Federal Aviation Administration

Human-In-The-Loop (HITL) Pilot Demonstration Category (CAT) I Instrument Landing System (ILS) Approaches to 200' Decision Height (DH) and 1,800' Runway Visual Range (RVR) Minima and CAT II ILS Approaches on Type I ILS to 1,600' and 1,200' RVR

Flight Operations Simulation Laboratory
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NOTICE

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Flight Operations Simulation Branch
Flight Technologies and Procedures Division
Flight Standards Service

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Technical Report

Technical Report Documentation Page

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12. Abstract This report presents the results of a safety study conducted on Category (CAT) I Instrument Landing System (ILS) approaches to 200' Decision Height (DH) and 1,800' Runway Visual Range (RVR) minima and CAT II ILS approaches to 1,600' and 1,200' RVR. This safety evaluation report was conducted by the Federal Aviation Administration (FAA) Flight Operations Branch (AFS-440). The purpose of this operational demonstration was to collect Human-In-The Loop (HITL) pilot data during simulated ILS approach scenarios under reduced RVR conditions.		
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Executive Summary

This report presents the results of a demonstration study conducted on Category (CAT) I Instrument Landing System (ILS) approaches to 200' Decision Height (DH) and 1,800' Runway Visual Range (RVR) minima and CAT II ILS approaches to 1,600' and 1,200' RVR. This demonstration evaluation report was conducted by the Federal Aviation Administration (FAA) Flight Operations Branch (AFS-440) using a B737-800 Level D Full Flight Simulator located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma.

The purpose of this operational demonstration was to collect Human-In-The Loop (HITL) pilot data during simulated ILS approach scenarios under reduced RVR conditions. This report provides background information about minima for CAT I ILS and CAT II ILS approaches, describes the evaluation process, explains the methods used to analyze the data, and presents conclusions based on this study. In addition, the appendixes provide the approach chart (refer to Appendix A), copies of the original questionnaires used to gather subjective data during the study (refer to Appendix B: Post-Run Questionnaire, Appendix C: Post-Demonstration Session Questionnaire, and Appendix D: Post-Demonstration Session Debriefing), and acronyms used throughout the report (refer to Appendix E).

The approach scenarios of the demonstration were developed based upon the minimum requirements to conduct CAT I operations. These requirements included CAT I ILS to CAT I runways and CAT II approaches to a CAT I runway with a Category I ILS being maintained to CAT II flight inspection tolerances. High Intensity Runway Lighting (HIRL) and Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) were used to a DH of 200 feet Height Above Touchdown (HAT) with RVR of 1,800 feet and a DH of 100 feet HAT with RVRs of 1,600 feet and 1,200 feet.

Of the three Test Criteria Violation (TCV) criteria—(1) descent rate, (2) airspeed, and (3) touchdown point—there were no violations in airspeed and only two in touchdown point in any of the 180 runs (each scenario/aircrew combination is considered a run, [e.g., Run 1 = Scenario 1/ Aircrew 1]). However, in 12 of the 30 hand-flown runs with no HUD (200 feet/1,800' RVR), the aircraft had a descent rate greater than 1,000 feet per minute (fpm) sustained for more than three seconds. HUD, auto-land, and autopilot/Flight Director runs contained no descent rate TCVs. The descent rate TCV percentage difference (40% vs. 0%) between hand-flown and all others is statistically significant.

From a HITL perspective, there does not appear to be any appreciable increase or change in workload (physical or mental) directly resulting from the variable conditions of this demonstration. Pilot subjective comments and debriefing remarks indicated that all aircrews felt that the hand-flown scenarios were the most problematic of all the scenarios. On a continuum, they felt that the HUD scenarios were optimally flown, followed by auto-land, autopilot/Flight Director, and Flight Director/hand-flown, in that order.

Overall, the objective and subjective data indicated no appreciable increase or change in workload (physical or mental) directly resulting from the variable conditions of this demonstration.

However, descent rate violations where the aircrew exceeded 1,000 fpm for longer than three seconds occurred during 40% (12 of 30) of the hand-flown scenarios (200 feet/RVR 1,800 feet). No such violations occurred when the HUD, auto-land, or autopilot/Flight Director were being used.

With the exception of the hand-flown scenarios, there were no appreciable performance anomalies due to changes in the TDZ and CL lighting while flying to a DH of 200 feet HAT with RVR of 1,800 feet and a DH of 100 feet HAT with RVRs of 1,600 feet and 1,200 feet respectively.

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1.0 Introduction

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1.1 Purpose and Structure of This Report

The purpose of this operational demonstration was to collect Human-In-The Loop (HITL) pilot data during simulated ILS approach scenarios under reduced RVR conditions. This report provides background information about minima for CAT I ILS and CAT II ILS approaches, describes the evaluation process, explains the methods used to analyze the data, and presents conclusions based on this study. In addition, the appendixes provide the approach chart (refer to Appendix A), copies of the original questionnaires used to gather subjective data during the study (refer to Appendix B: Post-Run Questionnaire, Appendix C: Post-Demonstration Session Questionnaire, and Appendix D: Post-Demonstration Session Debriefing), and acronyms used throughout the report (refer to Appendix E).

1.2 Background

FAA Order 8400.13B, *Procedures for the Approval of Special Authorization Category II and Lowest Standard Category I Operations*, dictates the minimum requirements for the approval of special authorization CAT II operations to qualifying runways which do not meet the performance or equipment requirements normally associated with a U.S. Standard or International Civil Aviation Organization (ICAO) compliant CAT II operation, e.g., touchdown zone (TDZ) lighting, centerline (CL) lighting, or CAT II Approach Lighting System with Sequenced Flashers II (ALSF2). [1] It also provides the criteria to implement the harmonized FAA and European Aviation Safety Agency (EASA) lowest standard CAT I RVR 1,800 feet visibility

Modern technologies such as Head-Up Display (HUD) systems and automatic landing systems have resulted in additional operational capability of airborne avionics systems and the potential for additional landing minima credit. These airborne systems, coupled with modern reliable ILS and more restrictive performance requirements developed for low visibility operations, can be used at approved runways that were originally certified to support basic CAT I operations only.

JAR-OPS1: *Commercial Air Transportation (Aeroplanes)* [2] uses 550 meters (1,800' RVR) as a base visibility on an ILS without the requirement for TDZ/CL lights. Recent harmonization efforts have resulted in an FAA-JAA agreement for ILS operations at 1,800 feet RVR without TDZ/CL lights if the operator employs the use of an aircraft Flight Director, autopilot, or HUD equipment.

The Flight Operations Branch, AFS-410, requested that the Flight Operations Simulation Branch, AFS-440, conduct an operational demonstration to further investigate the use of Flight Director, HUD, and autopilot technology to 200 feet/1,800 feet RVR or 100 feet/RVRs of 1,600 feet and 1,200 feet minima on Type I facilities. This demonstration used an FAA B737-800 Level D simulator using industry pilots qualified in the B737 to evaluate reduced RVR conditions on Type I facilities.

2.0 Concept of Demonstration

The demonstration approach scenarios were developed based upon the minimum requirements to conduct CAT I operations. These requirements included CAT I ILS to CAT I runways and CAT II approaches to a CAT I runway with a Category I ILS being maintained to CAT II flight inspection tolerances. High Intensity Runway Lighting (HIRL) and Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) were used to a DH of 200 feet Height Above Touchdown (HAT) with RVR of 1,800 feet and a DH of 100 feet HAT with RVRs of 1,600 feet and 1,200 feet. Tables 1-6 display the various flight scenarios.

Demonstration subject pilots were Boeing 737 qualified Part 121 aircrews from multiple airline companies. Company integrity was maintained (i.e., pilots from the same company flew together) except for Aircrew 1 and Aircrew 5 (see Section 3.4). An operational pre-brief was conducted with each aircrew, outlining the purpose of the demonstration and operational requirements. All approaches were flown to 200 feet DH/1,800 feet RVR or 100 feet DH/1,600 feet RVR or 100 feet DH/1,200 feet RVR. All approaches made a full stop landing. During each approach, pilot and human factors evaluators annotated significant events and/or anomalies in in-flight techniques and procedures. Between approaches, a post-run questionnaire was completed by both the captain and first officer (see Appendix B). Following the demonstration, a post-demonstration questionnaire was completed (see Appendix C) and a debriefing was conducted to gather subjective aircrew feedback (see Appendix D).

Prior to each data run, the simulator was positioned inbound 4 nautical miles (NM) from the runway threshold on the ILS approach glide slope and localizer. The instrument approach used was the Atlanta (ATL), RWY 26R ILS. (See Appendix A.) Variables within the scenario mix are shown in Tables 1-6. Constant parameters included the altimeter setting at 29.92 inches Hg; surface temperature at standard 15 degrees centigrade; weight and fuel constant at the Maximum Landing Weight of 144,000 pounds; and flight turbulence of 10%.

For each approach, the simulator was released from flight freeze in the final landing configuration and in trim. All checklists and approach briefings were completed prior to release from flight freeze. Flight aircrews verified that the aircraft configuration agreed with these conditions prior to performing the ILS approach procedure.

The captain and first officer each performed the ILS approaches as outlined in Tables 1-6. For the RVR demonstration, six aircrews performed the 30 scenarios, in daytime or nighttime conditions for a total of 180 RVR data run sessions.

Table 1: (1,800' RVR)
Approach Configuration
Flight Director/Hand Flown (FD/HF) Scenarios to 200' HAT/1,800' RVR

Scenario	Wind and Other Conditions	Flown By
1	Calm , Day, No TDZ/CL	Capt
2	15 kt X R, Night, No TDZ/CL	FO
3	15 kt Tail, Day, TDZ/CL On	Capt
4	15 kt X R, Day, TDZ/CL On	FO
5	Calm, Night, No TDZ/CL	FO

Table 2: (1,800' RVR)
Approach Configuration
Autopilot/Flight Director (Coupled) to 200' HAT/1,800' RVR

Scenario	Wind and Other Conditions	Flown By
6	15 kt X L, Day, No TDZ/CL	FO
7	Calm, Night, TDZ/CL On	Capt
8	15 kt Tail, Day, No TDZ/CL	Capt
9	15 kt X R, Day, TDZ/CL On	Capt
10	Calm L, Night, No TDZ/CL	FO

Table 3: (1,800' RVR)
Approach Configuration
HUD/HF Scenarios to 200' HAT/1,800' RVR

Scenario	Wind and Other Conditions	Flown By
12	15 kt X L, Day, No TDZ/CL	Capt
13	Calm, Night, No TDZ/CL	Capt
14	15 kt Tail, Day, TDZ/CL On	Capt
15	15 kt X R, Day, No TDZ/CL	Capt
16	15 kt X L, Night, TDZ/CL On	Capt

Table 4: (1,800' RVR)
Approach Configuration
Auto Land Scenarios to 100' HAT/1,600' RVR

Scenario	Wind and Other Conditions	Flown By
17	15 kt X L, Day, No TDZ/CL	Capt
18	15 kt X R, Night, No TDZ/CL	FO
19	15 kt Tail, Day, TDZ/CL On	Capt
20	Calm, Day, No TDZ/CL	FO
21	15 kt X L, Night, TDZ/CL On	Capt

Table 5: (1,200' RVR)
Approach Configuration
HUD/HF Scenarios to 100' HAT/1,200' RVR

Scenario	Wind and Other Conditions	Flown By
23	15 kt X L, Day, No TDZ/CL	Capt
24	Calm, Night, No TDZ/CL	Capt
25	15 kt Tail, Day, TDZ/CL On	Capt
26	15 kt X R, Day, TDZ/CL On	Capt
27	15 kt X L, Night, No TDZ/CL	Capt

Table 6: (1,200' RVR)
Approach Configuration
Auto Land Scenarios to 100' HAT/1,200' RVR

Scenario	Wind and Other Conditions	Flown By
28	15 kt X L, Day, No TDZ/CL	Capt
29	15 kt X R, Night, No TDZ/CL	FO
30	15 kt Tail, Day, TDZ/CL On	Capt
31	15 kt X R, Day, No TDZ/CL	FO
32	Calm, Night, TDZ/CL On	Capt

Note: The numbering of scenarios is not sequential because Scenario 11, Scenario 22, and Scenario 33 were deleted because they contained wake turbulence modeling. These wake turbulence models were used for a separate data collection program which was not a part of this demonstration.

Data collected included the following:

- Aircraft position in both latitude/longitude coordinates to 0.01 of a second, standard X
- Longitudinal distance, Y
- Lateral distance
- Lateral and vertical course deviation
- MSL altitude
- Aircraft bank angle
- Rate of descent
- Autopilot engaged
- Flight Director captured
- Indicated airspeed (IAS)
- Time
- Ground contact (touchdown)

Data collection began from the time the B737-800 simulator was released from flight freeze until a full-stop landing was completed. Cockpit displays and aircrews were video and voice-recorded. Data capture rate was at five samples per second.

Specific data collected during this evaluation provided the capability for an analysis of Test Criteria Violations (TCVs). The following TCV criteria were established to note those events of particular interest that may need further analysis through audio, video, questionnaires, and observer inputs:

1. Descent rate greater than 1,000 feet per minute sustained for more than three seconds. This 3-second duration is for TCV benchmark only and not FAA Advisory Circular guidance.

2. Simulator airspeed deviation from 500 feet Above Ground Level (AGL) to runway threshold less than V_{REF} or greater than V_{REF} +10 for more than three seconds. This 3-second duration is for TCV benchmark only.

3. Simulator touchdown point exceeding 3,000 feet, i.e., aircrew landings beyond the touchdown zone.

All demonstration approach procedure scenarios were validated by AFS-440 simulator pilots prior to data collection. The simulator database was in compliance with the published ATL ILS RWY 26R demonstration procedure, i.e. the TDZE, Threshold Crossing Height (TCH), localizer course alignment, and glide slope path angle were verified by AFS-440 personnel.

The Test Director (TD) was responsible for the operation of the simulator, which included the initiation and termination of each scenario. This ensured that each run was conducted in accordance with the agreed-upon variable set. An AFS pilot and an engineering psychologist also monitored the aircrew performance in addition to the TD.

3.0 Summary of Aircraft Data and Pilot Questionnaires Analysis

This HITL pilot demonstration collected both objective and subjective data. Objective data included aircraft approach deviation, descent rate, touchdown, and stopping distance data collected as a demonstration of the operational capabilities of modern aircraft avionics systems and flyability characteristics on qualifying runway ILS installations without CL or TDZ lighting systems. Objective observation of aircrew performance was also included in the demonstration methodology. As part of that data collection, the AFS-440 engineering psychologist also administered post-run and post-demonstration session questionnaires.

Flight scenarios included Flight Director hand-flown approaches, HUD approaches, and autopilot/Flight Director (coupled) approaches both in daytime and nighttime conditions for the 1,800 feet RVR; HUD or auto-land approaches both in day and nighttime conditions for the 1,600 feet or 1,200 feet RVRs. Each category of scenarios contained a mix of TDZ and CL lighting on/off.

3.1 Quantitative Analysis

Of the three TCV criteria—(1) descent rate, (2) airspeed, and (3) touchdown point—there were no violations in airspeed and only two in the touchdown point exceeding 3000 feet in any of the runs (each scenario/aircrew combination is considered a run, [e.g., Run 1 = Scenario 1/ Aircrew 1]). However, in 12 of the 30 hand-flown runs with no HUD (200 feet/1,800 feet RVR), the aircraft had a descent rate greater than 1,000 fpm sustained for more than three seconds. HUD, auto-land, and autopilot/Flight Director runs contained no descent rate TCVs. The descent rate TCV percentage difference (40% vs. 0%) between hand-flown and all others is statistically significant. Table 8 shows the number of events by duration of the descent rate violation. Table 9 shows the number of events by maximum descent rate[1].

Table 7 reflects the minimum, maximum, and average distances from the threshold to full stop[2].

Table 7: Distances to Landing and Full Stop, Feet—All Scenarios

	Min	Max	Average
Distance to landing from threshold	476	3201	1,801
Distance to full stop from threshold	3,838	8,574	5,712

Table 8: Descent Rate Violation Duration and Number of Events

Number of Seconds	Number of Events
3–3.9	3
4–4.9	6
5–6	2
7	1

Table 9: Maximum Descent Rate and Number of Events

Descent Rate [fps]	Number of Events
1,000–1,099	4
1,100–1,199	5
1,200–1,300	3

[1] Analyzing the recorded data indicated there were no significant differences noted between lights on and lights off.

[2] Out of the 180 runs that were evaluated, only two resulted in the aircrew touching down beyond 3,000 feet (3,201 feet and 3,142 feet). Touchdown at 3,201feet occurred with a 15-kt tailwind and the 3,141-foot touchdown occurred during an auto-land; however, prior to touchdown the first officer disengaged the auto-throttle which invalidated the auto-land touchdown footprint.

Figure 1 shows a graph of all Scenario 5 runs (hand-flown) and all Scenario 30 runs (auto-land). Pilot subjective responses and debriefing comments also point to pilot perception of a "duck-under" or "dive-down" effect. Since the ceiling in each scenario was set at or near the Decision Altitude (DA), the pilot transition from Instrument Meteorological Conditions (IMC) to visual conditions happened almost simultaneously with reaching the DA. In such conditions, pilots occasionally perceived that their position was higher than they should be and sometimes felt they should duck or dive towards the intended point of landing, thus dipping below the actual glide path. Although one-half of the subject aircrews mentioned this, neither performance data (glide slope deviation) nor do observer logs corroborate pilot perceptions in this demonstration. Note that of the 12 decent rate violations, only two occurred after the DA.

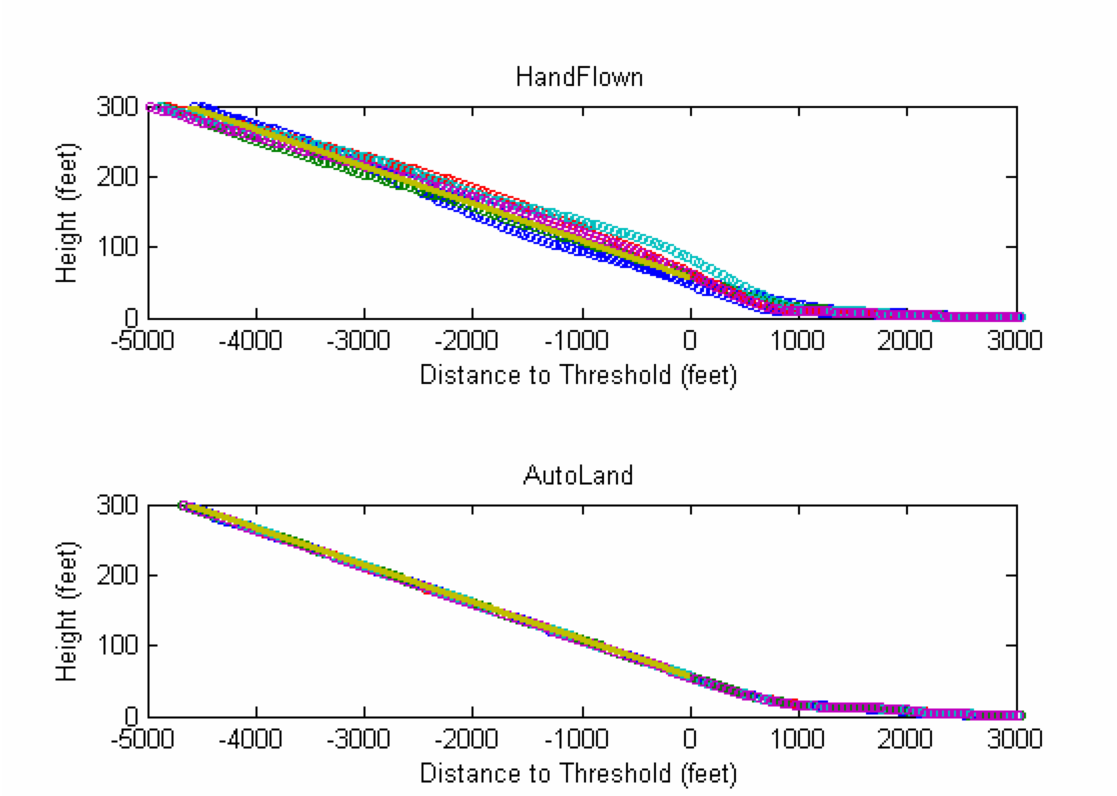

Figure 1: Glide Path View: Hand-Flown and Auto-Land Scenarios

3.2 Subjective Analysis

The evaluation of performance (e.g., aircrew cockpit coordination, aircraft control, and visual acquisition strategies) and potential changes in mental/physical workload and comfort levels were accomplished through elicited subjective responses and comments from flight aircrews, as well as objective observation of flight aircrew performance. Throughout the simulation, a short questionnaire was used to capture the aircrews' subjective measures of sense of difficulty, perceived comfort level, level of aircraft stabilization, and perceived level of both individual and flight aircrew workload.

Given the intrusive nature of any data-gathering procedure of this type, the number of questions was minimized to reduce the time required to complete the questionnaire. After each approach scenario/run, both pilots were given a five-question, check-the-block, subjective questionnaire, which normally took from one to three minutes to complete. It was stressed that each questionnaire was designed to capture each pilot's reaction, as either the Pilot Flying (PF) or Pilot Monitoring (PM), to that particular stand-alone scenario/run.

Objective aircrew performance measures were taken through simple observation of pilot/aircrew performance. All flight scenarios were carefully scripted and observers were unobtrusively positioned directly behind the pilot stations in the simulator. When the flight aircrew and/or pilot might be required to perform an unexpected task out of the norm, both primary and secondary task completions were monitored. Specifically, during periods of heightened activity or workload, out-of-norm reactions or task shedding may have taken place and were to be observed and recorded.

Following each simulator session, both the captain and first officer were given a final post-simulation questionnaire to gather their overall perceptions of the operation, encompassing all scenarios/runs.

The human factors evaluation focused on evaluating approach operations within the constraints of the visual scene as presented to the pilots in a particular simulator environment. It was not possible to fully evaluate the pilot's perception of a real-world operation in a flight simulator visual scene (especially under varying lighting configurations), given that depth perception and other important visual cues are not presented in a continuous, one-to-one relationship between real-world and simulated environments. Additionally, time and simulator constraints did not allow the demonstration to depict the full spectrum of varying atmospheric and visibility conditions that may affect the visual scene. These variables are important and could impact real-world operations. This study also did not fully evaluate the effect of the visual scene on visual scan or aircraft system monitoring as well.

Pilot comments were relatively consistent across all aircrews with no observed or recorded anomalies or extreme deviations from normal flight aircrew and aircraft performance. Pilot post-simulation comments were not completely consistent with subjective responses elicited after each run, specifically concerning perceived ability to perform the approaches and pilot perception of both individual and aircrew workload. Pilots generally felt that all approaches were easily performed, although the hand-flown approaches were perceived to be more difficult, with recorded increases in collective aircrew workload. However, two aircrews perceived a lighter individual workload during hand-flown approaches than all others combined. Several pilots commented that adverse weather and wind conditions, such as blowing snow, gusty winds, or stronger crosswinds, might make these procedures more difficult.

Other specific comments from the questionnaires included the following:

- Night, with a crosswind and without centerline/TDZ lights were the most challenging combination factors.
- Lack of centerline lights was more difficult but manageable.
- Visual acquisition strategies changed, especially in a crosswind.
- Lack of touchdown zone lighting had more of a negative effect than lack of centerline lighting from the standpoint of useable visual cues.
- Several pilots were concerned about potentially “ducking under” glide slope.
- The visual effect of concrete versus asphalt should be taken into account. There may be an impact on depth perception and relative positioning.

From a HITL perspective, there does not appear to be any appreciable increase or change in workload (physical or mental) directly resulting from the variable conditions of this demonstration. Pilot subjective comments and debriefing remarks indicated that all aircrews felt that the hand-flown scenarios (Scenarios 1-5) were the most problematic of all the scenarios. On a continuum, the subject pilots felt that the HUD scenarios were optimally flown, followed by auto-land, autopilot/Flight Director, and Flight Director/hand-flown, in that order.

3.3 Subjective Questionnaire Responses

Figures 1-5 represent subjective pilot responses across all trial scenarios, by aircrew. Also, pilot responses for just the hand-flown approaches (Scenarios 1-5) are included. A breakdown of each question by Pilot Flying and Pilot Monitoring reveals one aircrew (Aircrew 3) whose subjective responses were consistently lower than the other subject aircrews in all areas except the aircrew’s perception of aircraft stabilization. Clearly, pilot workload and stabilization was negatively impacted during hand flown approaches versus HUD, autopilot and autoland.

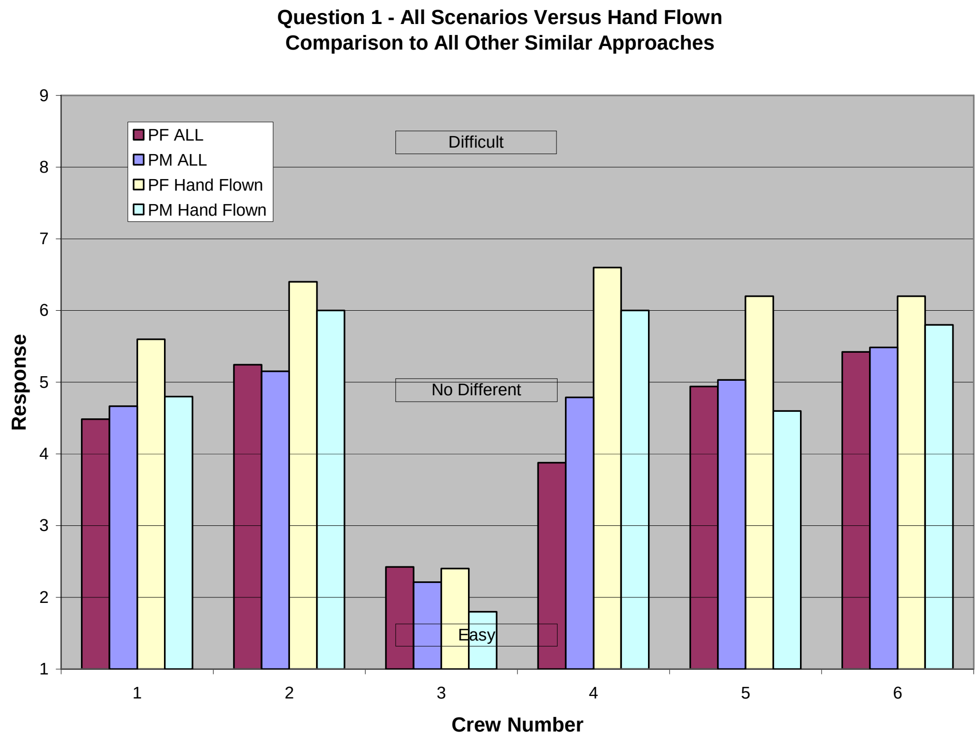

Figure 2: Q1 Responses: All Scenarios Versus Hand-Flown Comparison to All Other Similar Approaches

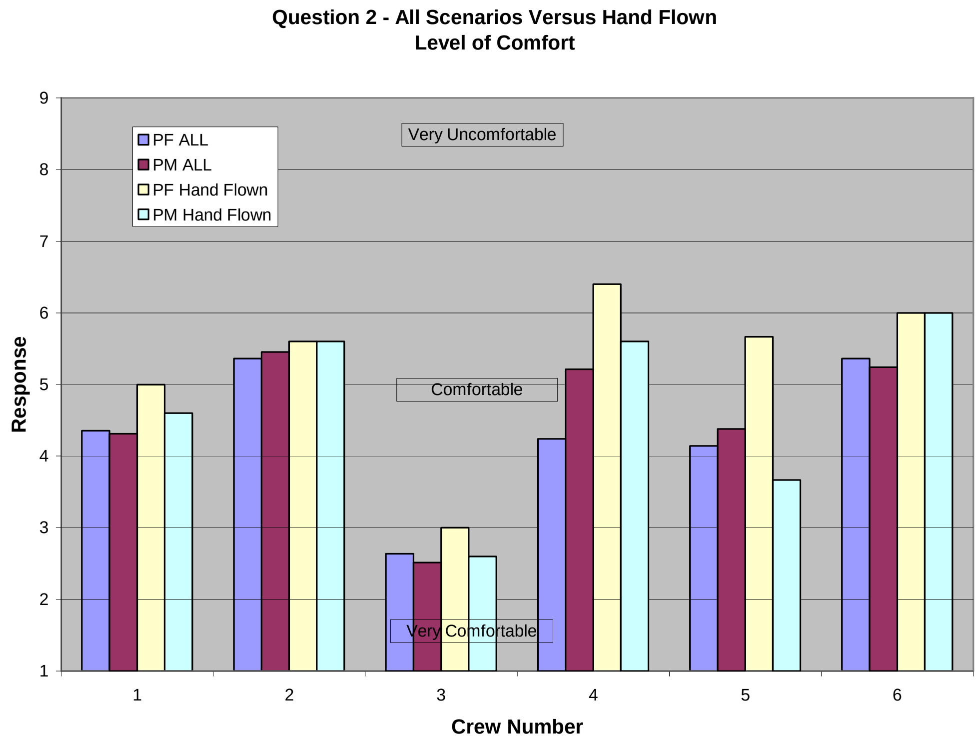

Figure 3: Q2 Responses: All Scenarios Versus Hand-Flown Level of Comfort

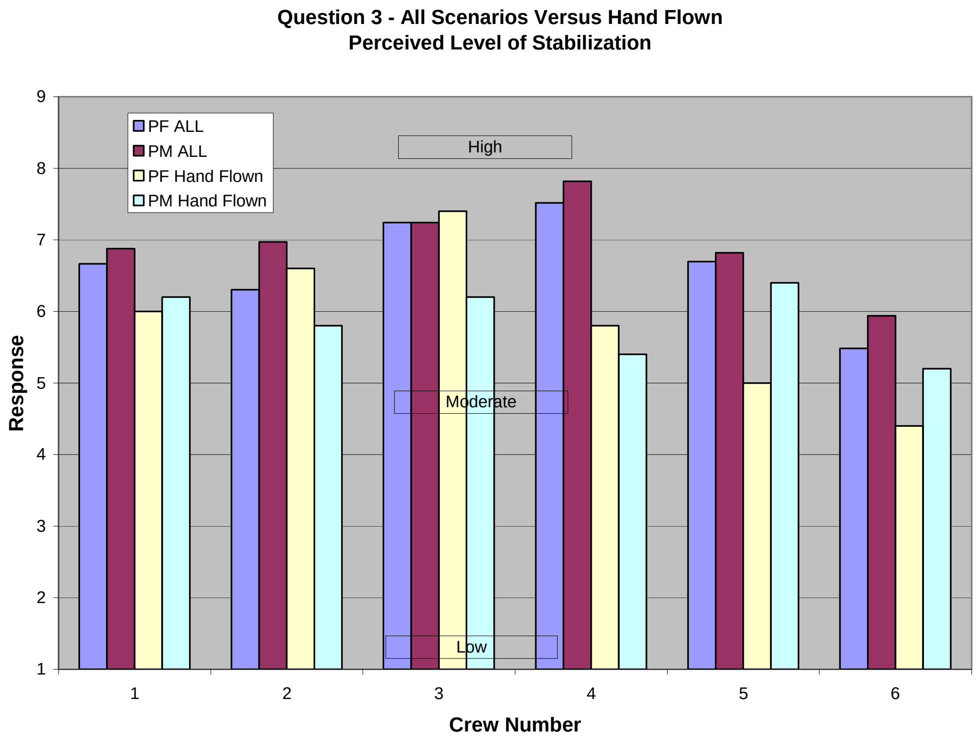

Figure 4: Q3 Responses: All Scenarios Versus Hand-Flown Perceived Level of Stabilization

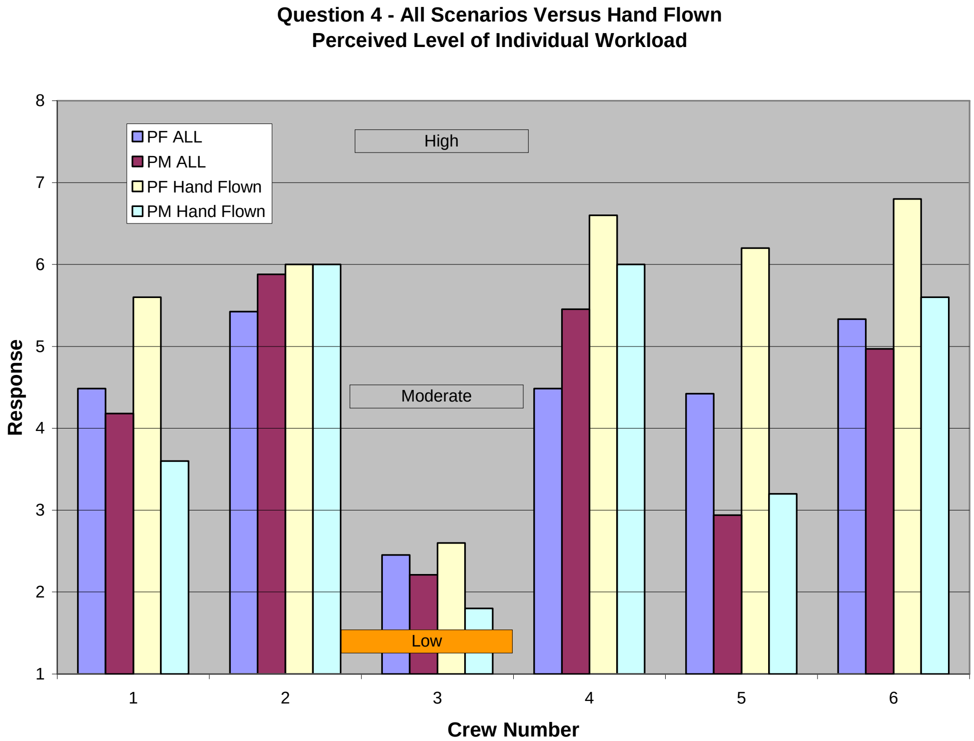

Figure 5: Q4 Responses: All Scenarios Versus Hand-Flown Perceived Level of Individual Workload

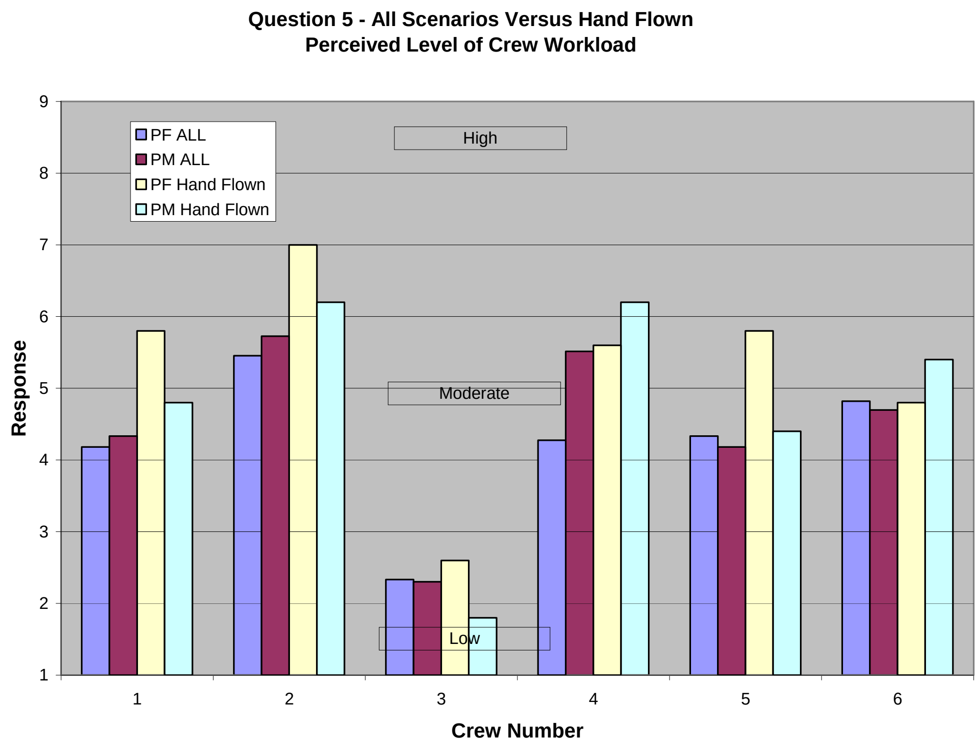

Figure 6: Q5 Responses: All Scenarios Versus Hand-Flown Perceived Level of Crew Workload

3.4 Test Director/Observer Observations

The pilots from Aircrews 1 and 5 were from two different airlines. There were no issues with crew one however crew two generated much discussion during the scenarios and the post-debriefing about company policies and procedures. One aircrew member adhered to constant communication throughout the approach (i.e., "communication-by-rule"). The other adhered to communicating only when needed to change course or respond to anything out of the ordinary (i.e., "communication-by-exception"). Both subject pilots viewed the aircrew coordination as poor since they were not following the same company policies and procedures. Thus, they erred on the side of safety and were more apt to execute a go-around if experiencing approach concerns. In fact, during four of five hand-flown scenarios, Aircrew 5 executed a missed approach or go-around.

With very few exceptions, observer notes indicated that all approaches were stabilized. Note that each Part 121 carrier has its own interpretation of what constitutes a stabilized approach. In general, the aircraft needs to be configured for landing (gear/flaps), on speed, on course, and on glide path, with a descent rate not to exceed 1,000 fpm below 1,000 AGL. These parameters enable the aircraft to make a smooth transition from IMC to visually acquiring the runway for landing. It was briefed to each aircrew to adhere to their respective company's procedures for maintaining stabilized approach requirements. However, several aircrews experienced "sink rate" automated callouts and continued the approach through landing.

Several Part 121 airlines stipulate that the captain must be the PF for all approaches when the weather is below 4,000 feet RVR or less than ¾-mile visibility. Other airlines allow the first officer to be the PF for the approach down to the DA at which time the captain, with landing criteria met, takes over the controls and lands. For this demonstration, first officers were asked to conduct auto-land approaches, down to 1,200 feet RVR, regardless of company procedures, to garner a cross-section of first officer performance under these scenarios.

Although the recorded data indicated there were no significant differences noted between lights on and lights off, it appeared that pilot workload increased in the "no lights" conditions. With the centerline lights turned off, depth perception cues may be degraded. This degradation may be more critical in crosswind conditions. In several cases, poor depth perception may have been a causal factor as evidenced by a number of sink rate callouts from the automated callout system.

The transition from IMC to visual conditions was of particular concern to observers. Pilots, more specifically the PFs, are trained and accustomed to transitioning away from the instruments at the DA, visually acquiring the runway environment, and making a decision whether to land or perform a missed approach. This is a critical point where pilots are observing visual cues from an ever-changing visual scene, processing the visual information, and making time-critical decisions. Several subject pilots commented during the demonstration and observers noted that approaches with the RVR 1,200 feet appeared less difficult than the RVR 1,800 feet. This was attributed to having less time between transitioning from instruments and visually acquiring the runway environment and landing.

Post-demonstration discussions by observers pointed out that during reduced RVR, pilots feel compelled to maintain visual focus on the Flight Director for a perceptually longer period of time thereby reducing potential glide path and/or descent rate deviations. Thus, perception of difficulty decreased with less Flight Director and/or glide path deviations observed. In two separate instances, each with the first officer (FO) as the PF, one FO maintained focus on the Flight Director, well past the DA (until approximately 100' AGL) while the second FO focused his attention outside the aircraft, relying on outside visual landing cues. The first FO fully transitioned to visual conditions close to the ground and landed on the centerline. The second FO was not able to maintain stabilized flight configuration and properly executed a go-around.

4.0 Conclusion

Overall, the objective and subjective data indicated no appreciable increase or change in workload (physical or mental) directly resulting from the variable conditions of this demonstration.

However, descent rate violations where the aircrew exceeded 1,000 fpm for longer than three seconds occurred during 40% (12 of 30) of the hand-flown scenarios (200 feet/RVR 1,800 feet). No such violations occurred when the HUD, auto-land, or autopilot/Flight Director were being used. Pilots indicated that there was a tendency to duck under immediately after transitioning from IMC to the visual segment of the final approach. This tendency was corroborated by a number of “sink rate” callouts made by the automated callout system. The “duck-under” is a known phenomenon that could occur during low visibility and/or night operations with reduced depth perception. Pilots have a sense that they are higher, above the glide path, and feel that they should expedite their descent to compensate.

With the exception of the hand-flown scenarios, there were no appreciable performance anomalies due to changes in the TDZ and CL lighting while flying to a DH of 200 feet HAT with RVR of 1,800 feet and a DH of 100 feet HAT with RVRs of 1,600 feet and 1,200 feet.

Appendix A: Demonstration Approach Chart Atlanta KATL RWY 26R ILS

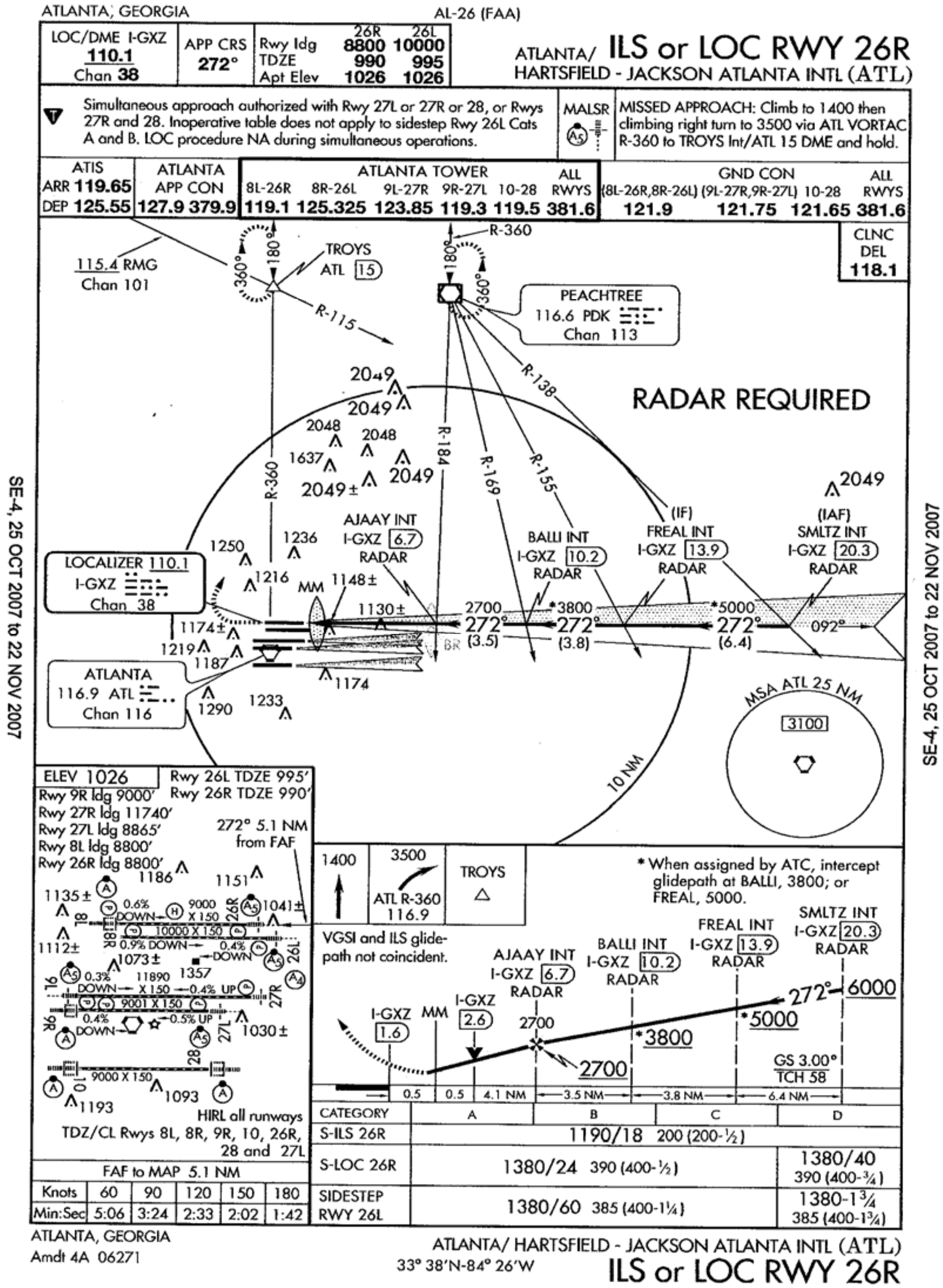

Figure A1: Demonstration Approach Chart Atlanta KATL RWY 26R ILS

Appendix B: Post-Run Questionnaire

Post-Run Questionnaire

1. In general, compare this approach to other, straight-in, ILS, approaches that you perform.

Easy			Moderate			Difficult		
1			4	5	6	7	8	9

2. Rate your level of comfort at the point of breaking out and transitioning from IMC to Visual conditions

Very Comfortable			Moderately Comfortable			Uncomfortable		
1	2	3	4	5	6	7	8	9

3. Rate the level of stabilization for this approach based upon your organization's guidance for a stabilized approach.

Low			Moderate			High		
1	2	3	4	5	6	7	8	9

4. Rate your perceived level of individual workload for this approach from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low			Moderate			High		
1	2	3	4	5	6	7	8	9

5. Rate the level of aircrew workload for this approach from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low			Moderate			High		
1	2	3	4	5	6	7	8	9

Appendix C: Post-Demonstration Session Questionnaire

Post Demonstration Session Questionnaire

1. In general, compare this approach to other, straight-in ILS approaches, that you perform.

Easy			Moderate			Difficult		
1	2	3	4	5	6	7	8	9

2. Rate your overall level of comfort with this approach.

Very Comfortable			Moderately Comfortable			Uncomfortable		
1	2	3	4	5	6	7	8	9

3. Rate the level of stabilization for this approach based upon your organization's guidance for a stabilized approach.

Very Comfortable			Moderately Comfortable			Uncomfortable		
1	2	3	4	5	6	7	8	9

4. Rate your perceived level of individual workload for this approach from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low			Moderate			High		
1	2	3	4	5	6	7	8	9

5. Rate the level of aircrew workload for this approach from the standpoint of mental demand (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.).

Low			Moderate			High		
1	2	3	4	5	6	7	8	9

Appendix D: Post-Demonstration Session Debreifing

Post Demonstration Session De-Brief

1. Overall, did you feel comfortable with this approach, based upon your experience with all other approaches that you perform?

____

____

2. What additional mental or physical requirements, if any, were imposed on you during this approach?

____

____

3. Was this approach stabilized based upon your company’s/organization’s guidelines for a “stabilized approach”?

____

____

4. Did you sense any additional requirements during the transition from IMC to the Visual Segment?

____

____

5. What impacted your performance most (e.g. cross-winds, runway lighting, visibility, etc.)?

____

____

Appendix E: Acronyms

AGL	Above Ground Level
ALSF	Sequenced Flashing Lights
Capt	Captain
CAT	Category
CL	Centerline
DA	Decision Altitude
DH	Decision Height
HAT	Height Above Threshold
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FO	First Officer
ft	Feet
fpm	Feet Per Minute
HAT	Height Above Touchdown
HGS	Head-Up Guidance System
HIRL	High Intensity Runway Lighting
HITL	Human-In-The-Loop
HUD	Head-Up Display
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
JAA	Joint Aviation Authorities
kt	Knots
MALSR	Medium Intensity Approach Lighting System
MSL	Mean Sea Level
PF	Pilot Flying
PM	Pilot Monitoring
RVR	Runway Visual Range
RWY	Runway
TCH	Threshold Crossing Height
TCV	Test Criteria Violation
TD	Test Director
TDZ	Touchdown Zone
TDZE	Touchdown Zone Elevation
X L	Crosswind Left
X R	Crosswind Right

References

[1] FAA Order 8400.13B. *Procedures For The Approval Of Special Authorization Category II and Lowest Standard Category I Operations.* February 15, 2005.

[2] JAR-OPS1: *Commercial Air Transportation (Aeroplanes)* May 01, 2007.