not want to do this in real world. Very uncomfortable without centerline lighting.**
- **If runway was contaminated and stripes were covered—this would not be acceptable.**
- **Almost unacceptable—marginal at best.**
- **Caused too much concentrated scan on runway—no time to scan instruments.**
- **Initially the lack of centerline lights was distracting. These lights in particular are very helpful for runway centerline alignment.**
- **Difficult to pick up heading deviation caused by weather vaning in crosswind. Miss the centerline lights.**
- **Had to really concentrate on runway marking—more difficult than normal.**
- **With runway obstruction (water, ice/snow blowing) this operation would be unacceptable.**
- **Centerline lights should be required.**
- **Would prefer centerline lights.**

TAKEOFF SCENARIO 14 AND 15 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 14 AND 15

CONFIGURATION PRESENTED: High-Intensity Runway Edge Lights Only.

REDUCED VISIBILITY CONDITION: 1000-FT RVR

SUBJECT PILOT NUMBER:______ DATE:______

Please place a check in the appropriate square to indicate the relative effectiveness of this lighting configuration in allowing you to complete the takeoff or aborted takeoff operation safely under the visibility conditions presented.

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
1	**8%**	**2**	**15%**	**6**	**46%**	**4**	**31%**	**0**	**0%**

Acceptable or Above—69% **Below Acceptable—31%**
(Total of 13 Subject Pilots)

Comments:______

(SEE FOLLOWING SUMMARY OF COMMENTS)

COCKPIT OBSERVER:______

Comments:______

(SEE FOLLOWING SUMMARY OF COMMENTS)

TAKEOFF SCENARIO 14 AND 15 COMMENT SUMMARY

Comments relating to the adequacy of high-intensity runway edge lights only to support takeoffs in 1000-ft RVR conditions:

- **Still used centerline markings rather than edge lights.**
- **Significantly better than 850.**
- **Better, but still very uncomfortable.**
- **Same comment as before [If runway stripes were covered—would be unacceptable].**
- **Better than 850 RVR, but barely acceptable. Would prefer centerline lights to edge lights.**
- **A little more safe [than doing it at 850 RVR].**
- **Almost uncomfortable without centerline lights.**
- **Noticeably better than 850-ft RVR. Abort easy, but rotation difficult without centerline lights. Felt easier than 850-ft RVR. Centerline lights critical during V1 cut.**
- **Easier than 850-ft RVR—markings more visible.**
- **Barely acceptable. Degradation of centerline markings over time must be considered.**
- **Not a problem at low or high speed.**

TAKEOFF SCENARIO 3 AND 4 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 3 AND 4

CONFIGURATION PRESENTED: High-Intensity Runway Edge and Centerline Lights.

REDUCED VISIBILITY CONDITION: 500-FT RVR

SUBJECT PILOT NUMBER:______ DATE:______

Please place a check in the appropriate square to indicate the relative effectiveness of this lighting configuration in allowing you to complete the takeoff or aborted takeoff operation safely under the visibility conditions presented.

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
2	**13%**	**4**	**27%**	**5**	**33%**	**4**	**27%**	**0**	**0%**

Acceptable or Above—73% **Below Acceptable—27%**
(Total of 15 Subject Pilots)

Comments:______

(SEE FOLLOWING SUMMARY OF COMMENTS)

COCKPIT OBSERVER:______

Comments:______

(SEE FOLLOWING SUMMARY OF COMMENTS)

TAKEOFF SCENARIO 3 AND 4 COMMENT SUMMARY

Comments relating to the adequacy of both high-intensity runway edge and centerline lights to support takeoffs in 500-ft RVR conditions:

- **Visibility too low. Would prefer no centerline. More workload. [Tracked centerline OK—Observer]**
- **Although the RVR is only slightly less than present requirements, I felt these takeoffs were too uncomfortable (Read "Dangerous").**
- **Centerline lights were primary difference.**
- **No problem.**
- **Tended to have to look closer to the aircraft nose than usual—this felt unnatural. Centerline lights useful in beginning of abort.**
- **As compared to 600-ft RVR, it is not a significant difference—probably wouldn't notice difference.**
- **Not good, but certainly minimally acceptable—more so than without the centerline lights—the real test, however, will be an engine failure at or after V1.**
- **Does detract from instrument scan.**
- **Not much difference between 500- and 600-ft operations. Additional or standard centerline lights virtually necessary.**
- **Little difference from current 600 ft—rotation more difficult than in 600-ft RVR—lights disappear slightly sooner—abort no problem.**
- **Seemed to get target fixation on runway centerline marking—edge lights not much help, but some.**
- **OK at slower speeds. At greater than 120 knots you miss the last short segment of lights that are not visible. Lights disappear slightly sooner than usual.**
- **This should be tested in daylight when lights tend to be less effective. Nerve wracking at higher takeoff roll speed.**
- **While scanning instruments, centerline lights are not visible with peripheral vision.**

LANDING SCENARIO 5-7 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 5,6 AND 7

CONFIGURATION PRESENTED: Standard Cat. II/III Approach and Runway Lighting, Except With 100-ft Spacing on Centerline Lights.

REDUCED VISIBILITY CONDITION: 500-FT RVR

SUBJECT PILOT NUMBER:______ DATE:______

Please place a check in the appropriate square to indicate the relative effectiveness of this 100-ft spacing centerline lighting configuration in allowing you to complete the Category III 500-ft RVR runway rollout operation safely.

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	**0%**	**3**	**20%**	**6**	**40%**	**4**	**27%**	**2**	**13%**

Acceptable or Above—60% **Below Acceptable—40%**
(Total of 15 Subject Pilots)

Comments:

(SEE FOLLOWING SUMMARY OF COMMENTS)

COCKPIT OBSERVER:

Comments:

(SEE FOLLOWING SUMMARY OF COMMENTS)

LANDING SCENARIO 5-7 COMMENT SUMMARY

Comments relating to the adequacy of runway centerline lights with extended (100-ft) spacing to support landing and rollout in 500-ft RVR conditions:

- **The offset approaches with touchdown on the TDZ lights calls for a conclusion by the pilot as to which way the centerline is located. The [standard] 50-ft spacing is important. If centerline guidance was available at the TDZ lights [coded pattern], the centerline lights may be less.**
- **Prefer 50-ft spacing. Without 50-ft spacing it is very hard to determine which way centerline is. Don't make this change to 100-ft spacing.**
- **Not comfortable—even before touchdown with both visibility and lights. Only experienced in Category IIIa.**
- **Similarity of runway edge light versus runway centerline lights is too close. "Thrown" into environment at 160 mph, it's too easy to confuse centerline with edge.**
- **Marginally acceptable—I think I depended more on the stripes for centerline guidance. I don't know if 50-ft spacing would have been any better.**
- **TDZ lights helped on orientation on runway.**
- **100-ft spacing uncomfortable with offset. Difference is significant. If [painted] stripes are dim or covered, 100-ft spacing is worse than 50 ft.**
- **Not as good as 50 ft, but OK. Noticeable, but manageable.**
- **Used crabbing angle to help estimate where centerline would be.**
- **Not enough centerline guidance.**
- **When not touching down near centerline—too tempting to head toward nearest lights—that might be edge lights.**

LANDING SCENARIO 5-7 INCIDENT SUMMARY

SCENARIO	MISSED APPROACH	HARD LANDING	CRASH
5	None	None	None
6	1	None	None
7	None	None	None

Definitions:

Missed Approach: Pilot abandoned the approach at decision height or later due to lack of visual guidance.

Hard Landing: The aircraft rate of descent is greater than 500 feet/minute at touchdown.

Crash: Any of the following are exceeded while on the ground:

1. Bank angle greater than ±6°
2. Pitch angle greater than 8°
3. Nose gear touches first
4. Rate of descent greater than 13.38 feet/second

LANDING SCENARIO 8-10 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 8 TO 10—CONFIGURATION "C"

CONFIGURATION PRESENTED: ICAO Simple Single Source Centerline ALS.

REDUCED VISIBILITY CONDITION: 2400-FT RVR

SUBJECT PILOT NUMBER:______ DATE:______

Please place a check in the appropriate square to indicate the relative usefulness of this lighting configuration in providing the following forms of guidance.

1. FINDING THE RUNWAY:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	0%	1	7%	3	20%	7	46%	4	27%

Acceptable or Above—27% **Below Acceptable—73%**
(Total of 15 Subject Pilots)

2. AWARENESS OF ALTITUDE ABOVE THE GROUND:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	0%	1	7%	3	20%	6	40%	5	33%

Acceptable or Above—27% **Below Acceptable—73%**

3. LATERAL ALIGNMENT WITH THE RUNWAY:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	0%	2	14%	3	20%	3	20%	7	46%

Acceptable or Above—34% **Below Acceptable—66%**

4. ROLL GUIDANCE:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	0%	1	7%	4	27%	3	20%	7	46%

Acceptable or Above—34% **Below Acceptable—66%**

LANDING SCENARIO 8-10 COMMENT SUMMARY

5. Did the guidance that was provided by the displayed ALS configuration allow you to complete the approach and landing safely?

Yes: 7 (47%) No: 8 (53%) Could Not Judge: 0 (0%)

Comments:

- **Approximately 100 ft below minimums, visual references were adequate.**
- **If not aligned perfectly, or very near so, system is unacceptable.**
- **Lights not seen at decision height.**
- **Very uncomfortable—no confidence. Did not feel totally in control.**
- **Without strobes and shortness of display—led to near missed approaches. This system would probably result in many missed approaches.**
- **If seen in time [answered "yes" to question].**
- **Too few lights: singles plus lack of strobes and runway centerline lights.**
- **Very challenging—lights at decision height.**
- **Single lights in ALS OK [answered "yes" to question].**
- **Short length delays decision to last possible second.**
- **Inadequate ALS for 2400-ft RVR.**
- **Not enough lights.**

LANDING SCENARIO 8-10 COMMENT SUMMARY (CONTINUED)

6. What guidance information (roll, height, direction, etc.), if any, did you feel was lacking or deficient?

None: 2 (13%) or See Comments Below: 13 (87%)

Comments:

- **Not enough roll bar information, and height perception was distorted.**
- **Directional guidance was extremely lacking**
- **Lights not seen.**
- **Too short.**
- **All [guidance] lacking plus too short, no strobes.**
- **All [guidance lacking].**
- **Once acquired—none [answered "none" to question].**
- **Height, roll [guidance lacking].**
- **Centerline alignment, distance from runway [guidance lacking].**
- **Too few lights: singles plus lack of strobes and centerline lights.**
- **Depth, roll, height [guidance lacking]. Alignment more difficult—very few lights.**
- **Roll [guidance lacking]—due to lack of runway centerline and TDZ lighting.**
- **None, once acquired [answered "none" to question].**
- **No roll guidance. Single light source does not give a horizontal line for wings level guidance—(roll).**
- **ALS too short. Hardly recognized as an ALS—could have been street lights.**

LANDING SCENARIO 8-10 COMMENT SUMMARY (CONTINUED)

7. Do you feel that this ALS configuration merits further consideration as a replacement for the standard MALSR?

Yes: **1** (7%)   No: **14** (93%)

Comments:

- **Least safe of any system tested to this point.**
- **Acquiring lights late in approach, possibly leading to a late decision or a go-around.**
- **Would be OK if included strobes. Lights visible only at minimums.**
- **ALS visible right at minimums—when weather at minimums there would be a lot of missed approaches.**
- **Do not like this system.**
- **ALS is on edge regarding decision—ALS is uncomfortable.**
- **A lot of missed approaches will result. Would not want to fly a manual approach to this system.**
- **Nothing seen until minimums—very unsettling.**

LANDING SCENARIO 8-10 INCIDENT SUMMARY

SCENARIO	MISSED APPROACH	HARD LANDING	CRASH
8	5	1	None
9	4	1	1*
10	6	None	None

Definitions:

Missed Approach: Pilot abandoned the approach at decision height or later due to lack of visual guidance.

Hard Landing: The aircraft rate of descent is greater than 500 feet/minute at touchdown.

Crash: Any of the following are exceeded while on the ground:

1. Bank angle greater than ±6°
2. Pitch angle greater than 8°
3. Nose gear touches first
4. Rate of descent greater than 13.38 feet/second

*Subject pilot commented that the crash had nothing to do with the visual guidance provided by the approach lighting system.

LANDING SCENARIO 11-13 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 11 TO 13—CONFIGURATION "D"

CONFIGURATION PRESENTED: ICAO Simple Barrette Centerline ALS

REDUCED VISIBILITY CONDITION: 2400-FT RVR

SUBJECT PILOT NUMBER:______ DATE:______

Please place a check in the appropriate square to indicate the relative usefulness of this lighting configuration in providing the following forms of guidance.

1. FINDING THE RUNWAY:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	**0%**	**2**	**13%**	**6**	**40%**	**6**	**40%**	**1**	**7%**

Acceptable or Above—53% **Below Acceptable—47%**
(Total of 15 Subject Pilots)

2. AWARENESS OF ALTITUDE ABOVE THE GROUND:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	**0%**	**2**	**13%**	**9**	**60%**	**1**	**7%**	**3**	**20%**

Acceptable or Above—63% **Below Acceptable—27%**

3. LATERAL ALIGNMENT WITH THE RUNWAY:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	**0%**	**4**	**27%**	**6**	**40%**	**4**	**27%**	**1**	**6%**

Acceptable or Above—67% **Below Acceptable—33%**

4. ROLL GUIDANCE:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
0	**0%**	**4**	**27%**	**6**	**40%**	**3**	**20%**	**2**	**13%**

Acceptable or Above—67% **Below Acceptable—33%**

LANDING SCENARIO 11-13 COMMENT SUMMARY

5. Did the guidance that was provided by the displayed ALS configuration allow you to complete the approach and landing safely?

Yes: 9 (60%) No: 6 (40%) Could Not Judge: 0 (0%)

Comments:

- **Better than ICAO Single Source. System is too short. Necessary lateral guidance occurs too late in the approach. Can't see drift soon enough.**
- **Not visible at decision height.**
- **Decision to land made below minimums on every approach. Missed approaches would have been done in reality.**
- **Without strobes and shortness of display—led to near missed approaches. This system would probably result in many missed approaches.**
- **Better than single source (three lights vs one an improvement). Width of 1000-ft bar no factor.**
- **Missed strobes. With crosswind and offset there is a lack of centerline reference (it occurs too late in the approach).**
- **Versus 1800-ft RVR—helpful.**
- **Short length delays decision to last possible second.**
- **ALS is too short—needs to extend out further.**
- **Not comfortable with display at decision height.**

LANDING SCENARIO 11-13 COMMENT SUMMARY (CONTINUED)

6. What guidance information (roll, height, direction, etc.), if any, did you feel was lacking or deficient?

None: 5 (33%) or See Comments Below: 10 (67%)

Comments:

- **Lateral [guidance lacking].**
- **Not visible at decision height.**
- **Not comfortable with this system. Want strobes! This system would be worthless in daytime.**
- **Height, sink rate, depth [guidance lacking]. System too short, but bright enough (false sense of security).**
- **Once acquired [answered "none" to question].**
- **Centerline guidance (direction) [lacking].**
- **Runway centerline, red side row bars, strobes [lacking].**
- **Direction plus lateral guidance [lacking] due to short length.**
- **Depth [guidance] for flare [lacking] due to lack of runway centerline and TDZ lights.**
- **Roll barely adequate.**
- **Length too short—[lights] seen too late in approach.**

LANDING SCENARIO 11-13 COMMENT SUMMARY (CONTINUED)

7. Do you feel that this ALS configuration merits further consideration as a replacement for the standard MALSR?

Yes: **5** (33%)   No: **10** (67%)

Comments:

- **But if made longer would consider it. Drift problem mentioned above ["Can't see drift soon enough"] has an impact on touchdown location.**
- **Acquiring lights late in the approach. Possibly leading to a late decision or go-arounds.**
- **The strobe lights [lacking in this system] are crucial.**
- **But would need additional training [answered "yes" to this question].**
- **Roll information better on this than on the single source system due to wider 1000-ft bar.**
- **But better than nothing [answered "no" to this question].**
- **[Three lights] vs one in center an improvement. Offset results in difficult visual transition.**
- **Not without strobes and runway centerline lights. ALS minimal—any less would result in a missed approach. Lack of ALS and runway centerline lights is uncomfortable with offsets.**
- **May result in some missed approaches. First seen very near decision height. Once ALS seen—not bad.**
- **Much more acceptable than single source. Cue picked up slightly sooner—could be due to experience flying scenarios 8-10.**
- **Strobes to 2400 ft [would] allow pilot to continue. Appearance of ALS and decision height occur simultaneously—could result in missed approaches.**

LANDING SCENARIO 11-13 INCIDENT SUMMARY

SCENARIO	MISSED APPROACH	HARD LANDING	CRASH
11	None	1	1
12	2	1	None
13	3	None	None

Definitions:

Missed Approach: Pilot abandoned the approach at decision height or later due to lack of visual guidance.

Hard Landing: The aircraft rate of descent is greater than 500 feet/minute at touchdown.

Crash: Any of the following are exceeded while on the ground:

1. Bank angle greater than ±6°
2. Pitch angle greater than 8°
3. Nose gear touches first
4. Rate of descent greater than 13.38 feet/second

LANDING SCENARIO 17-19 SUMMARY

SIMULATOR POSTFLIGHT SESSION QUESTIONNAIRE

STUDY 1—JAA TAKEOFF, APPROACH, AND LANDING REQUIREMENTS

SCENARIO NOS. 17 TO 19—CONFIGURATION "A"

CONFIGURATION PRESENTED: Standard MALSR System With Runway Edge Lights Only.

REDUCED VISIBILITY CONDITION: 1800-ft RVR

SUBJECT PILOT NUMBER:_______ DATE:_______

Please place a check in the appropriate square to indicate the relative usefulness of this lighting configuration in providing the following forms of guidance.

1. FINDING THE RUNWAY:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
5	**33%**	**3**	**20%**	**4**	**27%**	**2**	**13%**	**1**	**7%**

Acceptable or Above—80% **Below Acceptable—20%**
(Total of 15 Subject Pilots)

2. AWARENESS OF ALTITUDE ABOVE THE GROUND:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
1	**7%**	**6**	**40%**	**4**	**26%**	**3**	**20%**	**1**	**7%**

Acceptable or Above—73% **Below Acceptable—27%**

3. LATERAL ALIGNMENT WITH THE RUNWAY:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
2	**14%**	**5**	**33%**	**3**	**20%**	**4**	**26%**	**1**	**7%**

Acceptable or Above—67% **Below Acceptable—33%**

4. ROLL GUIDANCE:

Excellent		Good		Acceptable		Almost Acceptable		Absolutely Unacceptable	
2	**13%**	**6**	**40%**	**3**	**20%**	**3**	**20%**	**1**	**7%**

Acceptable or Above—73% **Below Acceptable—27%**

LANDING SCENARIO 17-19 COMMENT SUMMARY

5. Did the guidance that was provided by the displayed ALS and runway edge lighting configuration allow you to complete the approach and landing safely?

Yes: **10** (67%) No: **4** (27%) Could Not Judge: **1** (6%)

Comments:

- **Approach lights lead to this answer, not edge lights.**
- **Marginal over runway—no distance down runway information (no TDZ lights) is distracting.**
- **Not as sure where I am in relation to runway centerline.**
- **Each operator should train, in simulation, for this configuration. Recommend an autopilot approach to 100 ft or less. Should not be flown without autopilot.**
- **Out of three times only [one missed approach]. Not comfortable. More visual cues on runway would allow pilot to properly line up sooner.**
- **Strobes helpful. Stayed on instruments more below minimums to help with glide path.**
- **Markings not enough.**
- **Centerline lights would be nice, but not necessary.**
- **Missed approach (scenario no. 18)—due to "black hole" and crosswind.**
- **Strobes to 2400 ft very helpful. Decision made sooner.**
- **No visual aids in TDZ—rely on ALS further into the approach.**

LANDING SCENARIO 17-19 COMMENT SUMMARY (CONTINUED)

6. What guidance information (roll, height, direction, etc.), if any, did you feel was lacking or deficient?

None: **4** (27%) or See Comments Below: **11** (73%)

Comments:

- **Roll, height [clues] were deficient.**
- **TDZ light [guidance lacking].**
- **Alignment over threshold more difficult, particularly with the crosswind.**
- **Roll, height, lateral [guidance lacking].**
- **Direction [guidance lacking].**
- **[No guidance, lacking] for ALS. Would prefer centerline lights on runway.**
- **Centerline runway lighting for alignment [lacking].**
- **Red side row bars [guidance lacking].**
- **Height—depth, lateral [guidance lacking].**
- **Lack of depth plus drift plus roll [guidance].**
- **Roll [guidance lacking] without TDZ lights.**
- **TDZ lights—roll, depth [guidance lacking]**

LANDING SCENARIO 17-19 COMMENT SUMMARY (CONTINUED)

7. Do you feel that this MALSR/Runway lighting configuration merits further consideration for use in 1800-ft RVR conditions?

Yes: **7** (47%) No: **8** (53%)

Comments:

- **TDZ lights/centerline lights nice, but not necessary.**
- **A larger aircraft (e.g., B767) would have a difficult time once autopilot is disconnected—too much time spent estimating distance down runway.**
- **With crosswind restriction of under 15 knots or using heads-up display or autoland to touchdown [answered "yes" to question].**
- **Not a safe operation.**
- **Must have centerline lights. Felt uncomfortable if not established on centerline extended from 150-ft AGL down to touchdown.**
- **Very difficult if trying to laterally correct aircraft near threshold. "Black Hole" after ALS. More challenging without centerline plus TDZ lights.**

LANDING SCENARIO 17-19 INCIDENT SUMMARY

SCENARIO	MISSED APPROACH	HARD LANDING	CRASH
17	None	1	None
18	5	1	None
19	1	1	None

Definitions:

Missed Approach: Pilot abandoned the approach at decision height or later due to lack of visual guidance.

Hard Landing: The aircraft rate of descent is greater than 500 feet/minute at touchdown.

Crash: Any of the following are exceeded while on the ground:

1. Bank angle greater than ±6°
2. Pitch angle greater than 8°
3. Nose gear touches first
4. Rate of descent greater than 13.38 feet/second