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St. Louis Lambert Field Close Parallel Approaches Using 3° Offset LDA with Glideslope To Runway 30L

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Final Report

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12. Abstract

The two primary runways used for approach and departure operations at St. Louis/Lambert International Airport are parallel runways, spaced 1300 feet apart. Since the runway spacing at St. Louis is less than 3,400 feet, parallel operations are not approved. In order to improve capacity at St. Louis, Localizer-type Directional Aid (LDA) approaches with a side-step maneuver for alignment with the runway, but without electronic vertical guidance, were developed and have proven to be operationally successful. In order to determine whether an offset LDA with an electronic glideslope usable throughout the visual approach segment and a Precision Runway Monitoring (PRM) system would significantly enhance the flying qualities of the LDA and provide additional operational efficiency and safety, the Flight Procedure Standards Branch designed and conducted a flight simulation of five LDA approaches with electronic glideslope. Statistical analysis of the data indicated that three of the LDA approaches with glideslope were definitely superior to the current LDA approach. One of those three LDA approaches is recommended by this report because of its stability qualities and because of the longer distance from the clear of clouds point to the missed approach point.

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EXECUTIVE SUMMARY

The two primary runways used for approach and departure operations at St. Louis/Lambert International Airport (STL) are closely spaced, parallel runways. Independent parallel ILS approaches have been approved by the FAA for runways spaced at least 3,400 feet apart, but less than 4,300 feet apart when the approach surveillance radar is a Precision Runway Monitoring (PRM) system. Since the runway spacing at St. Louis is only 1,300 feet, parallel operations are not approved. In order to improve capacity at STL, Localizer-type Directional Aid (LDA) approaches with a side-step maneuver for alignment with the runway were developed and commissioned approximately fifteen years ago. Although the current LDA approaches and subsequent visual lateral transition to Runways 12L and 30L do not have electronic vertical guidance, they have proven to be operationally successful.

A proponent, a major air carrier, believes an offset LDA with an electronic glideslope usable throughout the visual approach segment and a PRM system will significantly enhance the flying qualities of the LDA and provide additional operational efficiency and safety.

The Flight Procedure Standards Branch (AFS-420), with the aid and cooperation of Simulator Engineering (AFS-408), and Air Traffic personnel from the STL air traffic control tower, designed and conducted a flight simulation to determine whether an offset LDA with electronic glideslope would actually enhance instrument operations at STL. Five LDA approaches with electronic glideslope were tested and compared to the current LDA approach. The five approaches were designed for Runway 30L using various combinations of threshold to Missed Approach Point (MAP) distances, MAP to Clear of Clouds (C/C) point distances, and MAP to the extended centerline of Runway 30R distances. Each approach incorporated a 3° offset in order to increase lateral separation from traffic performing the straight-in approach to Runway 30R. The approaches can be easily adapted for Runway 12L so that all results and recommendations will extend to equivalent approaches designed for Runway 12L.

Seventy-five pilots from eight airlines and the Federal Aviation Administration (FAA) served as subject pilots during the simulation. Approximately 380 approaches, using three level C simulators, were flown with selected wind conditions including head winds and quartering tail winds. Parameters were recorded during each approach designed to measure the stability of the aircraft during the approach, the maximum overshoot of the extended Runway 30L centerline, and the touch down distance from threshold. Questionnaires were administered to each pilot to determine his/her opinion regarding the flying qualities of the approaches.

Statistical analysis of the data indicated three of the LDA approaches with glideslope were definitely superior to the current LDA approach. The three approaches were those which had MAPs farthest from the threshold of Runway 30L. The pilot questionnaires also indicated these three approaches were preferred by the pilots. One of those three LDA approaches is recommended by this report because of its stability qualities and because of the longer distance from C/C to the MAP. The longer distance from C/C to MAP allows more time for the visual acquisition of traffic performing the straight-in approach to Runway 30R. The MAP of the recommended LDA approach was located 2.27 NM from the threshold of Runway 30L and 3,000

feet abeam of the extended centerline of Runway 30R. The addition of a glideslope on Runway 30L LDA 3° Offset Approach and a PRM radar system will allow weather minimums for the simultaneous ILS/LDA 3° Offset Approach to be reduced from the current 1,200-foot ceiling and visibility of 5 miles to 1,000-foot ceiling and 4 miles visibility. Therefore, flyability of the LDA approach, safety, and capacity should be improved with the addition of the recommended LDA with glideslope.

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1.0 INTRODUCTION

The two primary runways used for approach and departure operations at St. Louis/Lambert International Airport (STL) are closely spaced, parallel runways. Independent parallel ILS approaches have been approved by the Federal Aviation Administration (FAA) for runways spaced at least 3,400 feet apart, but less than 4,300 feet apart when the approach surveillance radar is a Precision Runway Monitoring (PRM) system. Since the runway spacing at STL is only 1,300 feet, parallel operations are not approved. In order to improve capacity at STL, Localizer-type Directional Aid (LDA) approaches with a side-step maneuver for alignment with the runway were developed and commissioned approximately fifteen years ago. The Missed Approach Points (MAP), for these LDA approaches, were located about 4,600 feet and 4,900 feet abeam of the extended centerlines of Runway 12R and Runway 30R. The Minimum Descent Altitude (MDA) at the MAP was set at 1,200 feet Mean Sea Level (MSL) with a minimum ceiling of 1,200 feet above the airport or 1,800 feet MSL. Although the current LDA approaches and subsequent visual lateral transition to Runways 12L and 30L do not have electronic vertical guidance, they have proven to be operationally successful.

A proponent, a major air carrier, believes an offset LDA with an electronic glideslope usable throughout the visual approach segment and a PRM system will significantly enhance the flying qualities of the LDA and provide additional operational efficiency and safety. The PRM is a system that provides air traffic controllers with high-precision secondary surveillance radar data for aircraft on final approach to closely spaced parallel runways. High resolution color monitoring displays with visual and audible alerts, called Final Monitor Aids (FMA), are required to present surveillance track data to controllers along with detailed maps depicting approaches and the no transgression zone. According to FAA Order 8260.39A, Close Parallel ILS/MLS Approaches, simultaneous independent ILS approaches are authorized for dual parallel runways whose extended centerlines are separated by at least 3,400 feet, but less than 4,300 feet, and having a PRM system. In addition, runway separation may be decreased to 3,000 feet if the localizer courses are aligned at least 2-1/2° to 3° divergent to each other.

This proponent believes an offset LDA with electronic glideslope usable throughout the visual approach segment and a MAP located 3,000 feet to 3,400 feet abeam of the parallel localizer course will result in more stable approaches with smaller bank angles. In addition, the elimination of step-downs would provide other benefits such as noise abatement. With the decreased distances from MAP to threshold and MAP abeam the parallel runway, minimums could be decreased which would effectively increase capacity. The proponent also suggests the LDA approaches should be designed so that about 25 seconds would elapse from the time the aircraft crosses the Clear of Clouds (C/C) point until it reaches the MAP. The proponent believes this time is essential for the visual acquisition of traffic on the adjacent ILS approach. In order to meet this requirement altitude of the aircraft at the MAP would have to be as much as 347 feet below the cloud ceiling.

As a means to safely increase airport capacity at STL, the FAA was asked to evaluate LDA approaches using a 3° offset LDA with glideslope to Runway 30L. With the installation of a PRM system at STL, the instrument portion of an LDA approach with a 3° offset could be

designed with a MAP located as close as 3,000 feet abeam the extended centerline of Runway 30R. Since the approaches can be easily adapted for Runway 12L, all results and recommendations will extend to equivalent approaches designed for Runway 12L.

2.0 STATEMENT OF PROBLEM

During the instrument portion of the proposed LDA approach, with glideslope, the approach is conducted as a closely spaced parallel approach with an offset angle of 3°. With the addition of a glideslope, the instrument portion of the approach is essentially an ILS approach. This type of approach has been thoroughly tested by the FAA and, with the installation of a PRM, is approved under Order 8260.39A. After passage of the C/C point, the pilot must visually acquire traffic on the adjacent approach, perform a side-step maneuver to align the aircraft with the extended runway centerline, and then perform a normal landing.

The basic problem is to evaluate whether the flying qualities of the visual segment after leaving the LDA will be improved by the addition of a glideslope. However, it is obvious the MAP point of the LDA approach can be placed in several different positions relative to the runway threshold. Therefore, the flight test was designed to compare several different possible positions of the MAP. The primary focus of the flight test is to determine an optimal position of the MAP. The test criteria included the flying qualities of the visual segment of the approach, the magnitude of overshoots of the extended runway, and whether normal landings were the inevitable result.

2.1 DESCRIPTION OF THE EVALUATION

In order to determine an optimal placement of the MAP relative to the runway threshold, three types of LDA procedures to Runway 30L were tested. The approaches were designed to evaluate the significance of the distance of the MAP from the runway threshold and abeam the adjacent localizers course. Line pilots, current and qualified, were enlisted to fly flight simulators programmed to emulate the following:

a. Approaches using the current published LDA that is parallel to the adjacent approach path, scenario LDA 0, beginning from a DME of 18 NM and an altitude of 5,500 feet. Pilots flew the entire instrument approach even though only the visual segment was to be evaluated.

b. Approaches using a 3° angled offset LDA with glideslope to MAPs. These MAPs were spaced 3,400 feet from the adjacent approach path with MAP to threshold distances of 1.59 NM and 2.59 NM for scenarios LDA A and B.

c. Approaches using a 3° angled offset LDA with glideslope to MAPs. These MAPs were spaced 3,000 feet from the adjacent approach path with MAP to threshold distances of 1.94 NM, 2.58 NM, and 2.27 NM for scenarios LDA C, D, and E.
The LDA approaches are presented graphically in figures 1 through 7. The first six figures illustrate each of the LDA approaches. Figure 7 presents all six MAPs in order to illustrate their relative positions.

The current LDA approach was included in the test in order to have a baseline for comparison. Since the current LDA has proven to be operationally successful, the proposed LDA approaches were compared to it to determine whether an operational advantage would be gained by the addition of a glideslope. In addition, various positions of the MAP were tested to determine an optimal location of the MAP.

On the simulated approach charts provided to the crewmembers, LDA A was referred to as LDA 2a/LDA A. LDA B was referred to as LDA 2b/LDA B. LDA C was referred to as LDA 3a/LDA C. LDA D was referred to as LDA 3b/LDA D. LDA E was referred to as LDA 3c/LDA E. The designations, LDA A, LDA B, LDA C, LDA D, and LDA E are used throughout this report for brevity.

Winds were introduced to test the effect of headwinds and quartering tailwinds. The simulated winds were as follows:

a. 13 KT from 080°; a right quartering tailwind,
b. 13, 14, and 15 KT from 165°; a left quartering tailwind,
c. 9 and 10 KT from 300°; a headwind, and
d. 14 and 15 KT from 350°; a right quartering headwind

Although the test procedures were designed to Runway 30L, it is expected that test results will be applicable to Runway 12L. The test LDAs were positioned in theoretically ideal positions to satisfy the dimensions of the plan shown in appendix A. It is not known at this time if suitable locations are available on Lambert Field to accommodate the LDA positions used in this test. Airway Facilities is responsible for actual equipment siting.

The test scenarios were flown using FAA qualified, level C flight simulators. The simulators used were the FAA B-727, Trans World Airline (TWA) MD-80, and a Southwest Airline (SWA) B-737.

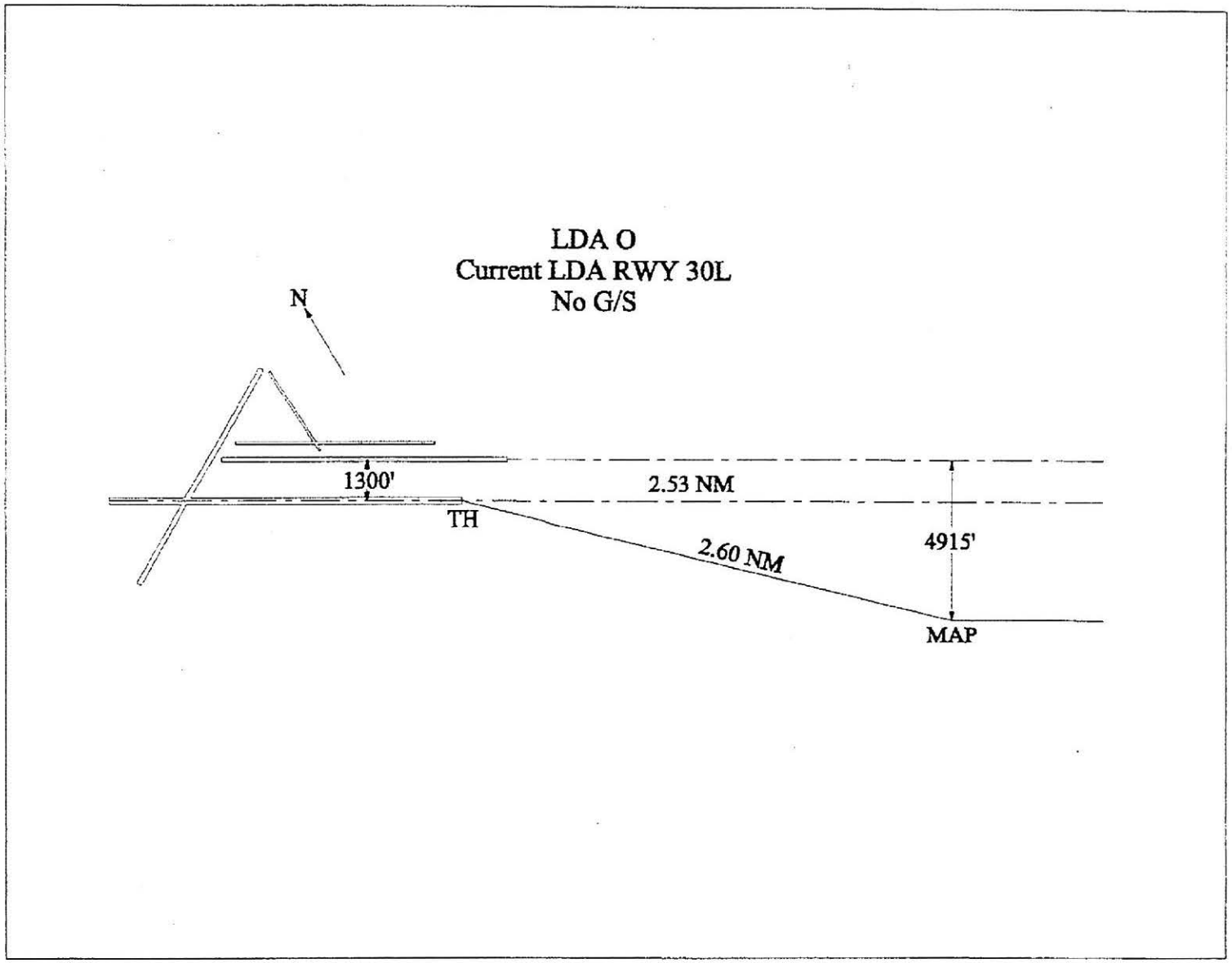


FIGURE 1. LDA O

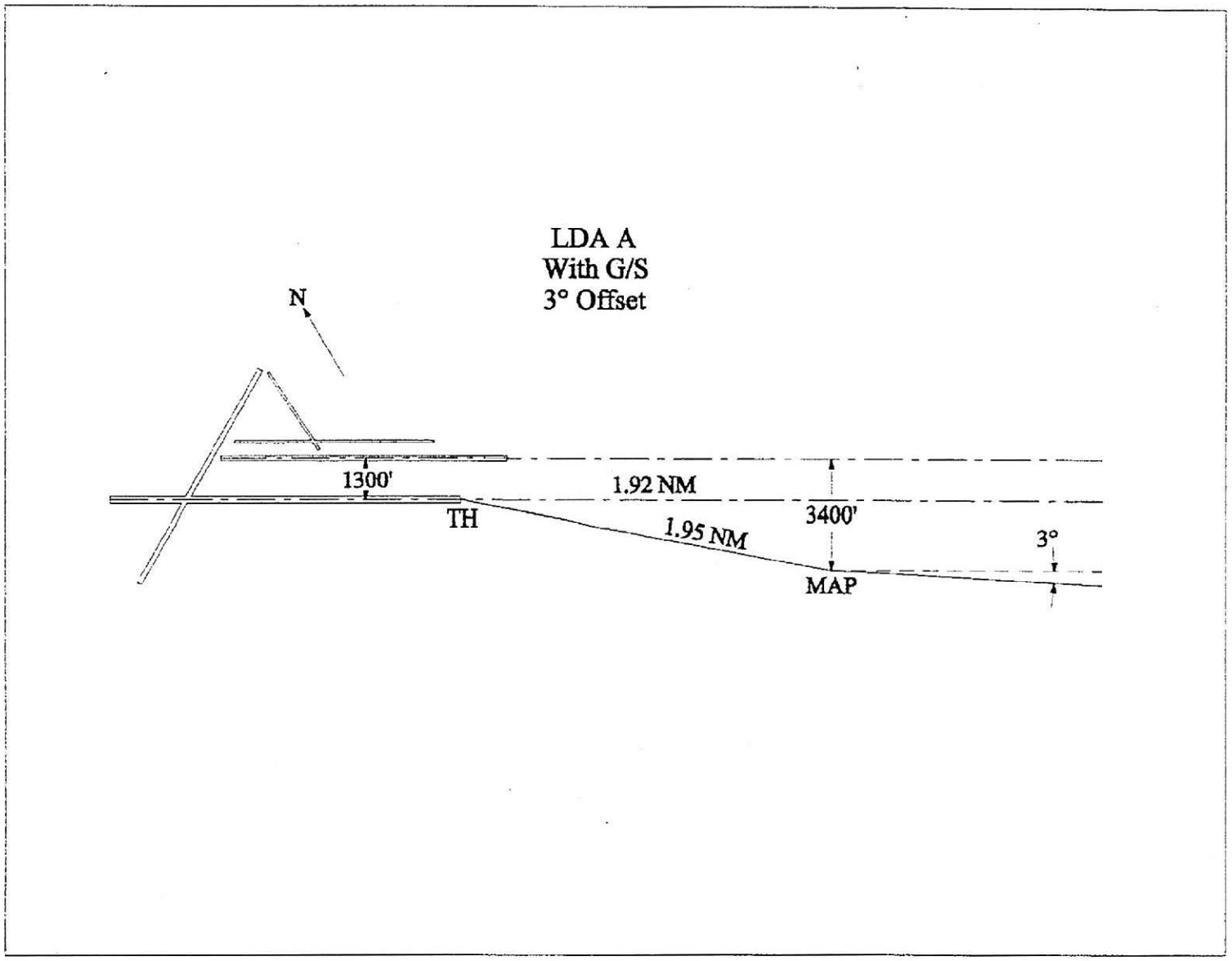


FIGURE 2. LDA A

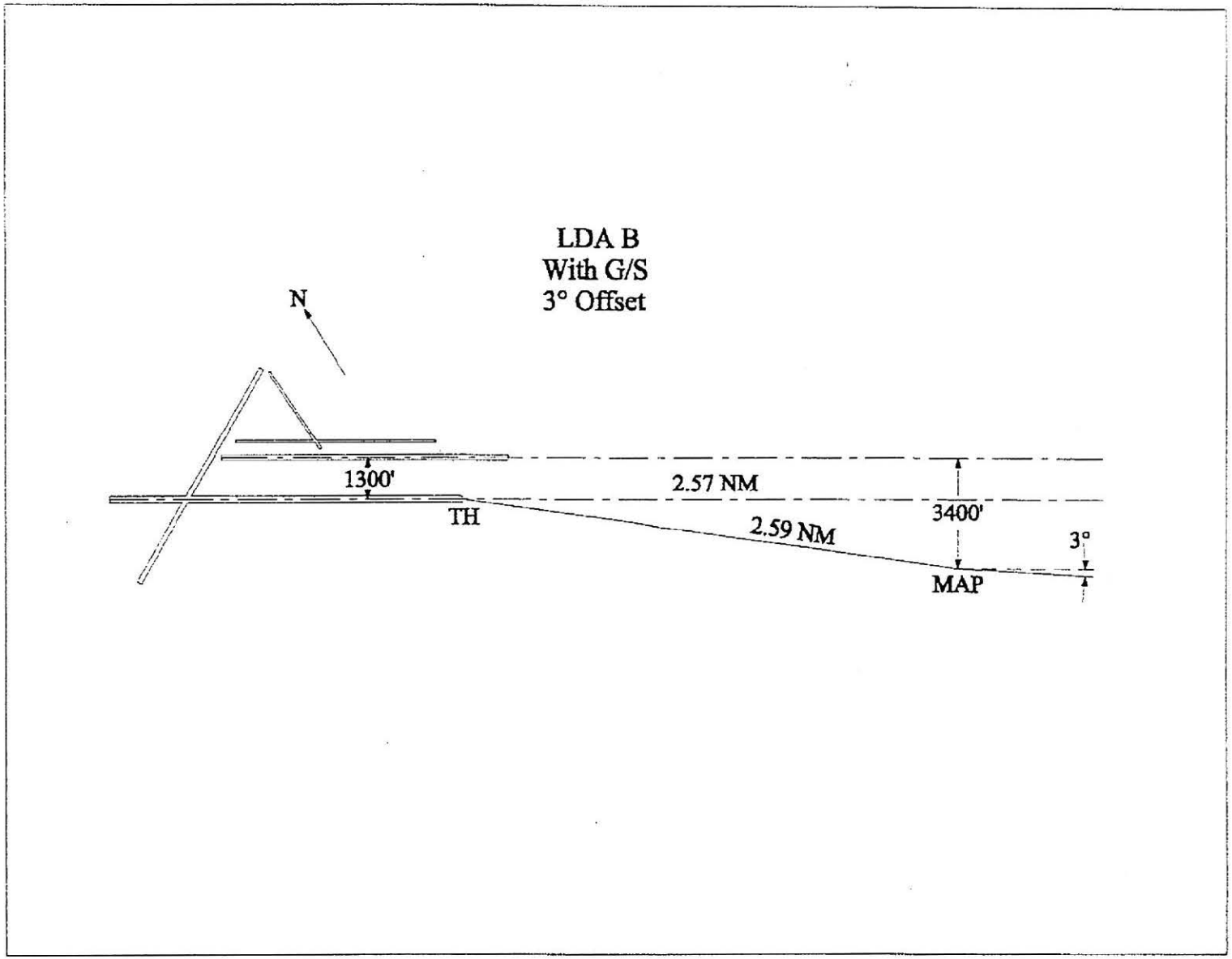


FIGURE 3. LDA B

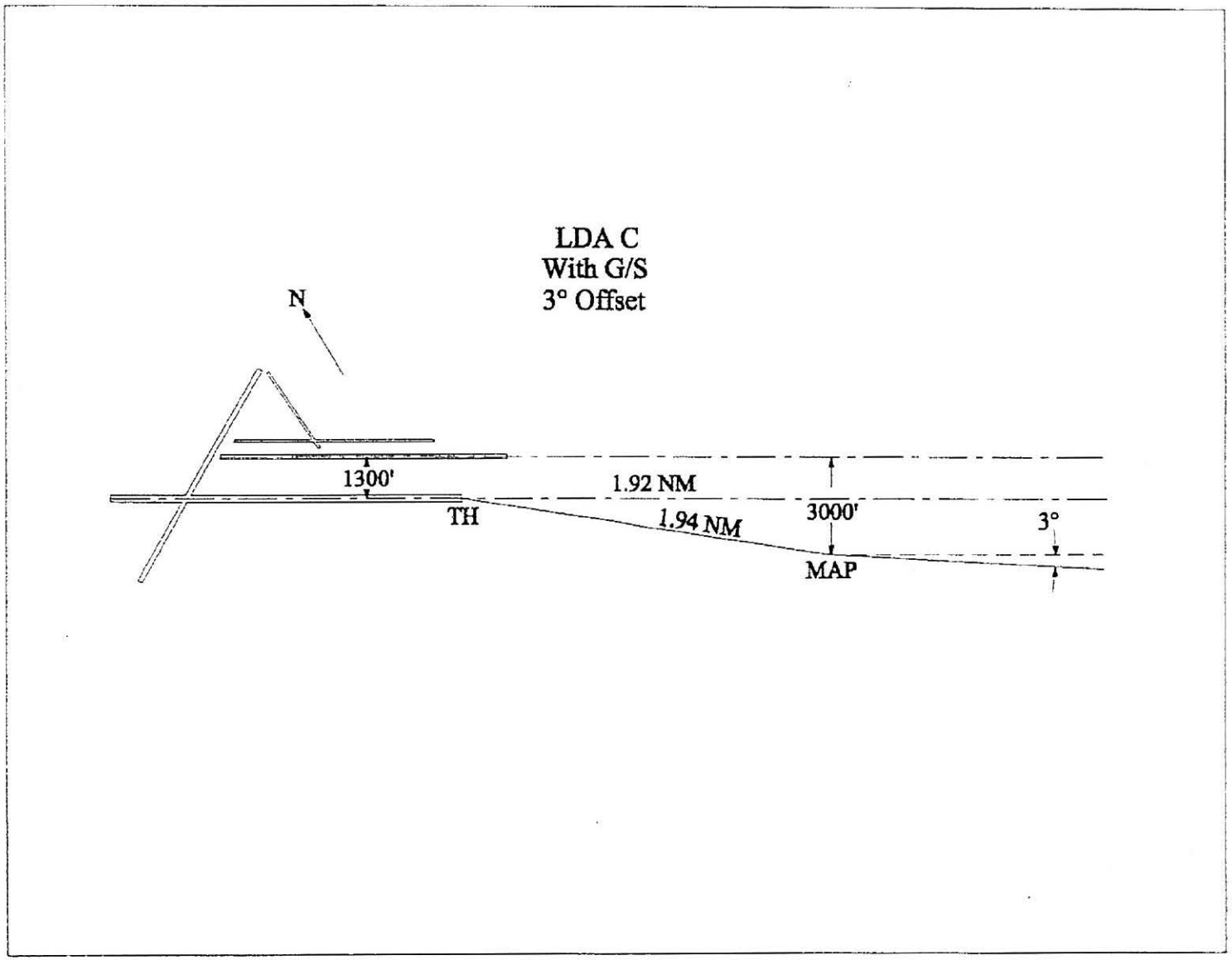


FIGURE 4. LDA C

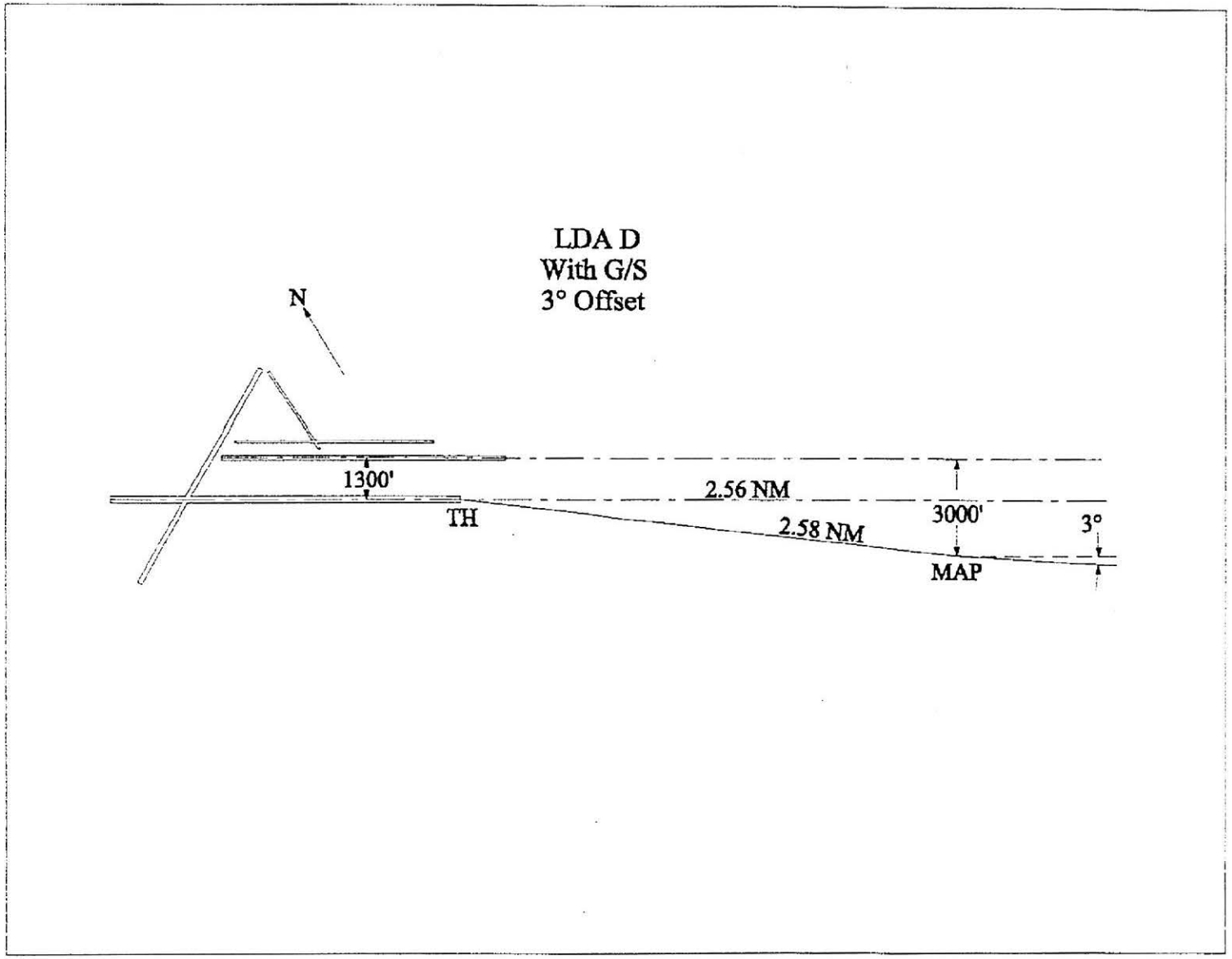


FIGURE 5. LDA D

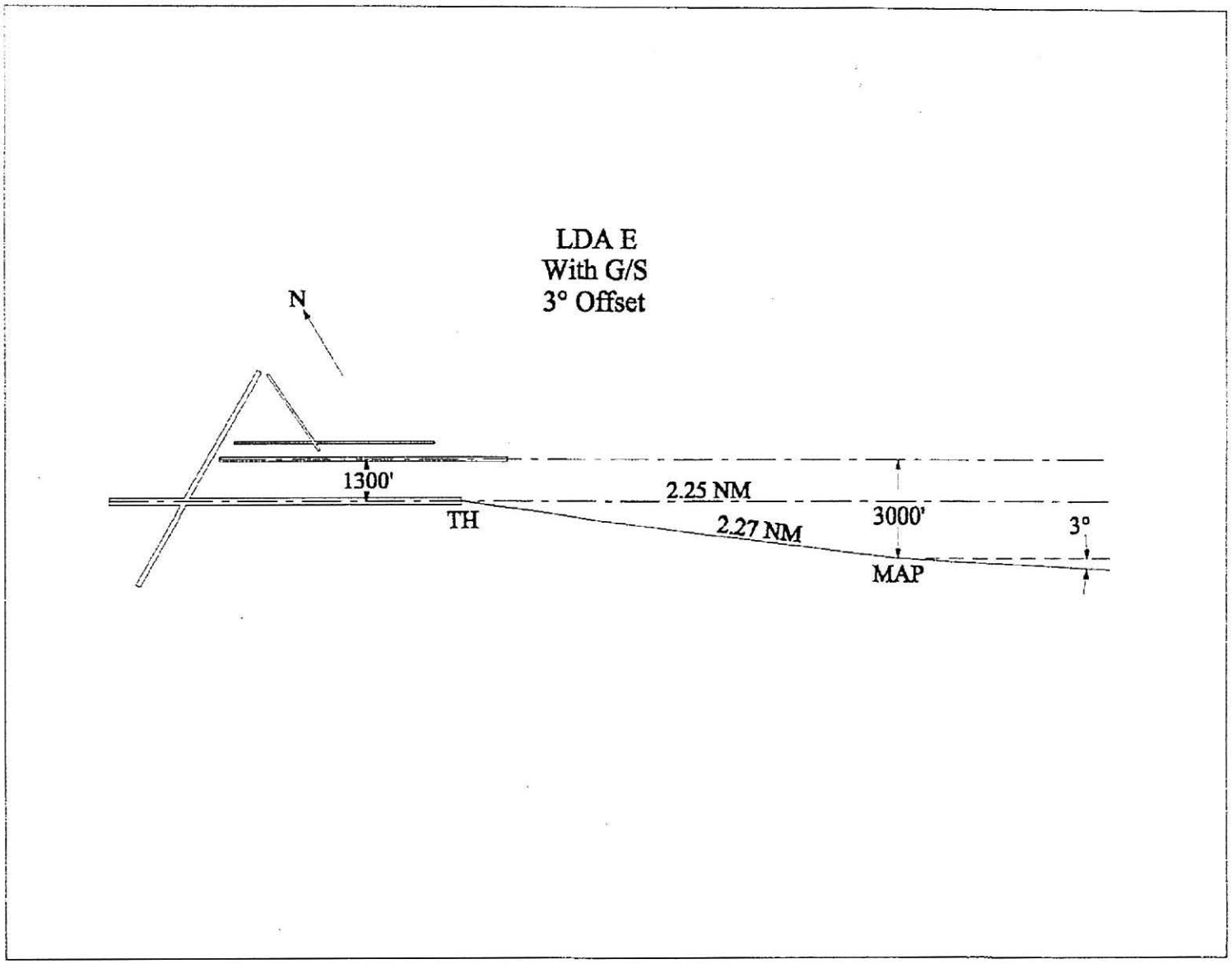
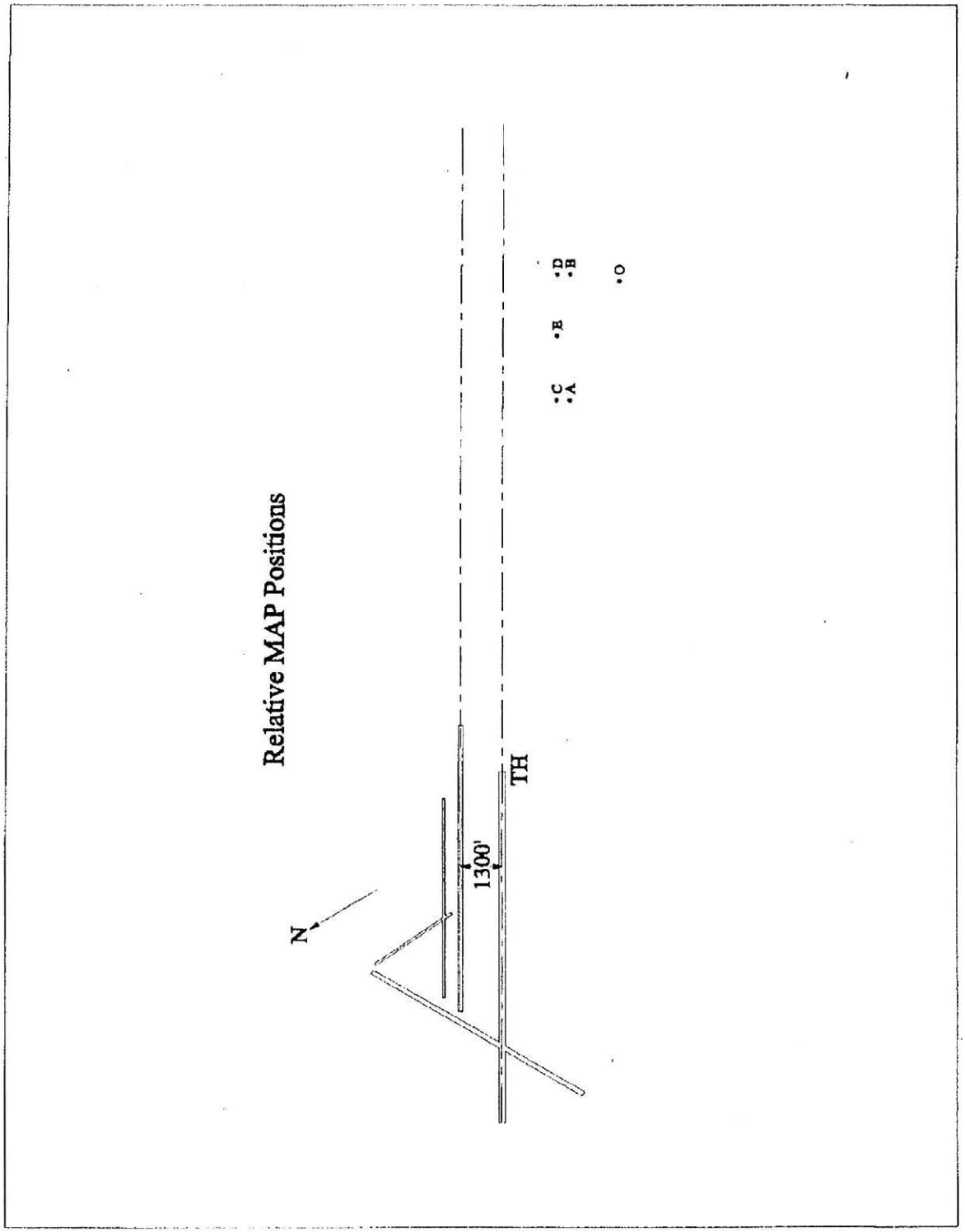


FIGURE 6. LDA E

FIGURE 7. RELATIVE MAP POSITIONS



.2 TASKS

The flight simulators were configured with the assistance of the National Resource Specialist for Simulator Engineering (AFS-408). The simulators provided a night visual presentation with adequate background for visual reference of STL. The configuration of the simulators was as follows:

a. The minimum separation of each LDA procedure from Runway 30R, the distance from the missed approach point to the displaced runway threshold, the presence of a glideslope, the offset angle, and the magnetic course of the LDA approach are given in table 2.1.

b. LDA and DME equipment were collocated. The LDA course width was set at 5°. The glideslope equipment was located at the current glideslope site and tuned on the associated LDA frequency.

c. Simulated aircraft traffic on the adjacent approach was presented from the C/C point on the LDA throughout the visual transition subject to specific simulator capability.

d. The ceiling and visibility for the current LDA approach to Runway 30L, LDA 0, were set at 1,200 feet and 5 statute miles (SM), respectively. The ceiling and visibility for the proposed LDA approaches with glideslope were set at 1,000 feet and 4 SM, respectively.

e. The MDA for each of the LDA approaches with glideslope was trigonometrically determined using the distance of the MAP to the glideslope point of interception and the glideslope angle.

f. Wake turbulence was not tested because existing Air Traffic Control wake turbulence procedures will be utilized for closely spaced parallel runways.

g. The Airspace Simulation and Analysis for TERPS computer system was used to extract pertinent flight data and to present graphically the results of the flight tests. Example track plots are included in appendix G.

The configuration of the flight simulators is summarized in table 2.1.

PROCEDURE	SEPARATION	MAP TO THRESHOLD	CEILING AND VISIBILITY	GS	OFFSET ANGLE	MDA
LDA 0	4915'	2.60 NM	1200' - 5SM	none	0.0°	1200' MSL
LDA A	3400'	1.95 NM	1000' - 4SM	3.0°	3.0°	1280' MSL
LDA B	3400'	2.59 NM	1000' - 4SM	3.0°	3.0°	1480' MSL
LDA C	3000'	1.94 NM	1000' - 4SM	3.0°	3.0°	1260' MSL
LDA D	3000'	2.58 NM	1000' - 4SM	3.0°	3.0°	1480' MSL
LDA E	3000'	2.27 NM	1000' - 4SM	3.0°	3.0°	1420' MSL

Table 2.1 PROCEDURE CONFIGURATIONS

3.0 EVALUATION PROCEDURES

3.1 EVALUATION EQUIPMENT AND PERSONNEL

The project required the use of three simulators and the participation of several personnel. The equipment and personnel participating in the test are as follows:

a. The flight simulators used were the FAA B-727 simulator located at the Mike Monroney Aeronautical Center, Oklahoma City, Oklahoma, a TWA MD-80 simulator located at St. Louis, Missouri, and a B-737/300 simulator located at Southwest Airlines in Dallas, Texas. These simulators were configured by AFS-408 as described in section 2.1a and table 2.1.

b. A population of approximately 37 crews from eight airlines and the FAA participated in this test. Each crew flew the aircraft simulator in which they were current and qualified.

c. An AFS-420 project pilot reviewed and validated each scenario set-up for each simulator.

d. An AFS-420 program manager supervised the project to ensure proper data acquisition.

e. AFS-408 assisted with simulator set-up and data acquisition in order to accomplish objectives of the evaluation.

f. Air Traffic personnel from the STL Air Traffic Control Tower (ATCT) provided ATC radio communication including weather information, traffic advisories, clearances to land, etc.

3.2 SIMULATOR DATA REQUIREMENTS

The data parameters recorded for this evaluation were:

a. Aircraft position, X (longitudinal distance) referenced to landing runway threshold, Y (lateral distance) referenced to landing runway centerline extended, and Z (height above runway threshold)

b. LDA course deviation from data logging point to MAP locations (4.0 NM DME)

c. Glideslope course deviation throughout the entire data-logging period

d. Indicated airspeed in knots

e. Bank angle

f. Pitch angle

g. Rate of descent

h. Time

i. Wind direction and speed

j. Flap position

k. Gear position

l. Ceiling

m. Visibility

n. Autopilot engagement

3.3 SUBJECT CREWS

Crews participating in this test were current and qualified in their respective aircraft, i. e., B-727, MD-80, and B-737. The evaluation was conducted with line pilots from the following airlines: American, Delta, Kiwi, Northwest, Reno Air, Southwest, TWA, and USAir. In addition, FAA

Aviation Safety Inspectors also served as pilots in the test. A pre-test briefing was conducted for each crew.

Flight crews were briefed (see appendix B) and familiarized with the simulator prior to data acquisition runs. Differences in simulator equipment were identified for the participating crews. During the evaluation, the pilot flying the simulator filled out a short questionnaire after each run (see appendix C). A post-evaluation questionnaire was administered at the conclusion of each session (see appendix D).

Project pilot's notes and subject pilot comments on their assessment of each completed approach were obtained and evaluated.

4.0 CRITERIA FOR SUCCESS

The analysis of the data from the test should show the proposed LDA operations, aided by glideslope augmentation, assisted the crews in maneuvering the aircraft during the visual segment after leaving the LDA to a safe airline acceptable approach and landing by providing the following:

a. During the lateral transition the aircraft parameters should be in accordance with airline operating guidelines for terminal operations at published minimums and at maximum gross landing weight.

b. A stabilized visual approach in the lateral transition segment from the MAP to threshold.

c. A successful and normal landing.

d. All lateral transitions to commence at the MAP. Data runs, which were observed to depart from the LDA prior to reaching the MAP, were excluded from the analysis.

e. Bank angles required during the visual segment not to be excessive for terminal, low level operations.

f. Rates of descent required during the approach not to exceed acceptable standard practice for safe terminal, low level visual transitions and landing operations.

g. Lateral dispersion beyond the extended centerline and vertical dispersions throughout the lateral transition would not exceed standard turbojet/air carrier practices.

5.0 RESPONSIBILITIES

The participating organizations and their responsibilities are as follows:

a. AFS-420 provided test program management.

b. AFS-408 provided assistance for the simulators used in the project.

c. AND-450 provided oversight and funding for the project. This included:

1. Simulator time and compensation for all pilots, required simulator operator personnel, and FAA personnel necessary to complete scenario set-up, validation, and data collection activities.

2. Travel for FAA personnel to accomplish simulator set-up, validation, and data collection activities.

3. Funding for the preparation of the procedure approach plates to be used in the test.

4. Funding for contract technical support for the preparation of the final report.

d. Kansas City Flight Standards District Office provided flight operations guidance for test scenarios to emulate conditions that would be acceptable to airlines under their jurisdiction.

e. Dallas/Fort Worth Flight Standards District Office provided flight operations guidance for test scenarios to emulate conditions that would be acceptable to airlines under jurisdiction.

f. St. Louis Airways Facilities Sector Field Office provided a survey of possible sites for LDA localizer and additional glideslope stations that will closely duplicate those used in the tests.

g. Data reduction and analysis was accomplished by DataCom Sciences, Inc., Oklahoma City, Oklahoma, and by System Resources Corporation, Mays Landing, New Jersey.

h. Many pilots for the test were obtained and compensated through System Resources Corporation, Mays Landing, New Jersey.

6.0 DATA ANALYSIS

6.1 DATA REDUCTION

Upon receipt of the recorded data from the three flight simulators, the data was converted to a form suitable for analysis. Since the primary criterion for comparison of the five scenarios was the degree of stability during the approach and the amount of lateral dispersion past the extended centerline of Runway 30L, data were extracted which would serve to measure those parameters. The data extracted for analysis were as follows:

a. LAT500: The distance from threshold where the perpendicular distance of the aircraft from the extended centerline first became less than 500 feet.

b. LAT300: The distance from threshold where the perpendicular distance of the aircraft from the extended centerline first became less than 300 feet.

c. LAT100: The distance from threshold where the perpendicular distance of the aircraft distance, the extended centerline first became less than 100 feet.

d. LAT50: The distance from threshold where the perpendicular distance of the aircraft from the extended centerline first became less than 50 feet.

e. LEFTBANK: The maximum bank angle (left) and the distance from threshold where it occurred.

f. TDDIST: The touch down distance from threshold.

g. RIGHTBANK: Maximum bank angle (right) and the distance from threshold where it occurred.

h. OVER: The maximum lateral distance across the extended centerline (overshoot).

i. GSDEV: The maximum deviation below the glideslope (assumed glideslope for LDA 0).

j. A600: The maximum bank angle achieved while the aircraft altitude was between 550 and 650 feet.

k. A500: The maximum bank angle achieved while the aircraft altitude was between 450 and 550 feet.

l. A400: The maximum bank angle achieved while the aircraft altitude was between 350 and 450 feet.

m. A300: The maximum bank angle achieved while the aircraft altitude was between 250 and 350 feet.

The variables listed above as (a) through (d) provide a measure of the distance from threshold where the aircraft became aligned with the extended centerline of the runway. Large distances are desirable since they indicate the aircraft achieved a more stabilized approach farther from the runway threshold. Variable (e) and (g) provide a measure of the bank angles that were required to perform the approach. Small values are preferred since they would indicate a more stabilized approach. Variable (f) represents the distance from the threshold where the aircraft landing gear first contacted the runway. A small value is preferred since it would indicate the aircraft touched down near the threshold. Variable (h) represents the maximum lateral distance the aircraft flew across the extended centerline toward Runway 30R. A small value of this variable is preferred. Variable (a) through (h) provide a measure of the stability of the aircraft on the extended runway

centerline. Variable (i) represents the maximum vertical deviation from the glideslope during the visual segment of the approach. This variable provides an indication of the vertical stability of the approach. LDA 0 does not have a glideslope so the distance from an assumed glideslope was computed. Variable (j) through (m) provide measures of the bank angles as the aircraft approached the runway threshold. Small values are preferred since these variables provide an indication of the turn rate necessary to align the aircraft with the extended runway centerline.

6.2 STATISTICAL TESTS

The primary statistical tests used in the analysis were the Analysis of Variance test (ANOVA) and Tukey's b test. The ANOVA test is designed to compare the means of several groups of data. The data can be grouped according to one or more variables. The ANOVA test assumes the groups of data are all normally distributed with equal variances. Tukey's b test is based on ANOVA and has the same assumptions regarding the data as ANOVA. Tukey's b test is designed to provide pair wise comparisons of means for several groups of data.

6.3 GROUPING VARIABLES

As indicated in section 2.1, several wind speeds with different directions were simulated in the flight test. These wind conditions were assembled into four groups called wind cases. The wind cases were numbered a through d as follows:

a. Wind case 1: 13 KT from 080°, a right quartering tailwind.

b. Wind case 2: 13, 14, and 15 KT from 165°, a left quartering tailwind.

c. Wind case 3: 9 and 10 KT from 300°, a headwind.

d. Wind case 4: 14 and 15 KT from 350°, a right quartering headwind.

In addition, the six approach scenarios represent six more grouping variables. Thus, the flight test data forms a two-way experiment with wind case and scenarios being the two independent variables.

6.4 ANALYSIS OF LATERAL DATA

A two-way ANOVA was performed on each of the variables, (a) through (f), which represent lateral stability on the extended runway centerline, using the approach scenarios and the wind cases as grouping or independent variables. The two-way ANOVA indicated significant differences at the 0.05 significance level for each of the variables, (a) through (f). The two-way ANOVA also indicated no interactions between the two independent variables. This will permit an analysis of the data by either scenario or wind case. The following table presents the results of the ANOVA test for interactions. The degrees of freedom, the F-value, and the significance or probability of F is shown. If the value of the significance of F, in the table, is less than 0.05 then a

significant interaction is present. Note that none of the values of significance of F is less than 0.05.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LAT500	12	0.847	.602
LAT300	12	0.637	.810
LAT100	12	1.304	.214
LAT50	12	1.109	.352

Table 6.1 INTERACTION OF LATERAL VARIABLES

Since there are no interactions of the independent variables, the dependent variables can be analyzed relative to each independent variable. The analysis continued by considering each wind case separately. For example, a one-way ANOVA was performed on wind case 1 data using the approach scenario as the dependent variable and LAT50 as the independent variable. In each case, significant differences between the approach scenarios were found. The results of the ANOVA analyses are presented in tables 6.2, 6.3, 6.4, and 6.5. The asterisk denotes a significant value of F.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LAT50	18	6.1813	0.0103*
LAT100	18	14.0667	0.0003*
LAT300	18	28.2032	0.0000*
LAT500	18	34.5899	0.0000*

Table 6.2 ANOVA, WIND CASE 1, RIGHT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LAT50	113	4.1784	0.0016*
LAT100	113	9.7539	0.0000*
LAT300	113	23.5312	0.0000*
LAT500	113	41.6669	0.0000*

Table 6.3 ANOVA, WIND CASE 2, LEFT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF	F-VALUE	SIGNIFICANC

	FREEDOM		E OF F
LAT50	128	4.4511	0.0009*
LAT100	128	6.1560	0.0000*
LAT300	123	14.0318	0.0000*
LAT500	128	19.5294	0.0000*

Table 6.4 ANOVA, WIND CASE 3, A HEADWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LAT50	114	5.6052	0.0001*
LAT100	114	6.4775	0.0000*
LAT300	114	15.5978	0.0000*
LAT500	114	24.8017	0.0000*

Table 6.5 ANOVA, WIND CASE 4, A RIGHT QUARTERING HEADWIND WITH APPROACH SCENARIO INDEPENDENT

6.4.1 TUKEY'S B TEST OF LATERAL VARIABLES FOR WIND CASE 1

To determine the ranking of the approach scenarios and the significant pairs of approach scenarios, the Tukey b test was performed by wind case. The results of the Tukey b test for wind case 1 are presented in tables 6.6, 6.7, 6.8, and 6.9. Only LDA C, LDA D, and LDA E were performed with wind case 1. The presence of an asterisk in the grid indicates the sets of data from the pair of approach scenarios are significant at the 0.05 level. In table 6.6, the mean of the variable LAT50 is significantly larger when LDA D is flown than when LDA C is flown. The variable LAT50, although not significantly larger when LDA E is flown, is larger, on average, than when LDA C is flown.

MEAN FT		LDA C	LDA E	LDA D
3371.4286	LDA C			
4260.0000	LDA E			
5757.1429	LDA D	*		

Table 6.6 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND, AND LAT50 INDEPENDENT

MEAN FT		LDA C	LDA E	LDA D
3842.8571	LDA C			
5080.0000	LDA E			
6785.7143	LDA D	*	*	

Table 6.7 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND, AND LAT100 INDEPENDENT

MEAN FT		LDA C	LDA E	LDA D
5028.5714	LDA C			
6840.0000	LDA E	*		
8557.1429	LDA D	*	*	

Table 6.8 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND, AND LAT 300 INDEPENDENT

MEAN FT		LDA C	LDA E	LDA D
5814.2857	LDA C			
7800.0000	LDA E	*		
9600.0000	LDA D	*	*	

Table 6.9 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND, AND LAT 500 INDEPENDENT

Tables 6.6, 6.7, 6.8, and 6.9 indicate, as expected, the distance from threshold to MAP is increased, the distance from threshold where the aircraft becomes stabilized on the approach is also increased. From the tables, the mean for LDA D is always significantly larger than for LDA C. The mean for LDA E is significantly larger than LDA C for LAT300 and LAT500. This indicates the aircraft performing LDA D and LDA E were within 500 feet abeam the extended runway centerline farther from the runway threshold than were the aircraft performing LDA C when a right quartering tailwind was present.

6.4.2 TUKEY'S B TEST OF LATERAL VARIABLES FOR WIND CASE 2

The results of Tukey's b test for wind case 2 are shown in tables 6.10, 6.11, 6.12, and 6.13. All five scenarios were tested using the conditions of wind case 2.

MEAN FT		LDA A	LDA C	LDA 0	LDA D	LDA E	LDA B
1857.142	LDA A						
2100.000	LDA C						
2242.857	LDA 0						
2800.000	LDA D						
3642.857	LDA E	*					
3876.470	LDA B	*	*				

Table 6.10 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND LAT50 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA D	LDA E	LDA B
3064.285	LDA A						
3442.307	LDA C						
3757.142	LDA 0						
4737.931	LDA D	*	*				
5321.428	LDA E	*	*	*			
5558.823	LDA B	*	*	*			

Table 6.11 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND LAT100 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
5014.285	LDA A						
5234.615	LDA C						
5985.714	LDA 0						
6764.285	LDA E	*	*				
7347.058	LDA B	*	*	*			
7731.034	LDA D	*	*	*	*		

Table 6.12 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND LAT300 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
5800.000	LDA A						
6030.769	LDA C						
6821.428	LDA 0	*	*				
7750.000	LDA E	*	*	*			
8347.058	LDA B	*	*	*			
8948.275	LDA D	*	*	*	*		

Table 6.13 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND LAT500 INDEPENDENT

Tables 6.10, 6.11, 6.12, 6.13 indicate that scenarios, LDA B, LDA D, and LDA E intercept the extended runway centerline further from threshold than do scenarios, LDA 0, LDA A, and LDA

C. LDA D is significantly different from LDA 0, LDA A, and LDA C for each independent variable except LAT50. LDA D is significantly different from LDA A and LDA C for the variable LAT50. LDA E is significantly different from LDA 0, LDA A, and LDA C for the variable LAT500. LDA E is significantly different from LDA A and LDA C for the variables LAT100 and LAT300. LDA E is significantly different from LDA A for the variable LAT50. The mean of LDA 0 is larger than LDA A and LDA C and in one case, for the variable LAT500, it is significantly larger. This is an indication the aircraft performing the LDA approaches, with MAP farthest from the runway threshold and a right quartering tailwind, attains a stabilized approach farthest from the threshold.

6.4.3 TUKEY'S B TEST OF LATERAL VARIABLES FOR WIND CASE 3

The results of Tukey's b test for wind case 3 are shown in tables 6.14, 6.15, 6.16, and 6.17. All five scenarios were tested using the conditions of wind case 3.

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA D	LDA B
2844.444	LDA A						
3170.000	LDA C						
3700.000	LDA 0						
3908.333	LDA E						
4523.333	LDA D	*	*				
4523.529	LDA B	*	*				

Table 6.14 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND LAT50 INDEPENDENT

MEAN		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
3655.555	LDA A						
4230.000	LDA C						
4895.454	LDA 0						
4900.000	LDA E						
5529.411	LDA B	*	*				
5763.333	LDA D	*	*				

Table 6.15 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND LAT100 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
5455.555	LDA A						
5660.000	LDA C						
6322.727	LDA 0						
6933.333	LDA E	*	*				
7305.882	LDA B	*	*				
7706.666	LDA D	*	*	*			

Table 6.16 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND LAT300 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
6305.555	LDA A						
6526.666	LDA C						
7295.454	LDA 0	*	*				
7891.666	LDA E	*	*				
8300.000	LDA B	*	*	*			
8803.333	LDA D	*	*	*			

Table 6.17 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND LAT500 INDEPENDENT

Tables 6.14, 6.15, 6.16, and 6.17 also indicate that aircraft performing LDA B, LDA D, and LDA E intercept the extended runway centerline further from threshold than LDA 0, LDA A, and LDA C. LDA B and LDA D are significantly larger than LDA A and LDA C for each of the independent variables. LDA D is significantly larger than LDA 0 for independent variables LAT300 and LAT500. LDA B is significantly larger than LDA 0 for the independent variable LAT500. The mean LDA E is significantly larger than the means of LDA A and LDA C for independent variables LAT300 and LAT500. The mean of LDA E is significantly larger than that of LDA 0 for the independent variable LAT500. This is an indication the aircraft performing the LDA approaches, with MAP farthest from the runway threshold and with a headwind attains a stabilized approach farthest from the threshold.

6.4.4 TUKEY'S B TEST OF LATERAL VARIABLES FOR WIND CASE 4

The results of Tukey's b test for wind case 4 are shown in tables 6.18, 6.19, 6.20, and 6.21. All five scenarios were tested using the conditions of wind case 4.

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
2737.500	LDA A						
3000.000	LDA C						
3012.500	LDA 0						
3961.538	LDA E						
4126.666	LDA B						
4803.571	LDA D	*	*	*			

Table 6.18 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND LAT50 INDEPENDENT

MEAN FT		LDA A	LDA 0	LDA C	LDA E	LDA B	LDA D
3662.500	LDA A						
3875.000	LDA 0						
4037.037	LDA C						
4853.846	LDA E						
5346.666	LDA B	*	*				
5671.428	LDA D	*	*	*			

Table 6.19 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND LAT100 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
5081.250	LDA A						
5440.740	LDA C						
5812.500	LDA 0						
6415.384	LDA E	*					
7213.333	LDA B	*	*	*			
7871.428	LDA D	*	*	*	*		

Table 6.20 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND LAT300 INDEPENDENT

MEAN FT		LDA A	LDA C	LDA 0	LDA E	LDA B	LDA D
5981.250	LDA A						
6244.444	LDA C						
6850.000	LDA 0						
7607.692	LDA E	*	*				
8293.333	LDA B	*	*	*			
9171.428	LDA D	*	*	*	*		

Table 6.21 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND LAT500 INDEPENDENT

The results for wind case 4 are very similar to those for wind cases 1, 2, and 3. Tables 6.18, 6.19, 6.20, and 6.21 indicate that aircraft performing LDA B, LDA D, and LDA E intercept the extended runway centerline further from threshold than LDA 0, LDA A, and LDA C. The mean of LDA D is significantly larger than the means of LDA A, LDA C, and LDA 0 for each of the independent variables. The mean of LDA B is significantly larger than the means of LDA A and LDA 0 for independent variables LAT100, LAT300, and LAT500. The mean of LDA E is significantly larger than the mean of LDA A for the independent variables LAT300 and LAT500. The mean LDA E is significantly larger than the mean of LDA C for the independent variable LAT500. This is an indication the aircraft performing the LDA approaches, with MAP farthest from the runway threshold and a right quartering headwind, attains a stabilized approach farthest from the threshold.

6.5 SUMMARY OF LATERAL DATA ANALYSIS

It was the purpose of this analysis to determine which approach scenario aligned most rapidly with the extended runway centerline by ranking the means of LAT50, LAT100, LAT300, and LAT500 for the four wind cases. Since these variables measure the distance from threshold where the aircraft approached within 50, 100, 300, or 500 feet of the extended runway centerline, larger values indicate the aircraft becomes stabilized on the centerline further from threshold. For each wind case and for each lateral variable it was found that LDA D became laterally stabilized significantly farther from the threshold than all the others. LDA B and E, with means smaller than those for LDA D, also exhibited better lateral stabilization than LDA 0, LDA A and LDA C. Therefore, the LDA approaches with glideslope farthest from the runway threshold became laterally stabilized farthest from the runway threshold regardless of the wind condition.

6.6 ANALYSIS OF AIRCRAFT BANK DATA

A two-way ANOVA was performed on each of the variables, (e) and (g), which represent the maximum bank angle achieved during the left and right turns using the approach scenarios and the wind cases as grouping or independent variables. The two-way ANOVA indicated significant differences at the 0.05 significance level for each of the variables, (e) and (g). The two-way ANOVA also indicated no interactions between the two independent variables. This will permit an analysis of the data by either scenario or wind case. The following table presents the results of the ANOVA test for interactions. The degrees of freedom, the F-value, and the significance or probability of F is shown. If the value of the significance of F, in the table, is less than 0.05 then a significant interaction is present. Note that none of the values of significance of F is less than 0.05.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LEFTBANK	12	0.277	0.993
RIGHTBANK	12	1.035	0.415

Table 6.22 INTERACTION OF AIRCRAFT BANK VARIABLES

Since there are no interactions of the independent variables, the independent variables can be analyzed relative to each independent variable. The analysis continued by considering each wind case separately. For example, a one-way ANOVA was performed on wind case 1 data using the approach scenario as the dependent variable and LEFTBANK as the independent variable. The data for wind case 1 showed no significant differences. In each of the other three wind cases, significant differences between the approach scenarios were found. The results of the ANOVA analyses are presented in tables 6.23, 6.24, 6.25, and 6.26. The asterisk denotes a significant value of F.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LEFTBANK	18	2.5691	0.1077
RIGHTBANK	18	0.4735	0.6312

Table 6.23 ANOVA, WIND CASE 1, RIGHT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LEFTBANK	113	4.1588	0.0017*
RIGHTBANK	113	5.6683	0.0001*

Table 6.24 ANOVA, WIND CASE 2, LEFT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LEFTBANK	128	4.9769	0.0003*
RIGHTBANK	128	10.1791	0.0000*

Table 6.25 ANOVA, WIND CASE 3, A HEADWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
LEFTBANK	114	5.5331	0.0001*
RIGHTBANK	114	7.0031	0.0000*

Table 6.26 ANOVA, WIND CASE 4, A RIGHT QUARTERING HEADWIND WITH APPROACH SCENARIO INDEPENDENT

To determine the ranking of the approach scenarios and the significant pairs of approach scenarios, the Tukey b test was performed by wind case.

6.6.1 TUKEY'S B TEST OF BANK VARIABLES FOR WIND CASE 1

It is not necessary to perform Tukey's b test of the bank variables for wind case 1 since it was shown by ANOVA that no significant differences were present.

6.6.2 TUKEY'S B TEST OF BANK VARIABLES FOR WIND CASE 2

To determine the ranking of the bank variables by approach scenario and the significant pairs by approach scenarios, the Tukey b test was performed by wind case. The results of the Tukey b test for wind case 2 are presented in tables 6.27 and 6.28. The presence of an asterisk in the grid indicates the sets of data from the pair of approach scenarios are significant at the 0.05 level.

MEAN DEG		LDA 0	LDA A	LDA C	LDA B	LDA D	LDA E
16.0714	LDA 0						
15.2429	LDA A						
14.5769	LDA C						
12.2059	LDA B						
11.6379	LDA D	*					
11.3714	LDA E	*					

Table 6.27 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND LEFT BANK INDEPENDENT

MEAN DEG		LDA D	LDA B	LDA E	LDA C	LDA A	LDA 0
10.9103	LDA D						
12.6294	LDA B						
13.0929	LDA E						
13.7846	LDA C	*					
14.0214	LDA A	*					
16.7500	LDA 0	*	*				

Table 6.28 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND RIGHT BANK INDEPENDENT

6.6.3 TUKEY'S B TEST OF BANK VARIABLES FOR WIND CASE 3

The results of the Tukey b test for wind case 3 are presented in tables 6.29 and 6.30. The presence of an asterisk in the grid indicates the sets of data from the pair of approach scenarios are significant at the 0.05 level.

MEAN DEG		LDA A	LDA C	LDA 0	LDA B	LDA D	LDA E
14.0611	LDA A						
12.7433	LDA C						
12.2500	LDA 0						
10.8176	LDA B						
9.7967	LDA D	*	*				
9.4750	LDA E	*	*				

Table 6.29 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND LEFT BANK INDEPENDENT

MEAN DEG		LDA E	LDA D	LDA B	LDA C	LDA A	LDA 0
10.2667	LDA E						
10.7267	LDA D						
11.4647	LDA B						
11.5833	LDA C						
12.8500	LDA A						
16.9864	LDA 0	*	*	*	*	*	

Table 6.30 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND RIGHT BANK INDEPENDENT

The results of the Tukey b test for wind case 4 are presented in tables 6.31 and 6.32. The presence of an asterisk in the grid indicates the sets of data from the pair of approach scenarios are significant at the 0.05 level.

MEAN DEG		LDA A	LDA C	LDA 0	LDA B	LDA E	LDA D
13.0062	LDA A						
12.1704	LDA C						
12.1125	LDA 0						
9.9933	LDA B						
9.1538	LDA E	*	*				
9.1179	LDA D	*	*	*			

Table 6.31 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND LEFT BANK INDEPENDENT

MEAN DEG		LDA D	LDA B	LDA E	LDA C	LDA A	LDA 0
9.8429	LDA D						
10.6733	LDA B						
11.9154	LDA E						
12.1556	LDA C						
13.1000	LDA A	*					
15.5188	LDA 0	*	*	*	*	*	

Table 6.32 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND RIGHT BANK INDEPENDENT

6.7 SUMMARY OF AIRCRAFT BANK DATA ANALYSIS

It was the purpose of this analysis to determine which approach scenario exhibited the most stabilized approach by ranking the means of LEFTBANK and RIGHTBANK for the four wind cases. It was found that for wind case 1 there were no significant differences for LEFTBANK or RIGHTBANK between the five flight scenarios. However, for the other three wind cases significant differences were found. LDA 0 was found to have the largest mean bank angle for the right turn for all three remaining wind cases. LDA 0 was also found to have the largest bank angle for the left turns with wind case 2. In general, LDA 0, LDA A, and LDA C exhibited the largest bank angles. LDA E exhibited the smallest bank angles in three of the six combinations of wind case and turn direction. LDA D exhibited the smallest bank angles in the remaining three combinations of wind case and turn direction. In general, LDA B, LDA D, and LDA E had the smallest mean bank angles. This is a further indication the aircraft were more stable when performing the approaches with MAP farthest from the runway threshold.

6.8 ANALYSIS OF AIRCRAFT OVERSHOOT AND LANDING DATA

A two-way ANOVA was performed on each of the variables, (f) and (h), which represent the touch down distance from threshold and the overshoot distance across the extended centerline using the approach scenarios and the wind cases as grouping or independent variables. The two-way ANOVA indicated significant differences at the 0.05 significance level for each of the variables, (f) and (h). The two-way ANOVA also indicated no interactions between the two independent variables. This will permit an analysis of the data by either scenario or wind case. The following table presents the results of the ANOVA test for interactions. The degrees of freedom, the F-value, and the significance or probability of F is shown. If the value of the significance of F, in the table, is less than 0.05 then a significant interaction is present. Note that neither of the values of significance of F is less than 0.05.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
OVER	12	1.168	0.305
TDP	12	1.304	0.214

Table 6.33 INTERACTION OF OVERSHOOT AND TOUCH DOWN POINT

Since there are no interactions of the independent variables, the independent variables can be analyzed relative to each independent variable. The analysis continued by considering each wind case separately. For example, a one-way ANOVA was performed on wind case 1 data using the approach scenario as the dependent variable and LEFTBANK as the independent variable. The data for wind case 1 showed no significant differences. In each of the other three wind cases, significant differences between the approach scenarios were found. The results of the ANOVA analyses are presented in tables 6.34, 6.35, 6.36, and 6.37. The asterisk denotes a significant value of F.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
OVER	18	5.3710	0.0164*
TDP	18	1.8747	0.1856

Table 6.34 ANOVA, WIND CASE 1, RIGHT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
OVER	113	1.9061	0.0992
TDP	113	0.3735	0.8659

Table 6.35 ANOVA, WIND CASE 2, LEFT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
OVER	128	0.5720	0.7214
TDP	128	2.6269	0.0271*

Table 6.36 ANOVA, WIND CASE3, A HEADWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
OVER	114	0.8221	0.5365
TDP	114	0.3976	0.8495

Table 6.37 ANOVA, WIND CASE 4, A RIGHT QUARTERING HEADWIND WITH APPROACH SCENARIO INDEPENDENT

Only two significant differences were detected, OVER for wind case 1 and TDP for wind case 3.

6.8.1 TUKEY'S B TEST OF OVERSHOOT FOR WIND CASE 1

To determine the ranking of the variable OVER by approach scenario and the significant pairs by approach scenarios, the Tukey b test was performed for wind case 1. The results of the Tukey b test for wind case 1 are presented in table 6.38. The presence of an asterisk in the grid indicates the sets of data from the pair of approach scenarios are significant at the 0.05 level.

MEAN FT		LDA C	LDA D	LDA E
17.5714	LDA C			
26.0000	LDA D			
36.2000	LDA E	*		

Table 6.38 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND AND OVER INDEPENDENT

ANOVA and Tukey's test will determine whether the mean or average values of the data sets seem to be different. However, in regard to overshoot data, and because of the important safety implications associated with overshoots, it is advisable to examine the extreme values of the distributions. Table 6.39 displays the ten largest overshoot values along with the scenario, which produced it. Table 6.40 displays the largest and the tenth largest overshoot value of each scenario for comparison purposes. In each of these tables, each of the wind cases for given scenarios have been combined into one set representing that scenario.

RANK	SCENARIO	OVER
1	LDA D	339
2	LDA B	263
3	LDA A	260
4	LDA C	222
5	LDA D	205
6	LDA D	204
7	LDA D	204
8	LDA D	201
9	LDA A	186
10	LDA A	180

Table 6.39 TEN LARGEST OVERSHOOTS, WITH SCENARIO

	LDA 0	LDA	LDA B	LDA C	LDA D	LDA E
Largest	151	260	263	222	339	109
10th Largest	35	63	61	85	128	47

Table 6.40 LARGEST AND TENTH LARGEST OVERSHOOT BY SCENARIO

Table 6.39 indicates the largest overshoot occurred during LDA D. In fact, five of the ten largest overshoots occurred during LDA D. LDA A had three of the ten largest overshoots. Table 6.40 indicates the smallest maximum overshoot occurred during an LDA E approach. LDA 0 had the next smallest maximum overshoot.

6.8.2 TUKEY'S B TEST OF TDP FOR WIND CASE 2

Although the ANOVA test indicated a significant difference for the means of touch down point (TDP), Tukey's b test did not indicate any significant differences by pairs. Table 6.41 presents the ranking of the means, but the absence of asterisks indicates no significant differences were detected. The table shows the aircraft flying LDA E landed, on average, nearest the threshold.

MEAN FT		LDA E	LDA D	LDA A	LDA C	LDA 0	LDA B
1366.666	LDA E						
1466.666	LDA D						
1550.000	LDA A						
1580.000	LDA C						
1877.272	LDA 0						
1888.235	LDA B						

Table 6.41 TUKEY'S B TEST, WIND CASE 2, A HEADWIND AND TDP INDEPENDENT

6.9 SUMMARY OF AIRCRAFT OVERSHOOT/LANDING DATA ANALYSIS

The overshoot and landing data analysis indicated only two significant differences between the various scenarios. In wind case 1, a significant difference was detected for the overshoot data. In table 6.38, Tukey's test indicated the overshoot variable for LDA E was significantly larger than for LDA C, although the average overshoot for LDA C was only about 18 feet and the average overshoot for LDA E was only about 36 feet. However, in wind case 1, no flights were performed using LDA 0, LDA A, or LDA B. Thus, there is no way to determine how LDA E would compare to those three. In addition, a significant difference between the landing scenarios was detected by ANOVA for touch down distance and wind case 3 independent. However, Tukey's b test failed to detect any pair wise differences. Therefore, it appears that very few differences in average overshoot or landing distance between the landing scenarios exist, regardless of the wind case. Although there seems to be little difference in the average overshoot

distance, the largest overshoot distances were produced by one approach, LDA D. LDA E produced the smallest overshoot distance.

6.10 ANALYSIS OF GLIDESLOPE DATA

A two-way ANOVA was performed on each of the variables, (i) through (m), which represent the maximum deviation of the aircraft below the glideslope and the maximum bank angle achieved during the left and right turns at various altitudes; using the approach scenarios and the wind cases as grouping or independent variables. The variables A300, A400, A500, and A600 represent the largest bank angle within ±50 feet of the indicated altitude. For example, the variable A300 contains the maximum bank angle, right or left that the aircraft achieved when its altitude was between 250 and 350 feet. These variables are designed to provide a measure of the stability of the aircraft dependent on altitude. The two-way ANOVA indicated significant differences at the 0.05 significance level for each of the variables, (i) through (m). The two-way ANOVA also indicated no interactions between the two independent variables. This will permit an analysis of the data by either scenario or wind case. Table 6.42 presents the results of the ANOVA test for interactions. The degrees of freedom, the F-value, and the significance or probability of F is shown. If the value of the significance of F, in the table, is less than 0.05 then a significant interaction is present. Note that none of the values of significance of F is less than 0.05.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
GSDEV	12	0.695	0.756
A300	12	0.927	0.520
A400	12	1.360	0.183
A500	12	0.712	0.740
A600	12	1.297	0.218

Table 6.42 INTERACTION OF VERTICAL VARIABLES

Since there are no interactions of the independent variables, the independent variables can be analyzed relative to each independent variable. The analysis was continued considering each wind case separately. For example, a one-way ANOVA was performed on wind case 1 data using the approach scenario as the dependent variable and GSDEV as the independent variable. The data for wind case 1 showed significant differences due to approach scenario for all of the vertical variables except GSDEV and A400. In each of the other three wind cases, significant differences between the approach scenarios were found. The results of the ANOVA analyses are presented in tables 6.43, 6.44, 6.45, and 6.46. The asterisk denotes a significant value of F.

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
GSDEV	18	1.7581	0.2041
A300	18	3.9436	0.0405*
A400	18	0.6175	0.5517
A500	18	5.0283	0.0202*
A600	18	9.9281	0.0016*

Table 6.43 ANOVA OF VERTICAL VARIABLES, WIND CASE 1, RIGHT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
GSDEV	113	73.8414	0.0000*
A300	113	4.4922	0.0009*
A400	113	3.7546	0.0036*
A500	113	6.5369	0.0000*
A600	113	9.5021	0.0000*

Table 6.44 ANOVA OF VERTICAL VARIABLES, WIND CASE 2, LEFT QUARTERING TAILWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
GSDEV	128	164.3714	0.0000*
A300	128	7.1142	0.0000*
A400	128	2.0333	0.0785*
A500	128	3.6736	0.0039*
A600	128	16.2524	0.0000*

Table 6.45 ANOVA OF VERTICAL VARIABLES, WIND CASE 3, A HEADWIND WITH APPROACH SCENARIO INDEPENDENT

VARIABLE	DEGREES OF FREEDOM	F-VALUE	SIGNIFICANCE OF F
GSDEV	114	69.0450	0.0000*
A300	114	9.3443	0.0000*
A400	114	1.1213	0.3534
A500	114	3.1988	0.0098*
A600	114	12.0695	0.0000*

Table 6.46 ANOVA OF VERTICAL VARIABLES, WIND CASE 4, A RIGHT QUARTERING HEADWIND WITH APPROACH SCENARIO INDEPENDENT

6.10.1 TUKEY'S B TEST OF VERTICAL VARIABLES FOR WIND CASE 1

To determine the ranking of the approach scenarios and the significant pairs of approach scenarios, the Tukey b test was performed by wind case. The results of the Tukey b test for wind case 1 are presented in tables 6.47, 6.48, and 6.49. It is not necessary to perform Tukey's b test of GSDEV or A400 for wind case 1 since it was shown by ANOVA that no significant differences were present. Only LDA C, LDA D, and LDA E were performed with wind case 1. The presence of an asterisk in the grid indicates the sets of data from the pair of approach scenarios are significant at the 0.05 level. In table 6.47, the mean of the variable A300 is significantly larger when LDA C is flown than when LDA D is flown. The variableA300, although not significantly larger when LDA E is flown, is larger, on average, than when LDA D is flown.

MEAN FT		LDA D	LDA E	LDA C
5.8000	LDA D			
10.7200	LDA E			
12.1857	LDA C	*		

Table 6.47 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND AND A300 INDEPENDENT

MEAN DEG		LDA D	LDA E	LDA C
7.5286	LDA D			
7.8400	LDA E			
14.6000	LDA C	*	*	

Table 6.48 TUKEY'S B TEST, WIND CASE 1 AND A500 INDEPENDENT

MEAN DEG		LDA D	LDA E	LDA C
5.6143	LDA D			
11.5200	LDA E	*		
14.8571	LDA C	*		

Table 6.49 TUKEY'S B TEST, WIND CASE 1, RIGHT QUARTERING TAILWIND AND A600 INDEPENDENT

6.10.2 TUKEY'S B TEST OF VERTICAL VARIABLES FOR WIND CASE 2

The results of Tukey's b test for wind case 2 are shown in tables 6.50, 6.51, 6.52, 6.53, and 6.54. All five scenarios were tested using the conditions of wind case 2.

MEAN FT		LDA 0	LDA E	LDA D	LDA C	LDA B	LDA A
-235.5714	LDA 0						
-68.7857	LDA E	*					
-56.8966	LDA D	*					
-54.0385	LDA C	*					
-49.5294	LDA B	*					
-45.9286	LDA A	*					

Table 6.50 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND GSDEV INDEPENDENT

MEAN DEG		LDA D	LDA E	LDA B	LDA C	LDA A	LDA 0
8.6345	LDA D						
9.4000	LDA E						
10.8765	LDA B						
11.4923	LDA C						
13.3357	LDA A	*					
13.5429	LDA 0	*					

Table 6.51 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND A300 INDEPENDENT

MEAN DEG		LDA A	LDA C	LDA E	LDA D	LDA B	LDA 0
8.0143	LDA A						
8.3077	LDA C						
9.5000	LDA E						
9.8069	LDA D						
9.8471	LDA B						
14.6286	LDA 0	*	*	*	*	*	

Table 6.52 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND A400 INDEPENDENT

MEAN DEG		LDA E	LDA D	LDA B	LDA A	LDA C	LDA 0
6.5643	LDA E						
7.9793	LDA D						
7.9941	LDA B						
11.0357	LDA A	*					
11.6654	LDA C	*	*	*			
13.4857	LDA 0	*	*	*			

Table 6.53 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND A500 INDEPENDENT

MEAN DEG		LDA D	LDA B	LDA E	LDA C	LDA 0	LDA A
6.4552	LDA D						
6.7059	LDA B						
10.0000	LDA E						
12.1654	LDA C	*	*				
12.7857	LDA 0	*	*				
12.9071	LDA A	*	*				

Table 6.54 TUKEY'S B TEST, WIND CASE 2, LEFT QUARTERING TAILWIND AND A600 INDEPENDENT

In general, the analysis indicates, as expected, LDA 0 experienced the most deviation below the (implicit for LDA 0) glideslope. The analysis also indicates, in general, LDA 0 experienced the largest bank angles at the various altitudes. This indicates a less stable landing approach. The scenarios with missed approach points closest to the parallel runway; LDA B, LDA D, and LDA E, but farthest from the threshold have the smallest bank angles at the various altitudes. This indicates a more stable approach for each of the scenarios, LDA B, LDA D, and LDA E.

6.10.3 TUKEY'S B TEST OF VERTICAL VARIABLES FOR WIND CASE 3

The results of Tukey's b test for wind case 3 are shown in tables 6.55, 6.56, 6.57, 6.58, and 6.59. All five scenarios were tested using the conditions of wind case 3.

MEAN FT		LDA 0	LDA E	LDA B	LDA D	LDA C	LDA A
-247.6364	LDA 0						
-76.3333	LDA E	*					
-64.4706	LDA B	*					
-64.1333	LDA D	*					
-57.4667	LDA C	*					
-51.7222	LDA A	*					

Table 6.55 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND GSDEV INDEPENDENT

MEAN DEG		LDA D	LDA E	LDA 0	LDA B	LDA C	LDA A
6.5833	LDA D						
7.1083	LDA E						
9.1227	LDA 0						
9.2412	LDA B						
11.0767	LDA C	*	*				
12.2056	LDA A	*	*				

Table 6.56 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND A300 INDEPENDENT

MEAN DEG		LDA C	LDA A	LDA D	LDA B	LDA E	LDA 0
6.3600	LDA C						
7.3556	LDA A						
7.5467	LDA D						
7.6529	LDA B						
8.9250	LDA E	*	*				
9.4727	LDA 0	*	*				

Table 6.57 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND A400 INDEPENDENT

MEAN DEG		LDA E	LDA B	LDA D	LDA C	LDA A	LDA 0
6.7083	LDA E						
6.9059	LDA B						
7.9267	LDA D						
9.6900	LDA C						
10.0222	LDA A						
11.6727	LDA 0	*	*	*			

Table 6.58 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND A500 INDEPENDENT

MEAN DEG		LDA D	LDA B	LDA E	LDA C	LDA A	LDA 0
6.4200	LDA D						
6.6059	LDA B						
6.9417	LDA E						
10.5733	LDA C	*	*	*			
12.5389	LDA A	*	*	*			
15.2773	LDA 0	*	*	*	*		

Table 6.59 TUKEY'S B TEST, WIND CASE 3, A HEADWIND AND A600 INDEPENDENT

This analysis indicates, as expected, LDA 0 experienced the most deviation below the (implicit for LDA 0) glideslope. The analysis also indicates, in general, LDA 0 experienced the largest bank angles at the various altitudes. Only at 300 feet did LDA 0 not exhibit the largest mean bank angle. This indicates a less stable landing approach for LDA 0. LDA E exhibited the second largest average bank angle at 400 feet. However, the scenarios with missed approach points closest to the parallel runway, but farthest from the threshold in general have the smallest bank angles at the various altitudes. This indicates a more stable approach for scenarios LDA B, LDA D, and LDA E.

6.10.4 TUKEY'S B TEST OF VERTICAL VARIABLES FOR WIND CASE 4

The results of Tukey's b test for wind case 4 are shown in tables 6.60, 6.61, 6.62, and 6.63. It was not necessary to test with A400 independent since ANOVA indicated no significant differences. All five scenarios were tested using the conditions of wind case 4.

MEAN FT		LDA 0	LDA E	LDA B	LDA D	LDA C	LDA A
-264.5625	LDA 0						
-65.5333	LDA E	*					
-62.3704	LDA B	*					
-62.2500	LDA D	*					
-61.2308	LDA C	*					
-50.8750	LDA A	*					

Table 6.60 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND GSDEV INDEPENDENT

MEAN DEG		LDA D	LDA E	LDA B	LDA 0	LDA C	LDA A
5.6143	LDA D						
7.3385	LDA E						
8.3600	LDA B						
9.3000	LDA 0	*					
11.0148	LDA C	*	*				
11.7000	LDA A	*	*				

Table 6.61 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND A300 INDEPENDENT

MEAN DEG		LDA D	LDA E	LDA B	LDA A	LDA C	LDA 0
6.3214	LDA D						
6.3385	LDA E						
7.1133	LDA B						
8.3875	LDA A						
9.6778	LDA C	*					
9.6813	LDA 0	*					

Table 6.62 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND A500 INDEPENDENT

MEAN DEG		LDA B	LDA D	LDA E	LDA C	LDA A	LDA 0
6.1267	LDA B						
6.4214	LDA D						
6.6615	LDA E						
10.2889	LDA C	*	*	*			
10.8688	LDA A	*	*	*			
14.4500	LDA 0	*	*	*	*		

Table 6.63 TUKEY'S B TEST, WIND CASE 4, A RIGHT QUARTERING HEADWIND AND A600 INDEPENDENT

This analysis indicates, as expected, LDA 0 experienced the most deviation below the (implicit for LDA 0) glideslope. The analysis also indicates, in general, LDA 0 experienced the largest bank angles at the various altitudes. Only at 300 feet did LDA 0 not exhibit the largest mean bank angle. This indicates a less stable landing approach for LDA 0. However, the scenarios with missed approach points closest to the parallel runway, but farthest from the threshold in general have the smallest bank angles at the various altitudes. This indicates a more stable approach for scenarios LDA B, LDA D, and LDA E.

6.11 SUMMARY OF GLIDESLOPE DATA ANALYSIS

It is the purpose of this analysis to determine which approach scenario exhibited the most stabilized approach by ranking the means of GSDEV, A300, A400, A500, and A600 for the four wind cases and five landing scenarios. A two-way ANOVA indicated significant differences for each of the variable (i) through (m). The two-way ANOVA also indicated no interactions between the two independent variables. This will permit an analysis of the data by either scenario or wind case. It was found that for wind case 1 there were no significant differences for GSDEV or A400 between the five flight scenarios, but there were significant differences between the other three variables. For the other three wind cases significant differences were found for all variables. As expected, LDA 0 was found to have the largest deviation from the glideslope. In general, LDA 0, LDA A, and LDA C exhibited the largest bank angles at the four altitudes. In general, LDA B, LDA D, and LDA E had the smallest mean bank angles at the four altitudes. Therefore, LDA B, LDA D, and LDA E were the most stabilized of the six approaches scenarios with regard to bank angle.

7.0 HUMAN FACTORS ANALYSIS

7.1 POST-TEST QUESTIONNAIRE ANALYSIS

The participating pilots were separated into two groups. The first group, test group 1, flew the current LDA approach, LDA 0, as well as LDA A, LDA B, LDA C, and LDA D. The second group, test group 2, flew the LDA 0 approach as well as LDA C, LDA D, and LDA E. Sixty-nine pilots participated in the flight test. Each pilot flew multiple test approaches and completed a post-flight questionnaire following the completion of each test flight. The purpose of this questionnaire was to ascertain the pilot's opinion regarding the flyability, altitudes, bank angles, and safety of the approach just completed. In addition, after completion of all test approaches, each pilot completed a post-test questionnaire in order to obtain a summary and comparison of the relative merits of the LDA approaches.

7.1.1 ANALYSIS OF GROUP 1 POST-TEST QUESTIONNAIRES

For convenience, each question of the questionnaire is presented along with the tabulated responses to the question.

Q1: Is any member of this crew currently flying into St. Louis?

Yes: Forty-six respondents
No: Seventeen respondents

Q2: If yes, have either of you been required to perform a balked landing or in any other way had a difficult experience with either of the current LDA approaches?

No or no response: 58
Yes: 5 respondents

Of the 5 respondents that answered yes to question 2, four provided an explanation of the incident. The explanations are as follows:

1. When flying an actual approach, IMC, down to minimums, set off the low altitude alert in the tower (at 1,200 feet).

2. Go around due to traffic.

3. Two go-arounds, both due to traffic. One A/C on T/O. The other due to RA on final.

4. IMC information from approach as to traffic without ability to visually acquire until end of approach.

Q3: Did this simulation present a realistic visual portrayal of the St. Louis operation?

Yes: 60 responses
No: 2 responses

1. No from one respondent. This respondent provided the following comment: "Didn't take into account ATC speed request, such as "maintain 170 KTS until (fix)".

Q4: How would you rate the flyability of the LDA with GS as compared to the present LDA without GS?

Easier			About the same			More Difficult		
1	2	3	4	5	6	7	8	9

The question presented a scale the pilot could use to rate the "flyability" of the group of LDA approaches with glideslope.

"1" was selected 32 times.
"2" was selected 22 times.
"3" was selected 8 times.
"5" was selected 1 time.
No other ratings were selected.

Q5: As a general observation, how would you characterize the new approach scenarios flown in this test as compared to the existing LDA with a 4,900-foot separation?

This question does not require the respondent to rank the approaches; however, many of the respondents ranked the approaches. In general, the pilots preferred LDA B and LDA D over LDA A and LDA C. Twenty-three of the pilots ranked LDA B and LDA D above LDA A and LDA C. Only one pilot ranked LDA A and LDA C above LDA B and LDA D. In many cases the pilots gave a reason for their preference. LDA A was considered the worst of the approaches because the MAP was the closest to the threshold and allowed less time for maneuver. LDA D was considered the best and easiest to fly since it's MAP was farthest from threshold. All pilots gave a favorable opinion of the LDA approaches with glideslope and preferred them in lieu of the current LDA approach without glideslope. A complete list of the pilot responses to this question may be found in appendix A.

Q6: Under VMC what is the minimum AGL at which the aircraft should be established on the centerline with wings level?

Possible altitudes were not suggested to the pilots so the response to this question varied widely. If the pilot responded with a range such as 500 - 700 feet, then the highest number was recorded. If the pilot responded with an altitude such as 250 feet then the altitude was rounded off to the next multiple of 100. The following table presents the responses to this question.

200 FT	300 FT	400 FT	500 FT	600 FT	700 FT	1000 FT
7	12	17	21	3	1	2

Table 7.1 MINIMUM WINGS LEVEL ALTITUDE

Q7: What would be your answer to 6 if a B-757 or B-747 was at 200 feet AGL ahead and landing on Runway 30R?

This question was used on only 20 of the questionnaires. The responses to this question are found in the following table:

300 FT	400 FT	500 FT	1000
1	4	11	2

Table 7.2 MINIMUM WINGS LEVEL ALTITUDE BEHIND A B-747 OR B-757

Q8: Additional comments.

This question appeared on all questionnaires, but was listed as question 7 on those questionnaires that did not contain the previous question. The answers to this question varied widely, but 17 pilots specified that the addition of a glideslope was desirable.

7.1.2 ANALYSIS OF GROUP 2 POST-TEST QUESTIONNAIRES

This group consisted of 12 pilots. Following the flight test with the group 1 pilots, the FAA observer recommended an additional LDA be tested. This LDA was a compromise between LDA A, which was deemed to be too close to threshold, and LDA D, which was deemed to be too close to the C/C point for effective visual traffic acquisition. This LDA was labeled LDA E. Group 2 only flew LDA C, LDA D, and LDA E along with the current LDA 0.

For convenience, each question of the questionnaire is presented along with the tabulated responses to the question.

Q1: Is any member of this crew currently flying into St. Louis?

Yes: No respondents
No: 12 respondents

Q2: If yes, have either of you been required to perform a balked landing or in any other way had a difficult experience with either of the current LDA approaches?

No or no response: 12 respondents
Yes: No respondents

Q3: Did this simulation present a realistic visual portrayal of the St. Louis operation?

All but 2 pilots answered yes to question 3, these two answered "no experience".

Q4: How would you rate the flyability of the LDA with GS as compared to the present LDA without GS?

Easier			About the same			More Difficult		
1	2	3	4	5	6	7	8	9

The question presented a scale that the pilot could use to rate the "flyability" of the group of LDA approaches with glideslope.

1 rated 11 times
2 rated 1 time
No other ratings given

Q5: As a general observation, how would you characterize the new approach scenarios flown in this test as compared to the existing LDA with a 4,900-foot separation?

LDA / RANKING	FIRST	SECOND	THIRD
LDA C	0		12
LDA D	7	5	0
LDA E	5	7	0

Table 7.3 LDA RANKING BY GROUP TWO PILOTS

Q6: Under VMC what is the minimum AGL at which the aircraft should be established on the centerline with wings level?

300 FT	400 FT	500 FT	OTHER
2	3	1	6

Table 7.4 MINIMUM ALTITUDE FOR WINGS LEVEL GROUP TWO PILOTS

Under "other" 4 answered "as necessary" and 2 answered "a minimum altitude is not required".

Q7: Additional Comments:

Only seven of the twelve pilots provided additional comments. Since the comments are short, they are included below:

Pilot #1: None
Pilot #2: The right seater is going to make a less aggressive sidestep turn because the wind screen center post becomes an obstruction to runway sighting.
Pilot #3: Current Stepdown LDA approach is unsatisfactory compared to any of these three glideslope options.
Pilot #4: With crosswinds the approach difficulty went up dramatically.
Pilot #5: Tailwinds - none should be allowed.
Pilot #6: Problems with spatial disorientation.
Pilot #7: If using autopilot, need to disconnect at MAP.

7.2 ANALYSIS OF POST-FLIGHT QUESTIONNAIRES

The questions of the post-flight questionnaire was designed for ease of completion by the subject pilot since only a short period of time was available between test flights. The pilot was required to select a ranking number ranging from 1 to 9. The responses from each question were grouped according to LDA type to determine whether the pilots were answering the questions differently according to which type LDA they had just flown. Since the test responses have the properties of an ordinal measurement, it is more appropriate to use a non-parametric statistical test such as the median test to analyze the data. The median of a set of data is the value above and below which one half of the observations fall. In the median test, the null hypothesis is that the groups have the same median, the alternate hypothesis is that the medians are different. The level of significance

used in the analysis of the questionnaire data was 0.05. When a significant difference is observed, the relative sizes of the medians may be ascertained by examination of the contingency table.

Of the nine questions comprising, questions 1, 8, and 9 were considered to be the most important. Therefore, the median test was only performed on these three questions.

Q1: Rate the flyability of this entire approach.

VERY EASY	AVERAGE	VERY HARD
1 2 3	4 5 6	7 8 9

The median of the combined data was 3.0. This indicates that 50% of the responses were 1, 2, or 3. The median test indicated a significant difference in the medians of the 6 LDA approaches. The contingency table is presented in the following table. The table shows the number of observations from each LDA approach that is above and below the median.

	LDA 0	LDA A	LDA B	LDA C	LDA D	LDA E
GT MEDIAN	72	49	29	86	38	10
LE MEDIAN	20	56	50	85	105	66

Table 7.5 MEDIAN TEST, CONTINGENCY TABLE, QUESTION 1, POST-FLIGHT TEST

The table indicates that LDA D and LDA E were considered to be the "easiest" of the six approaches. LDA 0 was considered to be the least flyable of the six approaches. Table 7.6 summarizes the responses to question 1.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	4	9	7	21	17	28	6	0	0
LDA A	17	17	22	21	18	5	5	0	0
LDA B	13	15	22	7	17	5	0	0	0
LDA C	20	27	38	24	34	23	5	0	0
LDA D	27	39	39	15	18	4	1	0	0
LDA E	16	32	18	9	0	1	0	0	0
TOTALS	97	139	146	97	104	66	17	0	0

Table 7.6 SUMMARY OF QUESTION 1, POST-FLIGHT TEST RESPONSES

Q2: Rate the transition from the instrument portion to the visual portion (location, finding the runway, maneuvering)?

VERY EASY	AVERAGE	VERY HARD
1 2 3	4 5 6	7 8 9

Table 7.7 presents a summary of the responses to question 2.

QUESTION RESPONSES								
	1	2	3	4	5	6	7	8
Number Responding								
LDA 0	4	7	15	18	15	23	10	0
LDA A	9	13	14	18	13	3	6	0
LDA B	9	14	24	13	11	8	0	0
LDA C	13	28	39	27	24	28	11	1
LDA D	19	41	38	18	18	8	1	0
LDA E	12	24	24	10	4	1	0	1
TOTALS	66	127	154	104	85	71	28	2

Table 7.7 SUMMARY OF QUESTION 2, POST-FLIGHT TEST RESPONSES

Q3: Describe the altitude you established as you rolled out on runway centerline during the visual segment.

TOO HIGH	ABOUT RIGHT	TOO LOW
1 2 3	4 5 6	7 8 9

Table 7.8 presents a summary of the responses to question 3.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	0	0	5	5	43	14	11	1	0
LDA A	0	0	2	13	46	8	5	2	0
LDA B	0	0	2	8	36	4	0	0	0
LDA C	0	3	5	24	96	21	21	1	0
LDA D	0	0	7	20	106	7	2	0	1
LDA E	1	0	1	5	63	4	2	0	0
TOTALS	1	3	22	75	390	58	41	4	1

Table 7.8 SUMMARY OF QUESTION 3, POST-FLIGHT TEST RESPONSES

Q4: Describe the bank angles required during the visual segment of the approach.

TOO SHALLOW	ABOUT RIGHT	TOO STEEP
1 2 3	4 5 6	7 8 9

Table 7.9 presents a summary of the responses to question 4.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	0	1	2	7	48	25	8	0	0
LDA A	0	0	0	16	53	28	8	1	0
LDA B	0	0	0	16	52	9	2	0	0
LDA C	0	0	2	18	85	38	18	0	0
LDA D	1	1	1	18	82	16	4	1	0
LDA E	0	0	2	5	60	8	1	0	0
TOTALS	1	2	7	80	380	124	41	2	0

Table 7.9 SUMMARY OF QUESTION 4, POST-FLIGHT TEST RESPONSES

Q5: How useful was the glideslope after you began the visual transition?

VERY USEFUL			USEFUL			NOT USEFUL		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Table 7.10 presents a summary of the responses to question 5. Since LDA 0 did not have a glideslope, no responses were recorded for LDA 0.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LDA A	35	17	17	11	11	7	7	0	1
LDA B	20	19	11	7	7	3	11	0	1
LDA C	32	31	28	7	14	15	28	1	15
LDA D	26	24	17	13	10	14	22	1	15
LDA E	6	6	6	6	5	10	22	1	14
TOTALS	119	97	79	44	47	49	90	3	46

Table 7.10 SUMMARY OF QUESTION 5, POST-FLIGHT TEST RESPONSES

Q6: Was the distance allowed to execute the transition maneuver sufficient?

TOO LONG			ADEQUATE			TOO SHORT		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Table 7.11 presents a summary of the responses to question 6.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	2	0	1	7	63	17	2	0	0
LDA A	0	0	0	19	54	24	9	0	0
LDA B	0	0	0	17	52	10	0	0	0
LDA C	0	0	0	17	90	42	21	1	0
LDA D	0	0	0	30	103	8	2	0	0
LDA E	0	0	0	9	57	9	0	1	0
TOTALS	2	0	1	99	419	110	34	2	0

Table 7.11 SUMMARY OF QUESTION 6, POST-FLIGHT TEST RESPONSES

Q7: Did the LDA CDI and lateral command bar not being centered during the visual segment cause any problems?

NO PROBLEM			MODERATE PROBLEM			SEVERE PROBLEM		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Table 7.12 presents a summary of the responses to question 7.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	29	18	31	3	1	2	0	0	0
LDA A	44	25	35	1	1	0	0	0	0
LDA B	25	23	27	2	1	1	0	0	0
LDA C	61	41	55	3	1	0	0	0	0
LDA D	52	31	44	4	2	0	0	0	0
LDA E	31	14	17	3	1	0	0	0	0
TOTALS	242	152	209	16	7	3	0	0	0

Table 7.12 SUMMARY OF QUESTION 7, POST-FLIGHT TEST RESPONSES

Q8: How safe is this procedure, considering the proximity to traffic, maneuvering required, stabilized visual approach segment concept, etc.?

VERY SAFE			AVERAGE			VERY UNSAFE		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

The median of the combined data for question 8 was also 3.0. This indicated that 50% of the

responses were 1, 2, or 3. The median test indicated a significant difference in the medians of the 6 LDA approaches. The contingency table is presented in table 7.13. The table shows the number of observations from each LDA approach that is above and below the median.

	LDA 0	LDA A	LDA B	LDA C	LDA D	LDA E
GT MEDIAN	61	46	27	96	48	20
LE MEDIAN	31	60	52	74	95	56

Table 7.13 MEDIAN TEST, CONTINGENCY TABLE, QUESTION 8, POST-FLIGHT TEST

The respondents considered all of the LDA approaches safe. However, the approaches having missed approach points farthest from threshold were considered the safest. LDA B and LDA D had almost twice as many responses less than or equal to the median and LDA E had more than twice as many responses less than or equal to the median. LDA 0, the current LDA approach, had almost twice as many responses greater than the median. A summary of the pilot responses is presented in table 7.14.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	4	10	17	17	20	22	2	0	0
LDA A	15	24	21	16	17	8	4	1	0
LDA B	19	6	27	13	10	2	2	0	0
LDA C	18	18	38	28	33	24	9	2	0
LDA D	25	26	44	21	20	5	1	0	1
LDA E	10	21	25	9	3	7	1	0	0
TOTALS	91	105	172	104	103	68	19	3	1

Table 7.14 SUMMARY OF QUESTION 8, POST-FLIGHT TEST RESPONSES

Q9: At rollout for alignment with runway centerline on final, were you in an acceptable position to complete an approach and landing in keeping with your personal standards?

NO PROBLEM	MODERATE PROBLEM	SEVERE PROBLEM
1 2 3	4 5 6	7 8 9

The median of the combined data for question 9 was 2.5. This indicated that 50% of the responses were 1 or 2. The median test indicated a significant difference in the medians of the 6 LDA approaches. The contingency table is presented in table 7.15. The table shows the number of observations from each LDA approach that is above and below the median.

	LDA 0	LDA A	LDA B	LDA C	LDA D	LDA E
GT MEDIAN	63	59	37	97	112	32
LE MEDIAN	29	47	42	64	174	44

Table 7.15 MEDIAN TEST, CONTINGENCY TABLE, QUESTION 9, POST-FLIGHT TEST

The pilots reported little problem with alignment with the runway centerline; however, the least problem was reported with the LDA approaches with MAP farthest from the threshold. LDA B, LDA D, and LDA E all had more than 50% responses below the median of 2.5. LDA 0, LDA A, and LDA C all had more the 50% responses above the median. A summary of the pilot responses to question 9 is presented in table 7.16.

QUESTION RESPONSES									
	1	2	3	4	5	6	7	8	9
Number Responding									
LDA 0	11	18	42	7	8	6	0	0	0
LDA A	20	27	36	7	5	5	4	2	0
LDA B	19	23	28	5	2	2	0	0	0
LDA C	30	34	51	23	9	9	5	0	0
LDA D	76	98	86	12	6	8	0	0	0
LDA E	16	28	29	2	1	0	0	0	0
TOTALS	172	228	272	56	31	30	9	2	0

Table 7.16 SUMMARY OF QUESTION 9, POST-FLIGHT TEST RESPONSES

7.3 SUMMARY OF PILOT QUESTIONNAIRES

Seventy-five pilots from eight airlines and the FAA participated in the simulator flight test. The pilots were divided into two groups. The first group consisted of sixty-three pilots that flew LDA A, LDA B, LDA C, LDA D and the current LDA 0. The second group consisted of twelve pilots that flew LDA C, LDA D, LDA E, and the current LDA 0.

Analysis of the post-test questionnaires indicated the pilots, without exception, considered the LDA approaches with glideslope to be superior to the current LDA without glideslope. In general, the pilots preferred the LDA approaches, which were laterally closer to the other approach, but farthest from the runway threshold. Twenty-three pilots of group one ranked LDA B and LDA D above LDA A and LDA C. Only one pilot ranked LDA A and LDA C above LDA B and LDA D. All twelve of the pilots of group two ranked LDA D and LDA E before LDA C.

The pilots of group two were about evenly split as to the rank of LDA D and LDA E with seven choosing LDA D first and five choosing LDA E second.

The post-test questionnaire also queried the pilots concerning the minimum altitude above ground level at which the aircraft should be established on the extended centerline with wings level. Of thirty pilots that answered the question, nineteen answered either 400 or 500 feet. Of those, twelve answered the altitude should be 500 feet. Only three pilots indicated an acceptable altitude lower than 400 feet. Therefore, the consensus was that the aircraft should be established on the extended centerline at least 1.5 NM from threshold. This conclusion provides further evidence that the LDA approaches farthest from the threshold, but closest abeam the adjacent approach, are preferred by the pilots.

The post-flight questionnaires indicated that pilots considered all of the LDA approaches to have acceptable flyability qualities. The LDA approaches with MAP farthest from the runway threshold, LDA B, LDA D, and LDA E, were considered to have the best flyability qualities. The current LDA, LDA 0, was considered to have flyability qualities, which were inferior to the other LDA approaches. In a similar fashion, the LDA approaches with MAP farthest from the runway threshold were considered to be the safest and provide the best position for landing at rollout on final. The current LDA, LDA 0, was considered to be inferior to all the other LDA approaches in safety and landing position.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The five LDA approaches with glideslope were found by the flight test pilots to be superior to the current LDA approach without glideslope. The pilots preferred three of the LDA approaches with glideslope over the other two. The pilots also preferred the approaches that were laterally closest to the approach to Runway 30R but farthest from the runway threshold. The three LDA approaches preferred by the pilots were LDA B, LDA D, and LDA E.

Statistical analysis confirmed that LDA B, LDA D, and LDA E should be the preferred approaches among those tested. The statistical analysis indicated the aircraft were stabilized earlier on the approach at a higher altitude while performing these three approaches, than while performing LDA 0, LDA A, and LDA C.

Analysis of the overshoot data indicated the largest overshoots occurred during quartering tailwind conditions. The largest observed overshoot recorded was 339 feet. This overshoot occurred during an LDA D approach with a quartering left tailwind. The largest observed overshoot during an LDA E approach was 109 feet, which was recorded with a left quartering tailwind. Analysis of the touch down points indicated the aircraft landed significantly farther from runway threshold when the wind had a tailwind component.

Among the three preferred approaches, LDA E exhibited sufficient stabilization qualities and provides more distance from the proposed C/C point to the Decision Altitude point (DA/H). The increased distance provides more time for the visual acquisition of traffic on the accompanying runway. This would increase the level of safety as well as capacity. Therefore, the

recommendation of this study is that of the five LDA procedures with glideslope that were tested, LDA E should be considered for implementation.

The implementation of LDA E must also include the following operational procedures and criteria:

1. All heavy/B757 aircraft shall execute the ILS Runway 30R/12R approach.

2. Aircraft shall NOT be cleared for simultaneous ILS/LDA approaches when ANY of the following conditions exists:

a. The surface wind results in a 90° crosswind exceeding 15 knots and/or a quartering crosswind, and/or tailwind component greater that 10 knots;

b. The ceiling is below 1,000 feet;

c. The visibility is less than 4 miles for Runway 30L/12L.

APPENDIX A

APPENDIX A

Group I Pilot Responses to Question 5.

Q5: As a general observation, how would you characterize the new approach scenarios flown in this test as compared to the existing LDA with '4900' foot separation?

Pilot #1:	A: Easy to fly, allows for smoother transition to visual. C: Easy to fly, could not tell difference between A & C.
Pilot #2:	A & C Easier.
Pilot #3:	A: No apparent problem G/S gives much needed time for visual part of APP. C: No response.
Pilot #4:	A: Haven't actually flown this approach at STL in real world. C: No response.
Pilot #5:	A & C: No response.
Pilot #6:	A & C much easier with glideslope.
Pilot #7:	A & C same, general flying workload easier with addition of G/S.
Pilot #8:	A & C easier.
Pilot #9:	A & C much nicer approach; the glideslope makes a much more stable approach to enter the visual maneuver phase.
Pilot #10:	A through D: easier.
Pilot #11:	A: G/S is help - still no problem to align. B: Easier to align with RWY. C: G/S help - no problem with alignment. D: Easier to align with RWY.
Pilot #12:	A through D: easier.
Pilot #13:	A: Too close but better than present. B: Too close but better than A. C: Good. D: Best.
Pilot #14:	A: Safe enough. It would be good to see these approaches in the SIM as part recurrent before line flying. B: Fine approach, safe, better w/glideslope. C: Safe, but a lot of banking in close. D: Same as B - fine, safe.
Pilot #15:	No response.
Pilot #16:	A & C not as good. B & D good.
Pilot#17:	A through D: All seemed to be a big improvement over the old LDA approach. A bit more aggressiveness seems to be required. All easier to fly ESP during the transition visually.
Pilot #18:	A through D: All better than the LDA - very little difference between these 4.

Pilot #19:	A & C easier
	B & D easiest.
Pilot #20:	A through D: easier.
Pilot #21:	A through D: much better.
Pilot #22:	A & C good, little more difficult.
	B & D: great.
Pilot #23:	A & C: more difficult to maneuver to final.
	B & D: easier.
Pilot #24:	A through D: much better.
Pilot #25:	A: Average to slightly difficult.
	B & C: average.
	D: Average to slightly above average.
Pilot #26:	A through D: Glideslope makes transition easier.
Pilot #27:	A through D: More pilot friendly.
Pilot #28:	A through D: Better.
Pilot #29:	A through D: Easier.
Pilot #30:	A: Transition to final more difficult than B
	B & D: Transition with G/S easier than LDA
	C: Transition to final more difficult than D.
Pilot #31:	A: Easier.
	B: Much easier transition.
	C: Easier (hardest of four w/GS)
	D: Nice, easy approach.
Pilot #32:	A: Much better than regular LDA.
	B: Easier.
	C: Better than regular LDA.
	D: Easiest by far.
Pilot #33:	A through D: Much better.
Pilot #34:	A & C: Too close for let down.
	B & D: Works well.
Pilot #35:	A & C: Too close at NUJOS - not enough time.
	B: Still a little too much maneuvering required.
	D: Best of the four.
Pilot #36:	A: 3.
	B: 1.
	C: 4.
	D: 2.
Pilot #37:	A & C: Best for operations.
	B & D: Are more comfortable from a pilots perspective but any of the four are better than a stepdown.
Pilot #38:	A & C: Better.
	B: Better - allows a little more time to align.
	C: Better - allows for better alignment.

Pilot #39:	A: The worst of the four due to distance/offset B: The second best. C: The third best. D: The best of four due to distance/offset. All four are much better than present.
Pilot #40:	A & C: Flyable but slightly more difficult than B&D. B & D: Flyable - could use lower MDA.
Pilot #41:	A through D: The glideslope is a great improvement for all of the scenarios we flew in the test. The two with the transmitter closer to the RWY seemed to have smoother transitions. All were flyable however.
Pilot #42:	A: Much better than current approach. B: Transition time better a little further out. C: Felt good overall with tailwind wind quartering, a little tight. D: Nice, much easier than LDA w/o glideslope.
Pilot #43:	A through D: Easier.
Pilot #44:	The glideslope helps on all 4 of these approaches.
Pilot #45:	GS is very helpful since no level and re-start descent is required.
Pilot #46:	LDA B and D preferred, LDA A and C are more work.
Pilot #47:	LDA B and D ranked 1, LDA A and C ranked 2.
Pilot #48:	All four rated "good".
Pilot #49:	All four rated "great".
Pilot #50:	LDA A rated "good, easier in general, harder w/tailwind. LDA B rated "easy compared to A." LDA C rated "easier". LDA D rated "easier".
Pilot #51.	LDA A "easier", LDA B "easier", LDA C "much easier", LDA D "much easier".
Pilot #52.	LDA A: Easier, but more difficult than B&D. LDA B: Easier, more time to align. LDA C: Easier, but more difficult than B&D. LDA D: Easier, more time to align.
Pilot #53.	LDA A: Easier turns to line up with runway. LDA B: More difficult to align with runway. LDA C: Easier turns to line up with runway. LDA D: More difficult to align with runway after MDA.
Pilot #54:	All four rated "better".
Pilot #55:	LDA A: bit harder - especially wind 350° LDA B, C, D rated "ok".
Pilot #56:	LDA A: Easier, LDA B: easier than A, LDA C: easier than A, LDA D: easiest.
Pilot #56:	LDA A: Easier because closer alignment with centerline. LDA B: 2.6 NM gives better distance to intercept localizer. LDA C: easier because closer alignment with centerline. LDA D: 2.6 NM gives better distance to intercept localizer.

Pilot #57: LDA A: better than LDA (existing).
LDA B: better than LDA (existing).
LDA C: much better than LDA (existing).
LDA D: much better than LDA (existing).

Pilot #58: LDA A: better than the LDA with no G. S.
LDA B, C, and D rated "ok".

Pilot #59: LDA A: Somewhat easier.
LDA B: Easier still than LDA A, but greater distance to RWY makes it a little more challenging to visually interpret the relative RWY position.
LDA C: Easier.
LDA D: Easiest!

Pilot #60: LDA A: Easier than old LDA.
LDA B: Easier than old LDA also.
LDA C: Better than A:
LDA D: Better than B:

Pilot #61: Rated all 4 "much better" than current LDA.

Pilot #62: LDA A: Little far left on Tailwind approach.
LDA B: Fine
LDA C: Provided best transition to VMC.
LDA D: Much easier to fly & transition to VMC.

APPENDIX B

APPENDIX B

SUBJECT PILOT BRIEFING

I am _____, Project Pilot/Observer, From the Standards Development Branch in the Office of Flight Standards. At this time I am going to proceed with the pilot briefing. Please hold any questions until the end of the briefing.

Acting as your final approach and local controller is _____, and assisting us with the simulator operations is _____ of the _____ organization.

Today the FAA is currently examining possible ways to increase capacity at this nation's busy airports.

Some of these that are already in place or will soon be in place are 1) parallel LDA facilities at STL; 2) Converging Runway Display Aid (CRDA) at STL; 3) ILS triple approach procedures at DFW and DEN; 4) closely spaced parallel approach procedures at MSP; and 5) converging simultaneous approach procedures at DFW and ORD.

Additional work continues in all areas for capacity improvements.

This brings us to why we are here.

The FAA has been asked to examine several procedures that may result in greater capacity at STL. These procedures add a glideslope for vertical guidance and angles the LDA at 3° from runway centerline.

You, as an _____ qualified crew are being asked to participate in a data gathering effort to examine these operations.

Today you will fly approaches to STL RWY 30L including the current LDA and the four proposed approaches with glideslope and 3° offset LDA. The four approaches to be evaluated are as follows:

Procedure #	Separation	MAP to threshold	Offset Angle	Mag Course
LDA A	3400'	1.95 NM	3.0°	302.2°
LDA B	3400'	2.59 NM	3.0°	302.2°
LDA C	3000'	1.94 NM	3.0°	302.2°
LDA D	3000'	2.58 NM	3.0°	302.2°

You will be positioned 17-18 miles out on the current LDA approach or 12-13 miles out on one

of the proposed angled LDA approaches to STL RWY 30L, and the procedure will be 'AS PUBLISHED' for the purpose of this evaluation. During the IMC portion of the approaches you will fly, you will have your choice of flight modes, that is, hand flown, flight director only, or fully coupled and as recommended by your company. You are expected to fly this approach as you would on the line.

Weight and fuel will be frozen at the maximum landing weight. Altimeter setting will be 30.00" Hg. and the surface temperature will be 90° F. The simulator will be released with appropriate speed and flaps for the aircraft and with the gear up. All check lists except for final are presumed complete. You should assure yourselves that the 'aircraft' configuration agrees with this condition. ATIS information will be provided on a card before each run.

One of the requirements of independent close parallel approaches (Less than 4,300 feet spacing between runways) is to review the film RDU (Raleigh Durham) PRECISION RUNWAY MONITOR: A PILOT'S APPROACH, which we will watch at this time.

(SHOW PRECISION RUNWAY MONITOR FILM)

(HAND OUT APPROACH CHARTS)

You may study and brief the approach procedures now, in order to satisfy the approach briefing and can be 'AS BRIEFED' for the remainder of the period or you may choose to brief each up coming procedure between approaches. Please note that the localizer frequency and the minimum descent altitude change with each approach. Also the flight director if used will be required to be turned off, and then on after the airplane is repositioned on final.

Alternating turns flying the approaches is your option, or as directed by your company.

This is not an ATP type examination. We are not inspectors nor involved with aircraft certification..

What are your questions, if any, at this time?

APPENDIX C

APPENDIX C

CREW QUESTIONNAIRE

SCENARIO _____

TO BE ADMINISTERED BETWEEN APPROACHES ON ONLY EVALUATION LDA RUNS

DATE_____ AIRCRAFT_____ AIRLINE_____ CREW #_____ SEAT L//R_____

PLEASE ANSWER THE FOLLOWING:

1. Rate the flyability of this entire approach.

VERY EASY			AVERAGE			VERY HARD		
1	2	3	4	5	6	7	8	9

2. Rate the transition from the instrument portion to the visual portion (location, finding the runway, maneuvering)?

VERY EASY			AVERAGE			VERY HARD		
1	2	3	4	5	6	7	8	9

3. Describe the altitude that you established as you rolled out on runway centerline during the visual segment.

TOO HIGH			ABOUT RIGHT			TOO LOW		
1	2	3	4	5	6	7	8	9

4. Describe the bank angles required during the visual segment of the approach.

TOO SHALLOW			ABOUT RIGHT			TOO STEEP		
1	2	3	4	5	6	7	8	9

5. How useful was the glideslope after you began the visual transition?

VERY USEFUL			USEFUL			NOT USEFUL		
1	2	3	4	5	6	7	8	9

6. Was the distance allowed to execute the transition maneuver sufficient?

TOO LONG			ADEQUATE			TOO SHORT		
1	2	3	4	5	6	7	8	9

7. Did the LDA CDI and lateral command bar not being centered during the visual segment cause any problems?

NO PROBLEM			MODERATE PROBLEM			SEVERE PROBLEM		
1	2	3	4	5	6	7	8	9

8. How safe is this procedure, considering the proximity to traffic, maneuvering required, stabilized visual approach segment concept, etc.?

VERY SAFE			AVERAGE			VERY UNSAFE		
1	2	3	4	5	6	7	8	9

9. At rollout for alignment with runway centerline on final, were you in an acceptable position to complete an approach and landing in keeping with your personal standards?

NO PROBLEM			MODERATE PROBLEM			SEVERE PROBLEM		
1	2	3	4	5	6	7	8	9

Comments:

APPENDIX D

APPENDIX D

POST-TEST CREW QUESTIONNAIRE

DATE_____ CREW #_____ AIRLINE_____ AIRCRAFT_____

PLEASE ANSWER THE FOLLOWING:

1. Is any member of this crew currently flying into St. Louis? _____

2. If yes, have either of you been required to perform a balked landing or in any other way had a difficult experience with either of the current LDA approaches? If so, please describe.

_____

3. Did this simulation present a realistic visual portrayal of the St. Louis operation?

_____

4. How would you rate the flyability of the LDA with GS as compared to the present LDA without GS?

EASIER			ABOUT THE SAME			MORE DIFFICULT		
1	2	3	4	5	6	7	8	9

5. As a general observation, how would you characterize the new approach scenarios flown in this test as compared to the existing LDA with '4900' foot separation?

LDA A: _____

LDA B: _____

LDA C: _____

LDA D: _____

6. Under VMC what is the minimum AGL at which the aircraft should be established on the centerline with wings level?

300 FT _____ 400 FT _____ 500 FT _____ OTHER _____

7. What would be your answer to 6 if a B-757 or B-747 was at 200' AGL ahead and landing on R 30 R? _____FT. Or go around due to wing tip vortex wake?

Additional Comments: _____

APPENDIX E

APPENDIX E

OBSERVER TEST LOG

St. Louis Visual Segment

Date	Scenario #	Run #	Pilot Flying	Observer Comments
				crew accepts sim for test_____

APPENDIX F

APPENDIX F

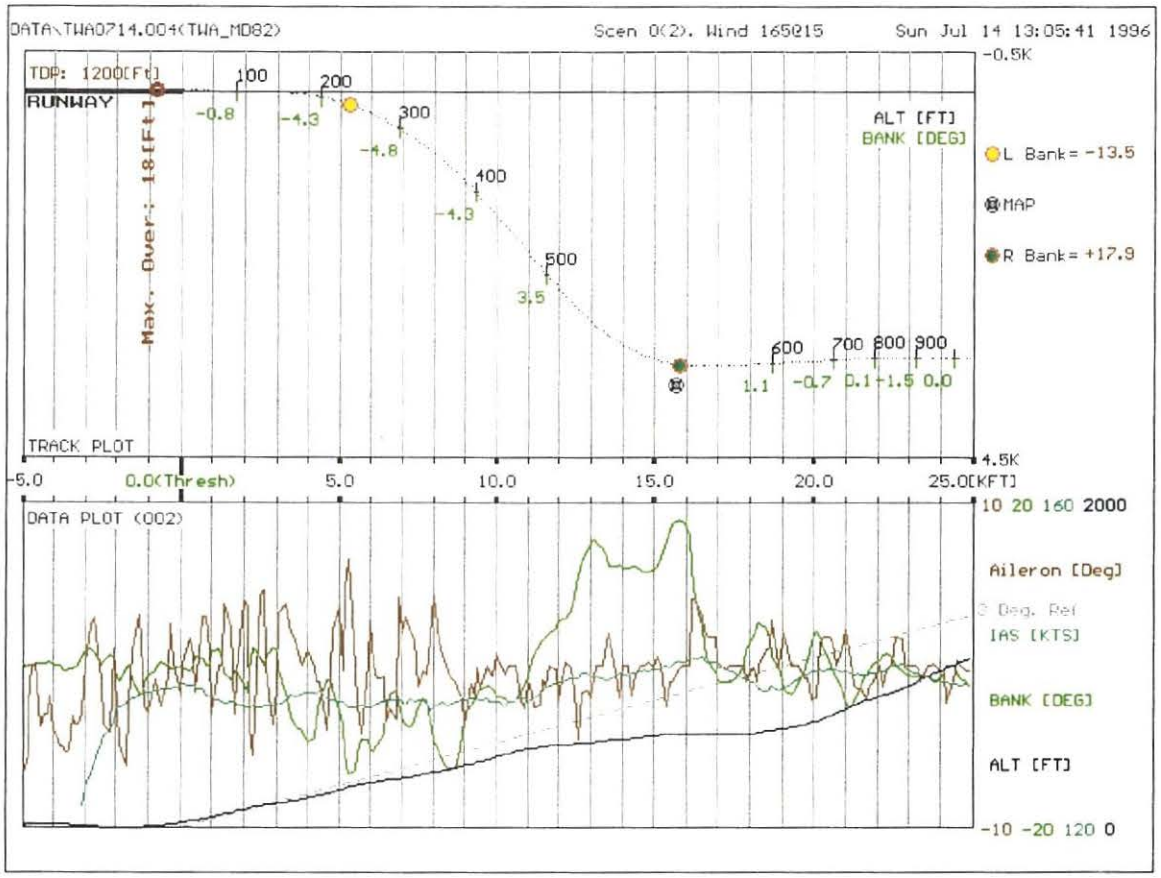
TEST DATA RUN MATRIX

PROCEDURE	RUNS	SAMPLE SIZE
CURRENT LDA		
SCENARIOS LDA A		
WIND 300°/10 KTS.	1	10
WIND 165°/15 KTS.	1	10
WIND 350°/15 KTS.	1	10
3,400 FOOT SPACING		
SCENARIOS LDA 2a/A		
WIND 300°/10 KTS.	1	10
WIND 165°/15 KTS.	1	10
WIND 350°/15 KTS.	1	10
SCENARIOS LDA 2b/B		
WIND 300°/10 KTS.	1	10
WIND 165°/15 KTS.	1	10
WIND 350°/15 KTS.	1	10
3,000 FOOT SPACING		
SCENARIOS LDA 3a/C		
WIND 300°/10 KTS.	1	10
WIND 165°/15 KTS.	1	10
WIND 350°/15 KTS.	1	10
SCENARIOS LDA 3b/D		
WIND 300°/10 KTS.	1	10
WIND 165°/15 KTS.	1	10
WIND 350°/15 KTS.	1	10

(15 RUNS/CREW, MINIMUM) × (10 CREWS/AIRCRAFT) = 150 RUNS/AIRCRAFT **

** Additional runs will be conducted, time permitting.

APPENDIX G



- Maximum Bank Angle Left
- Maximum Bank Angle Right
- Missed Approach Point (MAP)
- Maximum Runway Center-line Overshoot

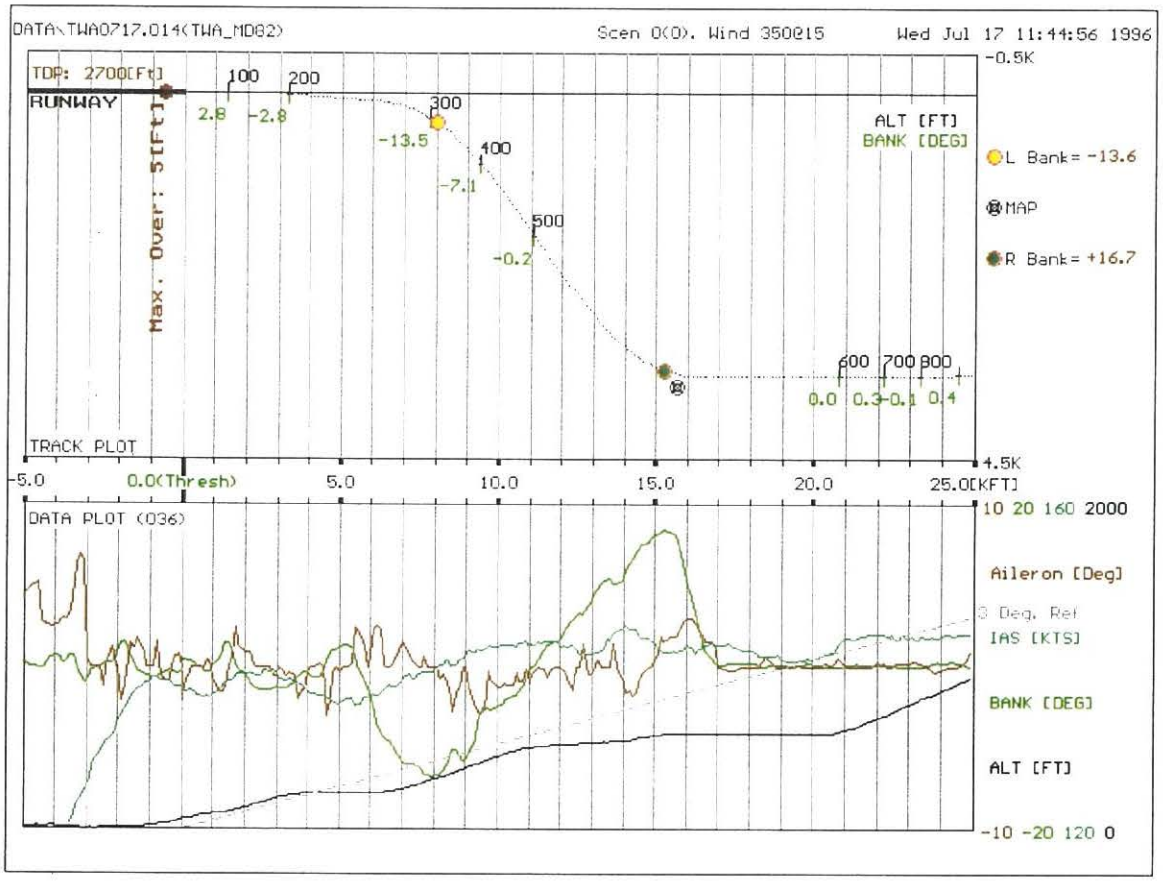
TDP: Touch Down Point (Positive indicates PASS the threshold point)

———Ailerons Deflection

———IAS

_____Bank Angle

_____Altitude



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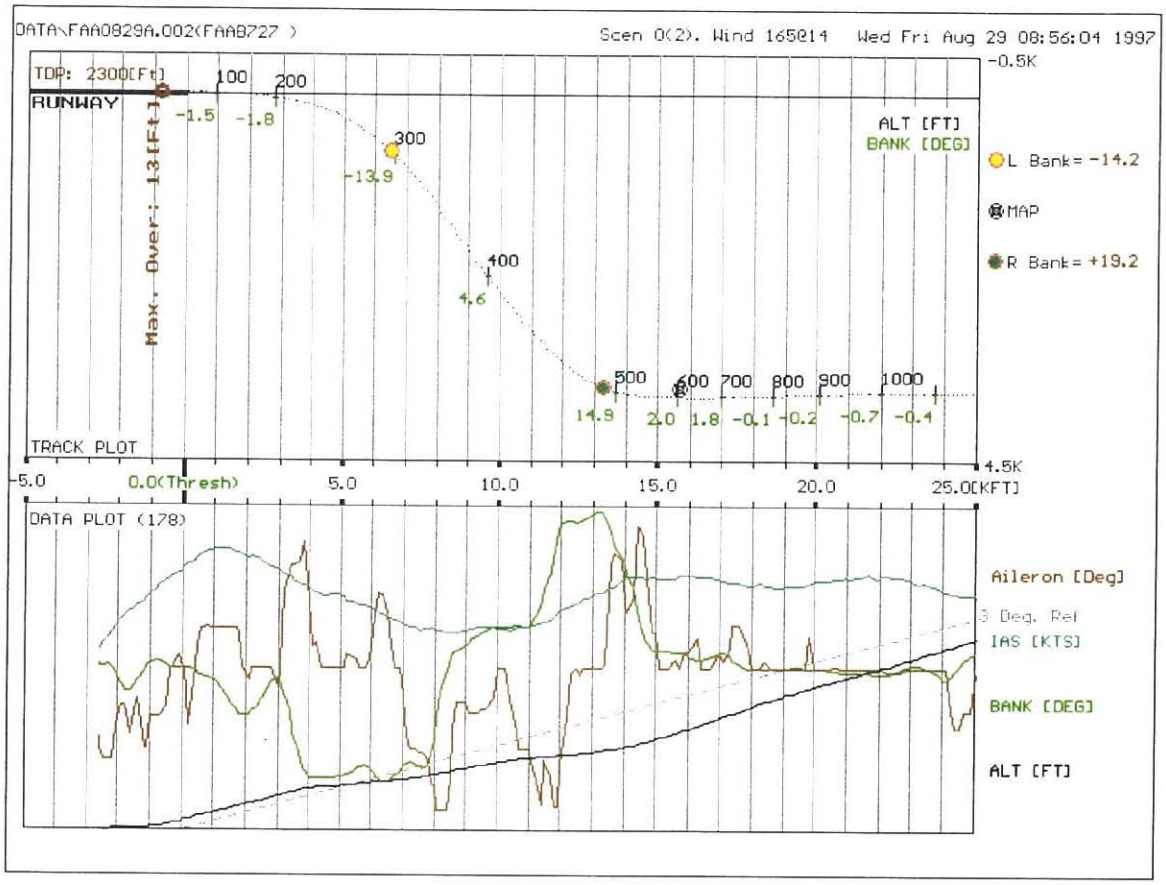
_____Altitude



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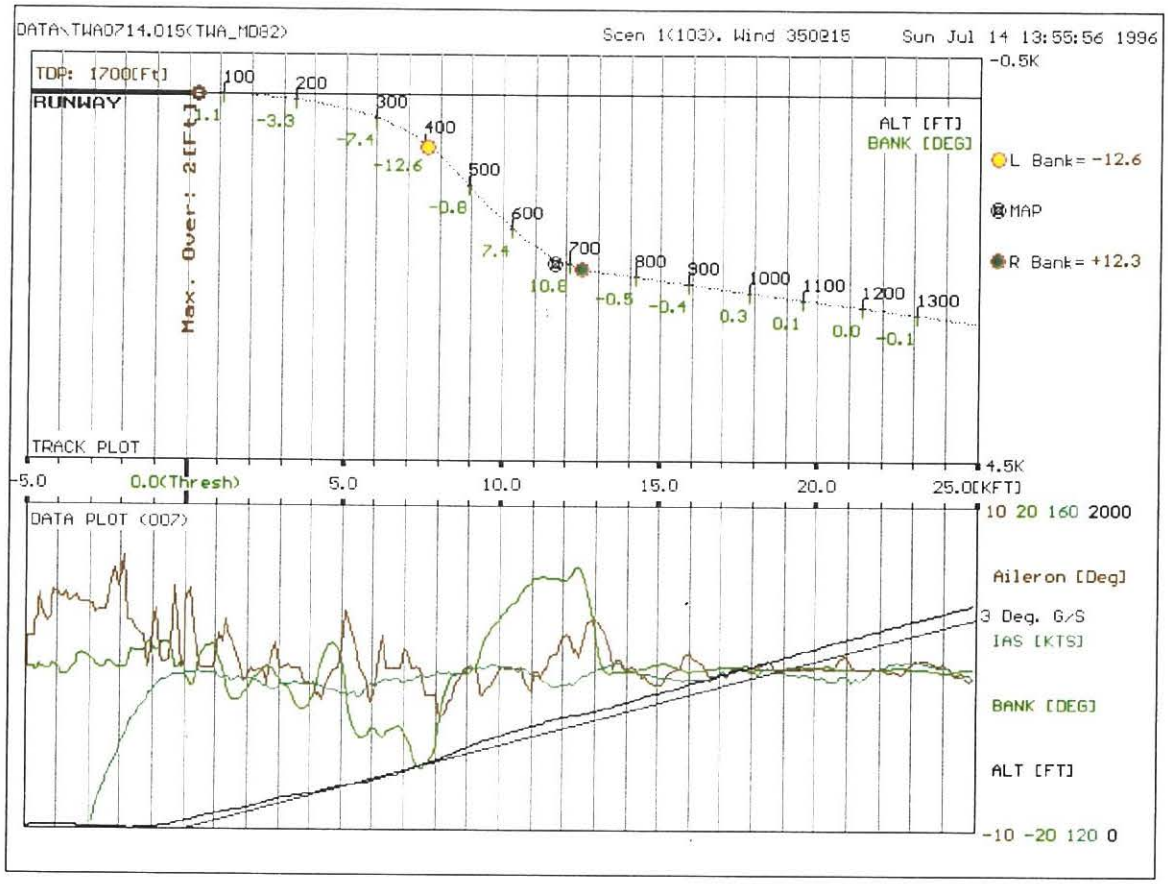
_____Bank Angle

_____Altitude



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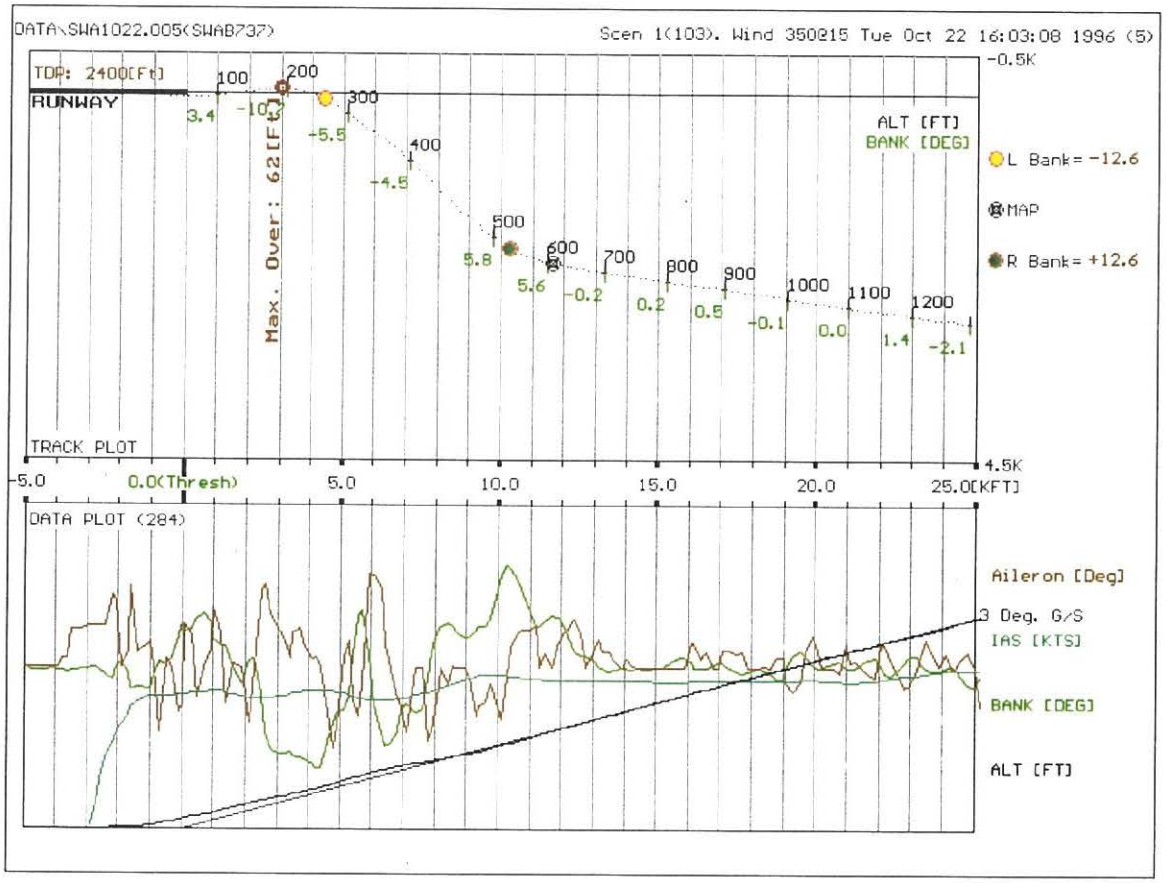
_____Altitude



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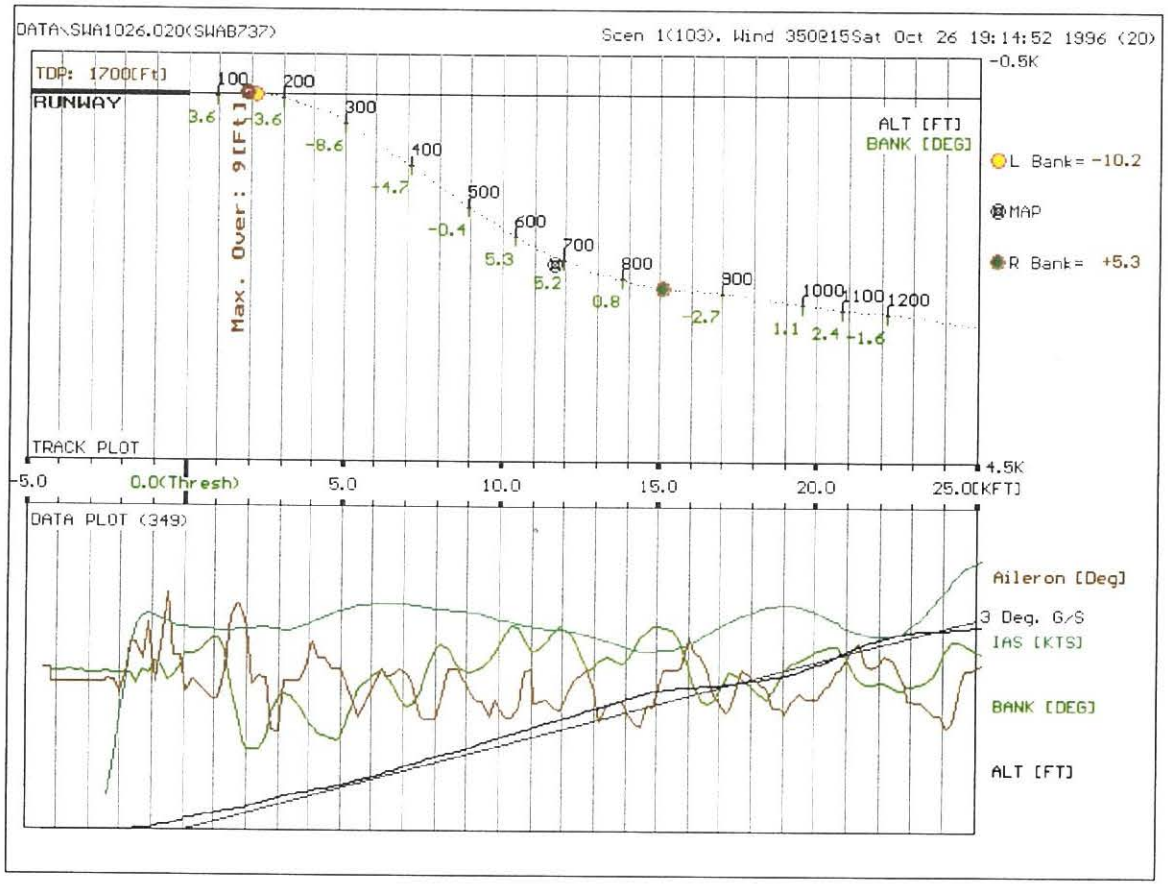

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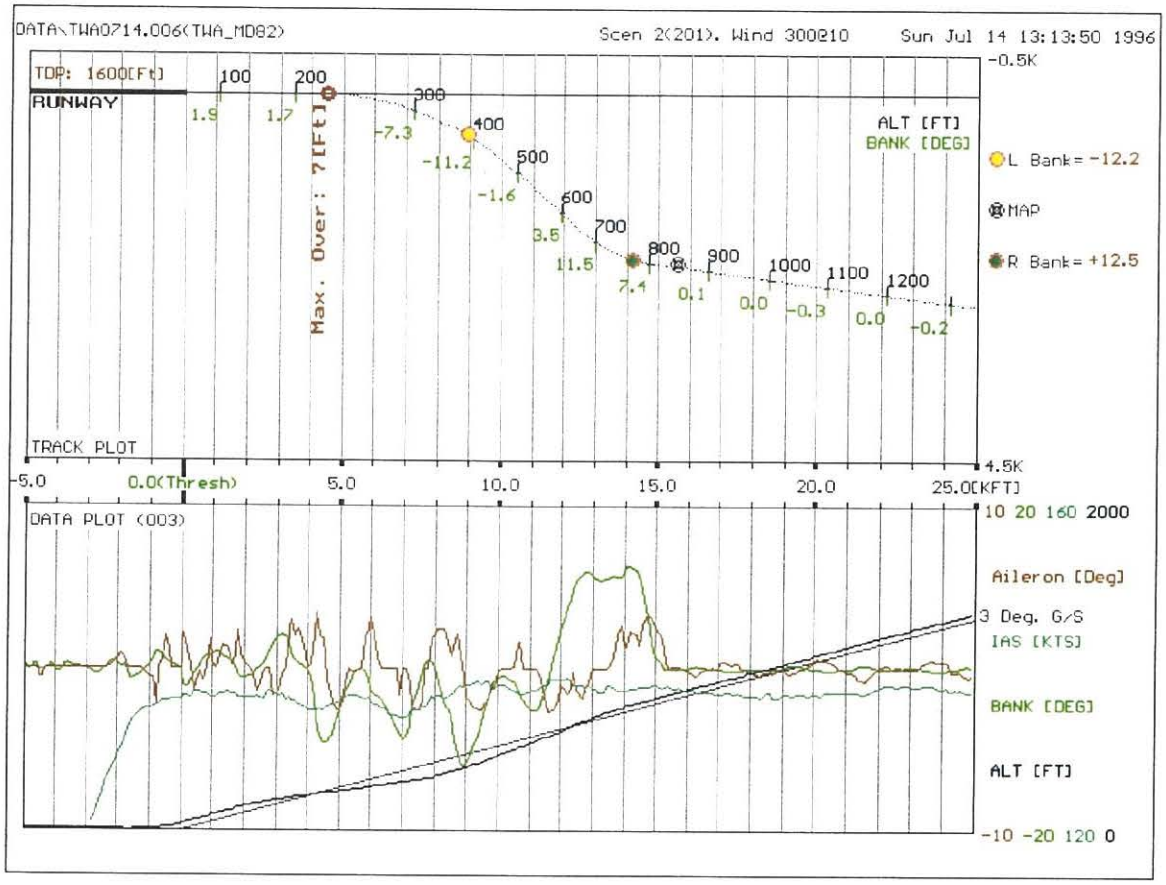

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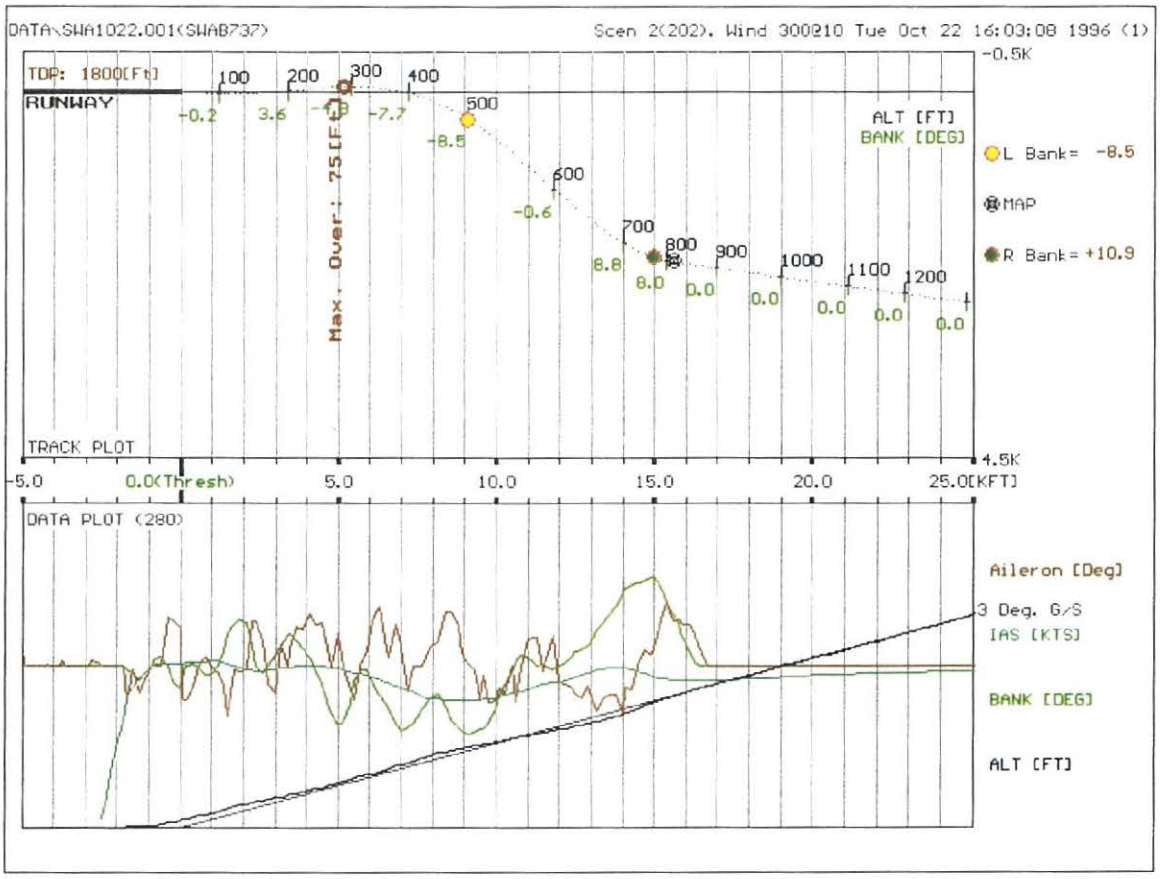

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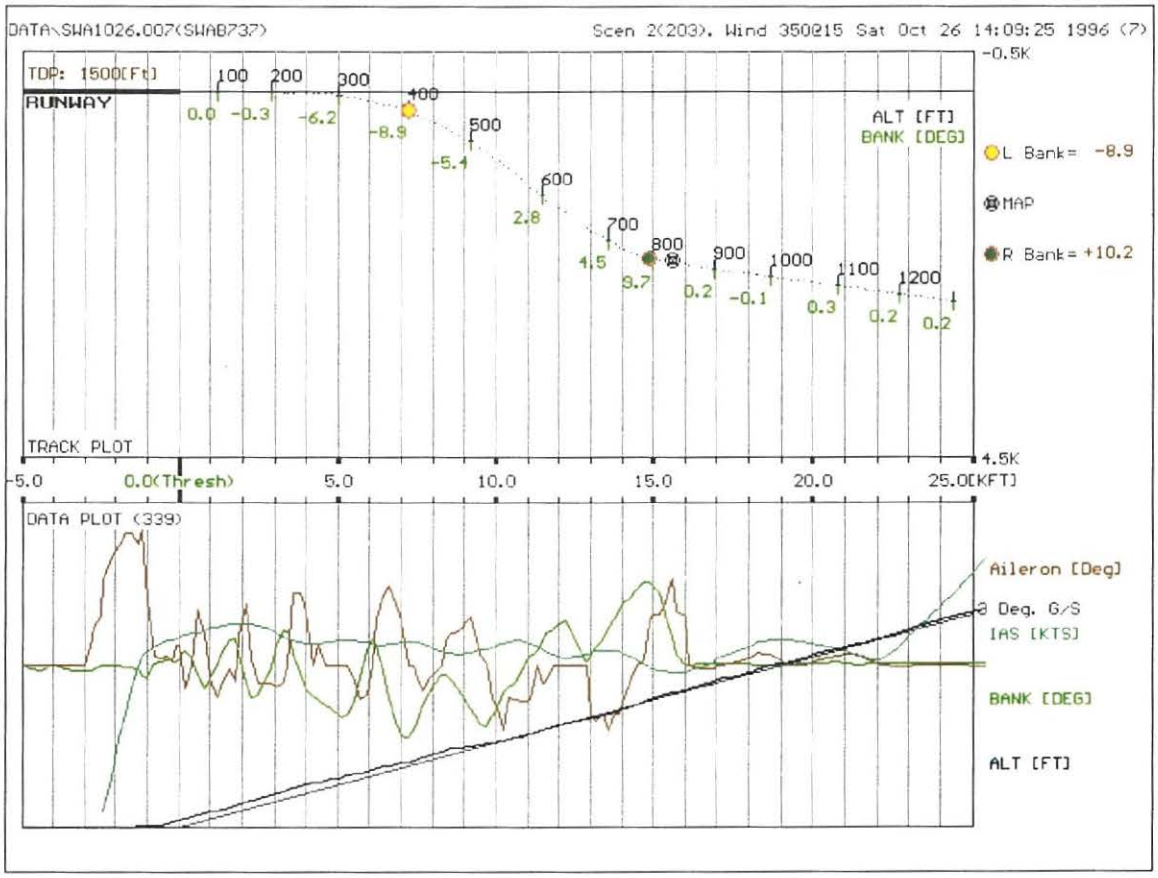

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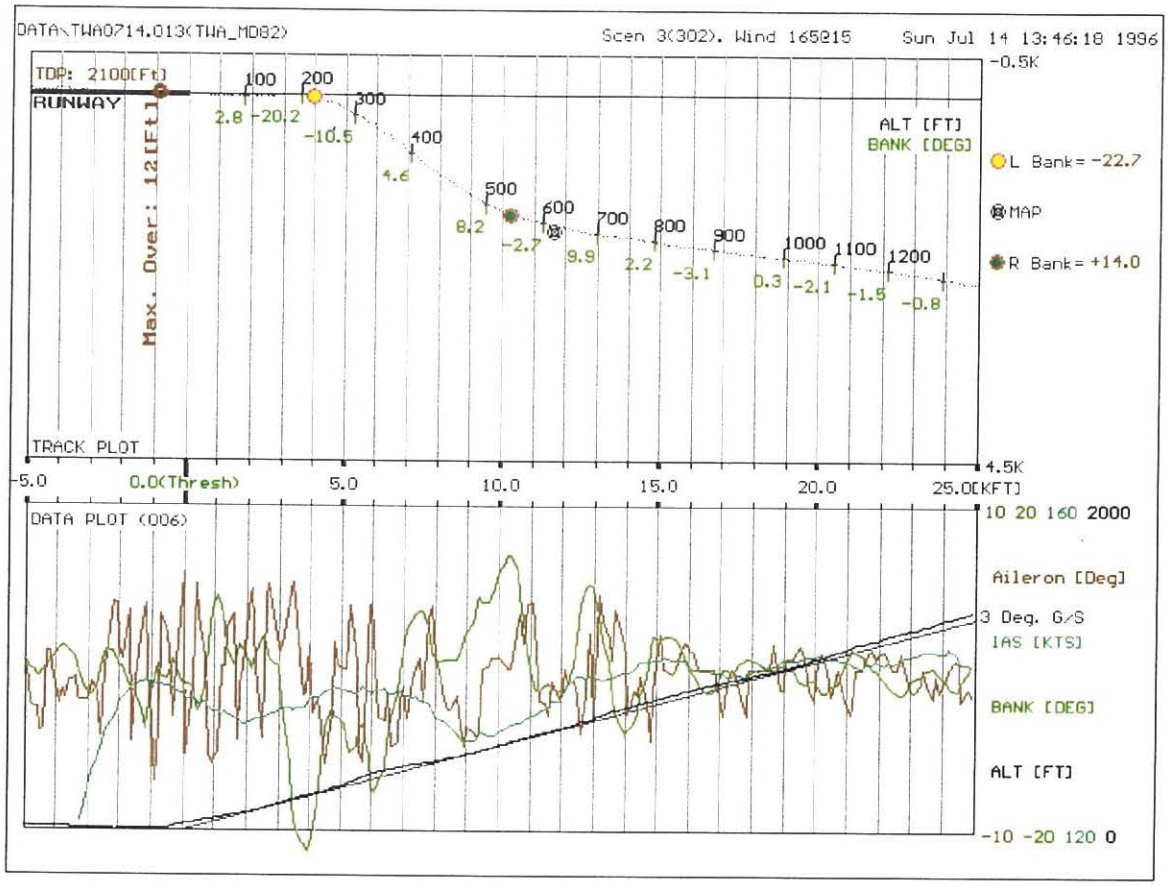

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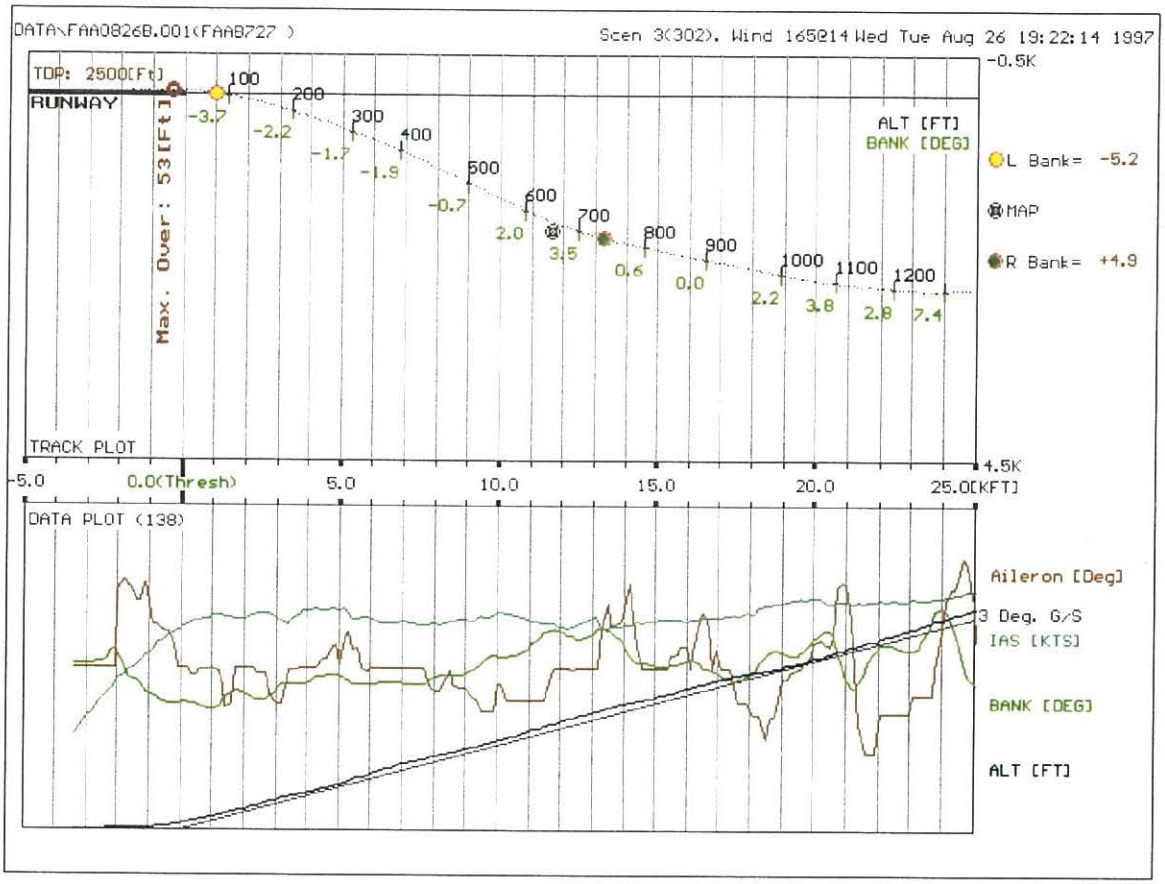

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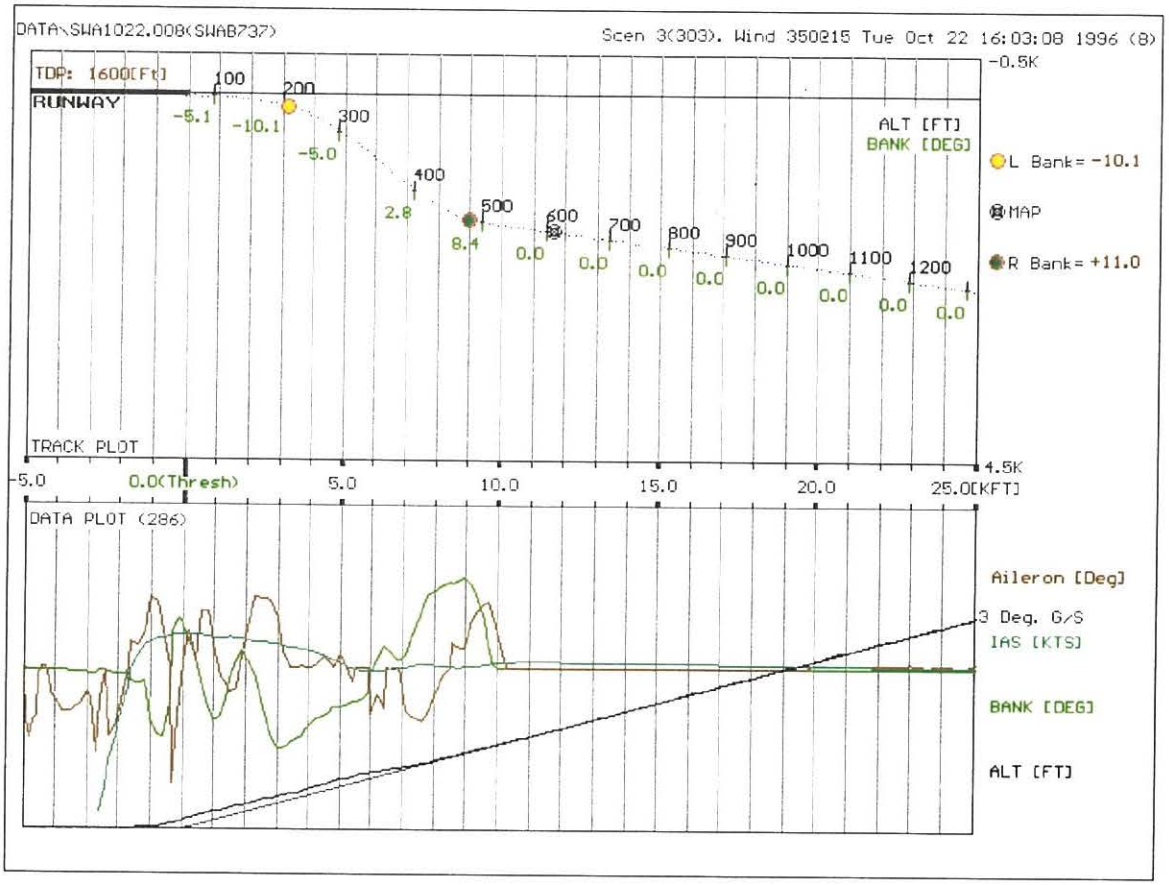

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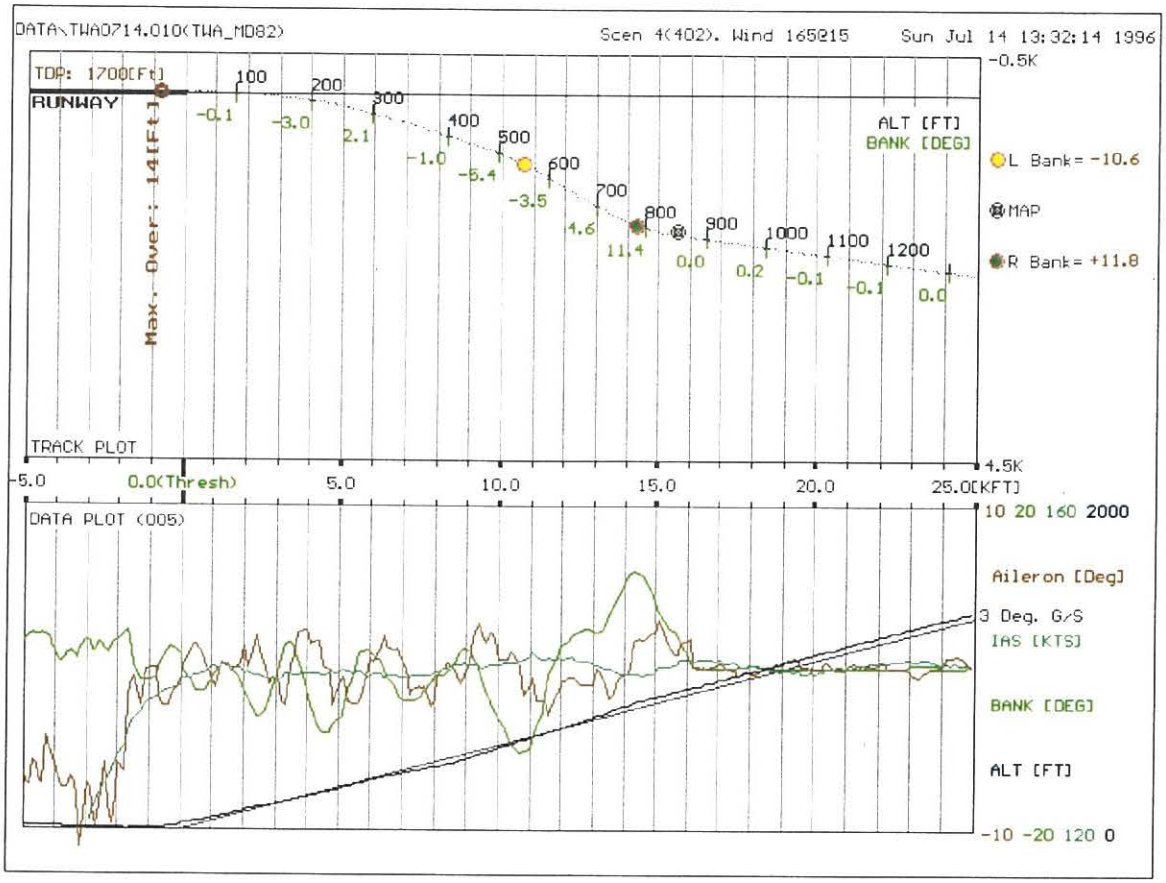

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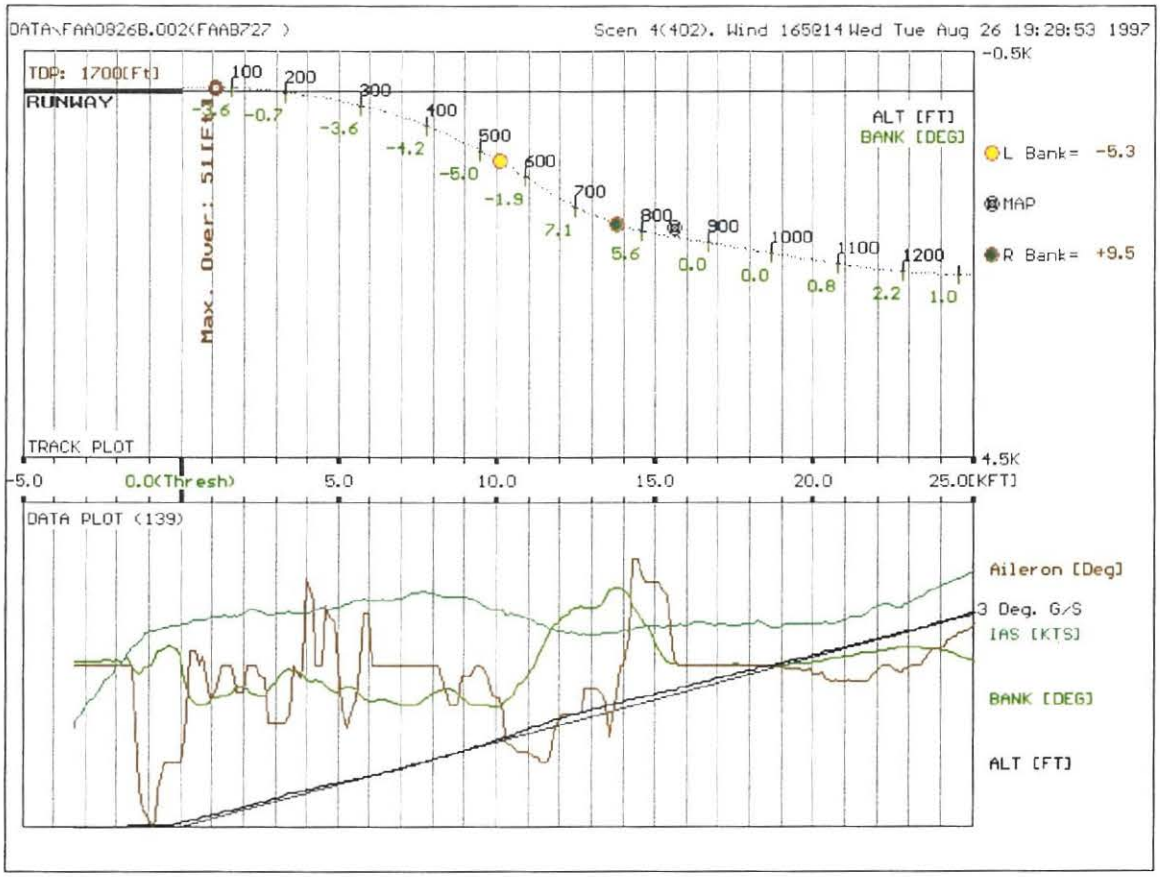

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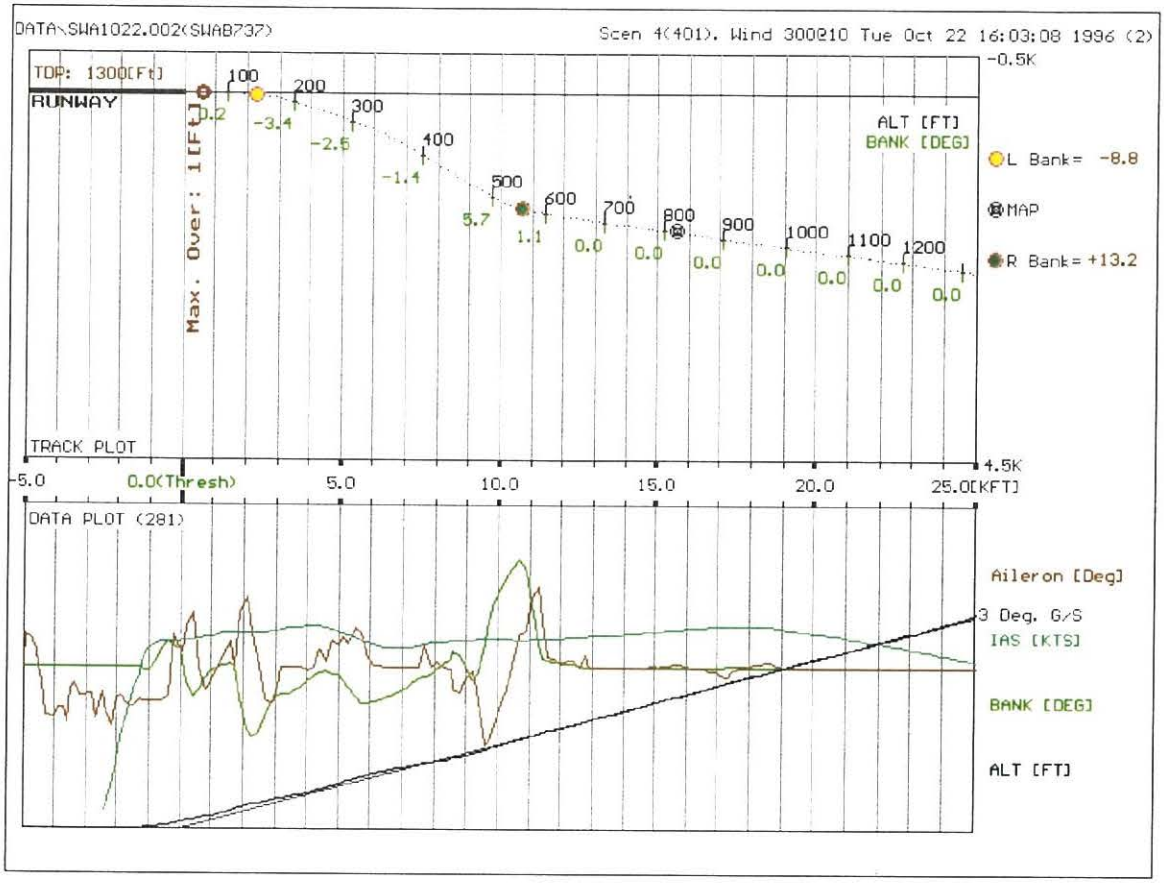

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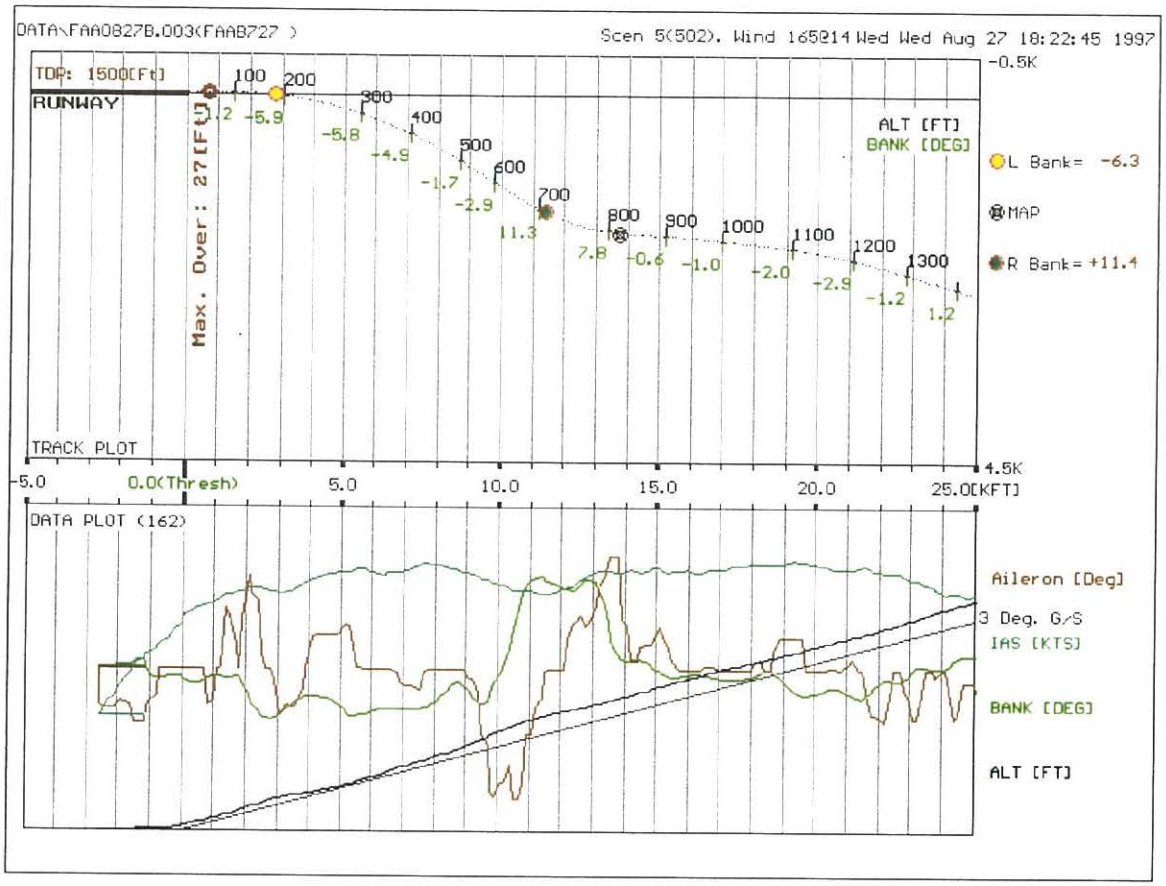

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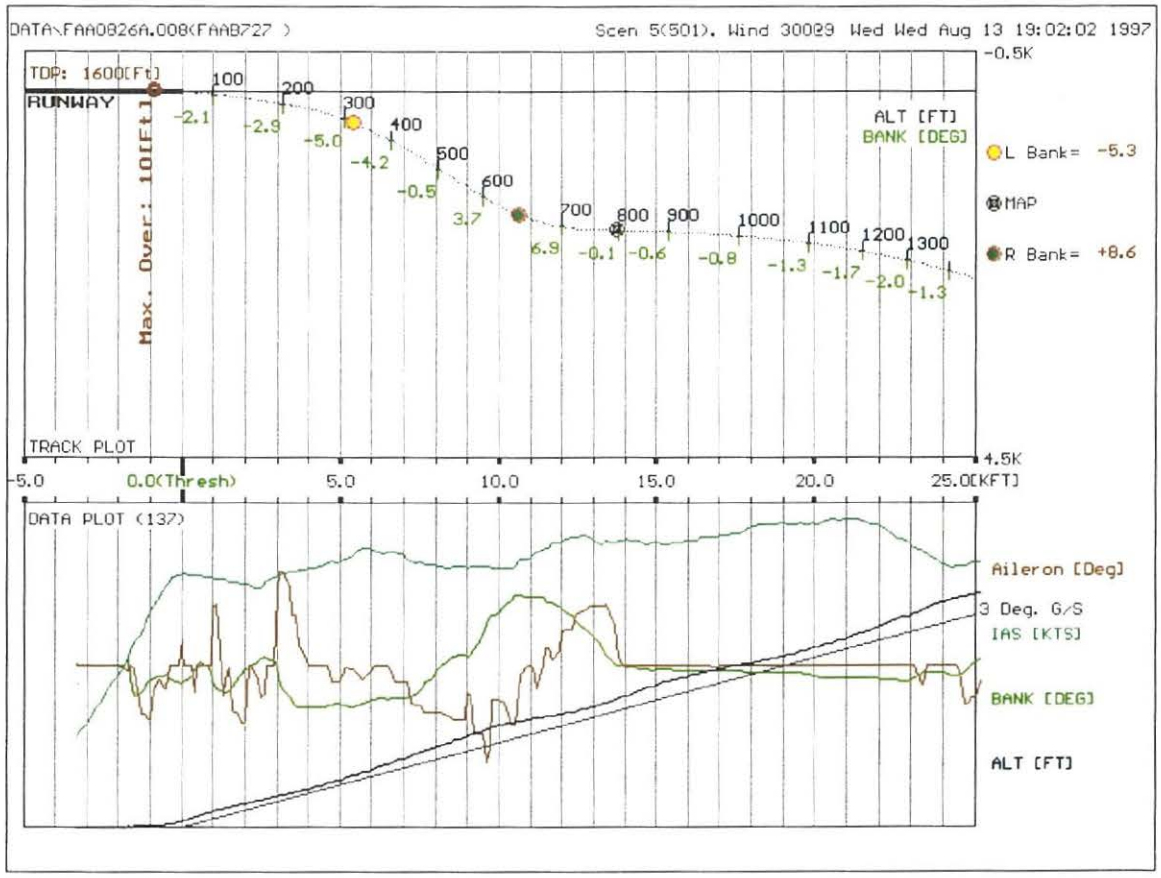

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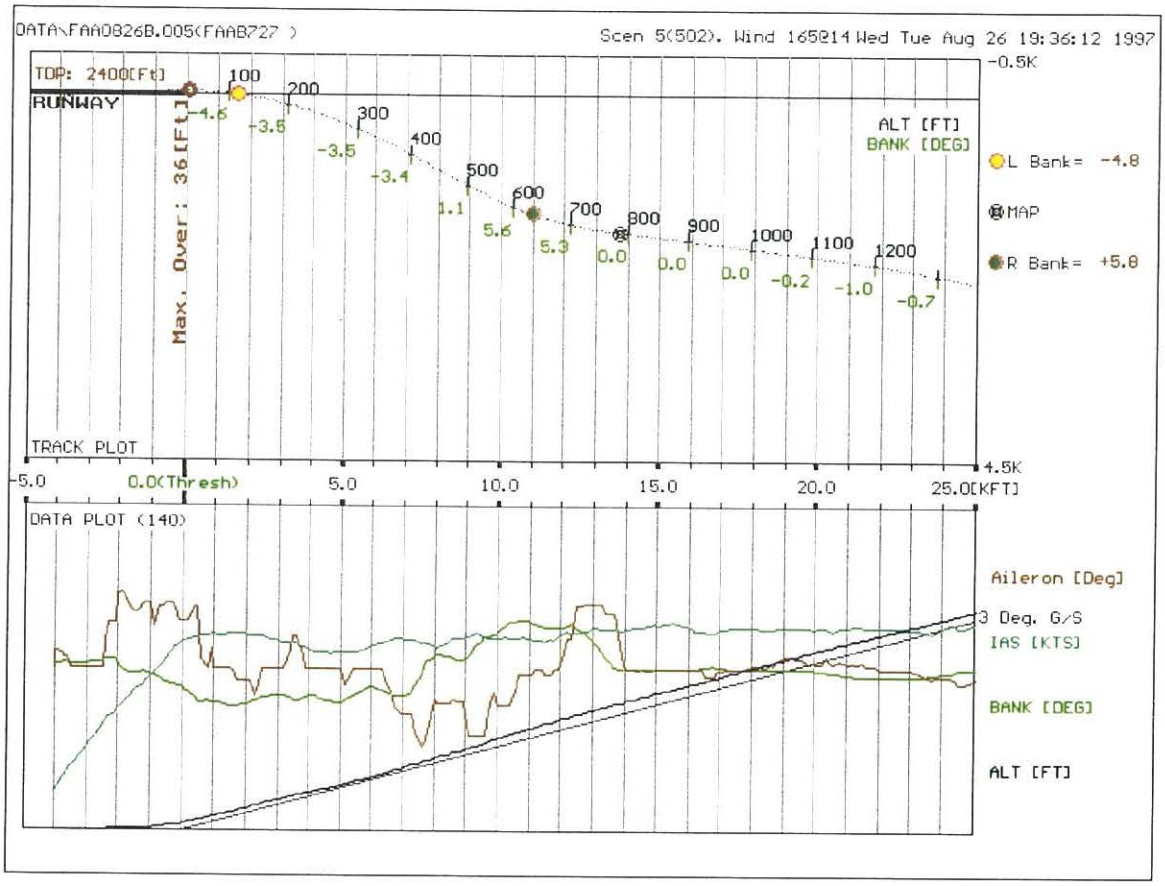

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