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SIMULATED GROUND-LEVEL STOL RUNWAY/AIRCRAFT EVALUATION

Roman M. Spangler, Jr.

SEPTEMBER 1973

FINAL REPORT

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16. Abstract

A De Havilland DHC-6, Series 100 Twin Otter was flown by a representative group of pilots on various steep-gradient approaches onto a ground-level STOL runway. Approximately 800 approaches and landings were accomplished to provide a data base to approve a first-generation STOL operation. Areas investigated included: aircraft handling and response on steep-gradient approaches with various approach electronic beam sensitivities; location of the ground point of intercept; co-located versus split localizer/glide slope signal source; obstacle clearance requirements; field length requirements; and influence of command-steering on aircraft/pilot performance.

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PREFACE

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for participating in the flight test program by supplying their line pilots to the project as subject pilots thereby providing current operating experience to the program. Their comments on recommended operating procedures are also greatly appreciated.

Mr. John Gaalaas of Oklahoma City, Federal Aviation Administration (FAA), Mr. Robert Kennedy of Flight Standards, Flight Test, Washington, D. C., Mr. Bryan Chestnut of Washington FAA, Flight Operations; and the guidance and many useful suggestions of Mr. Julius C. Staples our program manager from Washington, D. C.;

The Canadian Ministry of Transportation for the loan of the test aircraft.

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LIST OF ABBREVIATIONS

A/C	Aircraft
ADF	Automatic Direction Finder
ATC	Air Traffic Control
CAS	Calibrated Airspeed
CDI	Course Deviation Indicator
CL	Centerline
DH	Decision Height
DME	Distance Measuring Equipment
ESHP	Equivalent Shaft Horsepower
FAA	Federal Aviation Administration
GPI	Ground Point of Intercept
IFR	Instrument Flight Rule
ILS	Instrument Landing Approach
MLS	Microwave Landing Approach
MODILS	Modular Instrument Landing System
MSL	Mean Sea Level
NAFEC	National Aviation Facilities Experimental Center
NDB	Nondirectional Beacon
STOL	Short Takeoff and Landing
TALAR	Tactical Approach and Landing Air Radar
TD	Touchdown
TTP	Target Touchdown Point
TTZ	Target Touchdown Zone
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VOR	Very High Frequency Omnirange Station
V_{so}	Power OFF Stall Speed
WGP = 50	Where Glide Path Equals 50-Feet Altitude
WGP = 35	Where Glide Path Equals 35-Feet Altitude

INTRODUCTION

PURPOSE.

The purpose of this project was to investigate factors associated with the approach, landing and takeoff of a first generation Short Takeoff and Landing (STOL) aircraft operating from a simulated ground-level STOL runway. The tests were designed to study straight-in approaches using: a De Havilland DHC-6 series 100, Twin Otter; STOL runway requirements and operating criteria; and the location of the electronic approach guidance signal characteristics as presented to a pilot either on a flight director or an ID-249 Cross-Pointer Indicator. Over 800 approaches and landings were accomplished to provide a significant data base for analysis. No attempt was made to evaluate or compare the two microwave landing systems, used as the signal sources, nor to evaluate curvilinear or segmented approach techniques since the purpose was to develop a data base for the approval of a simple short-haul operation that could develop in the near term with aircraft having similar characteristics as the Twin Otter.

BACKGROUND.

The growing interest in reducing congestion at conventional airports and providing the public safe, quiet transportation for the high and/or low-density, short-haul market indicates the possible development of a STOL system. One basic part of such a system is a viable means of accomplishing instrument approaches and landings to STOLports. The STOL aircraft to be effective must be capable of making steep approaches, often in congested areas, and at low speeds in order to land on the short runways envisioned.

In the past 3 years, the Federal Aviation Administration (FAA) has conducted a cursory evaluation of approach, landing, stopping, and the departure characteristics of five different STOL-type aircraft. They were De Havilland Twin Otter (DHC-6) (see Figure 1), De Havilland Buffalo (DHC-5), Breguet 941 (McDonnell Douglas 188), Dornier DO27D, Fairchild Hiller "Heliporter." These preliminary evaluations have indicated a need to investigate many areas.

A significant portion of this project was devoted to acquiring data to establish approach, missed approach and takeoff obstacle clearance planes, touchdown dispersion, threshold crossing height, required runway length and width, decision height, etc. The above data was obtained under the following conditions:

1. VFR and IFR
2. Localizer offset and centered
3. Glide slope angles of 4°, 6°, and 7.5°
4. Day and night
5. Command-steering and Raw data
6. FAA versus commuter pilots

FIGURE 1. De HAVILLAND TWIN OTTER (DHC-6) AIRCRAFT

Tests were made to obtain information on the approach guidance configuration and Twin Otter operational performance using, for the most part, the aircraft made available by the Canadian Ministry of Transport.

DESCRIPTION OF EQUIPMENT.

TEST AIRCRAFT. The aircraft has the following general characteristics:

1. WEIGHT : 11,579 lbs max takeoff; 11,000 lbs max landing
2. ENGINE : (2) PT6A - 20A (579 ESHP) United Aircraft of Canada
3. PROPELLERS : (2) HC - B3TN-3, three-blade Hartzel. Fully controllable through reverse pitch.
4. FLAPS : Full span, double-slotted flaps. Deflection 0° to 37.5°.
5. WING LOADING : 26.2 lb/sq ft AREA: 420 sq ft
6. POWER LOADING : 9.9 lb/ESHP
7. CERTIFICATED : to FAR-23 and SFAR-23
8. CRUISE SPEED : 165 knots
9. STALL SPEED : 57 knots (V_{SO})
10. APPROACH SPEED: 76 knots ($1.3V_{SO}$)

It is recognized that the Twin Otter is not the sophisticated power-augmented lift STOL aircraft envisioned for future short-haul operations, but it is currently used widely in commuter-type operations.

The aircraft's ability to negotiate a 7.5° glide slope at relatively low speeds and land in a short distance, may result in its being the initial aircraft used to develop the first short-haul operations into small designated STOL runways.

For test purposes, the test aircraft has a special flight test engineers' seat mounted in the doorway between the pilots so that the flight test engineer could become an integral part of the test crew and observe the instrument panel.

STOL RUNWAY. The ground-level test STOL runway was identified on runway 17-35 at NAFEC (Figures 2, 3, 4, and 5) in accordance with Advisory Circular, AC 150/5300-8, "Planning and Design Criteria for Metropolitan STOLports," dated November 1970 (Figure 5).

The exception to this layout was the addition of Heliport-type floodlighting to the 200-foot Target Touchdown Zone (TTZ) aiming marks and also the addition of a 7.5° Visual Approach Slope Indicator (VASI) approach (2-box) lighting

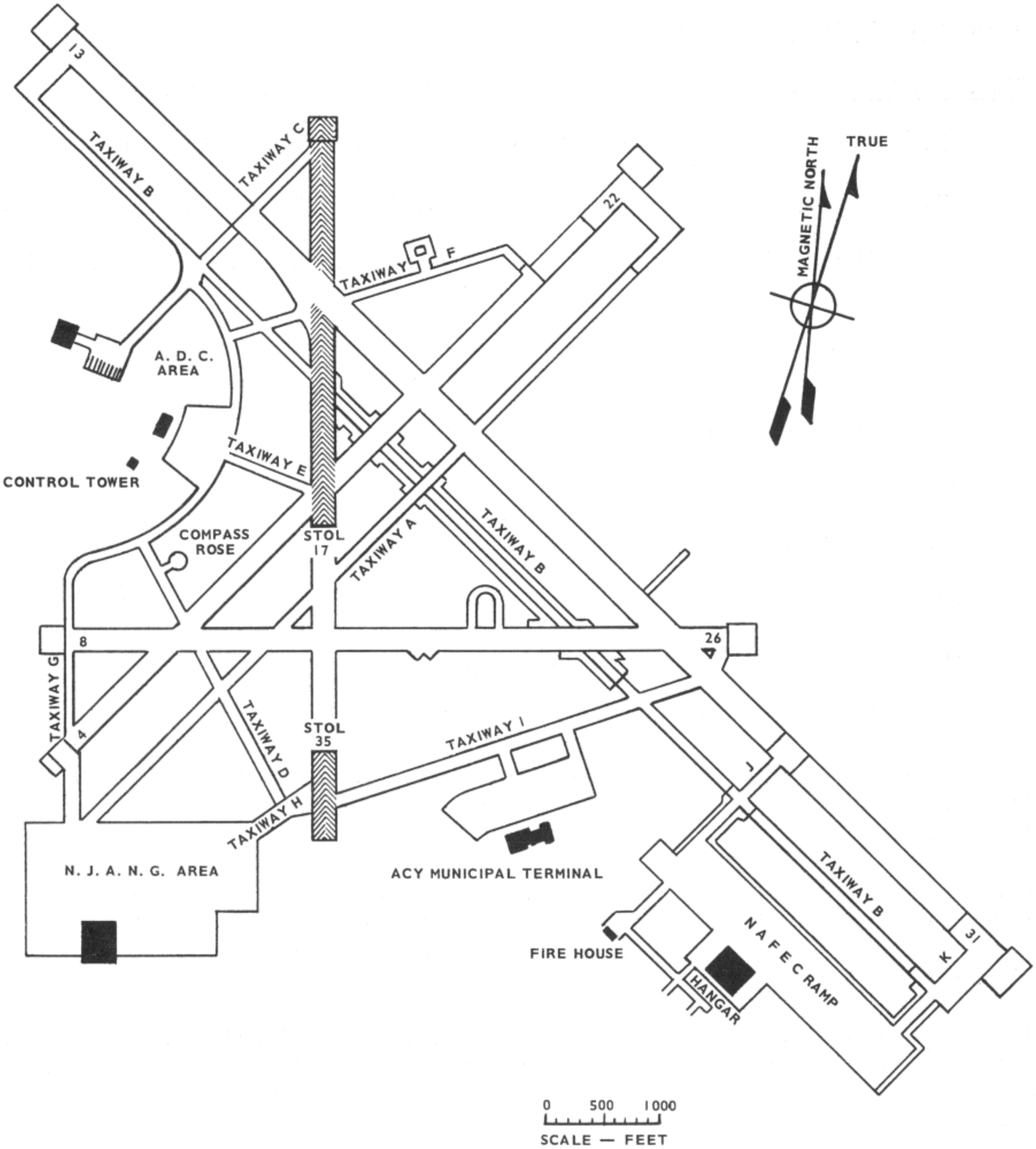


FIGURE 2. STOL RUNWAY LOCATION AT NAFEC

NOTE:
ALL MARKINGS ARE WHITE.
FOUR AIM POINT MARKINGS AS SHOWN TO BE PROVIDED FOR EITHER BIDIRECTIONAL OR UNIDIRECTIONAL OPERATION.

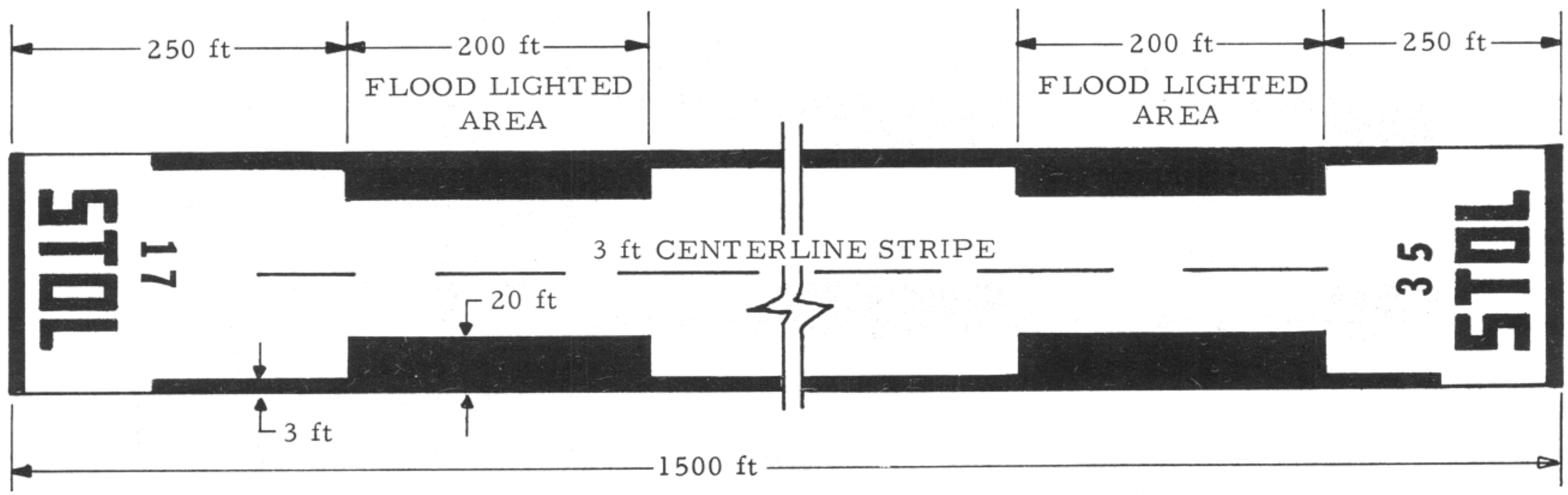


FIGURE 3. TEST STOL RUNWAY AT NAFEC

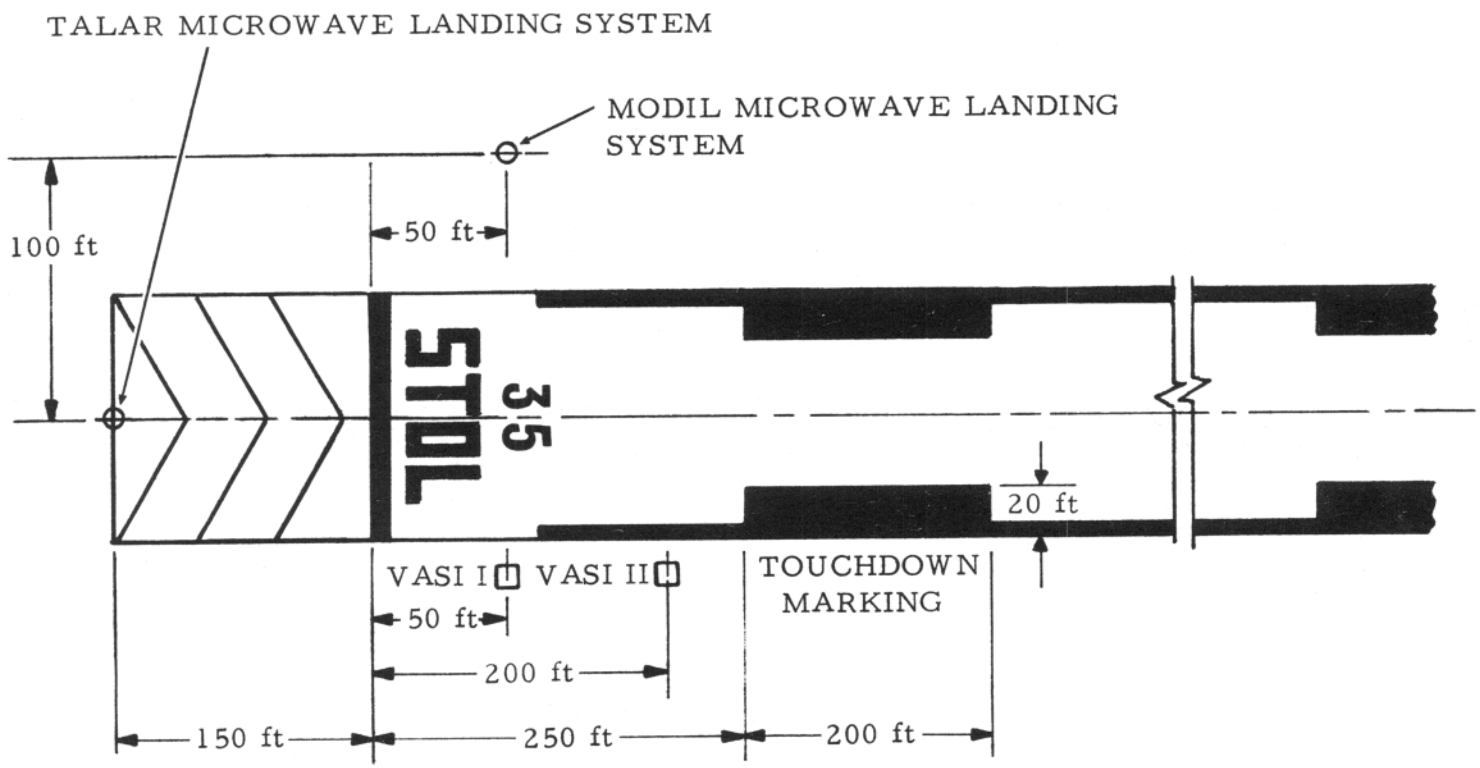


FIGURE 4. TEST STOL RUNWAY GUIDANCE EQUIPMENT LOCATION

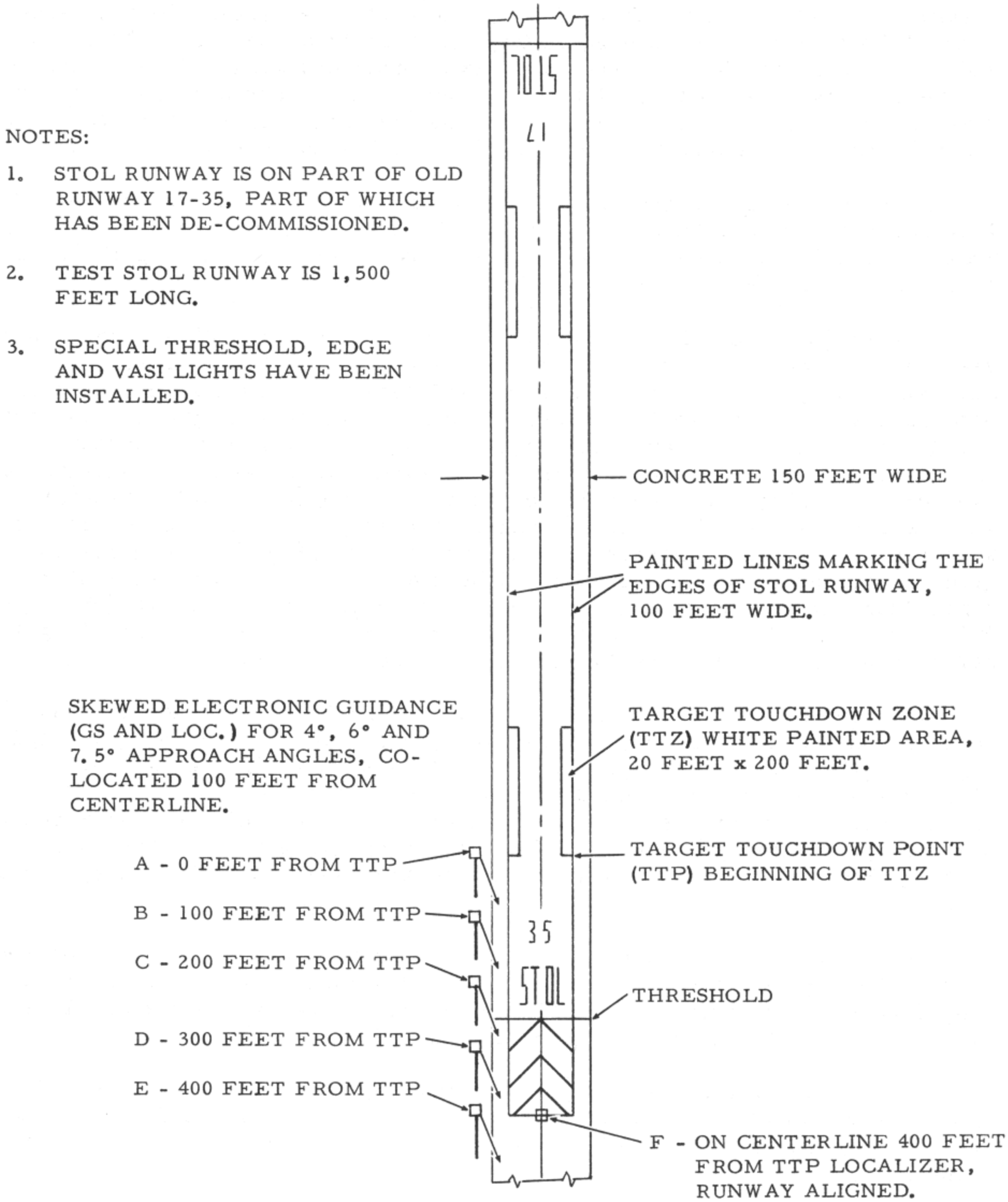


FIGURE 5. NAFEC STOL RUNWAY LAYOUT DETAILS

system. The STOL runway, as laid out, was 1,500 feet long, 100 feet wide, with 20-foot by 200-foot aiming marks, 250 feet from the threshold of each end. Also the test STOL runway overruns at each end were 150 feet instead of the currently recommended 100-foot value. This departure from the Advisory Circular criteria was not significant since the pilot task was to land within the painted aiming marks without regard to either threshold or overrun locations.

Approach/Landing Guidance. Two interim Microwave Landing Systems (MLS), Tactical Approach and Landing Radar (TALAR) and Modular Instrument Landing System (MODILS), were used to provide electronic guidance during the simulated Instrument Flight Rules (IFR) approaches.

The TALAR. The TALAR (Figures 4, 6, and 7) is a portable landing aid designed for the Air Force. It is in a case, 25 X 25 X 10 inches in size and weighs 57 pounds. The glide slope and localizer signals radiate from the same location. A single transmitter is used, time-shared by the localizer and glide slope. The transmitter output stage is a magnetron operating at 15.5 GHz. The signals are electronically switched between four antenna lobes; two for glide slope and two for localizer. The magnetron pulse repetition rate is a normal 200 kHz, but the exact frequency is varied to correspond with the lobe being transmitted. The airborne receiver then decodes the glide slope and localizer signals by the power level at each particular repetition rate. The receiver converts this energy to millivolt (mV) which drives a standard pilot's Course Direction Indicator (CDI), or the flight director depending on which is used in the test condition.

The transmitter is powered by 110 Vac or 28 Vdc. The case is mounted on a tripod, leveled forward and laterally boresighted with the telescopic sight for the localizer alignment. The glide slope alignment is set by the dial on the transmitter. The dial can change the glide slope from 6° to 9°, on the units made for the FAA (the standard Air force unit is restricted to glide slopes between 3° and 6°). The different glide slope angles are set by tilting the transmitter antenna to the required angle and checked by use of a scope.

The transmitter-radiated signal covers approximately ±30° for the localizer. The FAA unit has a localizer beam width (sensitivity) set at ±4.8°. The glide slope signals provide fly-up clearance down to approximately 1° elevation. The glide slope course width is ±2°.

The units for the FAA are provided with an audio Morse code identification feature added to the transmitter and to the receiver, and a separate far-field monitor. The far-field monitor is located 15 feet in front of the transmitter.

The MODILS. The MODILS (Figures 8 and 9) is an integrated MLS using step-scanned beams, consisting of localizer, glide slope, and Distance Measuring Equipment (DME), operating at 5.2 GHz (C-band) designed for the FAA for V/STOL operations. The equipment is housed in an 11- by 12-foot building with environmental control. It consists of prime and standby transmitters with dual monitors, a main power supply and a standby battery power supply.

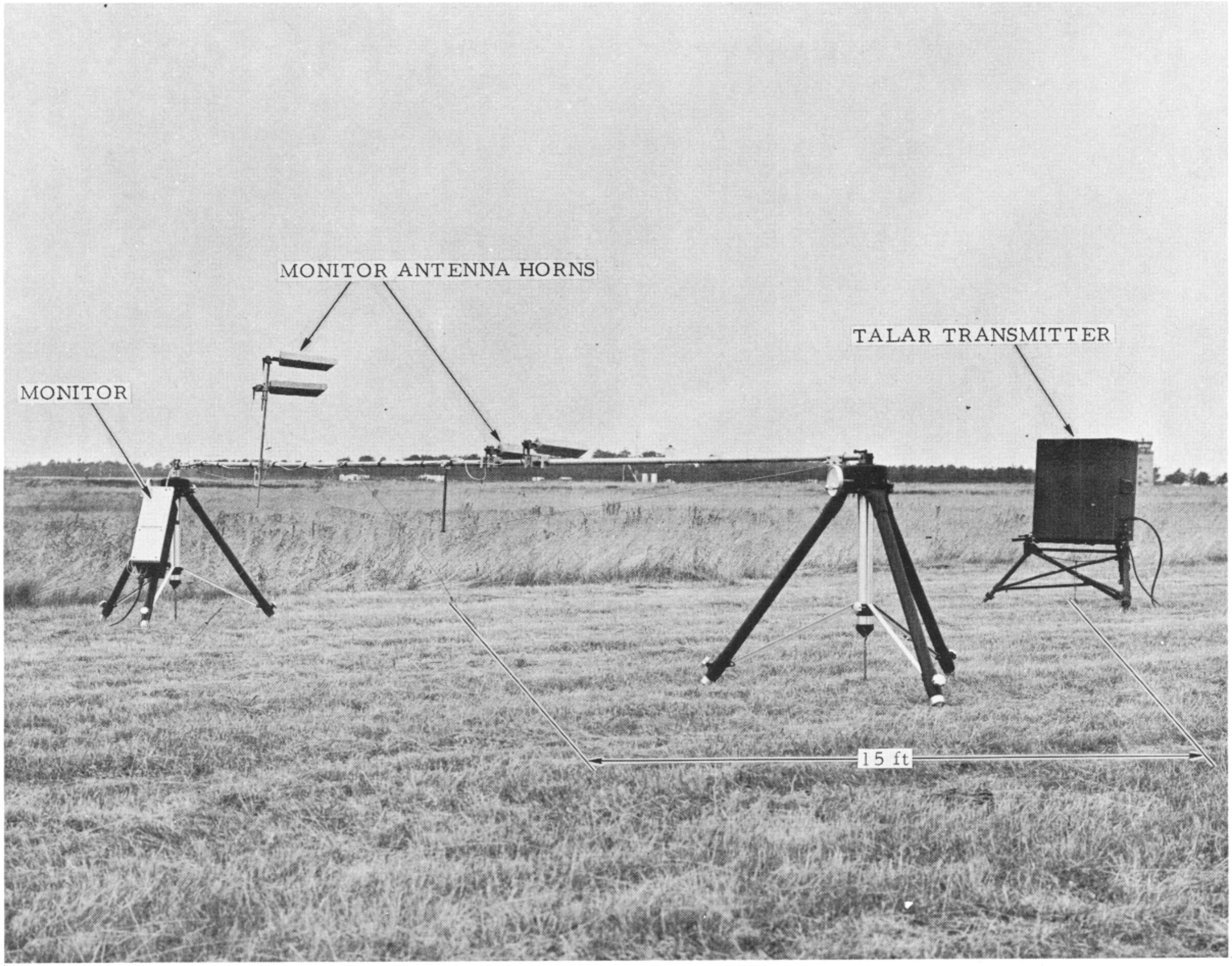


FIGURE 6.   TALAR IV TRANSMITTER AND MONITOR

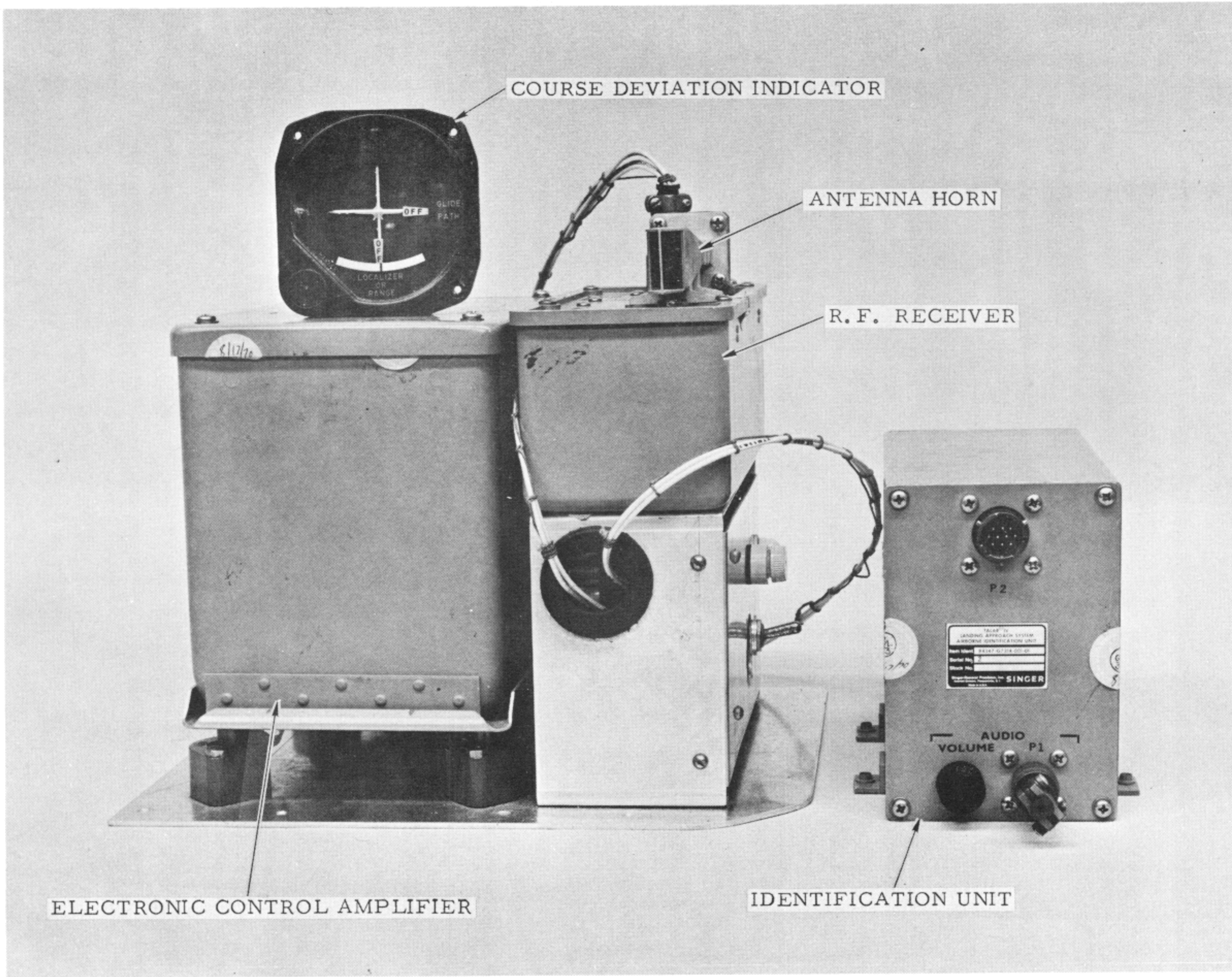
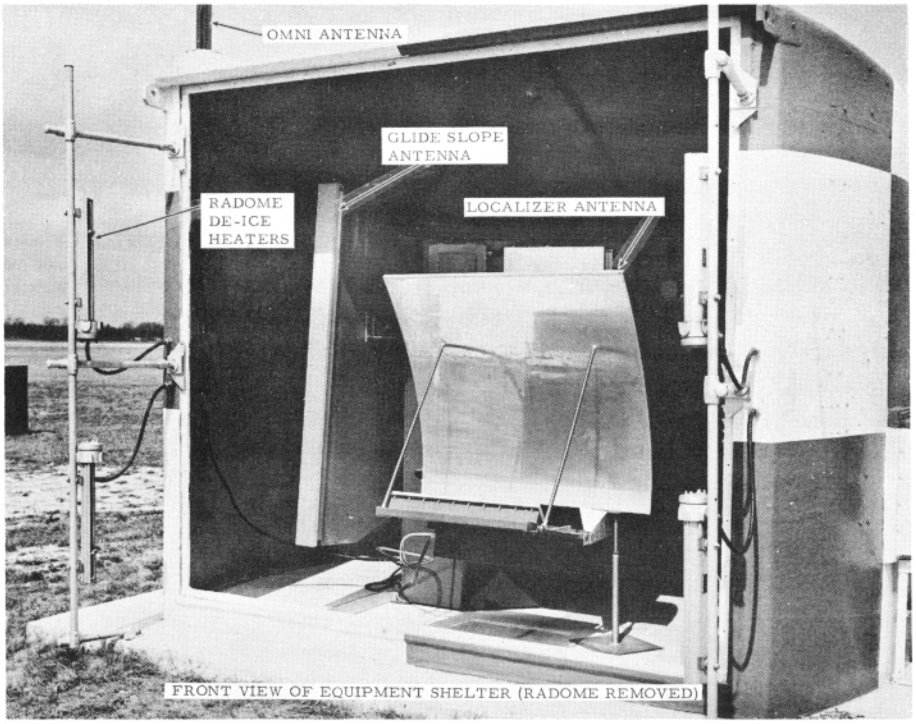


FIGURE 7. TALAR IV RECEIVER



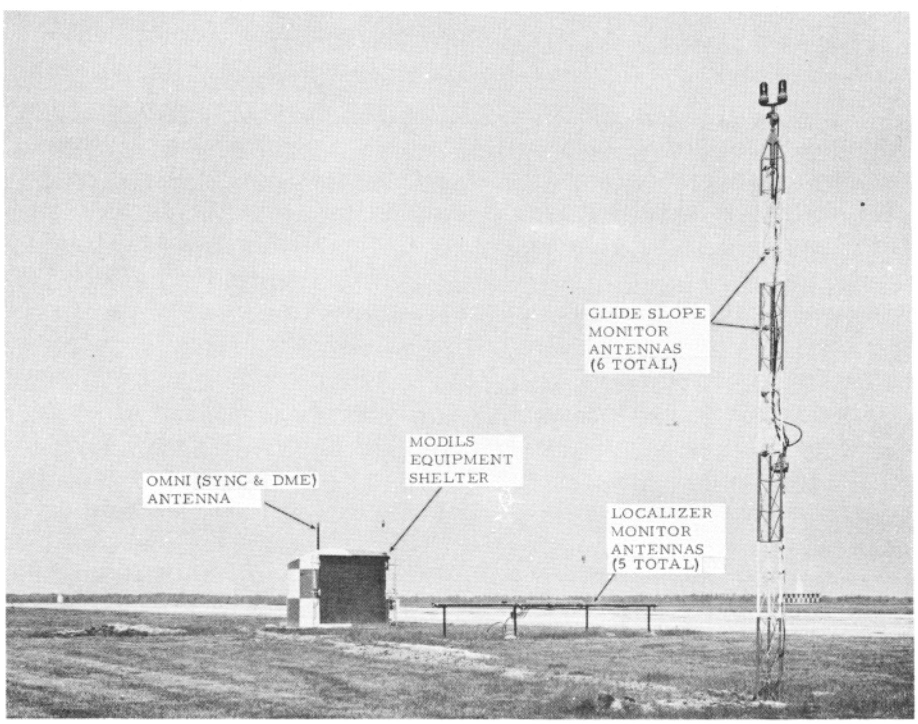


FIGURE 8. MODILS GROUND STATION ELECTRONICS CABINET

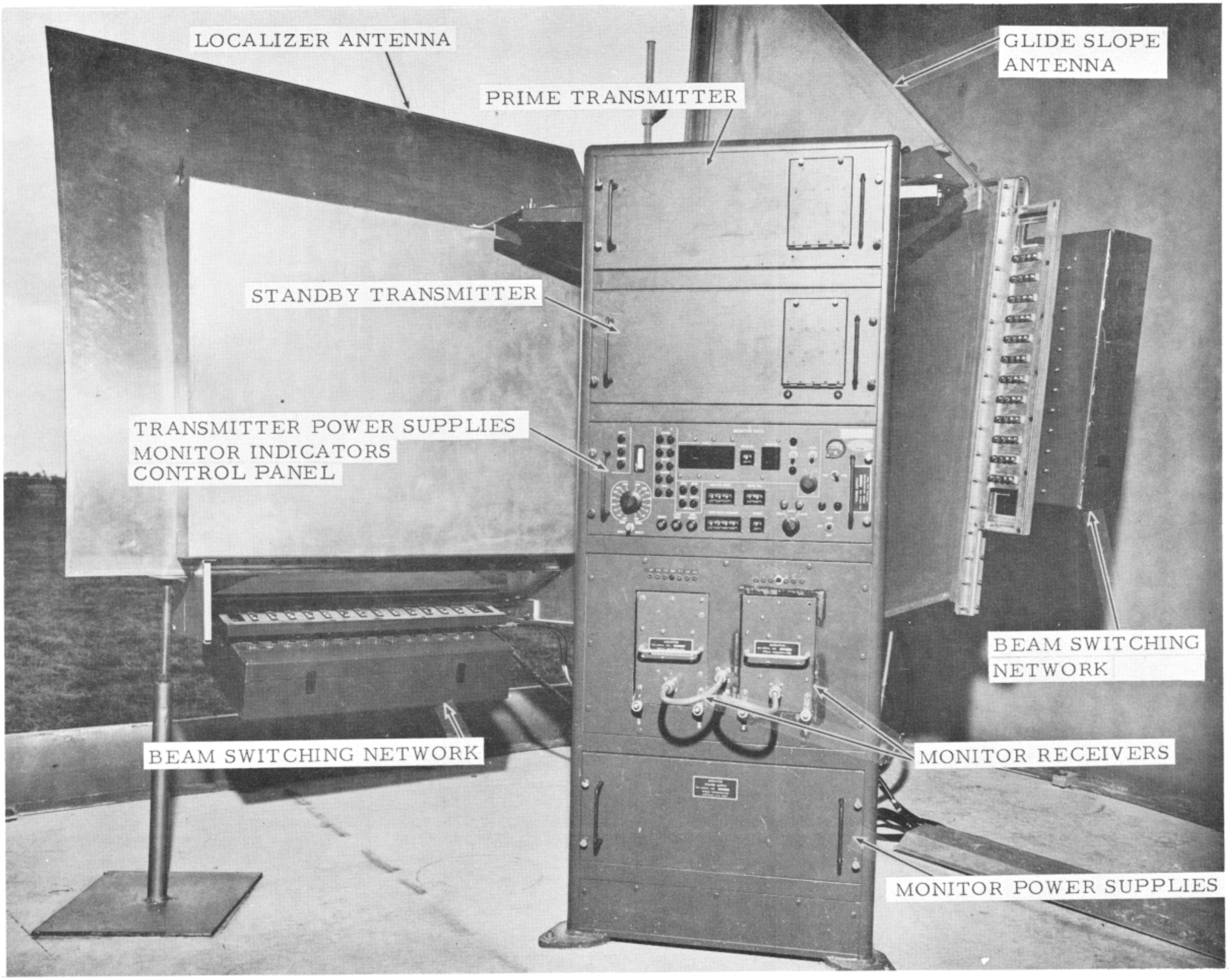


FIGURE 9. MODILS GROUND STATION

The localizer monitor antennas are located 40 feet in front of the building. The localizer is monitored at five separate azimuths.

The glide slope monitor antennas are mounted on a 25-foot pole, 100 feet in front of the transmitter. Six different elevation angles are monitored.

The transmitter operates on a time-share basis, about 40 times per second, between the localizer, glide slope and DME. At the start of a time sequence, a synchronizing signal is transmitted to synchronize a clock in the airborne receiver with a clock on the ground transmitter. In sequence, the ground transmitter transmits 13 separate glide slope beams which step across the localizer horizontal range of $\pm 30°$, and 11 separate glide slope beams which step through the vertical range of 3° to 12° of elevation.

The airborne receiver measures the time of arrival of the strongest beam switching across the airplane and interprets this as a localizer or glide slope angle. The interrogator in the airborne equipment interrogates the ground station for DME information.

The pilot's control box has a three-digit identification number showing which station he is receiving. He may select any one of four localizer courses, as predetermined for a project flight. These courses are centerline, 5.4°, 4.0°, or 2.4° skewed to the left. The skew could be left or right for a field installation.

The operator may select the desired glide slope angle with thumbwheel switches to the nearest tenth degree. He may select the sensitivity of his localizer CDI from full scale, $\pm 2°$ to $\pm 10°$, and the sensitivity of his glide slope CDI from full scale, $\pm .5°$ to $\pm 4°$. These controls are all "onboard" the aircraft.

Usage of TALAR and MODILS. The TALAR, being easily portable, was placed on the centerline for centerline approach guidance and tests of various GPI in relation to the target touchdown zone. The MODILS, having a greater flexibility of glide path angle and cross pointer sensitivity, was used to find a practical CDI sensitivity and for investigation of various glide slope angles. It was placed on the side of the runway for skewed approach guidance.

When the tests came to the portion requiring the localizer being separately located from the glide slope, both systems were used. The MODILS was used for the glide slope portion of the signal and the TALAR was located at the far end of the field to serve as a localizer. In the airplane, the appropriate receiver was connected to the proper instrument crosspointer to give the pilot guidance.

The TALAR was located at the far end of the field at the point which would correspond to the glide slope transmitter location for the opposite direction approach. This gave an approach which was not directly on centerline (the skew was 5.4° for 7.5° glide slope), but it was felt that this configuration would allow the most utilization from the least amount of equipment.

Interim Microwave Landing System (MLS) Specifications for TALAR. (Reference FAA-RD-72-15, dated April 1972)

1. Glide Slope: Full scale = ±150 μA = ±2.86° ±0.6°. Installation and alignment tolerance includes course shifts, nominal ±0.3°, (nominal 6.0°, actual tested 6.13°) (nominal 7.5°, actual tested 7.67°).

The Glide Slope Structure was ±5 μA. The structure about bias was ±5 μA (combined noise, beam bends and receiver errors).

2. Localizer: Full scale = ±150 μA = ±4.7° ±0.8°. Installation and alignment tolerance were none, any errors could be eliminated by adjustment of the ground transmitter alignment.

Localizer structure was ± 15 μA. The structure about bias was ±15 μA.

TALAR MLS met the required installation tolerances as per initial FAA specifications.

Interim MLS Specification for MODILS. (Reference FAA-RD-72-4, dated May 1972)

1. Glide Slope: Full scale = ±150 μA = ±2°, variable to ±5°. Installation and alignment tolerance were none, any errors could be eliminated by adjustment of the ground transmitter antenna alignment.

Glide Slope Structure (installation tolerance) was less than ±5° structure about bias (combined noise, beam bends and receiver errors).

2. Localizer: Full scale = ±150 μA = ±1° to ±4° variable. Installation and alignment tolerance, none.

Localizer structure ±0.5° displacement, less than ±0.275°, combine installation and signal error about the bias. (Bias is installor error) MODILS installation met the required installation tolerances as per initial FAA specifications.

Airborne Instrumentation. The following parameters were recorded on the airborne recorder in the aircraft (Figure 10):

1. Signal received by TALAR receivers 1 and 2.
2. Signal received by MODILS receivers 1 and 2.
3. Landing gear touchdown time.
4. Voice channel (all channels were time-correlated with real time).
5. Sperry Flight Director System.

Ground Instrumentation. There was a temporary ground weather observation station adjacent to and 100 feet off the runway at the touchdown zone and at 6-feet elevation. This station made observations just prior to each landing run and recorded:

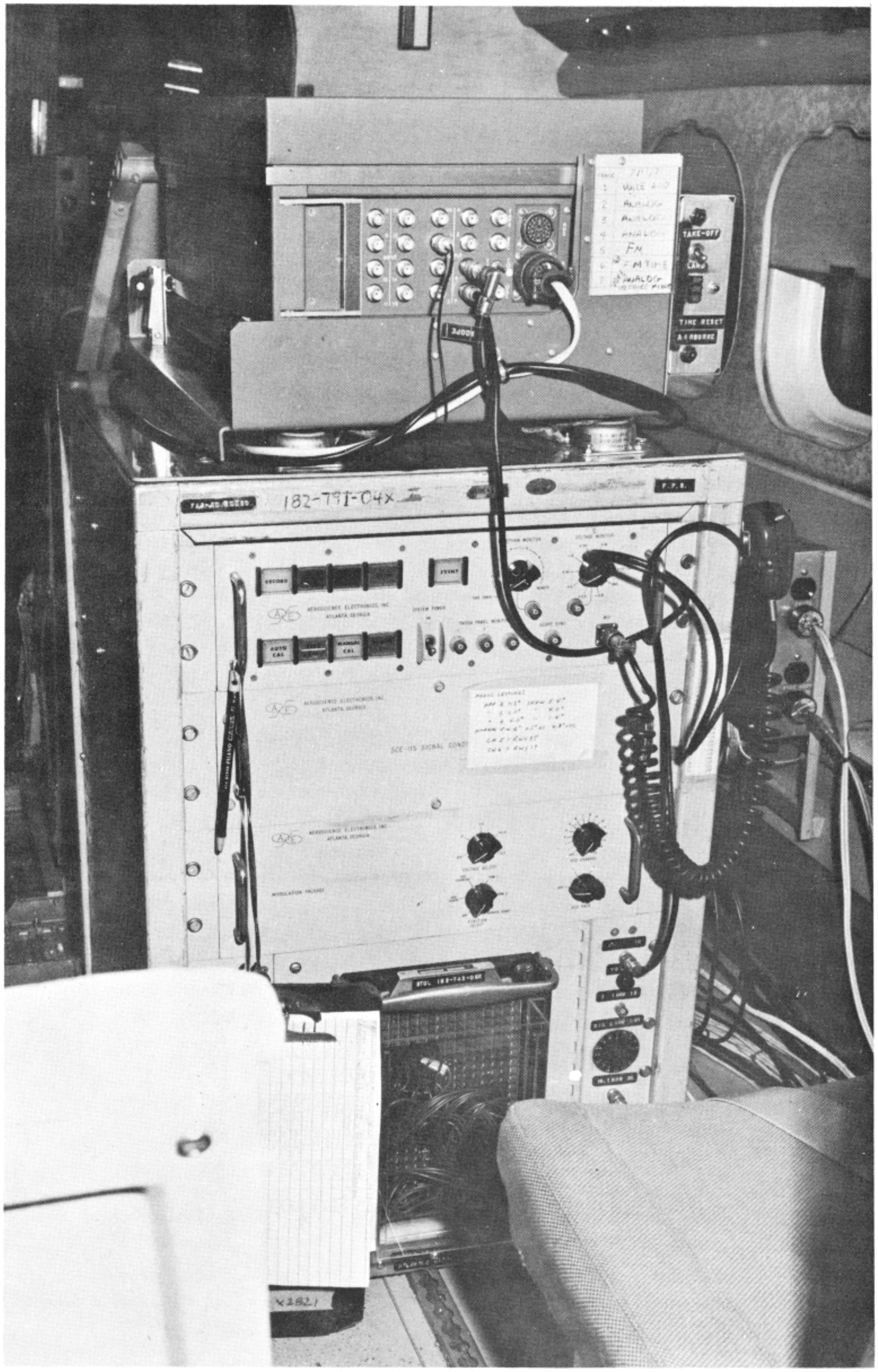


FIGURE 10. AIRBORNE RECORDER INSTRUMENTATION

1. Ambient temperature.
2. Ambient pressure.
3. Surface wind velocity.
4. Surface wind direction.
5. Upper airs to 3,000 feet by dispatching a weather balloon once per hour; or as required due to wind shift.

Theodolites. The aircraft position in space and on the runway throughout the takeoff, and from turning base to touchdown, rollout and stop was determined by use of the NAFEC theodolites. Actual aircraft position was compared to desired position for flight evaluation. The theodolite accuracy was ±1 foot at touchdown.

Other Instrumentation. The aircraft was equipped with normal communications, Very High Frequency Omnirange Section (VOR), ILS, Automatic Direction Finder (ADF) and beacon equipment (Figures 11, 12, and 13).

A switching arrangement was provided to substitute one TALAR or one MODILS receiver for the aircraft's conventional ILS equipment. This meant that the test receiver in the cockpit could drive the pilot's instruments, including the flight director, for an instrument approach to a runway equipped with TALAR or MODILS/MLS transmitter. The guidance signals from the test receivers, the time of day, the MODILS distance information, and accelerometer signals and signal strength measurements were recorded on tape in the aircraft for later analysis.

Flight Director. The Sperry Flight Director System was selected because of low cost and its availability at the time it was needed for this program. The flight director is a three axis reference system that utilizes the VOR-localizer and glide slope data furnished by standard navigation receivers; altitude data are received from an altitude control sensor; heading data from the directional gyro; and attitude data from the vertical gyro. Using this information, the system computes steering commands which are displayed on the pitch and roll flight director command bars (on the instrument display) to guide the aircraft along a selected flight path for navigation or for landing approach. The flight director system was used to evaluate pilot flight performance, both with this system, and a raw data display.

DISCUSSION

PRELIMINARY TEST WORK (PHASE I).

Prior to starting the active flight test program, the following work had to be accomplished:

1. Installation of airborne instrumentation and special receivers to accept the microwave steep-slope guidance transmission.

2. Flight checkout and calibration of the above equipment.

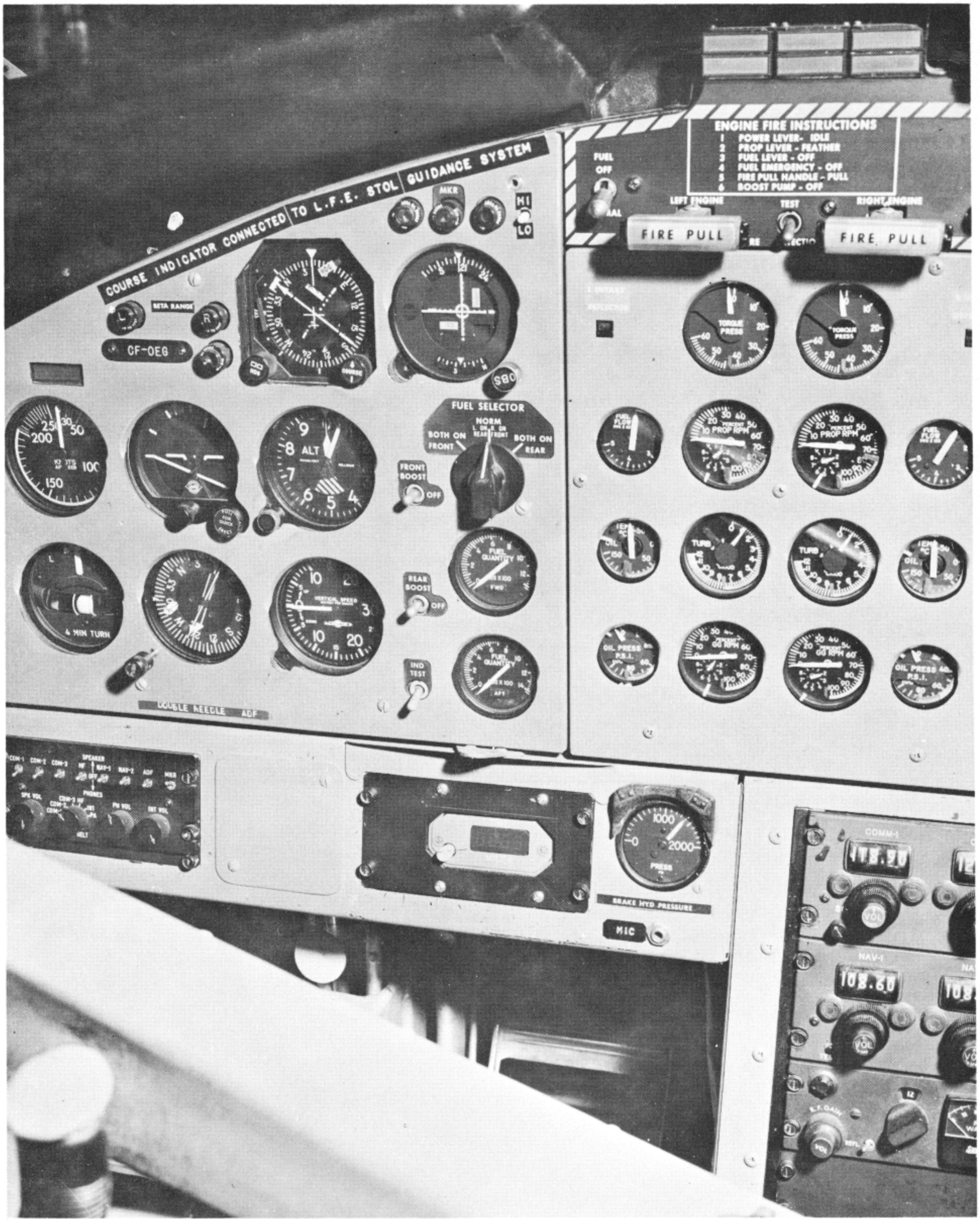


FIGURE 11. TWIN OTTER - STANDARD INSTRUMENT PANEL

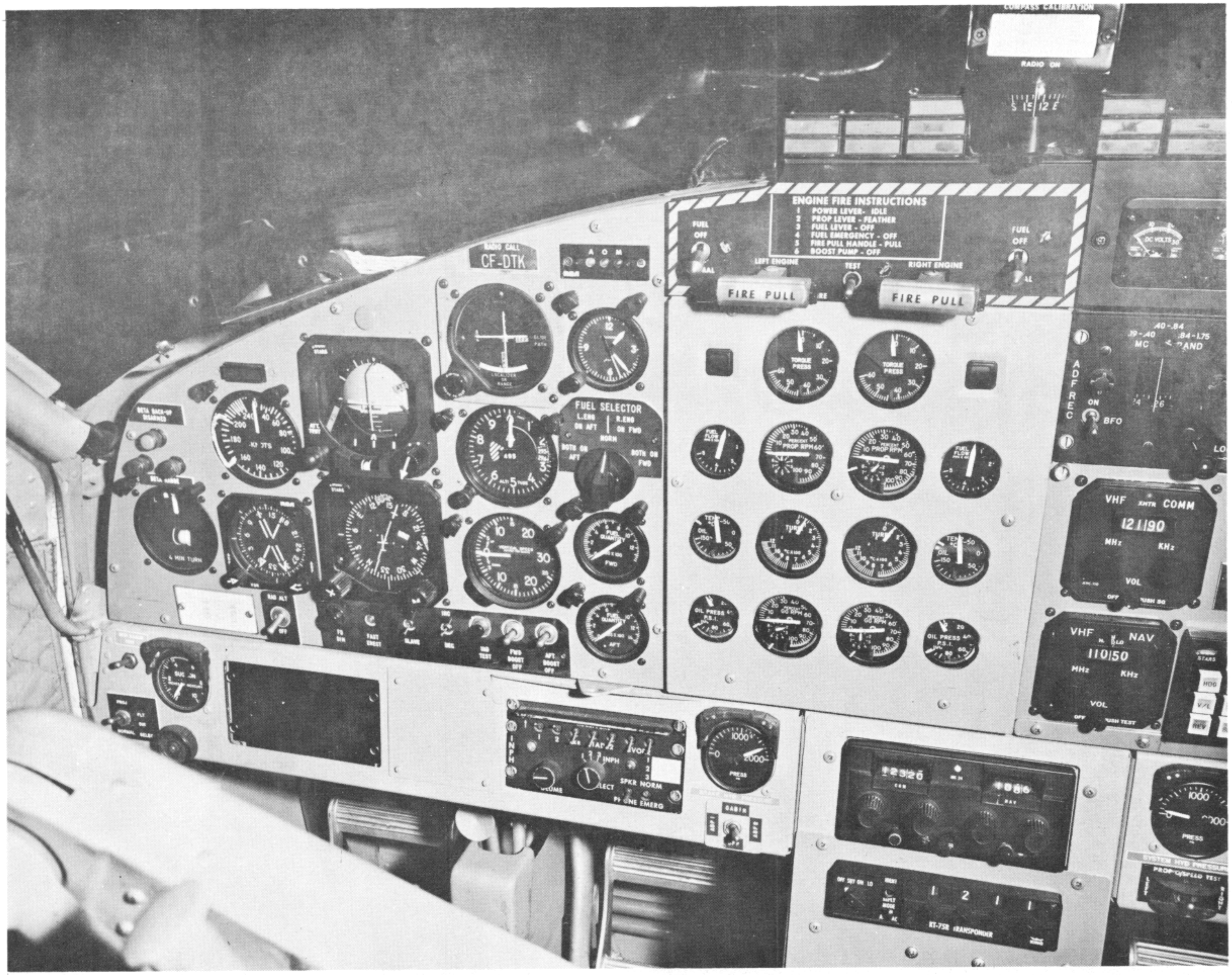


FIGURE 12. TWIN OTTER WITH FLIGHT DIRECTOR PANEL - PILOT SIDE

FIGURE 13. CO-PILOT PANEL SHOWING FLIGHT DIRECTOR CONTROL

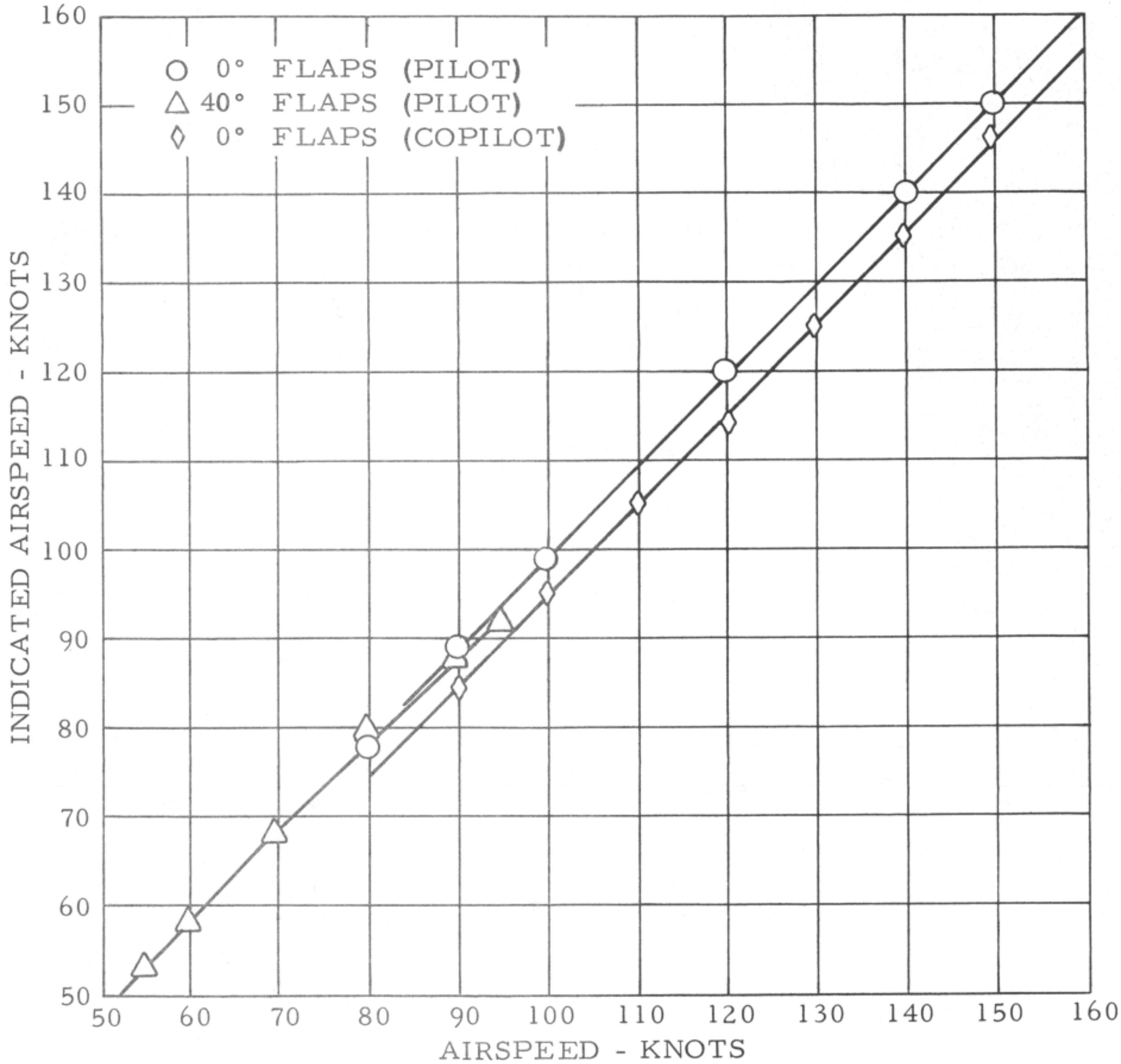


FIGURE 14. TWIN OTTER AIRSPEED CALIBRATION - LEVEL FLIGHT

3. Airspeed system calibration of Twin Otter in clean configuration and with flaps extended. See Figure 14. (NOTE: The system checked out to be within 1 knot on the pilots instrument.)

4. Crosswind flights in excess of 15 knots were flown by many of the subject pilots for evaluation of aircraft controllability only. Maximum crosswind used during data runs was 15 knots.

5. Determination of the Twin Otter rate of sink at various configurations. (See Table 1).

TABLE 1. TWIN OTTER RATE OF SINK AT 75 KNOTS
(Sea Level)

Rate of Sink "0" Thrust (5-psi torque)	865 feet/min
One Engine Idle, One Feathered	1005 feet/min
Both Engines Idle	1405 feet/min

6. Contract for installation of a flight director system, FAA certification, and conduct final acceptance tests on the installation. This system had not previously been installed in a Twin Otter and, therefore, required complete design of installation and certification. For these tests it was required that the flight director be capable of handling up to 9.5° glide slopes for the flight director phase development work.

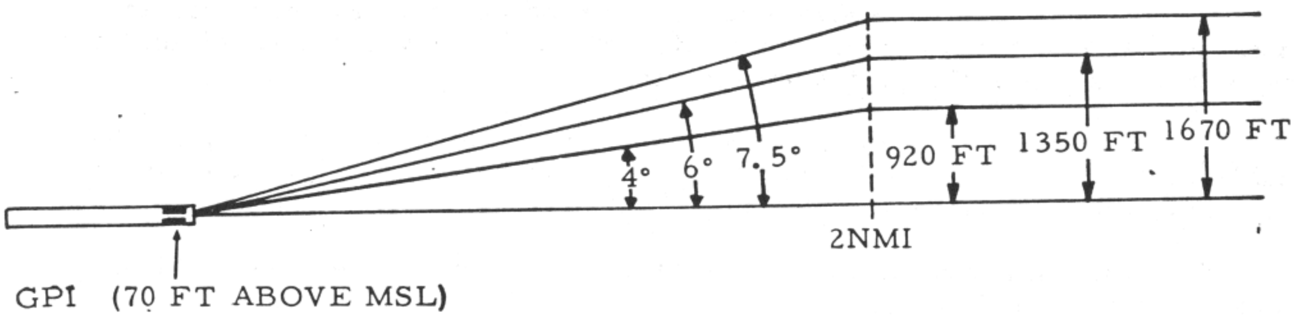
7. Flight checkout for 15 FAA subject pilots from operations and flight test engineering and to familiarize the 12 commuter airline pilots that participated in the flight phase of the program with the project and the test objectives.

8. Prior to the statistical data runs, preliminary runs with five subject pilots on 5.5°, 6.5°, 7.5°, and 8.5° glide slopes evaluated three sensitivity settings. The sensitivity settings (beam widths) determined to be most desirable considering variable turbulence encountered in normal operations were noted by the pilots, and were further evaluated using 4°, 6°, and 7.5° glide slopes, prior to Test V.

TEST PROCEDURES (PHASE II).

Approaches were made VFR, IFR, day and night. All IFR flights were simulated with hood in place. The aircraft was flown at three pattern altitudes to intercept the localizer at approximately 3 nautical miles (nmi) from target touchdown during approach.

FLIGHT ALTITUDE PRIOR TO GLIDE SLOPE INTERCEPT



On intercepting the glide slope (approximately 2 nmi), full flaps were selected and approach speed of 1.3 V_{so} maintained (75-knots Calibrated Airspeed (CAS) at 11,500 pounds) and the landing configuration continued until the Decision Height (DH) of 200 feet or 100 feet was reached. The DH was determined from a randomized run schedule. The selected approach speed was maintained throughout each approach and is based on 1.3 V_{so} for the aircraft weight at time of the test.

At DH, the hood was removed, and the flight engineer called for a missed approach or for continuation of the flight to landing. The flight engineer also called out stopping methods as per flight schedule. The aircraft pilot then aligned the aircraft to touchdown in the 200-foot TDZ white-marked area as near the start of the markings as possible.

Precision visual guidance was provided by VASI as required during some tests, and was employed to achieve the same aiming touchdown point. On all visual approaches, the same general criteria were applied.

The maximum allowable crosswind for landings was 15 knots. Landings were made with up to a 5-knot tailwind component, because this condition could occur during a reported "light to variable" wind condition. Any higher tailwind component was not acceptable.

From previous experience gained on the steep glide slopes, the following intercept altitudes were established for the specific glide slope angles in Table 2.

TABLE 2. LOCALIZER INTERCEPT ALTITUDES AND RANGE

Aircraft Intercept Altitude*	Range	Elevation	Skew Angle When Offset	Glide Slope
920 feet	12,160 feet	850 feet	2.4°	4°
1,350 feet	12,160 feet	1,280 feet	4.0°	6°
1,650 feet	12,160 feet	1,600 feet	5.4°	7.5°

*Field elevation + 70 feet

The above skew angles were established to cause the aircraft to breakout and make visual contact 500 feet or 4 seconds before intercept of runway centerline extended. This required the pilot to make only one heading correction to align himself with the runway and thus avoid an "S" turn. Approximately the same number of skewed approaches were flown as centerline approaches.

Ten of the subject pilots were engineering test pilots, five were operations pilots, and 12 pilots offered their services from commuter airlines.

DATA COLLECTION FLIGHTS. Over 800 takeoffs, approaches, and landings were accomplished to provide the sample size necessary for a reasonable confidence level for the data distribution, distributed over the following tests:

TEST I - Determination of Glide Slope and Localizer Sensitivities (Beam Widths).

The following sensitivities were evaluated during 36 approaches by five pilots in preliminary tests to reduce the number of possible beam settings prior to the statistical data gathering:

Glide Slope Angle	5.5° and 6.5°	7.5°	8.5°
Glide Slope Width	±0.8°, ±1.3°, ±2°	±1.3°, ±2°	±1.3°, ±2°
Localizer Width	±2.5°, ±4.8°, ±7.5°	±2.5°, ±4.8°	±2.5°, ±4.8°

Based on the above flights, no significant trend was obtained from the data confirming the adaptability of the pilots. Pilot opinion from a workload point of view suggested that a glide slope width of ±1.3° for the lower glide slope angles and ±2° for steeper approach paths would be acceptable. A localizer width of ±4.8° appeared to be an acceptable sensitivity for the range of glide slopes flown. The 8.5° glide slope was determined to be too steep for this class of aircraft using a 200-foot decision height (DH). The pilotage task was concluded to be limiting on a 5.5° glide slope with a 100-foot DH.

To finalize the conclusions determined from the above test runs, in order to finalize the approach guidance angles and sensitivities for the statistical data runs, each of the five pilots flew two additional approaches using the following settings:

Glide Slope Angle	4°	6°	7.5°
Glide Slope Width	±1.3°	±2.0°	±2.0°
Localizer Width	±4.8°	±4.8°	±4.8°

From a pilot workload standpoint, it was concluded that the above angles and sensitivities could be used in the rest of the test program.

TEST II - Determination of the Optimum Glide Slope Ground Point of Intercept (GPI) Location Relative to the TTZ to Minimize Touchdown Dispersion. Using the beginning of the 20- by 200-foot painted touchdown markings as a zero reference point. The runway intercept was evaluated at four additional locations short of the TTZ. The glide slope was established at 7.5° with a 200-foot DH, and each of the five subject pilots flew four approaches at each intercept position for total of 100 runs. The following touchdown data resulted from the various GPI location:

GPI Location from TTZ	Average Touchdown Point
0 Feet (Beginning of TTZ)	110 feet Inside TTZ
100 feet short of TTZ	75 feet inside TTZ
200 feet short of TTZ	20 feet inside TTZ
300 feet short of TTZ	-50 feet short of TTP
400 feet short of TTZ	-50 feet short of TTP, (with greater touchdown scatter)

TEST III - Co-located Glide Slope and Localizer. The objective of this test was to determine, with glide slope and localizer transmitters co-located, the maximum as well as the most desirable glide slope approach angles with a DH of 200 feet and 100 feet.

For a 200-foot DH (day)

- 10 runs (2 runs/subject) GS-8.5°
- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°

For a 100-foot DH (day)

- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°
- 10 runs (2 runs/subject) GS-5.5°

For a 200-foot DH (night)

- 10 runs (2 runs/subject) GS-8.5°
- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°

For a 100-foot DH (night)

- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°
- 10 runs (2 runs/subject) GS-5.5°

TOTAL RUNS 120

TEST IV - Split Glide Slope and Localizer.

For a 200-foot DH (day)

- 10 runs (2 runs/subject) GS-8.5°
- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°

For a 100-foot DH (day)

- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°
- 10 runs (2 runs/subject) GS-5.5°

For a 200-foot DH (night)

- 10 runs (2 runs/subject) GS-8.5°
- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°

For a 100-foot DH (night)

- 10 runs (2 runs/subject) GS-7.5°
- 10 runs (2 runs/subject) GS-6.5°
- 10 runs (2 runs/subject) GS-5.5°

TOTAL RUNS 120

TEST V. This test combined all of the variables to determine their effect on pilot performance. Runs were accomplished using the glide slope and localizer, ground point of intercept, skew angle, etc., that were established in previous tests. These tests were to determine the effects of the operational viability of a flight director, and determine the operational feasibility of the above mentioned variabilities during day/night and VFR/IFR operations.

Co-located glide slope and localizer skewed guidance.

- 40 runs VFR day
- 40 runs VFR night
- 40 runs IFR day with flight director
- 40 runs IFR night with flight director
- 40 runs IFR day without flight director
- 40 runs IFR night without flight director

Split glide slope and localizer (centerline guidance).

- 40 runs IFR day with flight director
- 40 runs IFR night with flight director
- 40 runs IFR day without flight director
- 40 runs IFR night without flight director
- 30 runs missed approach
- 10 runs missed approach one engine out

Takeoffs - straight ahead.

- 30 runs IFR day
- 30 runs IFR night
- 20 runs one engine out at liftoff (day)

Takeoffs - turning.

- 30 runs IFR day
- 30 runs IFR night
- 20 runs one engine out at liftoff (day)

TOTAL RUNS 440

NOTE: See Appendix A for randomized schedule.

ANALYSIS AND RESULTS

GLIDE SLOPE AND LOCALIZER SENSITIVITY (BEAM WIDTH).

Several beam widths were test flown at each glide slope angle. It was assumed that the optimum width would vary with the angle being flown. A standard ILS glide slope of approximately 2.5° would have a width of ±0.7°. As the glide slope angle is increased, the horizontal distance to fly through the glide slope on approach is reduced, because, as the glide slope angle is increased, the glide slope is intercepted closer to the transmitter making the distance to the runway less from a given glide slope intercept height. For example, the distance to traverse through a 7.5° glide slope at the point of intercept is 1/8 the distance of a standard 2.5°glide slope at its point of intercept for the same beam. For these reasons, tests at 4° were conducted at beam widths of ±0.8°, ±1.3°, ±2.0°, and the 6° and 7.5° slopes were evaluated with a beam width of ±1.3° and ±2.0°.

The localizer beam width required evaluation in generally the same manner. The ILS localizer beam width is normally ± 2.0°; however, it is located beyond the upwind end of the runway opposite the approach end - approximately 2 nmi from the Category I, 200-foot breakout point. Therefore, the sensitivity is still acceptable because of the distance from the transmitter. Because of the possible need for co-location of guidance for STOL, the glide slope and localizer were co-located approximately 1/4 nmi from breakout on the 7.5° slope. The width of a standard ILS, (±2.0°) at a 200-foot decision height is approximately eight times the width of a MLS. Therefore, localizer beam widths of ±2.0°, ±4.8° and ±7.5° were evaluated.

The lateral deviations, see Table 3, did not indicate a trend, therefore, to provide a beam that was not too sensitive at breakout, the localizer width was set at ± 4.8°. At this sensitivity, the beam is overly wide and insensitive at 4 or 5 nmi out, but can be tolerated. The preference of one sensitivity over another was not overwhelmingly obvious, and the pilot performance did not vary greatly as this sensitivity was changed, nor could he detect minor changes in width. This could indicate the desirability of a constant beam width for STOL.

If the installation could permit a split location for the glide slope and localizer, and if the localizer transmitter could be located further from the breakout point, then a narrower beam could be considered as an improvement. Beam sensitivities become evident when a narrow beam is flown in moderate turbulence. A constant beam width, then, would have to be the narrow limit still capable of being flown in turbulence.

TABLE 3. SENSITIVITY MEASUREMENTS
(Standard Deviation ±1σ in degrees)

GLIDE SLOPE 6 DEGREES
Localizer Width Set at ±4.8°

Glide Slope Beam Width ± 2.0°		Glide Slope Beam Width ±1.3°		Glide Slope Beam Width ±0.8°	
Localizer	Glide Slope	Localizer	Glide Slope	Localizer	Glide Slope
1.14	0.14	0.85	0.16	0.49	0.19
0.76	0.15	1.03	0.20	0.50	0.16
0.40	0.13	0.44	0.12	0.63	0.29
0.59	0.27	0.56	0.30	0.83	0.53
0.41	0.72	0.49	0.29	0.63	0.58
0.50	0.13	0.45	0.13	0.62	0.09
0.62	0.11	0.30	0.15	0.56	0.10
		0.34	0.15	0.98	0.17
		0.62	0.18		
		0.66	0.19		
		0.75	0.19		
Summary:					
0.63	0.24	0.59	0.19	0.66	0.26

Using the above listed standard deviations from glide path as a measure of sensitivity, no difference is evident for the three beam width settings in glide slope performance. Therefore, using pilot opinion, the sensitivities of ± 4.8° for localizer, and ± 2.0° for glide slope were selected for use at 6° and 7.5° glide slope; for 4.0° glide slope the sensitivity selected was ±1.3° glide slope, and ±4.8° for localizer. (Figures 15, 16, and 17).

MEASURING DATA SPREAD. Sigma (σ) is the notation used to designate a measure of dispersion of data called standard deviation. This value and multiples of this value can be used to describe the spread of data within specified limits under specified conditions.

With the assumption that the unimodal symmetrical bell-shaped distributions of data obtained in this study approximate the classical "Gaussian" or normal distribution, the following multiples of standard deviations describe the percent of data within their limits:

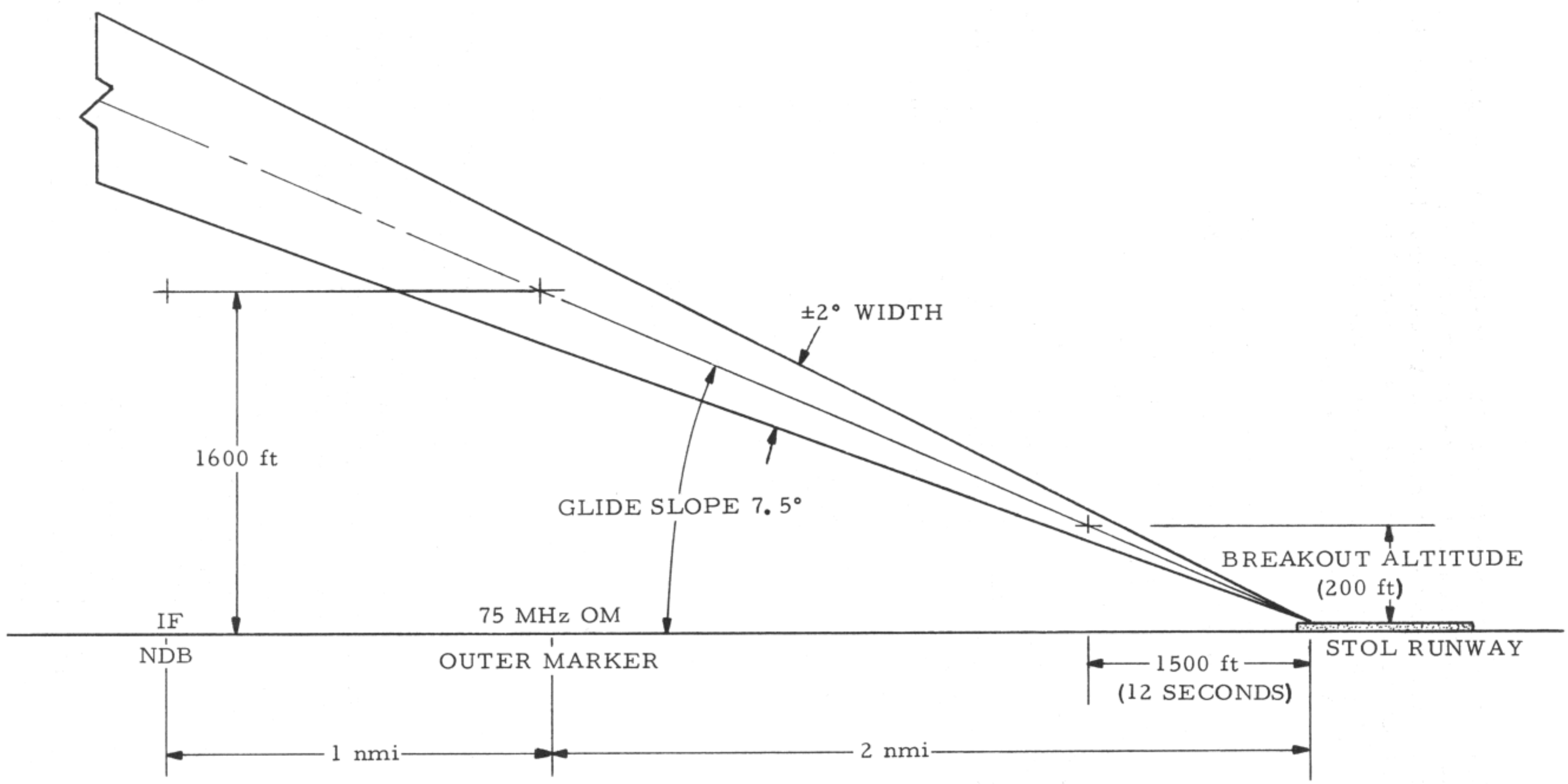


FIGURE 15. LAYOUT OF MICROWAVE LANDING SYSTEM SHOWING GLIDE SLOPE BEAM WIDTH

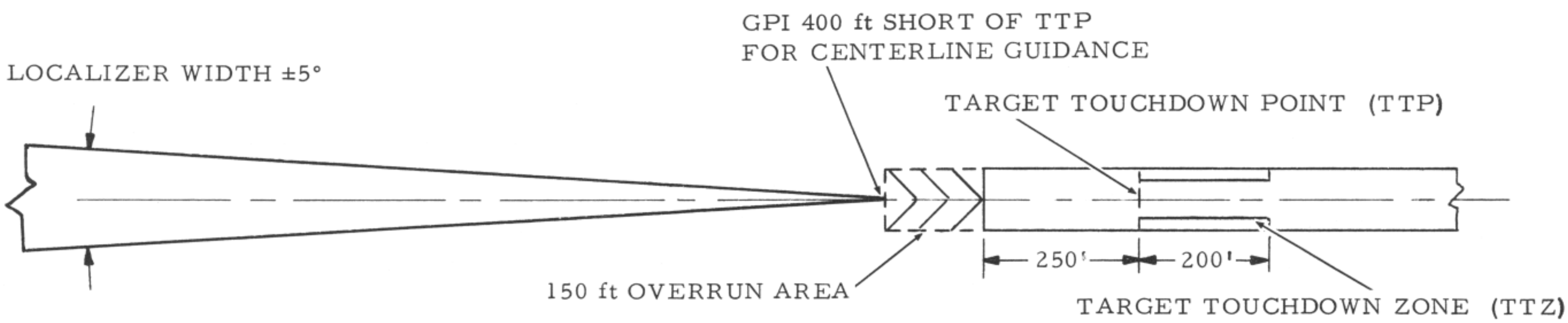


FIGURE 16. MLS FOR CENTER APPROACH SHOWING LOCALIZER BEAM WIDTH

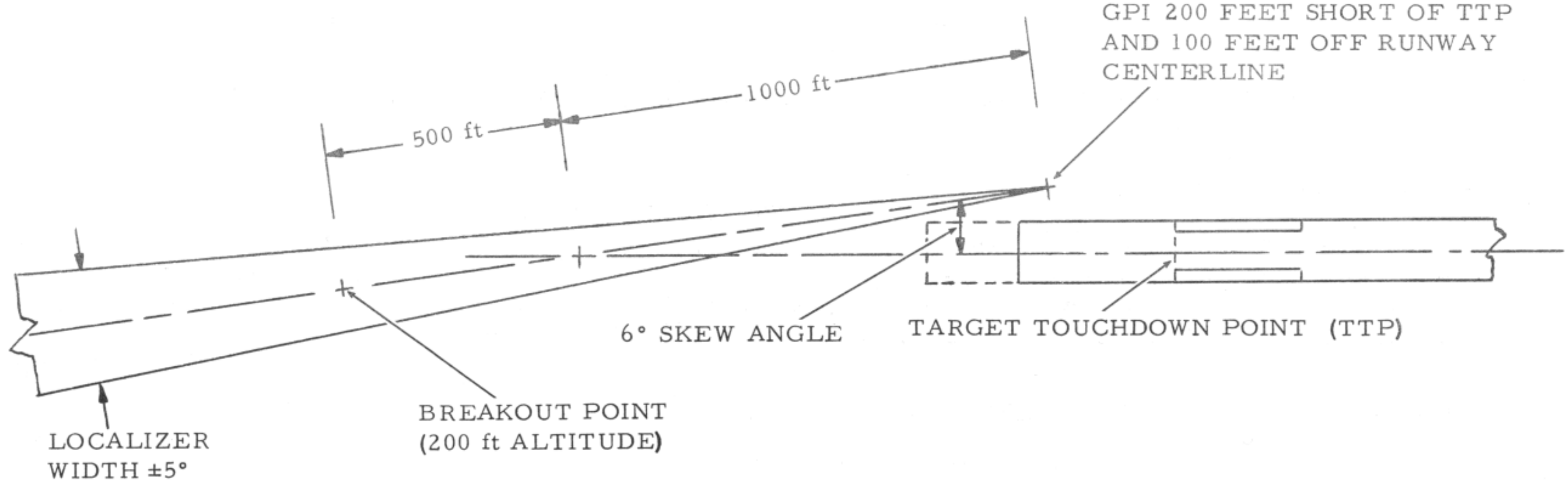


FIGURE 17. MLS FOR SKEWED APPROACH SHOWING LOCALIZER BEAM WIDTH

mean ($\bar{x}$)	Percent of data within limits
± 1	68.27
± 2	95.45
± 3	99.73
± 4.42	99.999

GROUND POINT OF INTERCEPT (GPI).

In a city-center STOLport, it is expected that runway length will be at a premium. With these short runways the problem arises how to get the pilot to land on the early part of the runway, thus providing maximum runway for deceleration and yet not land so short as to invite an undershoot. The objective of this test was to determine the optimum GPI location on the runway.

In earlier STOL approach tests, the GPI was located at the TTP or "0" position. It was found that after passing the 200-foot DH, an undesirable "duck under" procedure was necessary to prevent overshooting the TTP. On this current project, tests were therefore run to examine this duck under, by moving the GPI away from and short of TTP. Each subject pilot flew four approaches with the GPI at the five different locations with the resulting touchdown position indicated below in Table 4.

TABLE 4. GPI LOCATIONS VERSUS AVERAGE TOUCHDOWN POSITION

GPI Location from Aiming Mark		Average Touchdown Position
0 feet	(at beginning of TTZ)	110 feet (Inside TTZ)
100 feet	(short of TTP)	75 feet " " "
200 feet	" " "	20 feet " " "
300 feet	" " "	-50 feet " " "
400 feet	" " "	-50 feet with greater touchdown scatter

Approximately 20 runs were made with the GPI located at "0" position, or TTP which is at the start of the 20- by 200-foot TTP aiming marks, and at 100 feet, 200 feet, 300 feet, and 400 feet short of the TTP. All approaches were made at 1.3 V_{SO} for the specific weight of the aircraft at the time of the test. The approach speeds and gross weight of the aircraft were very closely monitored in an attempt to keep the variations to a minimum. DH was maintained at 200 feet.

It appears that the GPI located more than 200 feet short of the TTP causes a flat or "drag in" final approach, and, therefore, is more difficult for the pilot to determine his exact touchdown position. This was confirmed by a greater scatter of touchdowns when the GPI was 300 to 400 feet short of TTP. The GPI at the start of the aiming touchdown marks (TTP) does not provide time to prepare for a flare, and the overshoot condition usually prevailed, thus using up more runway to the final stopping point. The GPI located 200 feet short of the TTP aiming marks is the best, both from performance and from pilot opinion.

LOCALIZER INTERCEPT.

During the flight tests, the safety pilot (project pilot) simulated an Air Traffic Control (ATC) type approach by vectoring the subject pilots into a position for a 45° initial localizer intercept. This varied from 3 to 3.5 nmi from the STOL runway to simulate the actual variances that could be normal under average approach conditions. The pilot would then capture the localizer and proceed to the glide slope and to the STOL runway. The decision height being either 100 feet or 200 feet depending on the test plan.

TRANSITIONAL GUIDANCE.

It is difficult to appraise the need for transitional navigation guidance since, in these tests, the pilots did not have the apprehensions of being off course, over dangerous terrain, and in marginal weather operations. However, it was the pilot's opinion that a Nondirectional Beacon (NDB) was necessary at the initial localizer intercept to assist in acquiring the localizer; and a 75 MHz, ILS outer marker for a final check before descending.

In order to expedite the approach, the distances on the localizer and glide slope have been kept to a minimum. This tight procedure requires adequate navigation aids to provide these distances and allow for a precise approach. The NBD and outer marker will fill this need. DME is also highly desirable and may be necessary in some terminal areas, but is not a requirement for the final approaches simulated during this project. Where NBDs are not available, DME is essential.

The point of glide slope intercept was located during these tests 2 nmi from the glide slope transmitter, and the initial localizer intercept, 3 nmi. This provides approximately the same time as with CTOL, since the STOL is approaching at approximately one-half the CTOL speed.

During earlier 1969-1970 tests, these distances had been varied for pilot evaluation with the conclusion that 2 and 3 nmi, respectively, were adequate, if not slightly conservative; however, operational experience will be needed before shortening can be considered.

GLIDE SLOPE ANGLE - DECISION HEIGHT

The glide slope angle and DH are closely related. If the glide slope angle is steep, the vertical speed at breakout is high. Under these conditions, a low DH may not provide the pilot with sufficient time to arrest the rate of descent. On the other hand, if the glide slope angle is shallow, the rate of decent is less, and a lower DH may be permissible. Not only is the time for arresting vertical descent important, but also time for adjusting to visual conditions and aligning the airplane for landing. (See Table 5.)

To determine the maximum glide slope angle, and minimum DH, tests were run for a 200-foot DH at 8.5°, 7.5°, and 6.5° glide slopes; and for a 100-foot DH at 7.5°, 6.5°, and 5.5°. Dispersion at touchdown and pilot opinion were recorded. The dispersion for the 200-foot DH shows no significant trend, thus, pilot opinion was used as the criterion.

It was concluded that with a raw data display and a 6° skew angle for the co-located guidance, a 7.5° glide slope would be the maximum approach angle acceptable for a 200-foot DH (Category I). Excessive vertical speed and limited time to touchdown were cited as reasons for eliminating the 8.5° approach angle. The use of a flight director did not alter these findings.

For a DH of 100 feet (Category II), the pilots felt that 6° and 7.5° glide slope angles were too steep, both for the time to arrest the vertical descent, and the time for adjusting to contact conditions for runway alignment. The pilots felt that consideration of reduced DH should await accrual of operating experience using the 200-foot value.

For the Twin Otter, 100 Series, 7.5° is a maximum for an additional reason. Considering rate of sink and aircraft response characteristics, an aircraft approaching on a glide slope should have the capability with power retarded, or other means, to execute a glide angle with a maneuvering margin of 2°. This margin is necessary for smartly maneuvering down to the glide slope from above without picking up excess speed. The Twin Otter - 100 Series-configuration barely meets this criteria. With a propeller feathered, this glide angle capability is 9.2°. This does not provide sufficient margin for day in, day out approaches. (The section MISSED APPROACH in this report contains data for altitude lost.)

The 7.5 slope is based on the assumption of no tailwind, and an improved one-engine-inoperative maneuvering margin. Tailwind has the net effect of increasing the glide slope angle. For example, a 15-knot tailwind increases the effective glide angle from 7.5° to approximately 8.5°, for a 75-knot approach speed. It thus increases the rate of decent and shortens the time from breakout to touchdown. Rate of descent is given in Table 5.

TABLE 5. GLIDE SLOPE ANGLES VERSUS SINK RATE, DECISION HEIGHT, AND TRANSITION TIME

Glide Slope Angle Degree	Sink Rate Feet/Min	100 DH Distance from GPI Feet	100 DH Time Sec	200 DH Distance from GPI Feet	200 DH Time Sec
4.0	532	1430	11.4	2860	22.8
5.5	727	1004	8.2	2008	16.5
6.0	793	945	7.5	1890	15.1
6.5	860	885	7.0	1770	14.0
7.5	993	762	6.0	1524	12.1
8.5	1123	670	5.4	1340	10.7
9.5	1256	595	4.8	1190	9.6

Above approach, sink rates and transition times are based on 75-knots CAS.

SKEWED APPROACH PATH.

A skewed approach for landing was found necessary to accommodate guidance equipment co-located at the side of the runway.

At first, the localizer beams were directed parallel to the runway centerline, but this necessitated an "S" turn by the aircraft to realign to the runway centerline from the DH, and was considered a marginal technique at best.

The skewed approach is designed so that at the DH, the aircraft is still 500 feet from the runway centerline intercept, providing 4 seconds for the pilot to make one turn to get aligned with the runway. Figures 18, 19 and 20 summarize the skew angle for each flown. The vertical and lateral deviations were generally the same for day or night, with or without a flight director.

The 5.4° skew angle was determined to be the maximum acceptable for a 7.5° glide slope allowing the extended centerline to be crossed after becoming contact. Higher DH might allow greater skew angles to be acceptable.

AIRSPEED FACTOR.

The approach speed of 1.3 V_{SO} was used for all of the approaches, since it is the speed currently required during the certification landing distance tests. The tests were started each day with full fuel and maximum gross weight of 11,579 pounds for a 100-Series Twin Otter, and, as fuel was consumed, the approach speeds were adjusted to the speed for that weight. These approach speeds started at 76 knots and varied to a low of 68 knots.

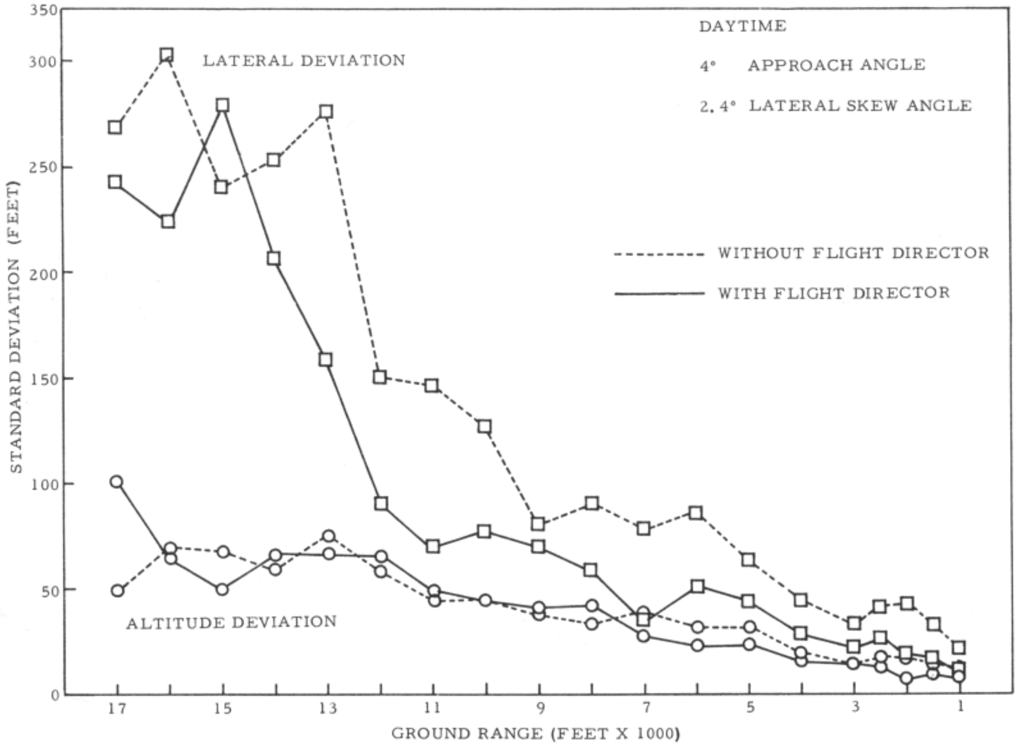
The pilot questionnaire asked the subject pilots their opinion on the adequacy of the 1.3 V_{SO} speed. All but one pilot, of a total of 24 subject pilots, thought the 1.3 V_{SO} speed was adequate for up to moderate turbulence. In smooth, calm air some pilots suggest a 1.2 V_{SO} speed might be adequate.

TOUCHDOWN VELOCITIES.

The investigation of the steeper glide slopes indicated a need to also investigate the touchdown velocities. The steeper slope required a more abrupt flare and therefore the possibility of a "harder" touchdown. Sixty touchdown velocities were evaluated (see Table 6). The maximum touchdown velocity noted from the 188 touchdowns evaluated was 4.34 feet per second.

TABLE 6. TOUCHDOWN VERTICAL VELOCITIES (FT/SEC)

Glide Slope Degree	Mean TD Vel Feet/Sec	Standard Deviation Feet/Sec	Observations
4	-2.5	1.6	17
6	-2.0	1.8	20
7.5	-2.6	2.7	23



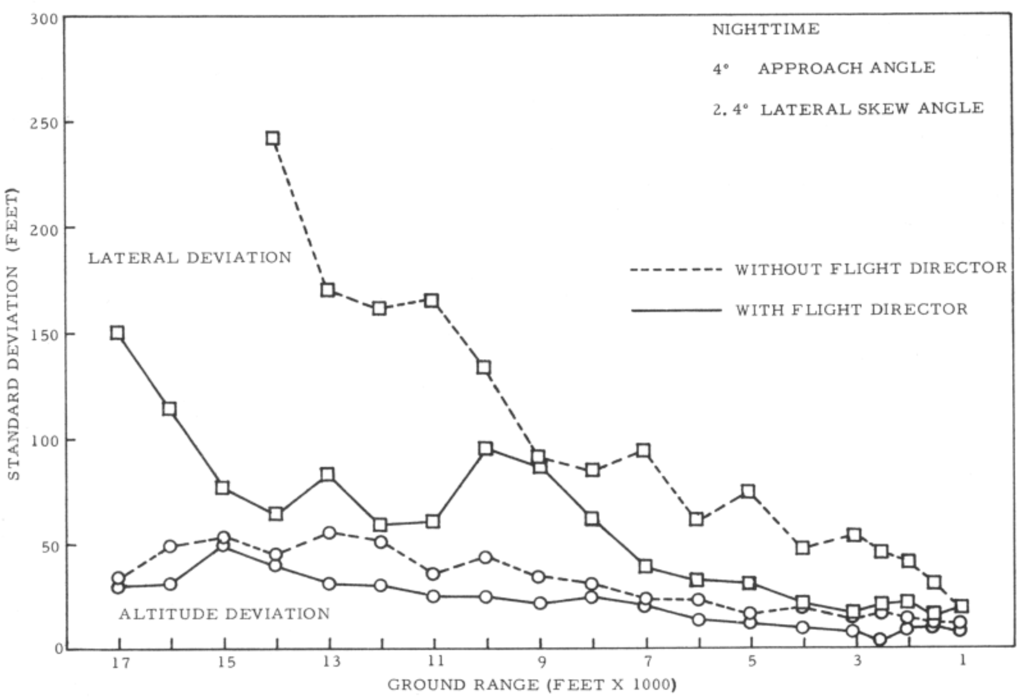
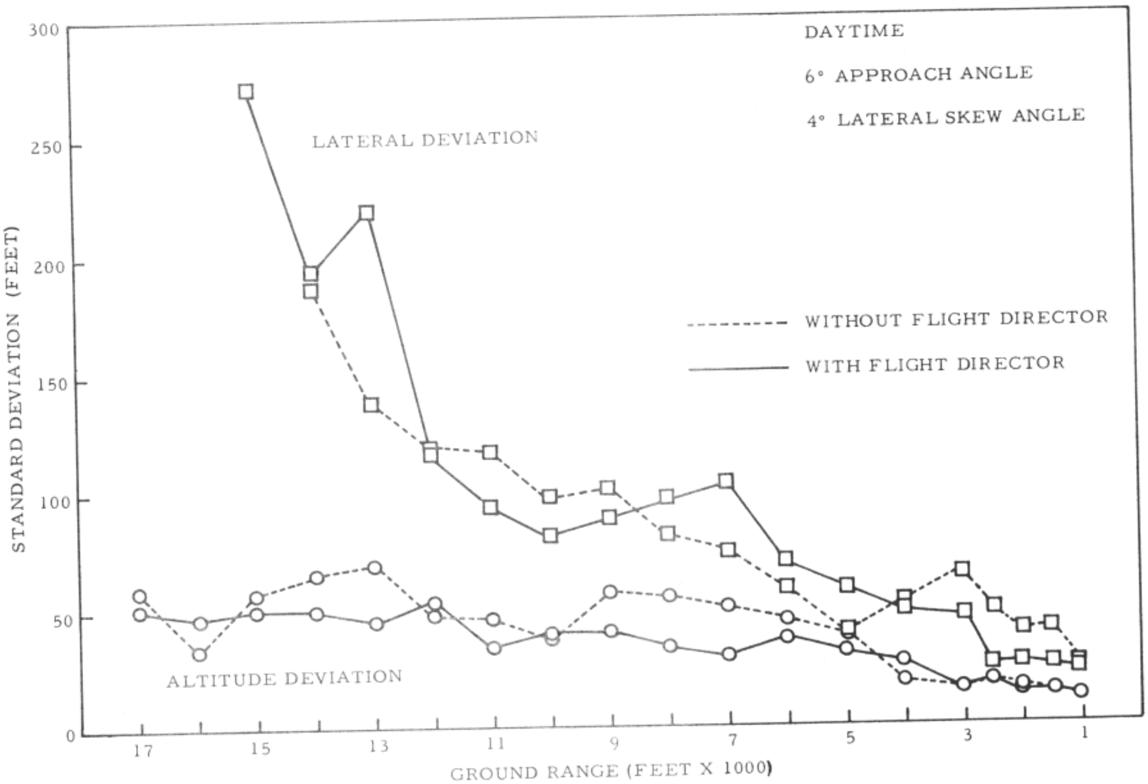


FIGURE 18. ALTITUDE DEVIATION FROM 4° GLIDE SLOPE, AND LATERAL DEVIATION FROM 2.4° SKEW, WITH/WITHOUT FLIGHT DIRECTOR



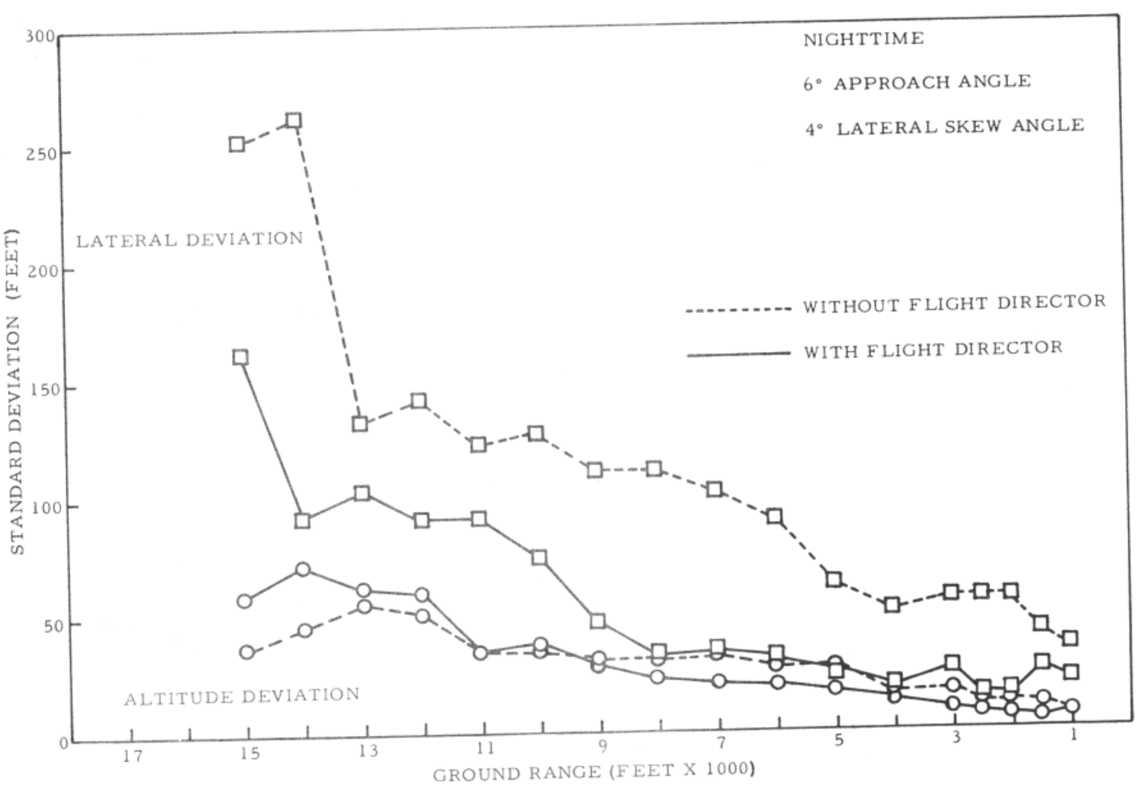


FIGURE 19. ALTITUDE DEVIATION FROM 6° GLIDE SLOPE, AND LATERAL DEVIATION FROM 4° SKEW, WITH/WITHOUT FLIGHT DIRECTOR

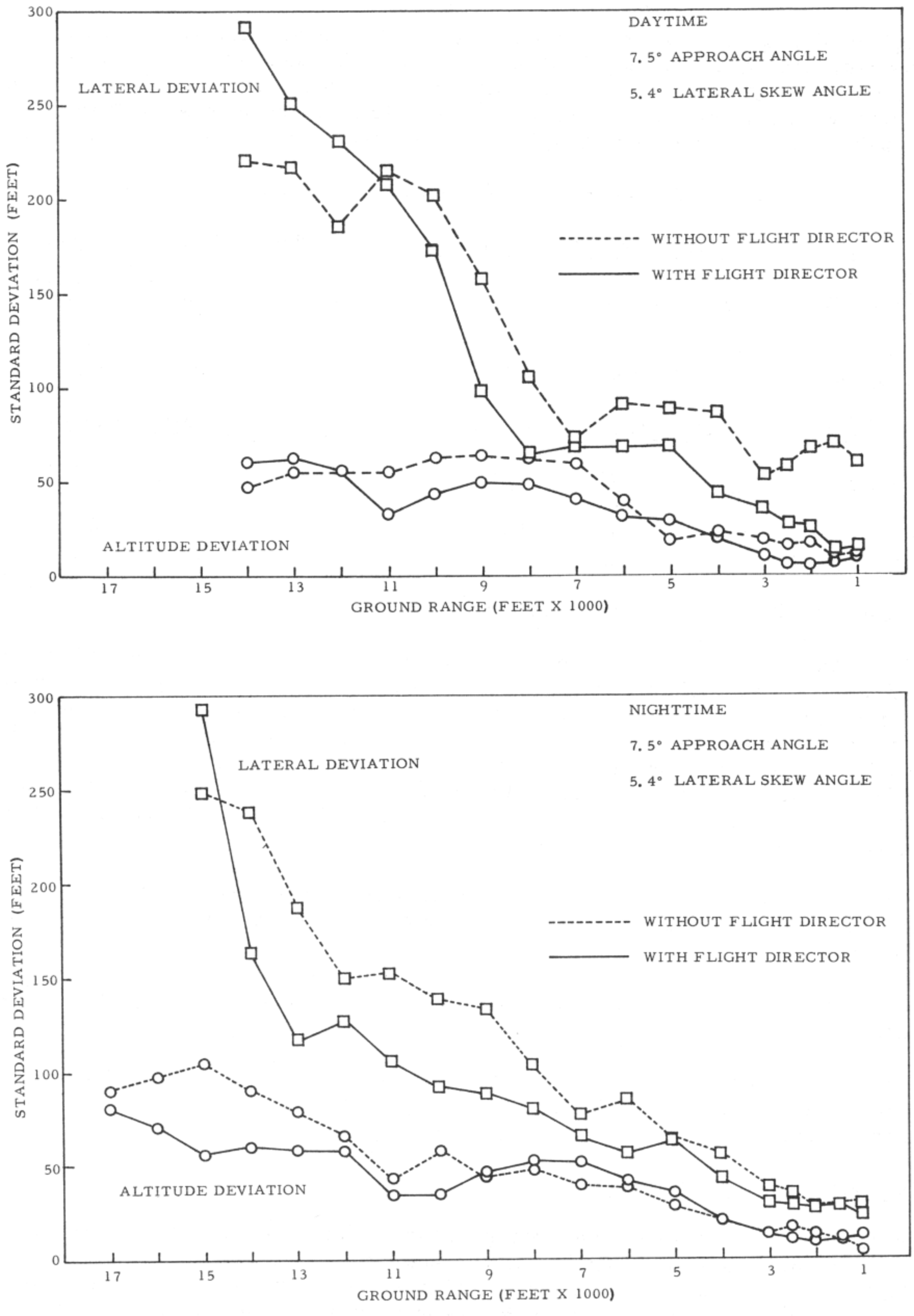


FIGURE 20. ALTITUDE DEVIATION FROM 7.5° GLIDE SLOPE, AND LATERAL DEVIATION FROM 5.4° SKEW, WITH/WITHOUT FLIGHT DIRECTOR

TOUCHDOWN POSITION. The touchdown position was evaluated by comparing the variables; viz, 4°, 6°, and 7.5° glide slope, day and night operation, offset and centerline guidance, with and without a flight director. This information is shown in Table 7. This indicates that night touchdowns were generally further into the TTZ, and were slightly longer with the use of a flight director.

TABLE 7. TOUCHDOWN POSITIONS FROM THE THRESHOLD IN FEET

Day	With Flight Director			Without Flight Director		
Glide Slope	4°	6°	7.5°	4°	6°	7.5°
Skewed	291	264	304	285	243	273
Centerline		285	316		283	323
Night	**With Flight Director**			**Without Flight Director**		
Glide Slope	4°	6°	7.5°	4°	6°	7.5°
Skewed	291	350	388	338	322	321
Centerline		335	341		298	289

See Appendix B for tabulated data on touchdowns and stops.

Both threshold altitude and touchdown distance from threshold (Figures 21 and 22) data yield skewed distributions. As a result, the application of multiples of standard deviations of these distributions shows unreal limits in the negative directions; i.e., underground for threshold altitude and touchdown before threshold for touchdown distance from threshold. Therefore, in order to apply commonly known statistics, most of the skew in the distributions of the data is removed by taking logarithms of the original data (Figures 23 and 24).

The distributions of logarithms are more bell shaped and the multiples of standard deviations and their associated probabilities now can be used for reasonable limits.

Antilogarithms of the limits are used to return the data to their initial dimension.

It is for these reasons that the original data in Table 8 show standard deviations and no limits, and the log transformation data show limits and no standard deviation.

STOL RUNWAY LENGTH AND WIDTH.

Landings for Test V were made using either brakes or brakes and idle reverse. Most runs were made with brakes only because this is the prime stopping method for certification. Commuter pilots preferred to stop with "reverse thrust only" to reduce maintenance costs on brakes and tires; however, most commuter operations are not critical on field length.

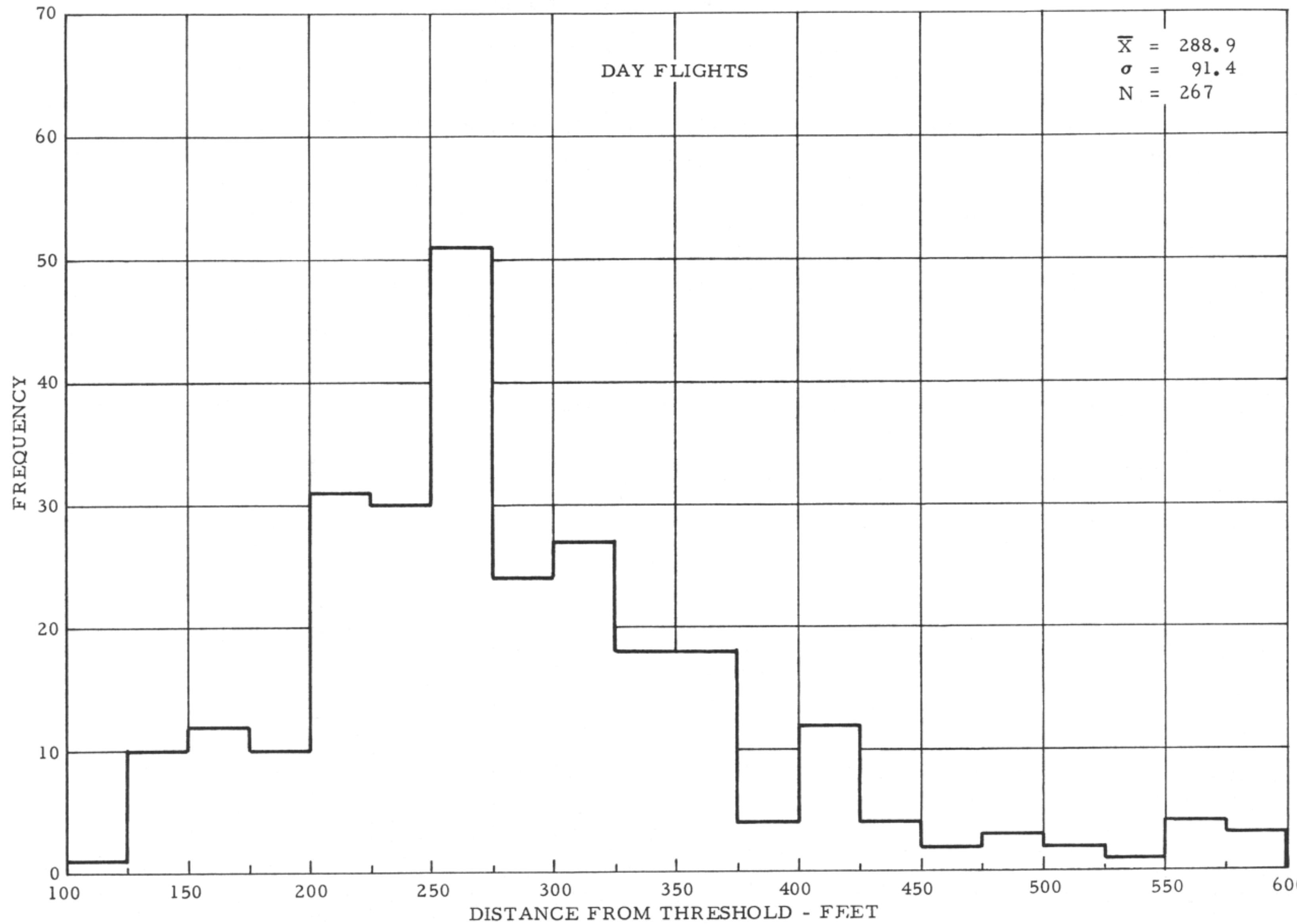


FIGURE 21. TOUCHDOWN POINT FOR ALL GLIDE SLOPES COMBINED (DAY)

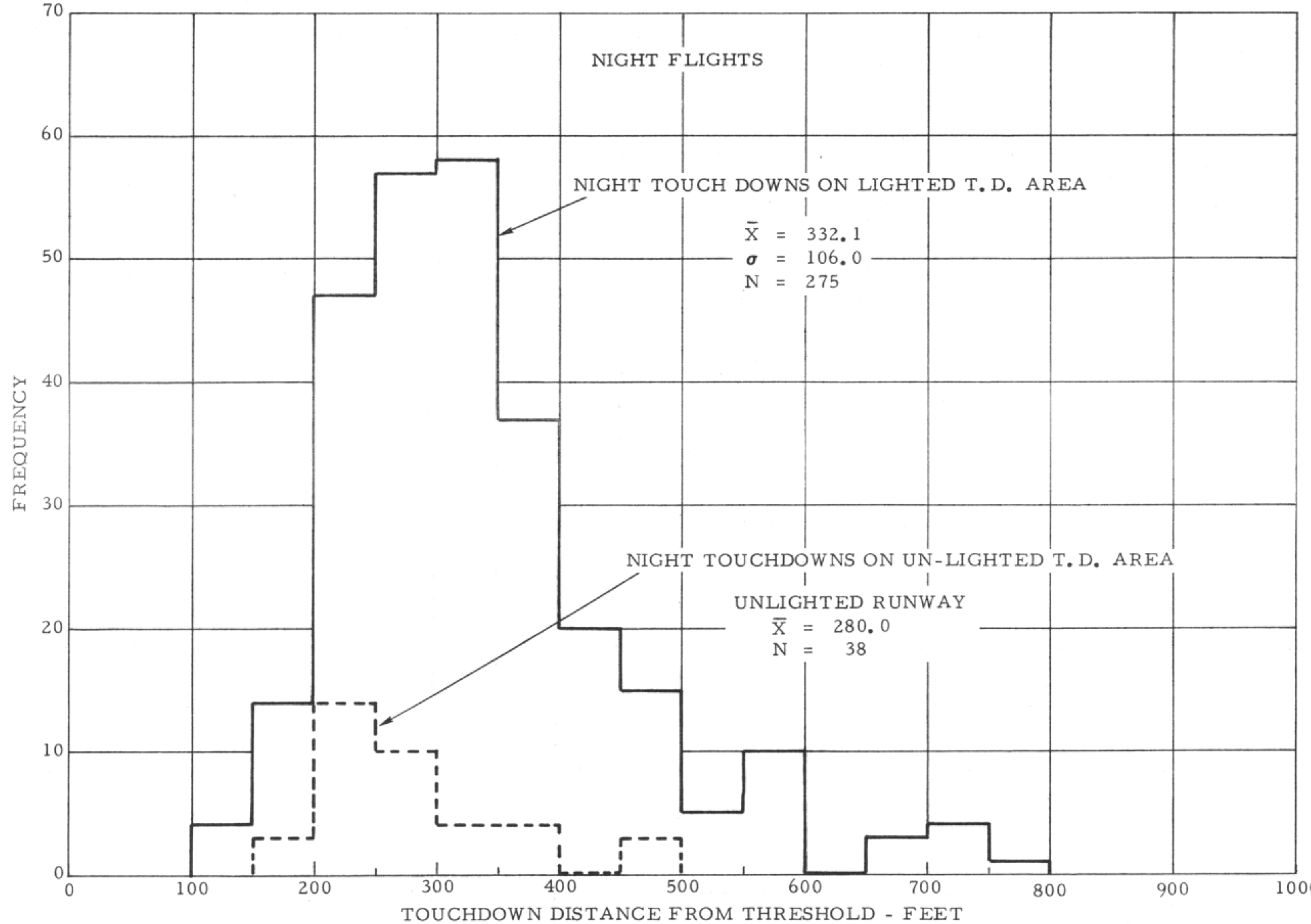


FIGURE 22. TOUCHDOWN POINT FOR ALL GLIDE SLOPES COMBINED (NIGHT) - LIGHTED AND UNLIGHTED TOUCHDOWN AREA

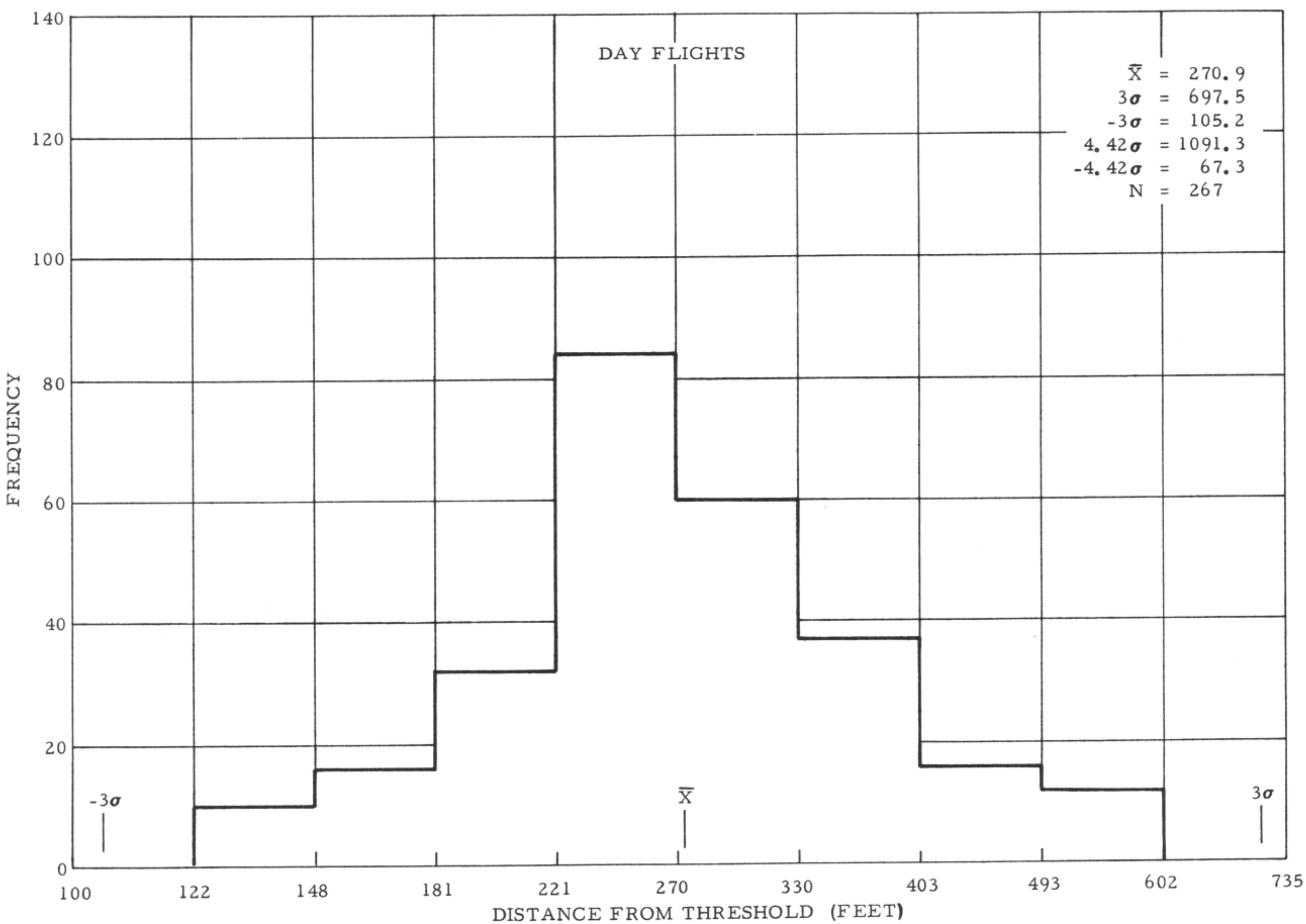


FIGURE 23. TOUCHDOWN POINT FOR ALL GLIDE SLOPES COMBINED (DAY) - LOG TRANSFORMATION

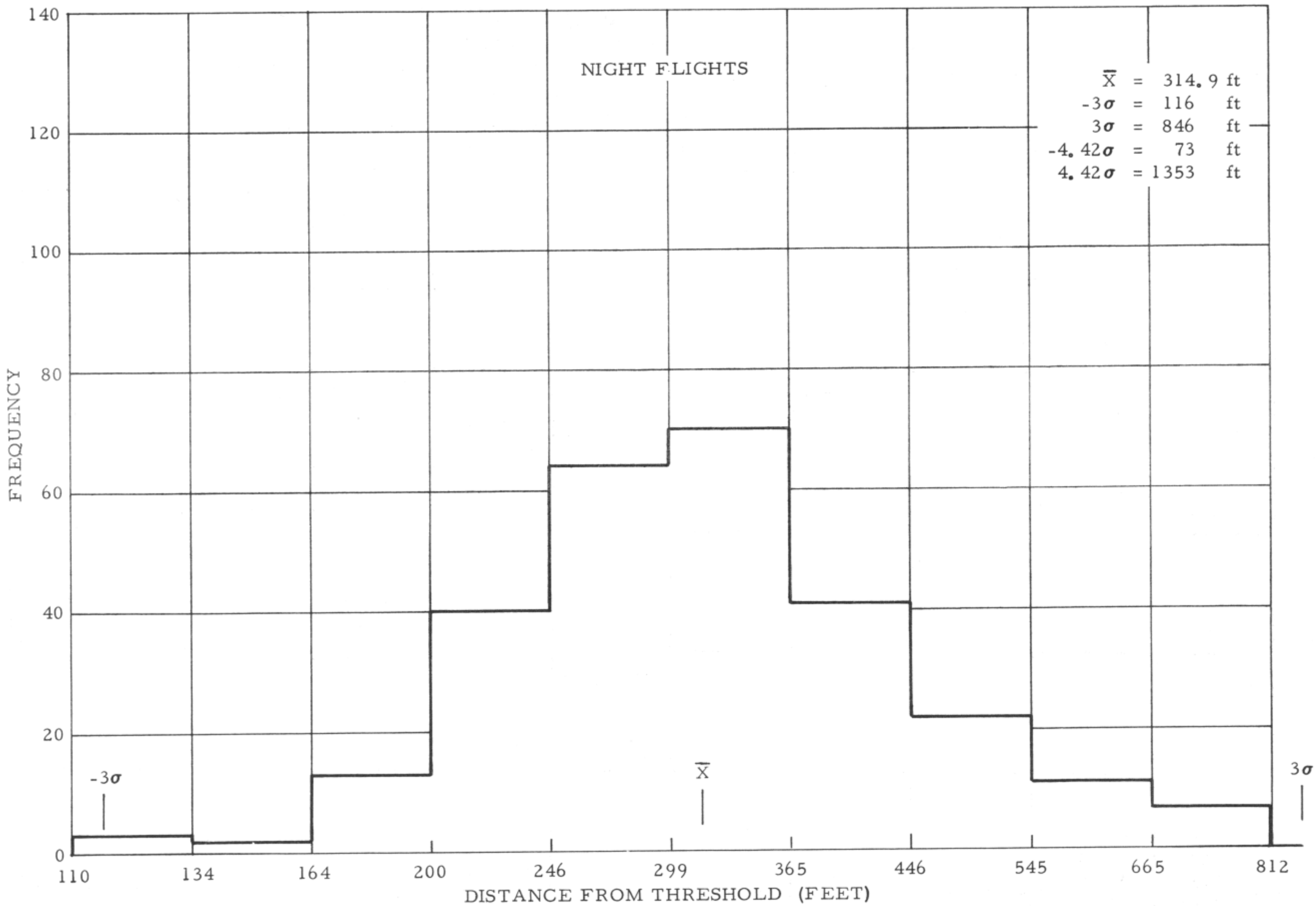


FIGURE 24. TOUCHDOWN POINT FOR ALL GLIDE SLOPES COMBINED (NIGHT) - LOG TRANSFORMATION

TABLE 8. STOL PILOT PERFORMANCE DATA BASED ON NAFEC TEST STOL RUNWAY

	$\overline{X}$ (feet)	σ (feet)	N	+3σ (feet)	-3σ (feet)
Day-Threshold Altitude	12.1	4.5	267		
Day-Threshold Altitude (Log Transformation)	11.3		267	31.5	4.1
Night Threshold Altitude	15.9	5.3	304		
Night Threshold Altitude (Log Transformation)	15.1		304	40.4	5.7
Day Touchdown	288.9	91.4	267		
Day Touchdown (Log Transformation)	270.9		267	697.5	105.2
Day-Corrected Stop (Log Transformation) Brakes Only	981.8		115	1449.5	664.5
Night-Corrected Stop(log Transformation) Brakes Only	1028.7		147	1669.0	639.1
Night Touchdowns Lighted - TD Area	321.1	106.0	275		
Night Touchdowns Unlighted - TD Area	280.0	70.2	38		

NOTE: See Appendix C for tabulated data on rollout and landing distances.

Table 9 summarizes the stopping distance from touchdown to stop for the various approach configurations. There was a shorter stopping distance with brakes and idle reverse than with brakes only.

TABLE 9. STOPPING DISTANCE
FROM TOUCHDOWN TO STOP

Ground Distance	Mean	Standard Deviation	Sample
DAY			
Brakes only	705	134	115
Brakes and idle reverse	632	107	130
NIGHT			
Brakes only	713	133	144
Brakes and idle reverse	637	127	145

The following summarizes the distances from 35-feet altitude to stop.

Approach Angle	4°	6°	7.5°
Mean Distance (ft)	1451	1275	1245
σ (Sigma) (ft)	167	205	100

RUNWAY LENGTH. One method of estimating the length of the runway would be by combining the distribution of touchdown distances with the distribution of stopping distances. This was accomplished by adding the means of the two independent distributions to obtain an overall mean, and adding the variances of the two distributions to obtain the dispersion of the combined distribution. Using the worst case:

$\overline{X}$ for TD distance at night (from Table 8) = 332 feet

$\overline{X}$ for stopping distances at night (brakes only) (from Table 9) = 713 feet

Combined Mean $\overline{X}$ = 1,045 feet

σ for TD distance at night (from Table 8) = 106 ft; σ^2 (variance) 11,236 feet
σ for stopping distance at night (from Table 9) (brakes only) = 133 feet
σ^2 (variance) = 17,689 feet

σ Combined Data = 170 feet
4.42σ = 4.42 x 170 = 751 feet
$\overline{X}$ = 1,045 feet

Total length of runway needed = 1,796 feet

With this method of computation of runway length, a runway 1,800 foot long with 100-foot overruns on each end should be adequate with the limitations as specified in the test program.

RUNWAY WIDTH. The means and standard deviation for the lateral dispersion around the TTP are as follows:

Day: Mean = -0.8 feet; Standard Deviation = 5.8 feet
Night: Mean = -0.2 feet; Standard Deviation = 5.3 feet

Using the day data, multiplied by $\pm$4.42 standard deviations, results in values of 24.8 feet to the right of runway centerline, and 26.4 feet to the left of runway centerline. This 51.2-foot runway width is well within the 100 feet recommended in Advisory Circular - AC150/53-8, November 1970. For rollout lateral variance see Appendix D.

A mean ($\overline{X}$) and standard deviation value were calculated for the MLS error and the flight technical error (pilotage) for individual approaches (Reference Appendix E, Figures E-1 through E-5 of this report). These values of MLS errors are shown for sample approaches throughout the test program as a measure of quality assurance that the guidance signals were of an acceptable quality.

These pilotage plots show that on an occasional approach the pilots appear to have an "off" time, but from the flyability standpoint, this "off" time was not related to the glide slope or localizer sensitivities (Appendix E, Figures E-1 through E-5). Also, there appears to be no significant difference in the flyability of the different glide slopes of 4°, 6°, and 7.5° from the pilot performance viewpoint.

In regard to the sensitivity setting, the pilots flew them all well and the "tighter" the sensitivity, the closer he flew the given track. The pilots indicated, however, that their workload increased with increased sensitivities and the tighter sensitivities that were investigated could not be flown in moderate turbulence. Naturally, a compromise sensitivity setting is required since the glide slope and localizer signals will have to be flown in moderate to high turbulence as well as smooth air.

MISSED APPROACH.

The pilot became aware of a need for missed approach when the copilot did not call contact at the 200-foot DH. The pilot task under these conditions was to climb out either straight ahead or with a 180° turn as designated. The flight path was recorded under both conditions for the determination of the expected flight path following the "no contact" command by the safety pilot. The altitude loss from the 200-foot DH was also recorded. There were no radio aids to follow after missed approach, the pilot either held his heading for the straight climbout or initiated a 180° turn for the turning climbout as directed. These runs were made with all engines operating, and one engine out. The missed approach path was not significantly affected by glide slope angle, flight director use, nor GPI location.

At the initiation of missed approach, the pilot added power, retracted flaps and initiated climb. Due to the rate of descent existing at DH, all runs showed an altitude loss below the 200-foot point.

Due to altitude loss on one-engine-out missed approach, a minimum contact altitude of 200 feet (CAT I) is suggested (Table 10).

TABLE 10. MISSED APPROACH

Approach Angle	Flight Cond.	Climbout Cond.	Alt. Loss (feet) $\bar{X}$	
4°	All Engines	Straight	61	17.4
4°	All Engines	Turning	56	19.3
7.5°	All Engines	Straight	83	29.0
7.5°	All Engines	Turning	86	22.8
7.5°	One Engine Out	Straight	74	14.0
7.5°	One Engine Out	Turning	101	33.3

NOTE: See Appendix F for departure data.

HEIGHT OVER THRESHOLD.

The steeper the approach angle, generally, the greater the height over threshold. (Table 11)

TABLE 11. MEAN HEIGHT OVER THRESHOLD WITH AND WITHOUT FLIGHT DIRECTOR

(a) Skew:

Day		Night	
4°	- 11.4 ft	4°	- 9.3 ft
6°	- 11.3 ft	6°	- 14.0 ft
7.5°	- 14.3 ft	7.5°	- 17.0 ft

(b) Centerline:

Day		Night	
6°	- 11.0 ft	6.0°	- 12.0 ft
7.5°	- 12.7 ft	7.5°	- 12.8 ft

The influence of using a flight director does not effect the threshold crossing height. (Table 12)

TABLE 12. MEAN HEIGHT OVER THRESHOLD BOTH SKEWED AND CENTERLINE APPROACHES

(a) With Flight Director

Day		Night	
4°	- 12.5 ft	4°	- 9.3 ft
6°	- 10.8 ft	6°	- 14.3 ft
7.5°	- 13.9 ft	7.5°	- 14.8 ft

(b) Without Flight Director

Day		Night	
4°	- 10.3 ft	4°	- 9.3 ft
6°	- 11.4 ft	6°	- 12.8 ft
7.5°	- 13.2 ft	7.5°	- 15.1 ft

Figures 25, 26, 27, 28, and 29 show how various factors effect threshold passage.

WEATHER FACTORS.

CROSS-WIND LIMITATION SUGGESTED. (STOL Operations - with Twin Otter -100 series.)

It was determined from pilot opinion (Appendix G) that:

1. Landings be limited to a maximum crosswind component of 15 knots.

2. No landings with a downwind component, except for light to variable wind (0 to 5 knots) were flown.

For co-located glide slope and localizer a general pilot opinion was:

1. CAT I - A glide slope of 7.5° (to 200-feet DH) was acceptable.

2. CAT II - Not recommended.

VASI.

It was the pilot consensus that the two-box VASI, as it was installed, was a useful guidance "tool" for VFR night operations and could be more useful for day operations with greater day range. On bright sunny days the VASI could not be picked up until approximately 1 nmi or less from touchdown.

The pilots' concensus was that the VASI was of no value from a 200-foot IFR breakout. After breakout the pilot concentrated on hitting his landing spot and did not need any other visual references other than runway lighting and marking.

NIGHT STOL LIGHTING AND MARKING.

Touchdown zone floodlighting was very good but some pilots suggested that the entire landing area be floodlighted.

Reflector markers do not seem adequate. If the STOLplane taxi light beam is adjusted to activate the markers in taxi position, they are not activated until the flare. If the taxi light beam is adjusted to reflect on an approach angle they are not activated after the flare when taxiing.

DAY VERSUS NIGHT OPERATIONS.

Day approaches showed greater variability than night approaches. This is evident in the data on height over threshold and touchdown dispersion. Dispersion data on night and day approach are given in Appendix H and I.

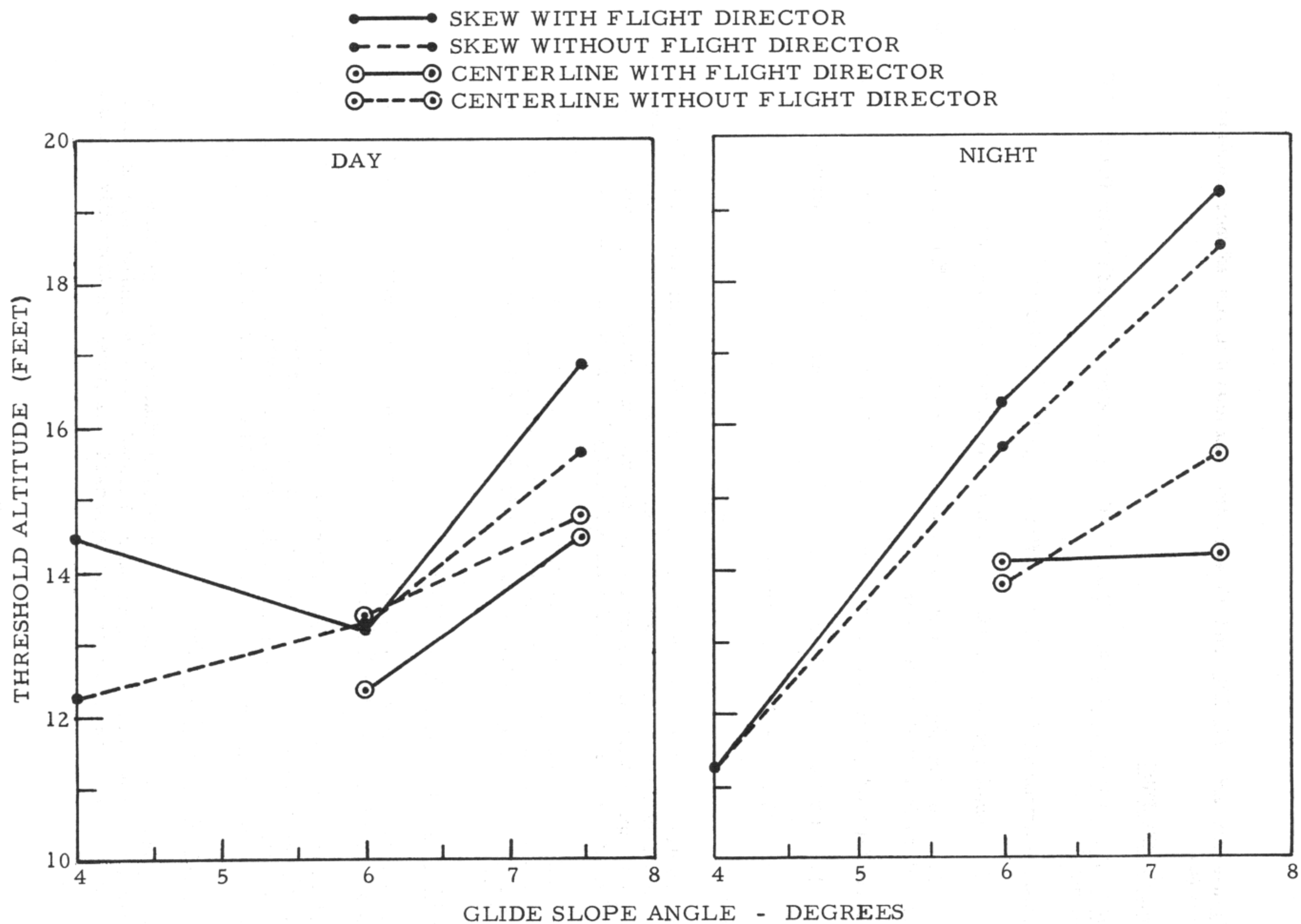


FIGURE 25. THRESHOLD PASSAGE HEIGHT - SKEWED APPROACH VERSUS CENTERLINE APPROACH

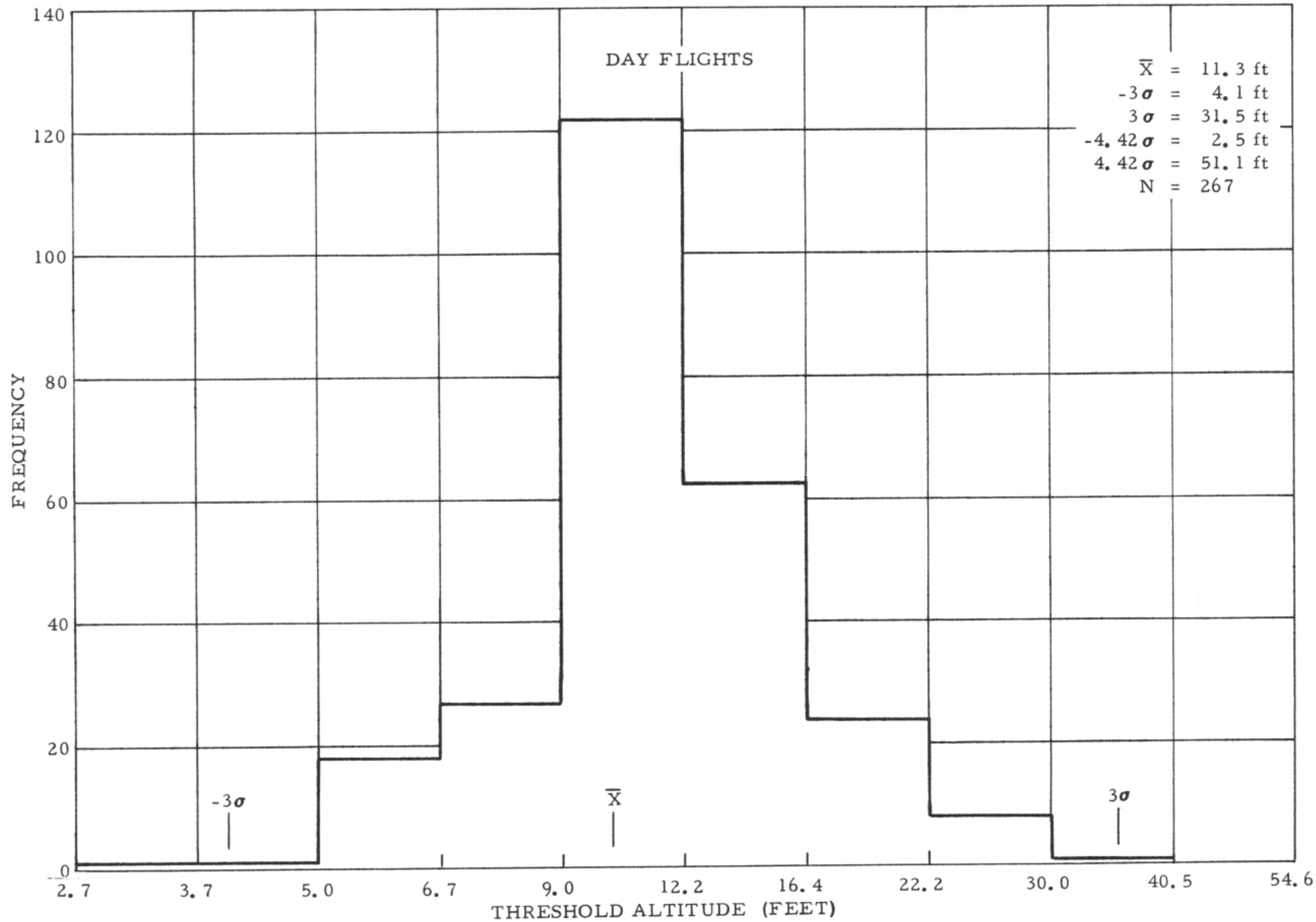


FIGURE 26. THRESHOLD PASSAGE HEIGHT (DAY)

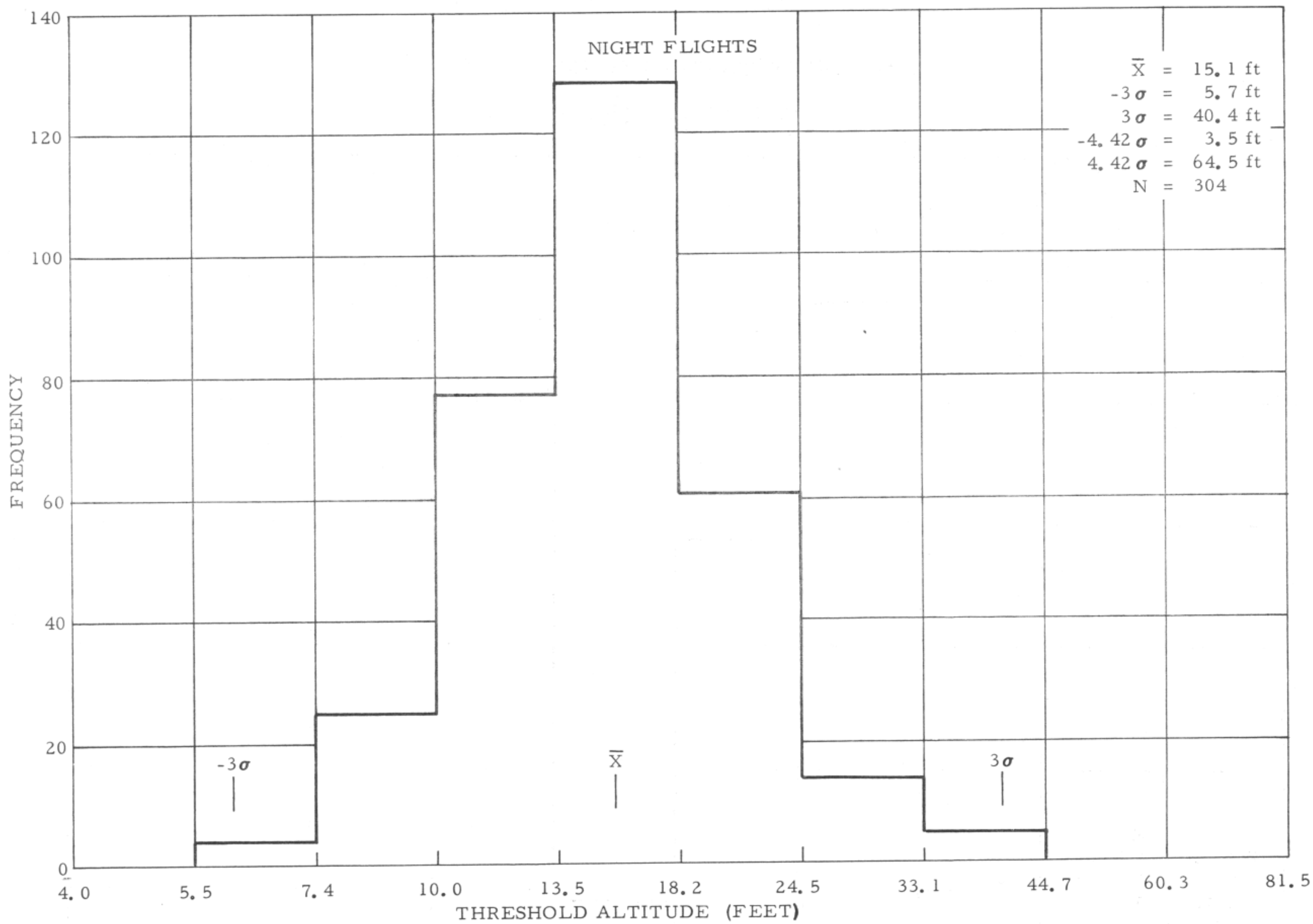


FIGURE 27. THRESHOLD PASSAGE HEIGHT (NIGHT)

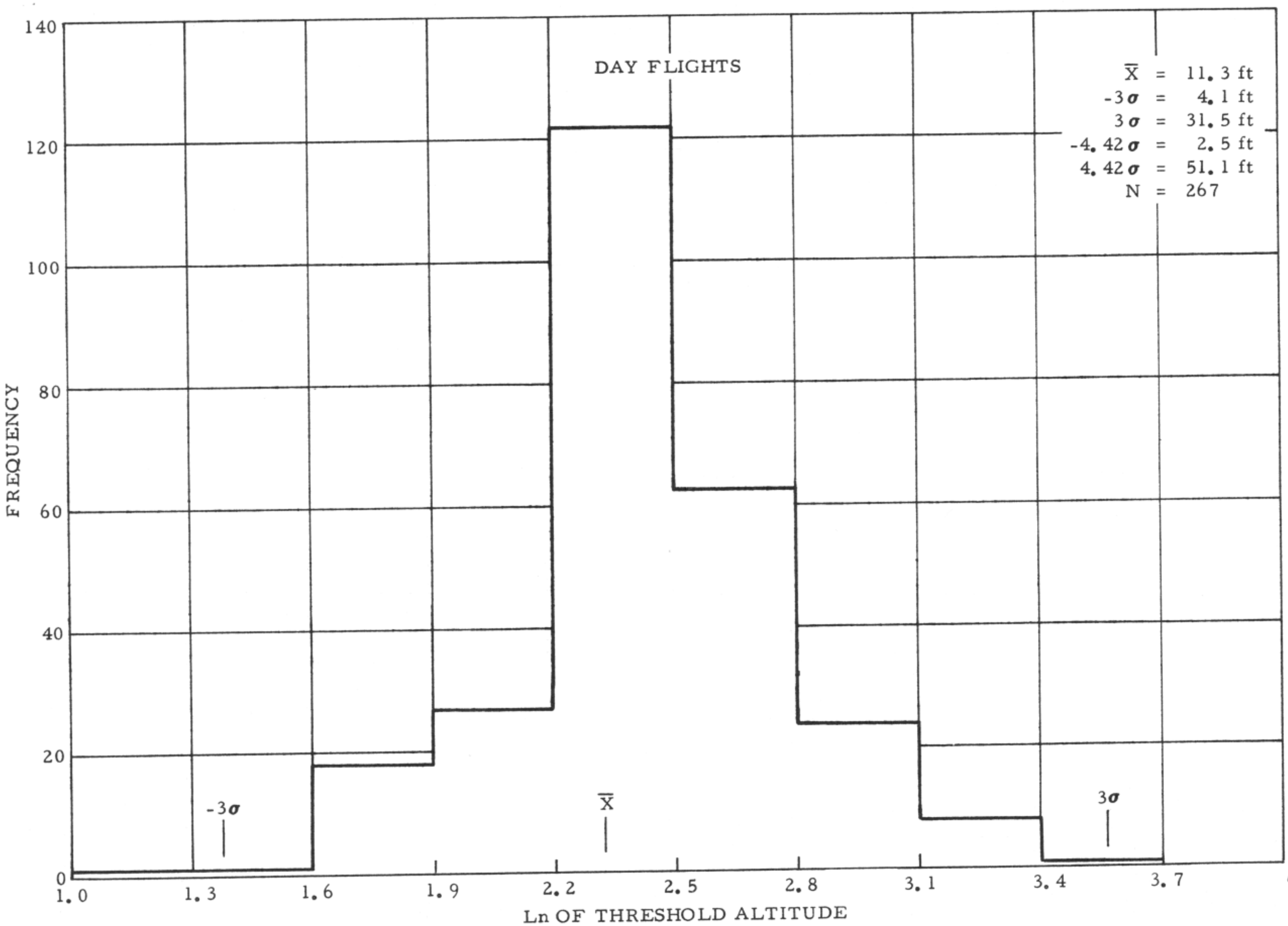


FIGURE 28. THRESHOLD PASSAGE HEIGHT (DAY) - LOG TRANSFORMATION

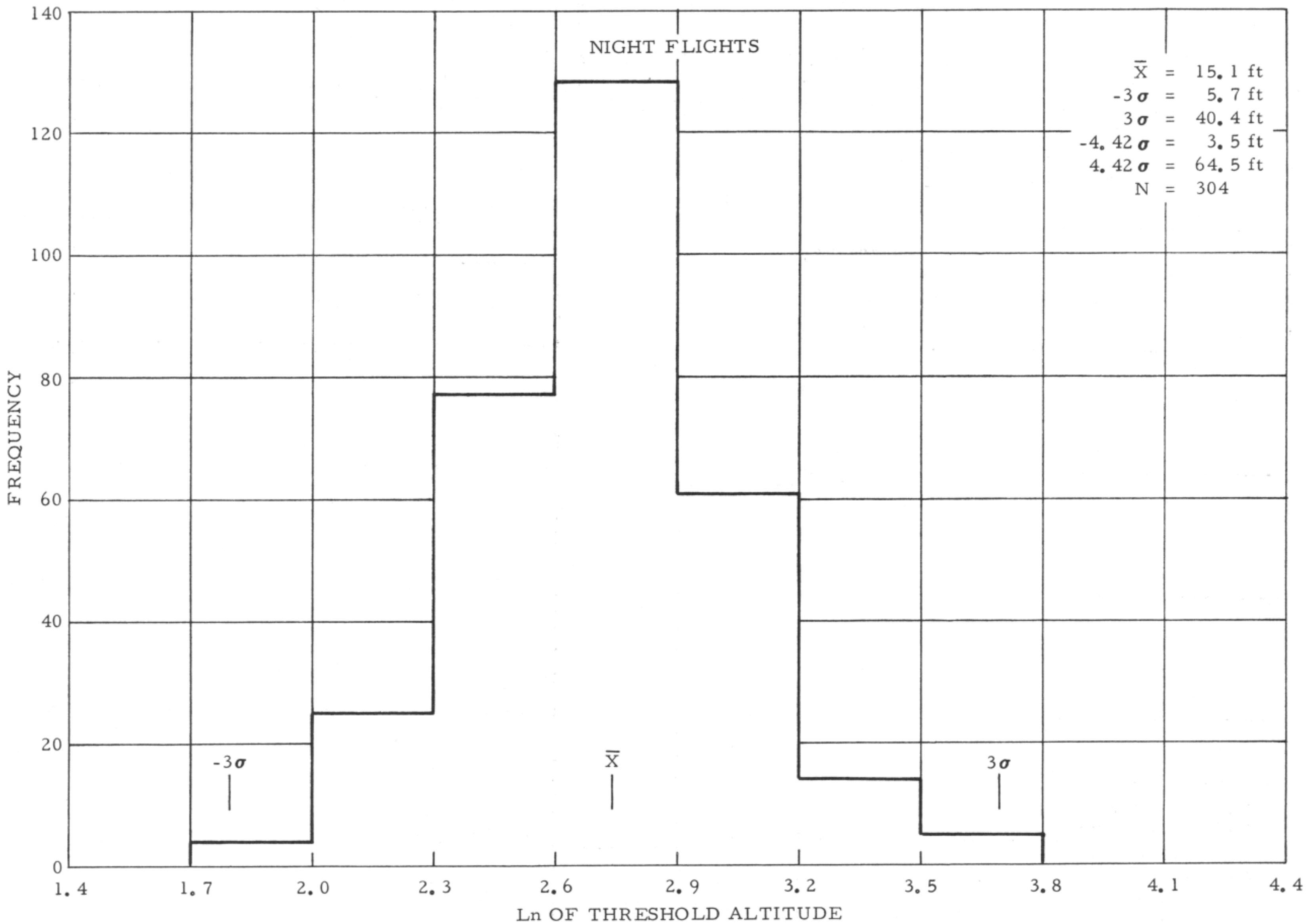


FIGURE 29. THRESHOLD PASSAGE HEIGHT (NIGHT) - LOG TRANSFORMATION

Pilots flying VFR felt that they had large latitude where they could place the aircraft in the approach area and still be safe - since obstacles can be seen. On the IFR approach he has a "tunnel" approach and, therefore, will fly more precisely. It was felt that there is no problem with this variability but to be aware that it does exist.

It should be noted that there was floodlighting at night on Runway 35 touchdown marks. The test results indicated that the mean touchdowns on the unlighted end were approximately 35 feet shorter than the lighted end.

TEST RESULTS WITH A FLIGHT DIRECTOR.

1. Most pilots flew a tighter glide slope and localizer beam with the flight director.

2. Although the flight director helped the pilots hit the "eye of the needle," breakout point more precisely, there was no discernable effect on height over threshold, touchdown position, and landing distance as illustrated in Figures 18, 19, and 20.

3. After the pilots became familiar with the use of the flight director, they preferred to use it, and felt that it relieved the pilot workload.

DATA FOR OBSTACLE CLEARANCE PLANES.

The pilots were issued instructions as to the proper altitude they should intercept the localizer, and this varied depending on the glide slope angle. The position of the aircraft in space was recorded by the NAFEC theodolites.

It was possible to show the position of all the aircraft flying a given glide slope in diagram form (See Appendix J). The circular area of the plots indicate the aircraft variance in space to 1σ . This was for illustration purposes. The greatest variance of all configuration flows (4.42) should be used to establish final clearance planes. This material will be used to develop appropriate obstacle clearance planes.

SUMMARY OF RESULTS

Test I Glide Slope and Localizer Sensitivities (Reference Page 23):

1. The glide slope and localizer sensitivities found to be satisfactory are:

Glide slope $\pm 2.0°$ - Localizer $\pm 5.0°$ for 6° and 7.5° glide slope.
Glide slope $\pm 1.3°$ - Localizer $\pm 5.0°$ for 4° glide slope.

Test II Ground Point of Intercept Location (Reference Page 24):

2. A GPI located between 50 feet ahead of threshold and 50 feet aft of threshold provides the best guidance for an optimum touchdown: i.e., the GPI at least 200 feet ahead of the target touchdown point.

Tests III and IV Split and Co-located Guidance (Reference Pages 24 and 25).

3. Approach angles of 6° and 7.5° are acceptable for the CAT I minimum (200-foot DH) with either split-located or co-located guidance transmitters.

4. Skew angles up to 6° are acceptable with 7.5° glide slope and 200-foot DH. Skew approach contact should be 500 feet before runway centerline intercept as tested.

Test V Performance (Reference Page 25).

5. The initial localizer intercept at 3 nmi and glide slope intercept at 2 nmi, used during the flight tests, is adequate for intercept speed up to 100 knots.

6. Transition guidance aids at the localizer intercept (3 nmi) and at the glide slope intercept (2 nmi) were of value in the absence of other aids (DME, R-NAV, etc).

7. A ground-level STOL runway 100 feet wide, 1,800 feet long with 100-foot overruns at each end, and the two 20- by 200-foot white aiming marks used to identify the target touchdown zone is acceptable for day/night, VFR/IFR STOL operations for aircraft with performance similar to the Twin Otter, Series 100, aircraft.

8. A 1.3 V_{SO} approach speed can be used as a reference approach speed with up to moderate air turbulence.

9. Operations should be limited to 15 knots of crosswind and no tailwind component other than reported light to variable for the Twin Otter, with recommended runway limits.

10. VASI as configured for the test is considered a useful guidance tool for night VFR operations.

11. Floodlighting of the TTZ was determined, by pilot concensus, to be required for a 1,800-foot STOL runway.

12. Day approaches showed greater variability than night approaches.

13. Obstacle clearance planes can be established for (1) STOL approaches day, (2) STOL approaches night, (3) STOL departures day and night, and (4) STOL missed approaches day and night (see Appendix J).

14. The average touchdown velocity for 188 runs evaluated was 1.28 feet per second. The maximum touchdown velocity noted was 4.34 feet per second which is well within the tolerance of the present design limitation of 8.5 feet per second.

CONCLUSION

The test results indicate that a De Havilland DHC-6, 100 Series, Twin Otter, or similar class aircraft, can be operated onto a STOL runway 1,800 feet long, with 100-foot overruns at each end, and 100 feet wide on glide slope angles up to 7.5° either with split centerline guidance or co-located to the side of the runway with skew angle up to 6° to a decision height of 200 feet. Crosswinds greater than 15 knots and tailwinds in excess of 5 knots are limiting.

APPENDIX A

CODING OF CONFIGURATIONS FLOWN (TEST V)

Since various types of approaches were flown by each pilot, it was necessary to randomize the types of approaches in any series of runs. This would eliminate the learning that would occur from this type of repetition. To diversify the order of runs, a randomized schedule was established. Table A-1 shows the way in which the runs were coded. Tables C-2 and C-3 show randomized schedule listings in the order they were carried out.

LIST OF TABLES

TABLE A-1 CODING OF CONFIGURATIONS FLOWN - TEST V

VFR

Code Day	Code Nights	Braking* Method	Take** Offs	Configuration	No. of Runs
600	900	1	1	Using all available aids	15
601	901	2	2	Using all available aids	15
602	902	1	1	VASI only	15
603	903	2	2	VASI only	15
604	904	1	1	Using no aids	15
605	905	2	2	Using no aids	15
					90

IFR

Code Day	Code Nights	Braking* Method	Take** Offs	Configuration	No. of Runs
610	910	1	1	Offset equip., w/Flt. Dir. 4° Glide slope	18
611	911	2	2	Same as above	18
612	912	1	1	Offset equip., w/Flt. Dir. 6° Glide slope	18
613	913	2	2	Same as above	18
614	914	1	1	Offset equip., w/Flt. Dir., 7.5° Glide slope	18
615	915	2	2	Same as above	18
616	916	1	1	Offset equip., w/o Flt. Dir., 4° Glide slope	18
617	917	2	2	Same as above	18
618	918	1	1	Offset equip., w/o Flt. Dir., 6° Glide slope	18
619	919	2	2	Same as above	18
620	920	1	1	Offset equip., w/o Flt. Dir., 7.5° Glide slope	18
621	921	2	2	Same as above	18
630	930	1	1	Centerline equip., w/Flt. Dir., 6° Glide slope	18
631	931	2	2	Same as above	18
632	932	1	1	Centerline equip., w/Flt. Dir., 7.5° Glide slope	18
633	933	2	2	Same as above	18

634	934	1	1	Centerline equip., w/o Flt. Dir., 6° Glide slope	18
635	935	2	2	Same as above	18
636	936	1	1	Centerline equip., w/o Flt. Dir., 7.5° Glide slope	18
637	937	2	2	Same as above	18
					360

<u>Missed Approach</u>
(All Offset Equipment)

640				All engines, straight ahead, 4° Glide slope	15
641				All engines, straight ahead, 7.5° Glide slope	15
642				All engines, turning 4° Glide slope	15
643				All engines, turning 7.5° Glide slope	15
650				One engine, straight ahead, 7.5° Glide slope	10
651				One engine, turning 7.5° Glide slope	10
					80

<u>IFR With VASI</u>

660	960	1	1	Without Flight Director, 7.5° Glide slope	10
661	961	2	2	Without Flight Director, 7.5° Glide slope	10
					20
				Total	550

* Braking Methods
1. Brakes Only.
2. Brakes, both propellors in idle reverse.

** Departure
1. Straight Ahead
2. Turning.

See pages A-3 through A-8 for randomization of the data runs.

TABLE A-2. STOL EVALUATION RUNS - TEST V - DAY

Run No.	Code	Run No.	Code	Run No.	Code
1	636	44	642	87	619
2	618	45	632	88	617
3	612	46	640	89	642
4	641	47	643	90	600
5	640	48	611	91	600
6	610	49	615	92	642
7	633	50	610	93	634
8	616	51	618	94	621
9	612	52	610	95	605
10	642	53	640	96	621
11	618	54	614	97	616
12	642	55	637	98	634
13	601	56	651	99	661
14	634	57	602	100	643
15	611	58	636	101	605
16	640	59	601	102	643
17	610	60	616	103	602
18	640	61	643	104	602
19	650	62	615	105	604
20	642	63	620	106	643
21	641	64	604	107	651
22	619	65	642	108	637
23	634	66	661	109	634
24	660	67	643	110	636
25	621	68	633	111	642
26	615	69	603	112	605
27	640	70	612	113	642
28	660	71	600	114	602
29	632	72	620	115	604
30	660	73	631	116	634
31	640	74	611	117	631
32	603	75	650	118	618
33	605	76	643	119	621
34	605	77	605	120	610
35	602	78	602	121	619
36	650	79	601	122	601
37	640	80	631	123	614
38	605	81	641	124	631
39	633	82	611	125	613
40	632	83	631	126	601
41	620	84	642	127	620
42	617	85	631	128	603
43	603	86	637	129	618

Run No.	Code	Run No.	Code	Run No.	Code
130	619	175	616	220	650
131	612	176	633	221	616
132	650	177	632	222	621
133	610	178	631	223	630
134	614	179	635	224	651
135	618	180	603	225	614
136	617	181	621	226	616
137	641	182	635	227	616
138	643	183	640	228	619
139	661	184	650	229	632
140	660	185	612	230	604
141	651	186	643	231	632
142	640	187	650	232	617
143	643	188	620	233	632
144	602	189	612	234	641
145	631	190	611	235	635
146	605	191	661	236	613
147	635	192	651	237	641
148	615	193	650	238	614
149	660	194	618	239	640
150	619	195	618	240	635
151	630	196	611	241	640
152	602	197	620	242	613
153	640	198	604	243	614
154	604	199	651	244	618
155	641	200	650	245	635
156	620	201	617	246	643
157	620	212	636	247	601
158	642	213	616	248	614
159	642	214	619	249	613
160	635	215	651	250	617
161	661	216	600	251	616
162	641	217	615	252	601
163	641	218	636	253	641
164	632	219	651	254	636
165	631			255	617
166	600			256	643
167	610			257	632
168	651			258	610
169	619			259	630
170	600			260	642
171	603			261	600
172	620			262	613
173	651			263	642
174	603			264	617

Run No.	Code	Run No.	Code
265	601	309	640
266	634	310	633
267	641	311	612
268	615	312	630
269	613	313	637
270	630	314	636
271	641	315	630
272	641	338	650
273	610	340	660
274	613	386	621
275	616	390	611
276	611	393	642
277	604	398	642
278	634	399	605
279	634	400	611
280	612	402	643
281	637	405	617
282	630	408	630
283	633	409	643
284	621	411	651
285	641	412	636
286	613	413	603
287	617	416	643
288	613	417	604
289	636		
290	637		
291	621		
292	630		
293	615		
294	614		
295	621		
296	637		
297	611		
298	637		
299	611		
300	612		
301	636		
302	614		
303	637		
304	615		
305	650		
306	633		
307	640		
308	640		

TABLE A-3. STOL EVALUATION RUNS - TEST V - NIGHT

Run No.	Code	Run No.	Code	Run No.	Code
1	921	46	961	91	914
2	935	47	917	92	919
3	934	48	961	93	910
4	932	49	960	94	931
5	918	50	905	95	935
6	917	51	903	96	917
7	936	52	902	97	902
8	918	53	904	98	934
9	930	54	932	99	930
10	933	55	900	100	911
11	960	56	937	101	930
12	910	57	911	102	913
13	933	58	913	103	936
14	930	59	961	104	915
15	911	60	937	105	934
16	934	61	905	106	918
17	914	62	921	107	904
18	911	63	921	108	937
19	961	64	932	109	902
20	913	65	919	110	919
21	930	66	914	111	934
22	915	67	935	112	905
23	932	68	914	113	913
24	937	69	912	114	904
25	934	70	903	115	935
26	961	71	917	116	910
27	911	72	917	117	919
28	905	73	904	118	916
29	903	74	918	119	918
30	937	75	911	120	912
31	901	76	916	121	935
32	913	77	903	122	931
33	921	78	903	123	920
34	913	79	921	124	916
35	912	80	903	125	937
36	904	81	915	126	916
37	910	82	901	127	936
38	918	83	901	128	921
39	936	84	910	129	913
40	911	85	930	130	901
41	911	86	934	131	933
42	918	87	916	132	912
43	910	88	920	133	914
44	903	89	936	134	918
45	934	90	911	135	902

Run No.	Code	Run No.	Code	Run No.	Code
136	930	181	919	230	931
137	920	182	917	231	900
138	910	183	937	232	900
139	934	184	901	233	933
140	917	185	920	234	933
141	902	186	910	235	933
142	920	187	932	242	901
143	916	188	915	243	910
144	920	189	937	244	931
145	917	190	931	245	935
146	919	191	931	246	917
147	914	192	913	247	902
148	936	193	914	248	934
149	903	199	935	249	930
150	902	200	912	250	910
151	918	201	912	251	920
152	900	202	919	252	961
153	904	203	960	253	905
154	960	204	915	254	937
156	905	205	912	255	903
157	916	206	901	256	903
158	905	207	912	257	920
159	920	208	936	258	914
160	916	209	933	259	900
161	910	210	920	260	901
162	917	211	919	261	931
163	902	212	930	262	933
164	916	213	933	263	912
165	905	214	915	264	915
166	932	215	915	265	900
167	921	216	936	266	933
168	935	217	201	267	919
169	914	218	935	268	901
170	920	219	932	269	916
171	931	220	921	270	905
172	921	221	932	271	936
173	919	222	936	272	902
174	914	223	900	273	900
175	904	224	931	274	930
176	932	225	931	275	913
177	960	226	935	276	918
178	921	227	933	277	933
179	904	228	900	278	936
180	937	229	900	279	919

No.	Code
280	932
281	901
282	933
283	915
284	932
287	905
288	920
289	932
290	921
291	935
292	905
293	901
296	935
297	921
298	912
299	900
300	915
301	903
303	912
304	934
305	915
306	919
307	931
308	914
309	900
310	931
311	930
314	936
315	931
317	912
319	935
320	933
322	902
323	900
325	912
326	930
328	931
329	934
330	915
331	916
332	936
333	935

APPENDIX B

NIGHT TABULATIONS - TOUCHDOWNS - STOPS, ETC.

LIST OF TABLES

TABLE B-1. TOUCHDOWNS (NIGHT)

SERIES	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	DISTANCE FROM THRESHOLD SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)
900	15	0.3	3.4	15	-353.0	94.9
901	13	-2.7	3.2	13	-365.8	183.2
902	7	0.0	3.9	8	-315.1	195.4
903	5	-0.2	8.1	6	-220.5	29.2
904	7	1.1	5.8	7	-300.0	63.4
905	8	-1.1	3.8	8	-328.6	125.1
910	8	1.6	5.0	11	-293.2	86.0
911	6	1.7	6.9	9	-250.3	57.7
912	14	-0.4	3.5	14	-394.2	142.2
913	8	2.9	5.3	9	-272.5	54.4
914	10	-1.6	5.6	10	-381.9	111.1
915	14	-2.1	6.5	14	-391.6	157.9
916	10	-1.3	4.7	10	-361.2	108.0
917	10	1.7	6.1	12	-315.9	73.5
918	8	0.9	4.0	9	-303.7	64.6
919	11	1.4	6.1	11	-330.6	83.0
920	11	1.2	3.7	12	-329.0	98.9
921	9	0.2	2.9	9	-305.2	44.6
930	11	-2.1	6.2	11	-332.6	139.9
931	13	0.6	5.1	13	-319.5	96.5
932	13	0.8	5.9	13	-325.9	96.7
933	15	0.2	5.0	17	-370.9	185.7
934	9	-0.3	3.9	10	-275.2	57.4
935	12	0.1	6.4	13	-304.0	84.8
936	9	-2.4	5.2	10	-301.6	98.2
937	9	-0.5	7.6	8	-274.5	70.2
960	4	-1.0	2.8	5	-363.8	124.8
961	2	-3.0	18.4	3	-281.3	35.3

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE B-2. STOP DISTANCE CORRECTED TO STANDARD CONDITIONS (NIGHT)

35-FOOT ALTITUDE TO CORRECTED STOP DISTANCE

SERIES	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
900	15	1344.8	174.4
901	12	1311.8	207.0
902	8	1198.3	150.5
903	5	1140.0	132.7
904	7	1201.4	142.6
905	9	1234.2	193.7
910	9	1423.0	131.8
911	9	1257.2	142.4
912	13	1270.8	118.8
913	10	1165.7	120.2
914	10	1226.4	134.7
915	11	1233.0	95.1
916	11	1413.5	209.5
917	15	1267.1	141.9
918	10	1172.0	105.4
919	11	1203.4	120.1
920	11	1252.3	132.1
921	9	1073.9	124.2
930	11	1324.3	133.6
932	12	1265.0	129.8
933	16	1229.3	186.8
934	10	1309.2	129.5
935	13	1273.6	101.8
936	10	1264.0	211.4
937	8	1126.3	63.4
960	5	1199.4	116.1
961	3	1080.3	52.7

TABLE B-3. CORRECTED STOP POINT DISTANCE FROM THRESHOLD (NIGHT)

SERIES	SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)
900	16	-1162.3	184.4
901	12	-1036.7	179.1
902	8	- 985.4	188.0
903	5	- 900.2	126.2
904	7	- 951.7	134.8
905	9	- 876.9	152.6
910	10	-1012.3	112.6
911	9	- 854.9	130.5
912	13	-1064.5	134.1
913	10	- 906.4	115.4
914	10	-1084.3	164.1
915	11	-1069.3	110.4
916	12	-1014.9	153.9
917	13	- 877.1	96.3
918	10	- 933.6	104.4
919	11	- 976.5	135.3
920	10	-1092.9	163.2
921	9	- 894.7	105.5
930	11	-1031.5	143.7
931	12	- 979.9	128.2
932	12	- 976.5	111.3
933	16	- 982.6	235.4
934	10	-1003.4	146.7
935	13	- 974.8	129.1
936	10	-1011.3	173.4
937	8	- 902.3	64.1
960	5	- 979.2	97.0
961	3	- 861.0	25.1

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE B-4. STOP COORDINATE (NIGHT)

SERIES	LATERAL DISTANCE SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	DISTANCE FROM THRESHOLD SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)
900	14	0.7	11.9	14	-1085.8	184.9
901	10	-1.1	3.1	10	- 963.4	213.4
902	8	0.6	4.0	8	- 913.4	200.4
903	4	-1.5	10.1	4	- 811.3	137.9
904	8	2.4	4.9	8	- 839.9	149.9
905	8	-2.4	5.4	8	- 848.5	132.2
910	5	1.0	6.0	8	- 901.1	131.4
911	7	2.3	9.6	9	- 778.0	117.7
912	12	0.8	7.0	12	- 969.6	141.6
913	9	4.7	5.7	10	- 828.9	96.0
914	8	-1.8	7.7	8	- 988.0	192.9
915	10	1.6	6.2	10	-1004.1	134.7
916	11	2.4	8.5	11	- 930.1	204.4
917	10	-1.5	4.6	11	- 828.7	126.7
918	8	4.3	6.9	8	- 857.4	121.9
919	11	-1.4	5.7	11	- 929.8	180.5
920	10	-0.6	4.2	10	- 983.2	179.2
921	9	-1.4	6.0	9	- 823.2	110.1
930	11	2.3	14.4	11	- 974.3	155.2
931	11	-0.2	4.1	11	- 950.3	140.3
932	11	-0.4	6.9	11	- 932.6	115.8
933	15	-3.2	4.5	16	- 944.2	231.9
934	10	-2.7	7.1	10	- 972.2	169.7
935	12	1.1	6.7	13	- 909.3	151.3
936	9	-3.0	4.2	10	- 965.5	185.6
937	8	-3.3	5.2	8	- 813.5	70.8
960	4	-1.0	2.2	5	- 930.0	135.0
961	2	-0.5	5.0	3	- 801.0	42.9

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE B-5. POSITION OF AIRCRAFT AT 35-FEET ALTITUDE POINT (NIGHT)

SERIES	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	RANGE - AHEAD OF THRESHOLD SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)
900	15	-0.8	7.9	15	197.0	57.8
901	12	1.6	4.5	12	298.6	86.5
902	7	2.7	6.5	8	212.9	66.4
903	6	-2.7	9.1	7	248.0	40.1
904	6	3.2	5.1	6	240.7	79.1
905	9	2.4	6.7	9	357.3	115.4
910	8	4.9	5.3	8	403.8	121.0
911	6	-1.7	4.5	9	402.3	92.1
912	13	-1.7	6.0	13	206.3	65.3
913	10	6.1	7.2	10	259.3	84.9
914	9	3.2	8.8	9	180.0	49.8
915	12	1.0	8.9	12	176.8	53.6
916	12	-1.8	7.1	12	394.5	98.0
917	12	-3.2	8.9	12	399.8	104.0
918	8	1.5	11.8	9	244.7	51.1
919	12	3.6	8.2	12	226.2	52.2
920	8	-3.4	14.7	9	194.3	76.2
921	7	-5.3	7.8	7	175.7	40.3
930	12	-4.2	7.7	12	294.6	62.4
931	13	-0.3	7.7	13	277.7	59.0
932	11	-1.1	4.6	11	285.1	53.8
933	15	0.5	7.2	16	265.1	74.2
934	8	-1.0	6.8	8	303.0	57.1
935	12	-1.8	5.9	13	301.5	78.2
936	11	-3.6	10.0	12	246.2	72.1
937	8	1.1	12.9	8	224.0	74.0
960	4	4.5	7.0	5	220.2	46.5
961	2	-1.5	2.1	4	196.3	63.7

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

APPENDIX C

LANDING DISTANCE - FROM 35-FEET ALTITUDE OVER THRESHOLD, AND TOUCHDOWN TO STOP

LIST OF TABLES

TABLE C-1. LANDING DISTANCE FROM 35-FEET ALTITUDE TO TOUCHDOWN (DAY)

SERIES	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
600	5	587.0	195.5
601	10	534.6	136.8
602	5	599.6	150.3
603	7	550.6	127.9
604	7	651.7	181.2
605	6	659.7	216.1
610	13	766.5	122.2
611	11	742.0	95.0
612	6	598.5	79.2
613	8	552.8	64.2
614	11	459.9	69.1
615	18	581.1	146.3
616	11	710.8	72.1
617	9	772.1	122.6
618	7	562.4	53.9
619	8	579.1	45.5
620	8	513.9	72.7
621	10	485.5	86.5
630	8	687.6	78.7
631	8	663.8	42.0
632	7	619.0	173.4
633	8	621.4	54.7
634	7	634.7	44.9
635	9	683.6	140.7
636	13	591.5	129.1
637	10	607.4	155.7
660	6	582.8	90.5
661	5	546.6	76.7

TABLE C-2. LANDING DISTANCE FROM 35-FEET ALTITUDE TO TOUCHDOWN (NIGHT)

SERIES	SAMPLE SIZE	AVERAGE (FT)	STANDARD DEV (FT)
900	15	544.2	92.4
901	12	653.3	168.0
902	8	528.0	145.1
903	5	462.6	73.3
904	7	549.7	103.5
905	9	683.1	182.0
910	9	679.3	96.6
911	9	653.0	89.2
912	13	575.0	92.2
913	10	527.4	70.4
914	10	538.3	109.6
915	11	568.4	163.3
916	11	682.6	223.6
917	15	682.7	115.3
918	10	539.3	73.6
919	11	557.8	70.3
920	11	475.5	74.5
921	9	483.8	88.3
930	11	625.4	110.5
931	12	599.4	91.1
932	12	602.6	62.3
933	15	583.3	148.5
934	10	581.0	60.1
935	13	609.7	53.4
936	11	581.6	173.2
937	8	498.5	52.9
960	5	584.0	152.1
961	3	500.7	52.4

TABLE C-3. TOUCHDOWN POSITION FROM THRESHOLD (DAY)

SERIES	RUNWAY DISTANCE SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)
600	5	-287.2	153.0	4	-1.0	2.8
601	12	-230.0	65.4	10	-1.4	4.9
602	6	-297.2	105.4	4	-2.5	2.4
603	7	-280.3	115.1	6	-4.2	3.9
604	9	-267.2	48.4	8	-2.4	4.4
605	5	-317.4	143.3	4	-2.8	2.5
610	14	-317.7	95.9	12	-2.3	4.2
611	13	-261.2	43.3	11	-1.3	5.5
612	8	-273.6	77.3	5	-0.6	6.6
613	8	-225.6	54.7	8	+1.5	2.9
614	10	-225.5	56.0	10	-0.6	4.1
615	17	-356.5	122.7	15	-1.8	7.1
616	12	-283.0	82.2	10	0.3	2.8
617	10	-274.6	76.7	10	1.5	3.7
618	9	-252.2	53.3	6	1.8	12.1
619	8	-232.4	38.0	8	1.6	3.4
620	8	-275.3	81.6	8	-3.3	3.9
621	10	-276.5	86.4	10	0.4	4.9
630	9	-300.0	85.0	9	0.3	3.1
631	8	-255.1	58.2	8	-1.5	6.3
632	9	-316.8	136.1	9	-4.7	4.7
633	10	-311.5	52.3	9	1.3	7.7
634	9	-274.2	76.7	9	1.8	4.7
635	9	-305.0	103.4	9	-4.8	5.5
636	14	-326.4	108.2	13	1.8	6.7
637	10	-317.5	65.5	10	1.7	6.4
660	7	-314.4	131.3	7	-2.6	6.8
661	5	-241.2	67.9	3	2.3	8.2

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE C-4. STOP DISTANCES FROM THRESHOLD CORRECTED TO STANDARD CONDITIONS (DAY)

SERIES	SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)
600	5	- 907.2	102.0
601	10	- 916.8	90.2
602	5	- 927.8	84.7
603	7	- 901.6	101.8
604	7	- 956.7	123.8
605	6	-1014.5	200.9
610	13	-1025.9	149.9
611	12	- 865.5	92.9
612	6	- 901.8	101.2
613	8	- 863.4	164.4
614	11	- 988.3	83.5
615	17	-1025.9	125.0
616	10	-1049.1	170.7
617	9	- 909.2	79.2
618	8	- 889.3	86.3
619	8	- 864.0	123.9
620	9	- 896.7	135.6
621	10	- 872.6	100.9
630	8	-1112.3	106.2
631	8	- 882.8	93.2
632	7	- 967.8	86.9
633	8	- 898.5	99.5
634	7	- 956.1	56.2
635	9	- 887.6	141.2
636	13	-1014.7	132.5
637	10	- 912.2	116.3
660	6	-1025.0	148.7
661	5	- 833.6	107.9

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE C-5. ROLLOUT DISTANCE FROM TOUCHDOWN TO STOP (DAY)

SERIES	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
600	5	520.6	146.0
601	10	584.4	113.9
602	5	587.4	176.5
603	7	502.6	93.4
604	7	606.9	139.9
605	6	632.3	126.9
610	13	592.7	139.4
611	11	492.0	92.9
612	6	598.3	221.6
613	8	520.6	171.9
614	11	616.4	147.5
615	18	532.1	121.8
616	12	659.3	93.9
617	9	505.2	104.8
618	7	513.9	59.4
619	8	482.5	112.3
620	8	522.4	197.2
621	10	483.9	66.9
630	8	582.0	112.3
631	8	531.0	97.4
632	7	597.3	147.6
633	8	488.0	102.0
634	7	582.0	114.4
635	9	467.1	65.0
636	13	560.8	111.6
637	10	476.0	122.6
660	6	513.5	145.0
661	5	494.2	84.0

TABLE C-6. ROLLOUT DISTANCE FROM TOUCHDOWN TO STOP (NIGHT)

SERIES	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
900	15	762.9	174.7
901	12	588.6	136.2
902	8	598.3	120.3
903	5	601.8	123.6
904	7	539.9	121.2
905	9	494.3	156.2
910	9	651.0	134.1
911	9	529.0	81.4
912	13	625.8	124.0
913	10	560.8	100.6
914	10	622.1	124.0
915	11	609.6	78.8
916	11	653.1	140.6
917	15	525.7	118.7
918	10	564.7	94.3
919	11	598.7	168.9
920	11	669.4	134.1
921	9	518.0	96.6
930	11	641.6	109.7
931	12	642.2	172.2
932	12	601.0	125.7
933	15	632.5	161.1
934	10	697.0	162.3
935	13	625.2	66.3
936	11	655.3	133.7
937	8	539.0	88.4
960	5	566.2	117.0
961	3	519.7	76.4

TABLE C-7. ROLLOUT DISTANCE CORRECTED TO STANDARD CONDITIONS (DAY)

SERIES	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
600	5	620.0	115.6
601	10	699.6	74.3
602	5	619.8	149.8
603	7	621.3	76.6
604	7	692.7	124.8
605	6	736.8	158.3
610	13	711.1	132.0
611	11	594.0	87.7
612	6	669.0	151.6
613	8	637.8	178.7
614	11	747.2	120.5
615	18	655.6	99.4
616	11	799.0	152.7
617	9	632.3	131.5
618	7	650.9	72.7
619	8	631.6	100.2
620	8	640.1	178.0
621	10	596.1	78.1
630	8	801.4	114.4
631	8	627.6	62.3
632	7	652.9	107.2
633	8	590.8	71.4
634	7	680.7	101.0
635	9	582.6	106.2
636	13	683.7	131.7
637	10	594.7	100.4
660	6	716.5	84.0
661	5	592.4	116.3

TABLE C-8. ROLLOUT DISTANCE CORRECTED TO STANDARD CONDITIONS (NIGHT)

SERIES	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
900	15	800.6	145.1
901	12	658.5	118.4
902	8	650.3	132.4
903	5	677.4	118.5
904	7	651.7	93.8
905	9	551.1	184.4
910	9	943.7	124.0
911	9	606.1	92.2
912	13	695.8	116.7
913	10	638.3	113.2
914	10	688.3	112.5
915	11	664.6	92.1
916	11	730.9	150.5
917	15	584.3	155.5
918	10	632.7	97.9
919	11	646.1	128.6
920	11	776.7	134.6
921	9	590.1	88.0
930	11	698.9	109.0
931	12	659.8	156.6
932	12	662.0	123.9
933	15	675.3	177.3
934	10	728.2	142.3
935	13	687.1	58.5
936	11	701.4	134.9
937	8	627.8	84.8
960	5	615.4	103.6
961	3	597.7	57.3

TABLE C-9. LANDING DISTANCE FROM 35-FEET ALTITUDE TO STOP (DAY)

SERIES	ACTUAL STOP DISTANCE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)	CORRECTED STOP DISTANCE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
600	5	1108.4	126.9	5	1207.8	140.3
601	10	1119.0	157.4	10	1234.2	141.5
602	5	1187.0	163.1	5	1219.4	134.5
603	7	1053.1	105.1	7	1171.9	94.5
604	7	1258.6	277.7	7	1344.4	272.3
605	6	1292.0	314.1	6	1396.5	333.0
610	13	1359.2	130.8	13	1477.6	120.4
611	11	1234.0	154.7	11	1336.2	145.6
612	6	1196.8	163.9	6	1267.5	89.6
613	13	1106.8	166.6	13	1217.1	162.8
614	12	1090.3	146.7	12	1200.7	108.3
615	13	1115.8	213.7	13	1256.8	137.4
616	11	1385.3	165.6	11	1520.5	210.7
617	9	1277.3	124.3	9	1404.4	148.6
618	8	1070.9	82.2	8	1198.1	98.4
619	8	1061.6	124.2	8	1210.8	100.7
620	9	1039.7	149.9	9	1158.2	121.8
621	10	969.4	117.5	10	1081.6	108.0
630	9	1237.9	157.7	9	1458.2	133.3
631	8	1177.6	134.1	8	1279.1	70.2
632	6	1205.8	86.0	6	1295.5	78.7
633	9	1115.1	101.6	9	1207.2	76.2
634	7	1216.7	117.9	7	1315.4	86.7
635	10	1113.4	195.9	10	1248.5	170.7
636	11	1175.4	143.4	11	1288.5	141.6
637	11	1075.8	169.2	11	1166.6	207.0
660	6	1096.3	89.3	6	1299.3	91.8
661	5	1040.8	86.3	5	1139.0	85.9

TABLE C-10. POSITION IN SPACE AT 35-FEET ALTITUDE (DAY)

SERIES	LATERAL DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	DISTANCE BEFORE THRESHOLD SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
600	5	-4.2	3.3	6	308.2	64.4
601	10	-3.3	8.9	12	313.1	98.7
602	5	-9.2	5.8	7	278.4	54.1
603	6	-4.7	4.8	7	270.3	47.7
604	9	-3.9	6.8	10	358.3	170.0
605	5	-3.2	4.7	6	382.0	164.6
610	13	-4.1	6.0	14	435.4	107.2
611	11	-1.3	8.7	13	472.6	91.8
612	8	1.4	8.7	8	329.1	67.3
613	8	3.3	5.1	8	327.1	77.1
614	8	-0.8	8.3	8	242.1	47.4
615	15	1.3	6.1	15	229.9	78.7
616	11	-2.3	6.8	11	455.0	116.6
617	10	0.6	6.2	10	514.4	128.6
618	6	-4.7	6.8	6	299.0	42.0
619	9	2.8	3.9	9	348.8	68.7
620	8	-1.6	12.3	8	255.8	60.5
621	9	-2.1	6.8	9	232.1	80.0
630	9	-1.0	5.2	9	391.7	79.8
631	7	-3.0	5.2	9	409.4	58.2
632	8	-1.3	6.2	9	318.4	96.4
633	9	-2.0	5.5	11	294.0	86.5
634	9	2.6	7.0	9	368.6	57.9
635	8	-3.9	6.2	8	381.4	96.3
636	13	0.5	7.3	14	262.6	69.8
637	7	-3.6	8.5	9	340.1	82.3
660	7	-5.6	9.6	7	304.6	52.3
661	4	-6.0	21.0	5	305.4	55.0

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

APPENDIX D

LATERAL DEVIATION DURING ROLLOUT AND STOP

LIST OF TABLES

TABLE D-1. MAXIMUM LATERAL DEVIATION DURING ROLLOUT (DAY)

SERIES	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	MAXIMUM LEFT*(FT)	MAXIMUM RIGHT*(FT)
600	4	-0.5	10.2	-12.0	10.7
601	9	-4.8	6.6	-14.1	6.2
602	2	-3.8	10.0	-10.8	3.3
603	6	-4.6	8.1	-13.9	10.4
604	6	1.3	15.4	-16.3	27.2
605	5	-2.3	7.7	- 9.2	10.6
610	10	-2.6	5.9	- 9.3	10.0
611	8	-2.7	9.9	-11.8	16.0
612	4	-0.8	6.8	- 9.5	6.0
613	8	4.8	6.5	4.8	16.0
614	9	-0.5	8.4	- 9.8	14.5
615	13	-3.8	7.1	-19.5	5.6
616	9	-0.6	8.7	-17.6	11.0
617	10	0.8	9.7	-13.0	13.7
618	6	-8.7	3.7	-15.3	- 5.5
619	8	3.3	5.3	- 6.4	8.0
620	8	-6.6	9.4	-16.7	11.3
621	10	0.4	6.9	- 8.6	9.5
630	8	0.4	7.5	-10.9	7.2
631	8	-4.7	10.2	-18.8	14.2
632	7	-6.7	7.1	-18.8	2.8
633	9	-0.9	10.2	-16.4	13.5
634	7	3.4	5.6	- 8.8	7.9
635	9	-5.0	9.3	-20.4	5.1
636	12	0.9	6.8	- 9.6	15.3
637	9	2.2	9.5	- 9.2	18.8
660	4	-3.2	14.6	-20.8	10.1
661	5	-1.0	9.6	-14.3	7.6

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

TABLE D-2. MAXIMUM LATERAL DEVIATION DURING ROLLOUT (NIGHT)

SERIES	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	MAXIMUM LEFT*(FT)	MAXIMUM RIGHT*(FT)
900	15	-1.9	15.1	-29.6	31.6
901	12	-4.2	11.7	-29.0	22.2
902	7	-1.8	6.1	-10.1	6.1
903	5	-5.4	17.9	-29.4	12.4
904	5	2.3	3.8	- 4.0	5.8
905	8	-3.9	8.5	-18.9	8.7
910	6	-7.1	18.7	-41.5	9.8
911	7	5.3	8.4	- 6.4	13.8
912	12	1.6	8.7	-14.8	16.5
913	9	8.4	7.2	- 6.1	17.3
914	10	-2.2	14.3	-27.1	19.3
915	11	-2.3	11.8	-23.8	16.0
916	10	1.8	10.9	-22.0	15.2
917	10	-1.2	10.6	-18.5	13.3
918	6	2.2	8.6	-11.6	10.3
919	11	-0.7	9.2	-13.8	15.9
920	10	1.8	6.3	- 7.6	8.4
921	9	-0.4	8.4	- 9.0	15.9
930	10	-3.1	9.0	-17.2	8.6
931	11	-1.5	7.4	- 9.6	9.8
932	11	1.0	10.9	-15.2	22.0
933	14	-3.8	7.1	-12.9	8.6
934	8	-2.6	10.2	-20.4	13.8
935	11	2.8	8.5	- 8.7	14.3
936	9	-4.5	6.4	-13.9	6.9
937	8	-4.7	8.6	-14.4	11.5
960	4	2.1	3.6	- 5.1	3.0
961	3	-10.6	18.0	-22.9	10.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

TABLE D-3. RUNWAY STOP POSITION AND LATERAL DEVIATION (DAY)

SERIES	RUNWAY DISTANCE SAMPLE SIZE	AVERAGE** (FT)	STAND DEV (FT)	LATERAL-POSITION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)
600	5	-807.8	112.5	5	3.0	9.5
601	10	-801.6	120.1	10	-2.8	6.4
602	5	-895.4	125.0	3	8.0	23.6
603	7	-782.9	94.3	7	-0.4	8.5
604	7	-870.9	132.0	6	4.0	16.4
605	6	-910.0	205.4	5	2.8	8.2
610	13	-907.5	159.2	10	8.1	12.6
611	10	-735.5	80.6	10	-1.6	7.5
612	6	-831.2	167.8	5	-0.5	11.6
613	8	-746.3	155.6	8	3.0	5.8
614	11	-857.5	118.8	10	1.7	10.8
615	18	-890.7	176.1	16	-2.3	14.5
616	10	-918.3	139.9	10	-1.8	8.1
617	9	-782.1	72.6	9	1.1	7.3
618	7	-762.1	89.1	6	-0.5	14.7
619	8	-714.9	135.6	8	1.6	3.3
620	9	-778.1	171.1	8	-2.5	10.5
621	10	-760.4	120.4	10	-0.6	3.8
630	8	-892.9	121.8	8	0.3	4.8
631	8	-786.1	133.9	8	-3.4	8.1
632	7	-907.0	123.1	7	-4.3	6.2
633	9	-823.2	143.9	9	-0.4	9.0
634	7	-857.4	88.7	7	2.0	2.9
635	9	-772.1	138.3	9	-3.6	7.4
636	13	-891.8	114.0	13	0.5	3.6
637	11	-785.8	143.9	11	2.5	6.6
660	6	-822.0	107.9	6	-1.3	12.1
661	5	-735.4	58.4	4	1.5	15.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

APPENDIX E

INDIVIDUAL RUN STATISTICS - PILOTAGE AND INTERIM MLS ERRORS FOR TEST V FLIGHTS

LIST OF ILLUSTRATIONS

NOTES:

1. EACH $\overline{X}$ AND S DATA POINT IS DERIVED FROM DATA SAMPLES TAKEN AT 200 FEET INCREMENTS ON AN INDIVIDUAL APPROACH BETWEEN 12,400 AND 1,600 FEET DISTANCE FROM THE MLS TRANSMITTER.
2. THE GLIDE SLOPE NOMINAL ANGLE (ON PATH) IS 6.0 DEGREES.
3. TALAR EQUIPMENT LOCATED 150 FEET FORWARD OF THRESHOLD ON RUNWAY CENTERLINE.

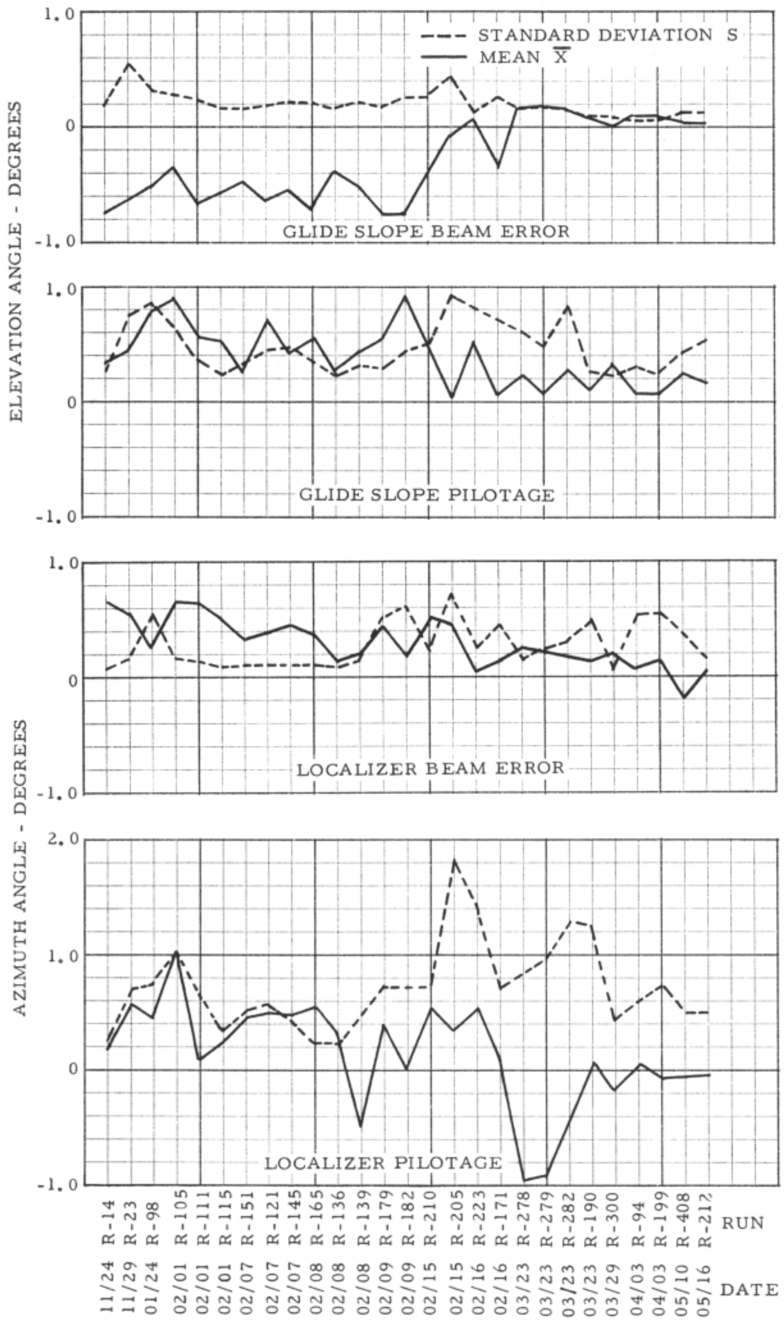


FIGURE E-1. INDIVIDUAL RUN STATISTICS - PILOTAGE AND MLS ERROR 6.0° - TALAR MLS - CENTERLINE APPROACH

NOTES:

1. EACH $\bar{X}$ AND S DATA POINT IS DERIVED FROM DATA SAMPLES TAKEN AT 200 FEET INCREMENTS ON AN INDIVIDUAL APPROACH BETWEEN 12,400 AND 1,600 FEET DISTANCE FROM THE MLS TRANSMITTER
2. THE GLIDE SLOPE NOMINAL ANGLE (ON PATH) IS 7.5 DEGREES.
3. TALAR EQUIPMENT LOCATED 150 FEET FORWARD OF THRESHOLD ON RUNWAY CENTERLINE.

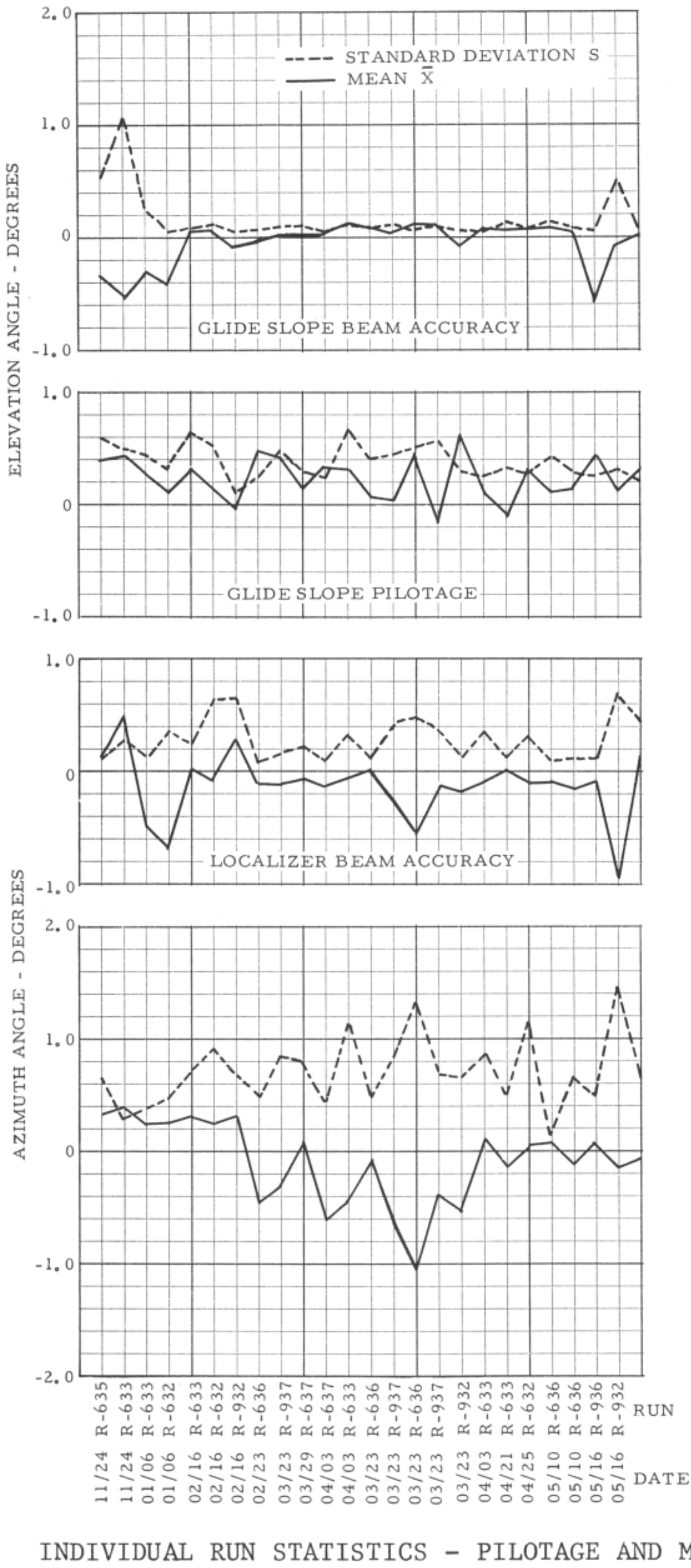


FIGURE E-2. INDIVIDUAL RUN STATISTICS - PILOTAGE AND MLS ERROR 7.5° - TALAR MLS - CENTERLINE APPROACH

NOTES:

1. EACH $\overline{X}$ AND S DATA POINT IS DERIVED FROM DATA SAMPLES TAKEN AT 200 ft. INCREMENTS ON AN INDIVIDUAL APPROACH BETWEEN 12,400 AND 1,600 ft DISTANCE FROM THE MLS TRANSMITTER.
2. THE GLIDE SLOPE NOMINAL ANGLE (ON PATH) IS 4.0 DEGREES.
3. MODILS EQUIPMENT LOCATED 100 ft. FROM RUNWAY CENTERLINE ON PILOT'S LEFT SUCH THAT GLIDEPATH INTERCEPT IS ABOUT 50 ft BEHIND THRESHOLD. THE LOCALIZER IS SKEWED TO THE PILOT'S RIGHT SO THE DECISION HEIGHT IS REACHED BEFORE RUNWAY CENTERLINE.

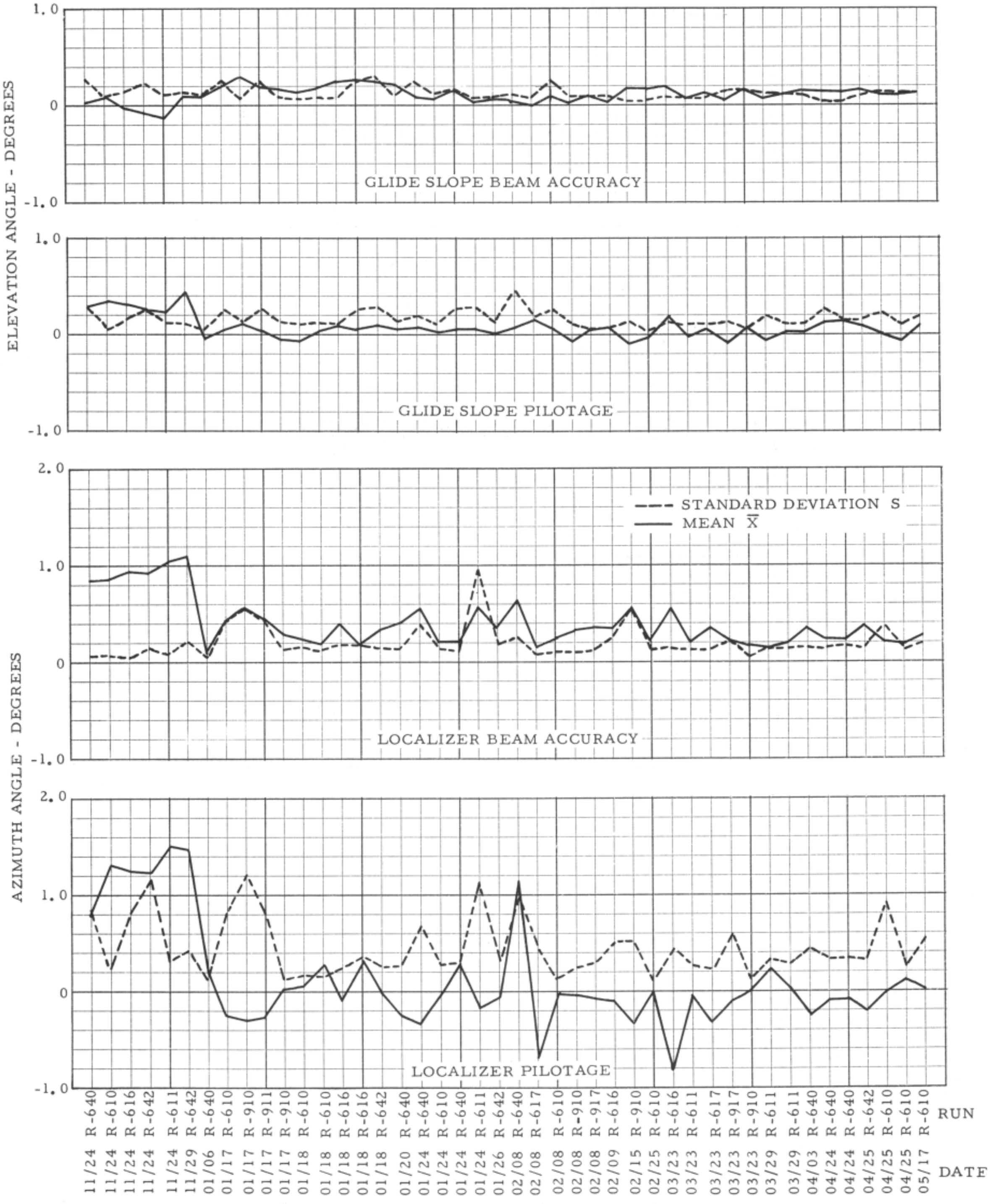


FIGURE E-3. INDIVIDUAL RUN STATISTICS - PILOTAGE AND MLS ERROR 4.0° - MODILS MLS - SKEWED APPROACH

NOTES:

1. EACH $\overline{X}$ AND S DATA POINT IS DERIVED FROM DATA SAMPLES TAKEN AT 200 FEET INCREMENTS ON AN INDIVIDUAL APPROACH BETWEEN 12,400 AND 1,600 FEET DISTANCE FROM THE MLS TRANSMITTER.
2. THE GLIDE SLOPE NOMINAL ANGLE (ON PATH) IS 6.0 DEGREES.
3. MODILS EQUIPMENT LOCATED 100 FEET FROM RUNWAY CENTERLINE ON PILOT'S LEFT SUCH THAT GLIDEPATH INTERCEPT IS ABOUT 50 FEET BEHIND THRESHOLD. THE LOCALIZER IS SKEWED TO THE PILOT'S RIGHT SO THE DECISION HEIGHT IS REACHED BEFORE RUNWAY CENTERLINE.

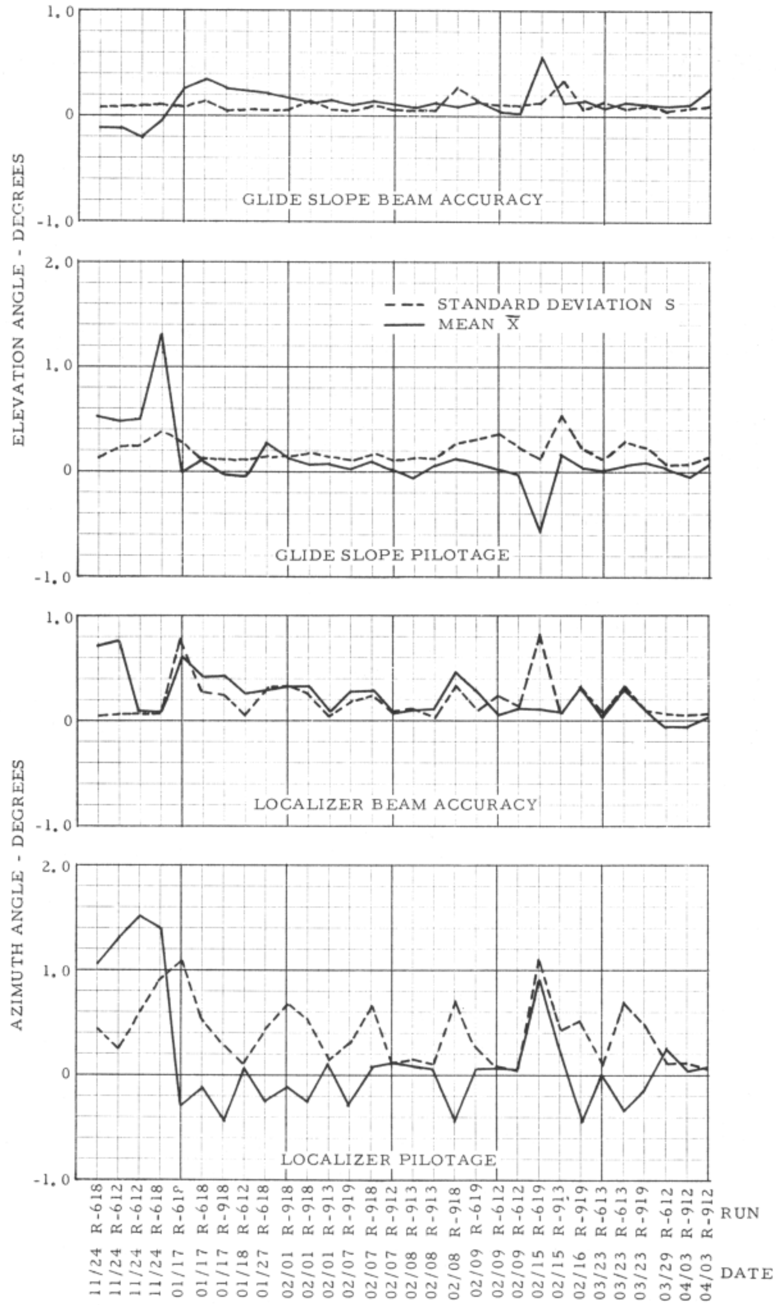


FIGURE E-4. INDIVIDUAL RUN STATISTICS - PILOTAGE AND MLS ERROR 6.0° - MODILS MLS - SKEWED APPROACH

NOTES:

1. EACH $\overline{X}$ AND S DATA POINT IS DERIVED FROM DATA SAMPLES TAKEN AT 200 FEET INCREMENTS ON AN INDIVIDUAL APPROACH BETWEEN 12,400 AND 1,600 FEET DISTANCE FROM MLS TRANSMITTER.
2. THE GLIDE SLOPE NOMINAL ANGLE (ON PATH) IS 7.5 DEGREES.
3. MODILS EQUIPMENT LOCATED 100 FEET FROM RUNWAY CENTERLINE ON PILOT'S LEFT SUCH THAT GLIDEPATH INTERCEPT IS ABOUT 50 FEET BEHIND THRESHOLD. THE LOCALIZER IS SKEWED TO THE PILOT'S RIGHT SO THE DECISION HEIGHT IS REACHED BEFORE RUNWAY CENTERLINE.

FIGURE E-5. INDIVIDUAL RUN STATISTICS - PILOTAGE AND MLS ERROR 7.5° - MODILS MLS - SKEWED APPROACH

APPENDIX F

DEPARTURES STRAIGHT AND TURNING

LIST OF TABLES

TABLE F-1. DAY DEPARTURES - STRAIGHT (ALL DATA)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	STAND DEV (FT)	SAMPLE SIZE
35	- 0.0	4.2	90	-1340.0	141.2	90
50	- 0.0	5.1	86	-1463.0	161.0	82
100	- 1.0	11.0	88	-1835.2	244.1	83
200	- 7.2	30.0	93	-2584.0	341.0	93
300	- 12.2	56.1	93	-3255.0	395.0	93
400	- 9.0	90.3	92	-3880.0	479.3	98
500	- 0.0	133.0	92	-4554.3	567.0	92
600	9.0	186.3	91	-5311.0	591.0	91
700	21.4	250.1	91	-6055.0	638.0	91
800	36.0	322.3	90	-6793.0	704.0	90
900	70.0	387.0	63	-7570.2	798.1	63
1000	221.0	409.4	08	-8241.0	898.0	08

TABLE F-2. DAY DEPARTURES - TURNING (ALL DATA)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	STAND DEV (FT)	SAMPLE SIZE
35	- 2.2	5.1	76	-1349.0	169.0	76
50	- 4.0	9.0	79	-1465.0	183.1	79
100	- 5.0	16.0	80	-1847.0	284.4	80
200	1.0	36.2	82	-2571.1	365.2	82
300	- 1.0	63.1	83	-3178.3	368.1	83
400	- 81.0	169.0	81	-3913.0	475.0	81
500	- 480.3	375.2	80	-4591.0	554.2	80
600	-1203.7	617.4	80	-4963.0	609.1	80
700	-1976.1	746.1	79	-4949.0	859.4	79
800	-2704.0	876.0	74	-4637.2	1128.1	74
900	-3327.0	983.0	53	-4131.0	1533.0	53
1000	-3660.0	1234.4	19	-4307.0	2010.2	19

Add 1500 feet to range data for A/C position related to threshold.

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE F-3. NIGHT DEPARTURES - TURNING (ALL DATA)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)	SAMPLE SIZE
35	- 0.2	4.3	58	-1288.0	131.4	58
50	- 1.0	5.0	59	-1396.0	143.4	59
100	- 2.3	9.0	57	-1727.0	215.0	57
200	- 2.4	31.0	63	-2521.0	411.0	63
300	- 12.0	58.1	62	-3162.0	460.4	62
400	- 39.0	105.0	61	-3730.0	586.0	61
500	- 256.0	243.2	65	-4421.0	697.0	65
600	- 903.4	515.0	65	-4936.0	761.4	65
700	-1654.0	599.3	65	-4999.3	859.0	65
800	-2330.0	601.0	64	-4709.2	1013.0	64
900	-2871.4	627.0	51	-4258.0	1243.0	51
1000	-3258.2	659.0	24	-4019.0	1444.0	24

TABLE F-4. NIGHT DEPARTURES - STRAIGHT (ALL DATA)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)	SAMPLE SIZE
35	1.0	5.0	69	-1343.4	132.0	69
50	- 1.0	6.0	69	-1470.0	150.0	69
100	- 1.0	10.0	69	-1844.0	248.3	69
200	- 1.0	27.2	69	-2628.0	374.3	69
300	- 12.0	56.2	71	-3259.0	412.0	71
400	- 33.0	93.0	70	-3839.0	529.4	70
500	- 72.2	157.3	69	-4470.0	658.0	69
600	- 119.0	228.0	69	-5167.0	760.1	69
700	- 155.0	307.0	69	-5865.2	826.2	69
800	- 183.0	377.4	67	-6565.0	922.0	67
900	- 209.0	452.1	61	-7105.0	1276.4	61
1000	- 305.0	641.0	08	-8413.0	1174.0	08

Add 1500 feet to range data for A/C position related to threshold.

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE F-5. DAY DEPARTURES - STRAIGHT (WITH FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL DEVIATION AVERAGE* (FT)	LATERAL DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)	SAMPLE SIZE
35	0.5	4.0	29	-1360.7	154.1	29
50	0.9	4.8	27	-1489.9	168.0	27
100	0.9	10.5	28	-1853.3	259.1	28
200	- 5.6	37.5	28	-2589.9	348.4	28
300	- 12.5	76.8	28	-3289.6	414.6	28
400	- 0.3	120.1	28	-3950.9	558.0	28
500	13.8	173.4	28	-4659.5	657.9	28
600	22.9	233.1	28	-5396.6	631.5	28
700	40.7	297.3	28	-6127.3	666.4	28
800	48.3	379.4	28	-6875.2	768.1	28
900	21.7	446.2	19	-7679.5	807.7	19
1000	339.7	599.5	3	-8687.7	1416.8	3

TABLE F-6. NIGHT DEPARTURES - STRAIGHT (WITH FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)	SAMPLE SIZE
35	- 1.3	4.7	29	-1341.1	135.1	29
50	0.5	4.8	29	-1472.7	157.5	29
100	0.7	10.8	29	-1862.9	230.5	29
200	1.8	31.5	29	-2658.7	365.2	29
300	10.6	64.8	29	-3275.2	418.0	29
400	29.4	108.8	29	-3830.2	496.6	29
500	66.1	183.7	29	-4428.6	588.4	29
600	98.7	259.1	29	-5096.2	636.3	29
700	117.7	341.5	29	-5788.1	688.6	29
800	148.7	404.4	28	-6465.3	773.2	28
900	168.2	500.3	24	-7021.4	845.8	24
1000	244.6	394.1	5	-8114.2	1012.0	5

Add 1500 feet to range data for A/C position related to threshold.

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE F-7. DAY DEPARTURES - STRAIGHT (WITHOUT FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)
35	- 0.4	4.3	61	-1329.5	135.0
50	- 0.5	5.3	59	-1450.8	157.1
100	- 2.0	10.7	60	-1826.9	238.7
200	- 8.0	26.3	65	-2581.4	340.2
300	- 12.2	45.3	65	-3239.7	388.6
400	- 12.1	74.5	64	-3849.0	441.9
500	- 6.1	111.9	64	-4508.4	520.8
600	2.7	163.1	63	-5273.1	573.1
700	12.8	228.2	63	-6022.6	627.4
800	30.2	296.3	62	-6755.6	675.7
900	90.8	362.1	44	-7523.0	798.7
1000	149.6	311.1	5	-7989.0	422.2

TABLE F-8. NIGHT DEPARTURES - STRAIGHT (WITHOUT FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)
35	- 0.1	5.1	40	-1345.2	131.1
50	0.9	6.2	40	-1467.7	146.0
100	0.8	8.7	40	-1830.0	262.5
200	0.4	24.2	40	-2605.0	383.8
300	12.5	50.8	42	-3247.0	412.0
400	34.8	80.8	41	-3845.7	557.5
500	76.7	137.5	40	-4499.2	709.5
600	133.1	203.9	40	-5218.1	842.8
700	182.0	280.3	40	-5921.2	917.8
800	206.9	360.3	39	-6636.5	1019.4
900	235.6	423.1	37	-7159.1	1500.3
1000	404.3	1049.9	3	-8910.7	1476.1

Add 1500 feet to range data for A/C position related to threshold.

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE F-9. DAY DEPARTURES - TURNING (WITH FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)
35	3.5	5.8	25	-1323.7	159.2
50	5.8	12.1	28	-1435.9	175.0
100	6.1	19.9	27	-1822.6	283.0
200	2.6	45.1	27	-2550.4	346.6
300	5.4	72.8	27	-3139.6	348.2
400	101.9	173.7	27	-3878.1	426.5
500	589.7	391.1	27	-4622.1	517.5
600	1384.0	644.5	27	-4939.1	587.5
700	2255.8	806.3	26	-4769.8	814.4
800	2949.8	960.5	23	-4410.8	1065.7
900	3429.0	1090.8	18	-3761.1	1430.8
1000	3636.2	1658.3	6	-4029.0	2804.9

TABLE F-10. NIGHT DEPARTURES - TURNING (WITH FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	LATERAL-DEVIATION STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	RANGE STAND DEV (FT)
35	- 0.5	4.2	21	-1298.1	137.0
50	- 0.1	4.7	21	-1401.2	154.6
100	0.5	8.5	21	-1721.7	232.0
200	7.3	21.3	23	-2501.3	337.5
300	25.2	39.1	23	-3149.5	359.8
400	65.1	73.5	23	-3718.5	462.2
500	263.3	201.4	23	-4387.8	631.6
600	889.6	445.7	23	-4957.2	733.9
700	1629.9	558.6	23	-5070.8	865.8
800	2337.3	604.3	23	-4831.1	1082.7
900	2995.8	635.6	18	-4421.8	1393.4
1000	3446.2	633.6	10	-4098.0	1673.5

Add 1500 feet to range data for A/C position related to threshold.

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE F-11. DAY DEPARTURES - TURNING (WITHOUT FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	STAND DEV (FT)
35	1.7	4.8	51	-1360.7	173.5
50	2.3	5.9	51	-1480.9	187.2
100	4.3	13.9	53	-1858.7	287.0
200	- 2.1	31.3	55	-2581.4	376.7
300	- 1.0	58.6	56	-3197.1	379.0
400	70.2	167.1	54	-3930.5	500.3
500	424.7	357.9	53	-4975.5	576.2
600	1110.3	587.9	53	-4975.5	625.1
700	1839.0	681.5	53	-5036.2	873.8
800	2592.4	820.5	51	-4739.4	1150.8
900	3275.0	934.8	35	-4321.1	1568.2
1000	3670.7	1067.4	13	-4434.6	1651.4

TABLE F-12. NIGHT DEPARTURE - TURNING (WITHOUT FLIGHT DIRECTOR)

ALTITUDE (FT)	LATERAL-DEVIATION AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	RANGE AVERAGE** (FT)	STAND DEV (FT)
35	0.7	4.5	37	-1282.4	129.8
50	1.7	5.3	38	-1392.6	138.9
100	3.4	9.4	36	-1792.4	207.6
200	- 0.3	34.9	40	-2532.5	451.2
300	4.0	66.1	39	-3169.2	512.0
400	23.1	118.0	38	-3737.0	655.0
500	252.1	265.6	42	-4439.0	736.8
600	911.0	554.4	42	-4924.0	784.6
700	1667.0	626.8	42	-4960.1	863.2
800	2325.3	606.6	41	-4690.9	978.5
900	2803.5	620.7	33	-4168.7	1165.1
1000	3123.9	666.3	14	-3962.2	1319.3

Add 1500 feet to range data for A/C position related to threshold.

* Negative (-) is left of centerline: positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

APPENDIX G

PILOT PERFORMANCE EVALUATION

Comments on Commuter Airline and Subject Pilot Performance by Project Pilot Jack Ryan

The participating pilots, were well-experienced captains and current in the De Havilland Twin Otter aircraft. Two of the participating airlines have a microwave landing system installed on their airports set at a 6° glide slope angle. Other airlines use the standard ILS/VOR/NDB.

Overall pilot performance varied to a greater extent between individual airlines and to a smaller degree between individual pilots from the same airline.

It became quite evident that for a safe operation from STOL runways under IFR conditions a large amount of transition and recurrent training will be required.

OVERALL PILOT HANDLING OF AIRCRAFT.

Good to excellent under test conditions.

TAKEOFF.

Good to excellent under test conditons.

APPROACHES (IFR).

Generally, the subject pilots performance on the interim MLS was good after they became familiar with the beam sensitivities of the equipment. Several pilots had difficulties due to lack of familiarity with the flight director, and actually found it easier to fly the raw data on the course deviation indicator (ID-249).

LANDING (DH TO TOUCHDOWN).

The problems generally arose when the hood was removed at the 200-foot DH, and the subject would find himself on what seemed to him to be an unusually steep glide slope. He would then reduce power and dive until he achieved a more normal glide slope. However, with full flaps, a large power application was then required to carry the aircraft over to the touchdown zone, resulting in an unstabilized approach and occasionally a poor landing.

TOUCHDOWNS.

The Twin Otter Aircraft (DHC-6) was operated on all project runs at or close to maximum gross weight. After the initial transition, all touchdowns were smooth and it was evident that these airline pilots stress the smoothness of landing rather than maximum performance. Touchdowns, relative to the runway marks, were good but it appears that most pilots favor the left side of the runway until this is brought to their attention.

STOPPING.

Except for a few instances, the airline pilot subjects were reluctant to use maximum braking action, and elected to execute gentler stops than the FAA pilot subjects. Many let the aircraft roll excessively increasing their stopping efforts only when the end of the runway was in sight. There again, the passengers comfort seemed to be their main objective.

GO-AROUNDS.

Go-arounds were initiated at the 200-foot DH using the radar altimeter on the safety pilot's command. No difficulties were noted on "both engines operating" go-arounds with either straight-out or turning departures.

APPENDIX H

DAY APPROACHES USING ALL AVAILABLE AIDS

LIST OF TABLES

LIST OF TABLES (continued)

TABLE H-1. DAY APPROACHES USING ALL AVAILABLE AIDS

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	4	-368.0	993.0	4	1505.3	64.4
16000	5	-307.8	767.0	5	1395.4	276.0
15000	6	-212.2	624.0	6	1398.7	251.1
14000	9	-145.2	461.8	9	1295.9	327.4
13000	11	-121.4	408.6	11	1282.4	329.0
12000	12	- 95.3	350.1	12	1226.8	317.7
11000	12	- 28.1	155.3	12	1171.7	283.7
10000	14	- 62.7	205.3	14	1121.0	238.9
9000	14	- 55.1	221.6	14	1057.1	177.2
8000	14	- 66.4	214.5	14	974.8	132.5
7000	15	-114.1	277.0	15	879.3	105.0
6000	16	- 79.4	211.3	16	768.3	90.8
5000	16	- 46.8	121.9	16	636.1	79.3
4000	16	- 12.9	96.7	16	502.2	57.5
3000	16	- 17.4	65.2	16	368.9	37.4
2500	17	- 24.4	51.9	17	304.3	33.1
2000	16	- 22.9	37.7	15	246.4	20.8
1500	16	- 3.1	17.7	16	176.5	17.4
1000	17	- 4.4	14.9	17	119.4	19.9
W.G.P.** 50	13	- 5.1	9.2	13	58.5	10.3
W.G.P. 35	13	- 5.1	7.9	13	46.2	9.4
1750	17	- 11.4	27.6	17	207.8	26.9
1335	17	- .9	15.1	17	161.3	25.4
1040	17	- 3.9	14.8	17	124.5	20.4
877	15	- 2.9	12.8	15	103.7	19.5
760	14	- 3.9	12.0	14	90.0	18.0
Threshold	15	- 1.1	4.2	15	11.4	2.5

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 - Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-2. DAY APPROACHES USING VASI GUIDANCE ONLY

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
14000	2	66.5	79.9	2	903.5	5.0
13000	3	- 14.7	145.3	3	957.3	101.2
12000	6	- 63.0	205.3	6	910.7	152.0
11000	7	- 33.4	134.3	7	908.0	144.7
10000	8	- 18.0	90.7	8	898.5	159.5
9000	8	- 13.9	77.8	8	877.8	188.7
8000	10	- 6.3	74.9	10	842.3	172.7
7000	13	- 14.2	67.3	13	804.5	132.4
6000	14	- 18.0	53.0	14	734.4	120.9
5000	14	- 16.9	37.6	14	634.7	92.6
4000	14	- 14.1	29.7	14	513.1	77.7
3000	14	- 13.9	25.0	14	373.9	53.3
2500	14	- 16.1	24.7	14	307.0	42.0
2000	13	- 10.3	17.9	13	243.4	30.0
1500	13	- 8.2	15.3	13	177.0	28.5
1000	14	- 6.1	10.1	14	123.5	17.8
W.G.P.** 50	4	- 3.3	4.0	4	45.8	3.3
W.G.P. 35	4	- 3.3	2.8	4	33.3	2.8
1700	13	- 7.8	14.0	13	212.9	26.0
1335	13	- 6.5	12.1	13	162.3	20.4
1040	14	- 5.8	10.6	14	129.1	19.3
877	12	- 6.8	9.1	12	108.3	13.5
760	11	- 7.5	9.1	11	94.6	11.3
Threshold	11	- 4.5	3.6	11	11.7	3.9

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-3. DAY APPROACHES USING NO AIDS - VFR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	2	-187.5	0.3	2	1114.0	302.6
16000	2	-172.0	234.8	2	1131.0	328.1
15000	4	- 63.8	123.4	4	1053.3	263.6
14000	4	- 32.5	85.6	4	1050.0	271.0
13000	6	- 9.3	61.1	6	993.8	221.3
12000	6	- 19.8	79.3	6	965.2	210.8
11000	7	- 45.0	95.9	7	896.3	169.1
10000	7	- 52.1	106.5	7	839.3	150.7
9000	8	- 57.4	123.3	8	776.1	136.5
8000	10	- 37.7	104.4	10	729.5	123.5
7000	11	- 39.1	90.6	11	656.6	139.3
6000	13	49.5	266.1	13	606.3	139.8
5000	14	- 8.6	72.2	14	530.1	141.6
4000	16	- 24.0	37.3	16	423.3	105.7
3000	16	- 16.8	26.5	16	313.8	89.1
2500	16	- 15.9	22.6	16	261.6	76.3
2000	16	- 11.0	18.1	16	209.2	58.0
1500	15	- 8.2	15.3	15	148.3	42.9
1000	15	- 5.9	12.1	15	98.1	30.4
1750	16	- 7.8	15.4	16	179.3	50.2
1335	15	- 7.6	15.4	15	131.5	38.2
1040	14	- 4.7	11.6	14	100.7	32.0
877	14	- 4.1	10.6	14	84.5	27.6
760	13	- 2.8	8.8	13	75.8	23.9
Threshold	13	- 2.0	4.4	13	12.0	4.7

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

TABLE H-4. DAY APPROACHES - 4° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT WITH FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	10	-656.7	243.9	10	830.1	100.6
16000	12	-553.9	223.2	12	815.7	64.5
15000	16	-497.7	279.3	16	822.5	49.1
14000	20	-449.9	205.9	20	842.3	67.0
13000	22	-420.3	159.5	22	847.6	67.7
12000	25	-374.6	89.8	25	828.1	66.1
11000	26	-336.3	69.7	26	799.7	47.9
10000	26	-301.9	77.2	26	740.0	42.3
9000	26	-279.9	70.3	26	661.9	41.6
8000	25	-241.9	58.5	25	573.2	42.9
7000	27	-214.0	35.2	27	498.1	27.5
6000	28	-164.9	50.9	28	430.9	23.1
5000	28	-129.3	44.6	28	364.1	23.8
4000	27	- 92.4	28.6	27	295.1	15.4
3000	26	- 42.2	21.9	26	213.3	13.9
2500	27	- 15.1	25.0	27	177.0	13.1
2000	27	- 3.6	19.7	27	141.2	6.8
1500	25	- 3.2	16.2	26	108.6	9.8
1000	23	- 1.9	9.7	24	74.0	7.6
W.G.P.** 50	20	- 3.3	6.6	23	51.6	6.0
W.G.P. 35	21	- 2.3	4.9	26	38.2	5.8
1750	25	- 4.9	18.5	26	124.9	8.2
1335	25	- 2.4	13.9	26	97.2	9.6
1040	24	- 1.7	10.0	27	76.8	7.9
877	22	- 2.4	8.5	27	64.9	7.4
760	21	- 3.1	7.2	26	56.6	6.9
Threshold	22	- 1.3	3.7	27	12.5	5.6

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-5. DAY APPROACHES - 6° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT WITH FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	7	-1070.6	921.8	7	1226.0	50.2
16000	8	-1030.3	573.0	8	1220.4	47.5
15000	10	-1033.2	271.6	10	1212.7	50.2
14000	10	- 960.9	193.5	10	1203.0	50.0
13000	11	- 810.6	219.0	11	1200.0	46.1
12000	12	- 761.3	116.4	12	1195.3	53.3
11000	14	- 665.4	93.1	14	1282.3	33.8
10000	14	- 511.9	80.7	14	1116.7	38.9
9000	15	- 503.5	89.6	15	1014.6	40.1
8000	15	- 461.3	95.6	15	888.5	33.8
7000	16	- 414.9	103.0	16	757.7	29.1
6000	16	- 348.5	69.9	16	643.4	37.4
5000	17	- 283.8	58.4	17	536.5	30.2
4000	17	- 200.0	48.4	17	436.5	25.4
3000	17	- 129.2	46.1	17	332.7	15.6
2500	17	- 86.4	25.0	17	275.4	18.5
2000	17	- 45.7	26.3	16	222.3	11.8
1500	17	- 16.9	25.0	17	163.0	12.2
1000	16	5.4	19.4	16	106.1	10.3
W.G.P.** 50	15	3.4	7.8	16	47.8	6.7
W.G.P. 35	15	2.8	5.7	16	35.7	6.0
1750	16	- 31.3	24.1	16	194.1	13.6
1335	17	- 8.1	24.6	17	144.6	13.5
1040	16	5.0	20.5	16	110.9	10.8
877	16	5.9	17.3	16	92.1	9.1
760	16	5.0	14.6	17	79.2	7.9
Threshold	15	1.1	3.9	17	11.2	3.2

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-6. DAY APPROACHES - 7.5° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT WITH FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	3	-1400.7	217.0	3	1617.3	120.9
17000	13	-1569.8	351.2	13	1537.4	80.2
16000	17	-1330.9	438.0	17	1543.1	71.7
15000	18	-1212.2	293.3	18	1533.7	55.8
14000	20	-1183.8	162.0	20	1522.4	61.3
13000	22	-1106.2	117.5	22	1537.0	59.6
12000	24	-1024.5	127.6	24	1549.4	59.4
11000	24	- 917.4	105.9	24	1524.7	34.5
10000	25	- 845.7	91.6	25	1429.6	35.8
9000	25	- 776.5	88.2	25	1288.5	47.8
8000	26	- 688.8	79.7	26	1131.4	52.4
7000	26	- 597.2	64.9	26	974.3	52.3
6000	26	- 492.5	55.8	26	819.8	42.2
5000	26	- 393.6	62.5	26	681.3	34.9
4000	26	- 297.5	42.8	26	542.2	20.5
3000	26	- 205.2	29.9	26	408.2	13.1
2500	26	- 150.1	28.5	26	341.2	10.5
2000	26	- 104.6	28.1	26	276.7	8.2
1500	23	- 62.1	28.6	23	208.0	11.7
1000	24	- 13.8	23.9	24	142.3	13.7
W.G.P.** 50	24	1.9	9.4	24	52.0	8.8
W.G.P. 35	24	0.3	6.9	24	38.8	8.1
1750	25	- 86.0	27.7	25	241.6	11.0
1335	21	- 47.0	28.4	23	186.2	12.3
1040	24	- 16.4	25.4	26	147.5	12.1
877	24	- 6.2	19.4	26	126.0	12.8
760	24	0.8	16.0	27	109.5	10.9
Threshold	24	- 1.2	4.7	28	14.9	6.0

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-7. DAY APPROACHES - 4° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT WITHOUT FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	8	- 570.0	267.6	8	824.8	48.7
16000	11	- 672.3	302.9	12	837.8	69.3
15000	13	- 588.2	239.7	15	822.8	67.2
14000	17	- 522.7	251.9	17	814.7	59.4
13000	20	- 558.9	276.2	20	806.3	74.3
12000	20	- 469.9	148.5	20	808.8	58.8
11000	20	- 440.1	145.3	20	775.2	44.4
10000	20	- 414.1	126.5	20	731.6	44.0
9000	22	- 378.1	80.1	22	666.4	37.5
8000	22	- 316.0	89.0	22	586.1	33.4
7000	22	- 245.0	82.9	22	518.7	37.0
6000	22	- 208.0	85.1	22	453.6	31.4
5000	22	- 165.0	63.3	22	381.3	31.8
4000	22	- 110.9	44.5	22	306.3	19.1
3000	21	- 64.9	34.1	21	230.9	14.7
2500	20	- 49.7	40.5	20	191.7	17.6
2000	21	- 26.0	41.9	21	147.5	18.9
1500	21	- 7.0	33.8	22	109.5	14.8
1000	21	- 2.5	20.5	22	74.5	12.0
W.G.P.** 50	21	- 1.2	10.9	22	50.8	10.3
W.G.P. 35	21	- 1.2	6.9	22	37.2	8.5
1750	22	- 13.7	37.6	22	126.8	15.9
1335	21	- 5.7	31.1	22	98.7	14.1
1040	21	- 3.1	22.1	22	77.5	12.1
877	21	- 1.4	16.0	22	65.3	11.6
760	21	- 1.4	12.6	22	56.5	10.6
Threshold	21	0.1	3.5	22	10.3	3.0

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

**W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 50-feet elevation.

TABLE H-8. DAY APPROACHES - 6° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT WITHOUT FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	- 615.0	0.	1	1255.0	0.
17000	4	- 960.5	253.3	4	1170.8	59.0
16000	6	-1053.7	127.8	6	1185.5	33.7
15000	9	- 865.7	382.3	10	1220.2	57.8
14000	13	- 873.1	186.7	13	1193.7	66.5
13000	15	- 821.5	137.6	15	1207.7	70.1
12000	16	- 730.3	119.1	16	1200.9	48.4
11000	16	- 626.8	117.0	16	1196.3	47.9
10000	17	- 579.2	98.5	17	1112.8	36.3
9000	18	- 531.9	100.2	18	1009.6	57.3
8000	17	- 497.8	81.3	17	894.5	55.5
7000	17	- 440.7	73.0	17	776.4	51.7
6000	18	- 347.4	57.4	18	663.7	44.7
5000	17	- 255.2	39.0	17	556.5	33.9
4000	18	- 216.3	52.3	18	450.1	18.7
3000	18	- 142.8	64.1	18	337.8	15.5
2500	18	- 110.4	48.8	18	278.1	17.3
2000	18	- 80.8	39.7	18	226.7	15.2
1500	17	- 32.6	41.4	17	164.2	14.6
1000	17	6.8	24.4	18	112.6	12.9
W.G.P.** 50	15	0.3	9.1	18	49.3	10.8
W.G.P. 35	15	- 0.5	6.4	17	35.4	5.5
1750	17	- 55.5	37.2	17	197.2	14.3
1335	16	- 4.5	27.3	17	151.2	10.2
1040	16	7.6	25.3	18	117.3	13.5
877	16	9.1	20.5	18	96.8	10.9
760	16	7.1	16.8	18	82.1	9.5
Threshold	15	- 0.3	4.8	18	11.3	2.9

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-9. DAY APPROACHES - 7.5° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT WITHOUT FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	-1813.0	0.	1	1574.0	0.
17000	10	-1510.0	263.3	10	1570.4	89.5
16000	12	-1437.2	255.7	12	1573.8	97.1
15000	14	-1361.9	248.3	14	1569.4	105.1
14000	16	-1272.3	238.2	16	1557.3	90.3
13000	18	-1214.2	188.2	18	1550.4	79.4
12000	18	-1141.3	149.2	18	1553.6	66.1
11000	18	-1094.7	150.4	18	1514.3	41.9
10000	19	-1000.0	137.9	19	1400.7	36.9
9000	20	- 860.3	132.5	20	1259.6	43.4
8000	20	- 751.2	103.8	20	1119.3	47.5
7000	20	- 659.2	77.0	20	984.3	39.6
6000	20	- 568.0	84.3	20	844.0	38.1
5000	20	- 420.0	69.7	20	695.3	32.8
4000	19	- 311.2	55.5	19	552.7	21.0
3000	19	- 237.3	37.3	19	420.2	13.5
2500	20	- 196.1	34.9	20	352.1	16.8
2000	20	- 143.5	26.5	20	279.6	12.9
1500	19	- 82.7	30.0	19	213.9	9.8
1000	20	- 25.7	29.6	20	142.7	8.3
W.G.P.** 50	18	- 2.5	12.4	18	50.1	10.2
W.G.P. 35	18	- 3.7	11.7	18	38.1	8.5
1750	20	- 114.4	24.4	20	244.6	9.0
1335	17	- 56.4	29.6	18	190.8	8.2
1040	19	- 26.0	27.7	20	148.3	8.0
877	20	- 12.1	22.7	21	125.5	9.4
760	20	- 7.9	21.0	21	108.0	9.7
Threshold	17	- 1.7	5.7	18	13.7	4.4

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 50-feet elevation.

TABLE H-10. DAY APPROACHES - 6.0° GLIDE SLOPE USING CENTERLINE GUIDANCE TALAR EQUIPMENT WITH FLIGHT DIRECTOR

RANGE	LATERAL-DEVIATION SAMPLE	AVERAGE*	STAND	ALTITUDE SAMPLE	AVERAGE	STAND
17000	5	122.0	84.3	7	1342.2	173.5
16000	8	106.5	133.9	8	1278.0	149.2
15000	12	74.3	78.1	12	1257.8	99.5
14000	14	77.6	93.0	14	1226.8	70.9
13000	18	90.0	166.8	18	1209.8	57.4
12000	18	41.3	58.4	18	1198.7	52.1
11000	18	49.2	78.8	18	1150.1	66.0
10000	17	33.0	55.2	17	1062.4	81.8
9000	20	29.6	86.0	20	960.4	88.4
8000	20	24.2	50.6	20	841.0	57.9
7000	19	5.6	46.8	19	717.7	33.4
6000	19	4.8	40.0	19	606.7	30.8
5000	19	4.1	20.5	19	497.8	28.6
4000	18	5.8	29.0	18	396.7	24.0
3000	19	4.6	41.3	19	300.9	21.9
2500	19	- 0.1	25.5	19	249.6	21.9
2000	19	1.6	25.4	19	194.6	16.4
1500	19	4.1	40.8	19	141.7	13.1
1000	19	- 3.8	24.3	19	90.4	11.3
W.G.P.** 50	18	- 5.9	15.5	18	51.0	9.2
W.G.P. 35	19	- 3.1	9.5	19	39.9	8.1
1750	19	5.3	38.3	19	165.4	16.4
1335	19	0.9	37.9	19	124.6	12.6
1040	19	- 3.6	26.1	19	94.3	11.5
877	19	- 3.7	19.4	19	78.6	11.1
760	19	- 4.0	15.5	19	67.2	10.6
Threshold	18	- 0.4	4.9	18	10.4	3.2

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-11. DAY APPROACHES - 7.5° GLIDE SLOPE USING CENTERLINE APPROACH TALAR EQUIPMENT WITH FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	8	153.4	189.4	8	1483.8	78.2
16000	10	131.7	153.6	10	1498.8	76.4
15000	15	143.0	136.0	15	1502.9	85.4
14000	16	134.1	152.7	16	1488.9	87.3
13000	18	63.2	168.5	18	1491.8	65.4
12000	14	62.9	151.5	14	1496.2	53.6
11000	16	93.4	115.2	16	1443.0	71.7
10000	16	76.8	102.5	16	1363.9	69.5
9000	17	7.1	114.7	17	1219.9	80.1
8000	19	- 22.7	99.5	19	1078.6	55.5
7000	19	8.6	74.6	19	916.9	41.6
6000	19	30.2	57.5	19	760.6	45.7
5000	19	9.5	53.2	19	623.0	37.7
4000	19	2.9	45.7	19	499.2	30.6
3000	19	7.3	73.7	19	371.1	21.8
2500	19	3.3	35.8	19	310.7	21.4
2000	19	0.1	32.8	19	247.4	18.0
1500	17	- 1.1	20.7	17	185.9	18.7
1000	19	- 5.4	20.6	19	117.7	13.5
W.G.P.** 50	18	- 7.3	12.3	19	57.2	11.8
W.G.P. 35	18	- 6.3	10.8	18	45.8	10.3
1750	19	3.4	26.1	19	217.5	17.7
1335	17	- 2.8	22.1	17	161.9	18.3
1040	19	- 4.3	21.5	19	122.9	14.0
877	18	- 6.5	18.4	19	101.8	12.0
760	18	- 7.3	16.5	19	87.2	11.6
Threshold	18	- 3.7	6.0	19	12.5	4.8

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-12. DAY APPROACHES - 6.0° GLIDE SLOPE USING CENTERLINE APPROACH TALAR EQUIPMENT WITHOUT FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	6	9.5	211.7	6	1206.0	36.5
16000	10	- 56.0	258.9	10	1192.3	46.1
15000	12	- 79.0	186.0	12	1193.8	48.7
14000	13	- 33.2	194.5	13	1197.1	41.4
13000	14	- 4.4	142.2	14	1198.1	45.0
12000	15	6.1	109.2	15	1188.4	43.9
11000	15	- 10.1	76.7	15	1139.6	75.2
10000	15	- 17.9	88.7	15	1057.3	72.6
9000	17	23.8	106.9	17	941.2	58.0
8000	17	- 0.5	96.0	17	815.8	55.7
7000	16	- 31.4	58.6	16	705.3	54.5
6000	17	6.1	101.9	17	602.3	45.4
5000	18	- 23.0	61.3	18	511.8	28.9
4000	18	- 43.4	59.5	18	412.8	24.0
3000	17	- 21.5	45.9	17	306.6	24.5
2500	18	- 11.6	39.3	18	256.6	23.2
2000	17	- 10.4	26.1	17	201.6	19.8
1500	18	- 13.2	24.8	18	152.4	19.4
1000	18	- 13.3	20.8	18	98.0	17.7
W.G.P.** 50	18	- 4.4	10.0	18	59.4	11.6
W.G.P. 35	18	- 1.8	7.8	18	47.0	9.3
1750	17	- 10.9	23.2	17	177.5	20.3
1335	18	- 14.6	25.1	18	133.1	19.4
1040	18	- 13.8	21.7	18	102.2	18.4
877	19	- 11.2	17.2	18	86.1	16.1
760	18	- 8.2	13.6	18	74.2	14.3
Threshold	18	- 1.3	6.9	18	11.4	2.8

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-13. DAY APPROACHES - 7.5° GLIDE SLOPE USING CENTERLINE APPROACH TALAR EQUIPMENT WITHOUT FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	88.0	0.	1	1543.0	0.
17000	10	41.4	172.3	10	1566.6	43.4
16000	14	39.7	166.5	14	1545.3	80.0
15000	18	23.7	167.7	18	1539.2	61.1
14000	20	44.4	152.6	20	1551.9	58.5
13000	17	48.4	139.0	17	1526.9	72.0
12000	18	31.3	147.7	18	1484.6	96.2
11000	18	- 4.3	115.6	18	1404.2	105.4
10000	18	- 8.4	89.3	18	1300.6	111.7
9000	20	- 3.5	59.2	20	1167.8	103.7
8000	22	-18.4	69.3	22	1029.5	87.1
7000	23	-33.8	73.0	23	897.1	74.3
6000	24	-23.3	60.7	24	766.4	65.9
5000	24	-23.7	47.8	24	642.0	47.9
4000	24	-20.4	65.3	24	511.0	52.7
3000	24	-16.8	50.8	24	386.9	39.5
2500	24	-15.3	50.9	24	325.1	34.4
2000	23	-10.6	48.6	24	254.3	27.8
1500	20	2.6	46.1	22	185.3	24.2
1000	20	2.1	42.7	22	120.9	17.6
W.G.P.** 50	22	- 0.1	15.9	24	63.1	13.9
W.G.P. 35	20	- 0.2	11.6	21	49.5	12.1
1750	22	- 7.7	46.5	23	219.0	24.8
1335	20	4.0	46.0	22	164.5	22.5
1040	20	2.7	43.9	22	126.2	18.2
877	21	- 0.2	37.1	23	106.0	16.1
760	21	- 1.0	30.4	23	91.9	14.6
Threshold	22	1.7	6.4	24	12.8	5.4

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-14. DAY APPROACHES - 7.5° GLIDE SLOPE USING CENTERLINE APPROACH TALAR EQUIPMENT WITHOUT FLIGHT DIRECTOR (IFR WITH VASI)

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	4	80.0	417.7	4	1642.5	99.0
16000	6	85.2	249.8	6	1594.5	124.4
15000	7	87.9	131.5	7	1573.4	142.1
14000	11	87.0	150.0	11	1543.5	115.6
13000	12	59.0	178.6	12	1526.6	75.1
12000	12	6.6	163.0	12	1512.5	61.3
11000	12	-13.2	109.0	12	1433.3	55.4
10000	12	-36.2	89.2	12	1314.5	72.3
9000	12	-35.7	86.4	12	1185.8	73.0
8000	12	-34.8	93.1	12	1052.8	57.9
7000	12	-30.8	69.6	12	912.4	52.4
6000	12	- 4.3	51.0	12	784.8	53.0
5000	12	- 5.0	51.8	12	645.5	56.2
4000	12	-26.7	71.5	12	510.4	48.7
3000	12	1.5	44.6	12	384.1	35.8
2500	12	- 0.1	41.2	12	322.2	31.0
2000	12	- 4.5	31.1	12	260.4	25.8
1500	11	- 7.9	21.8	12	193.3	25.7
1000	10	-10.1	29.8	11	129.1	13.2
W.G.P.** 50	8	-11.3	24.2	10	64.7	11.7
W.G.P. 35	9	- 9.4	17.9	11	50.5	10.4
1750	11	- 5.3	28.5	12	226.8	25.4
1335	10	- 9.8	21.7	12	175.1	21.0
1040	10	-10.0	28.6	12	137.4	15.8
877	10	-10.0	31.8	11	111.7	10.6
760	10	-10.2	30.6	11	95.8	8.6
Threshold	10	- 1.6	8.1	11	10.4	3.4

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE H-15. DAY MISSED APPROACH - 4.0° GLIDE SLOPE USING SKEWED APPROACH - MODIL EQUIPMENT AND STRAIGHT DEPARTURE - ALL ENGINES

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	2	-1199.5	1099.6	2	868.5	92.6
17000	6	- 482.8	245.5	6	889.0	132.3
16000	8	- 481.5	173.0	8	883.1	126.5
15000	10	- 507.7	206.7	10	875.6	110.6
14000	13	- 445.8	221.1	13	860.1	94.1
13000	14	- 459.5	159.9	14	851.1	73.2
12000	15	- 439.9	114.2	15	831.9	66.5
11000	15	- 386.1	88.6	15	795.9	42.4
10000	15	- 353.7	69.4	15	733.4	44.3
9000	15	- 347.1	75.5	15	659.3	34.5
8000	16	- 296.5	82.7	16	591.8	37.3
7000	16	- 245.9	56.7	16	509.8	30.1
6000	16	- 182.6	55.6	16	437.4	20.9
5000	16	- 149.4	47.2	16	360.6	22.4
4000	16	- 89.1	41.4	16	296.0	15.7
ALTITUDE (FT)					RANGE** (FT)	
200	16	- 43.9	37.8	16	2759.1	157.6
Low Point	16	- 8.1	29.9	16	1863.1	274.1
200	16	7.6	47.3	16	1277.2	342.9
300	16	4.9	80.8	16	575.5	553.5
400	15	19.1	136.0	15	- 171.4	594.1
500	15	7.7	223.0	15	-1137.3	843.5
600	15	27.9	311.8	15	-2050.1	892.4
700	15	63.4	377.0	15	-2742.5	863.4
800	15	106.1	463.8	15	-3349.7	836.9
900	14	230.0	512.8	14	-3852.4	356.0
1000	5	59.5	840.6	5	-4170.2	1829.6
Power Event 157	14	- 16.7	30.1	14	2089.3	314.2

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE H-16. DAY MISSED APPROACH - 7.5° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT AND STRAIGHT DEPARTURE - ALL ENGINES

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	3	-1396.0	410.8	3	1616.3	37.8
16000	6	-1432.8	296.8	6	1603.7	75.8
15000	6	-1364.8	318.1	6	1590.7	55.9
14000	7	-1335.4	290.8	7	1584.9	50.2
13000	9	-1256.0	260.0	9	1536.8	63.7
12000	10	-1194.2	241.0	10	1535.9	58.7
11000	10	-1121.2	187.1	10	1521.5	58.6
10000	11	- 964.8	162.9	11	1411.0	47.3
9000	12	- 844.5	139.9	12	1283.8	54.2
8000	11	- 729.1	148.7	11	1136.1	45.8
7000	12	- 662.0	124.2	12	994.2	35.3
6000	13	- 593.6	97.1	13	840.7	31.4
5000	14	- 465.6	84.4	14	699.0	22.6
4000	14	- 339.5	68.5	14	556.5	25.5
ALTITUDE (FT)					RANGE** (FT)	
200	14	- 60.4	39.7	14	1432.4	86.7
Low Point	14	- 0.9	66.7	14	652.9	218.3
200	14	33.4	59.7	14	- 174.4	497.2
300	14	38.6	108.7	14	- 866.4	528.9
400	14	45.6	153.5	14	-1496.4	556.1
500	14	27.4	220.6	14	-2441.6	899.6
600	14	39.5	261.7	14	-3072.1	908.2
700	14	58.9	304.1	14	-3731.5	861.6
800	14	83.5	361.5	14	-4347.0	983.4
900	10	175.9	334.6	10	- 487.2	1173.5
1000	1	217.0	0.	1	-4419.0	0.
Power Event 142	14	- 19.6	49.6	14	905.5	282.5

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE H-17. DAY MISSED APPROACH - 4.0° GLIDE SLOPE USING SKEWED APPROACH - MODIL EQUIPMENT AND TURNING DEPARTURE - ALL ENGINES

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	4	- 567.8	220.4	4	854.4	11.7
16000	5	- 677.2	120.9	5	824.4	23.5
15000	8	- 690.5	230.9	8	816.9	30.2
14000	9	- 655.0	162.3	9	814.2	36.1
13000	11	- 581.0	156.3	11	813.9	38.1
12000	13	- 496.5	152.9	13	812.2	49.0
11000	14	- 392.6	142.7	14	794.6	60.9
10000	14	- 356.4	145.1	14	744.1	31.2
9000	14	- 317.4	136.8	14	673.8	46.3
8000	14	- 289.7	124.0	13	608.6	76.2
7000	13	- 259.0	104.2	13	528.7	76.9
6000	15	- 220.9	71.2	15	455.9	56.3
5000	15	- 153.8	63.1	15	380.1	43.7
4000	15	- 100.6	74.0	15	300.6	45.6
ALTITUDE (FT)					RANGE** (FT)	
200	15	- 42.5	39.4	15	2733.3	254.8
Low Point	15	2.7	42.3	15	1935.6	311.3
200	15	6.5	92.1	15	1354.3	474.7
300	15	25.8	135.2	15	621.4	691.4
400	16	172.6	239.8	16	- 298.7	897.9
500	14	856.5	708.3	14	-1109.5	832.2
600	14	1679.7	854.0	14	-1540.9	747.3
700	13	2456.6	909.8	13	-1567.0	826.1
800	13	3116.2	1147.6	13	-1258.8	1054.5
900	11	3674.0	1247.2	11	- 702.2	1555.9
1000	6	4331.7	1065.2	6	- 290.2	1595.9
Power Event 161	15	- 13.9	3.7	15	2143.0	320.0

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE H-18. DAY MISSED APPROACH - 7.5° GLIDE SLOPE USING SKEWED APPROACH - MODIL EQUIPMENT AND TURNING DEPARTURE - ALL ENGINES

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	4	-1277.0	1037.2	4	1585.8	105.1
16000	5	-1288.0	628.2	5	1536.2	97.0
15000	5	-1151.8	491.3	5	1536.0	90.5
14000	8	-1195.4	299.3	8	1550.9	87.6
13000	8	-1161.8	212.2	8	1558.0	81.2
12000	12	-1033.3	210.6	12	1534.0	88.0
11000	14	- 948.5	160.0	14	1502.9	94.4
10000	14	- 871.4	116.7	14	1395.4	89.7
9000	14	- 786.2	126.8	14	1252.1	83.3
8000	14	- 697.2	128.6	14	1105.4	69.8
7000	14	- 604.6	107.1	14	953.6	59.5
6000	14	- 489.0	79.6	14	814.0	54.1
5000	14	- 385.3	84.9	14	669.6	48.7
4000	14	- 303.1	67.9	14	540.8	35.6
ALTITUDE (FT)					RANGE** (FT)	
200	14	- 121.6	101.5	14	- 121.6	352.2
Low Point	14	5.1	34.6	14	5.1	179.0
200	14	67.6	56.8	14	67.6	360.2
300	14	125.4	137.6	14	125.4	497.9
400	14	272.5	228.1	14	272.5	635.2
500	14	892.1	512.6	14	892.1	728.2
600	14	1610.1	643.4	14	1610.1	822.8
700	14	2278.3	814.3	14	2278.3	1191.6
800	13	2909.3	839.4	13	2909.3	1443.8
900	9	3876.2	851.7	9	3876.2	1336.7
1000	3	5177.0	1138.6	3	517.7	773.4
Power Event 143	14	- 6.4	45.9	14	- 6.4	333.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE H-19. DAY MISSED APPROACH WITH ONE ENGINE OUT - 7.5° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT AND STRAIGHT DEPARTURE - ONE ENGINE INOPERATIVE

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	1	-1265.0	0.	1	1528.0	0.
16000	4	-1537.0	389.3	4	1573.0	59.6
15000	5	-1400.0	329.0	5	1538.0	87.3
14000	6	-1267.5	338.8	6	1528.3	87.0
13000	8	-1281.3	219.4	8	1506.0	82.3
12000	9	-1194.6	152.7	9	1498.3	62.4
11000	9	-1080.2	83.0	9	1464.6	63.2
10000	9	- 957.4	98.9	9	1359.3	56.7
9000	9	- 850.2	107.0	9	1231.3	55.7
8000	8	- 761.0	91.3	8	1081.1	48.2
7000	8	- 631.8	96.9	8	944.1	37.6
6000	9	- 502.7	125.5	9	801.3	26.0
5000	9	- 401.4	133.1	9	684.4	28.4
4000	9	- 315.8	111.3	9	557.1	18.9
ALTITUDE (FT)					RANGE** (FT)	
200	9	- 81.6	39.4	9	1462.8	105.2
Low Point	9	19.2	106.7	9	375.7	528.8
200	9	124.8	293.3	9	-3007.6	2076.7
300	9	160.6	317.5	9	-5355.9	2319.2
400	9	301.3	349.6	9	-7305.0	2910.0
500	9	445.0	425.2	9	-9140.0	3511.9
600	8	663.0	535.5	8	-10358.4	3970.3
700	4	597.0	266.9	4	-10530.5	5106.3
800	4	745.0	153.0	4	-10701.3	5639.8
900	3	960.7	123.5	3	-11558.0	7928.6
Power Event 146	8	- 39.4	41.3	8	944.5	200.5

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

TABLE H-20. DAY MISSED APPROACH WITH ONE ENGINE OUT - 7.5° GLIDE SLOPE USING SKEWED APPROACH MODIL EQUIPMENT AND TURNING DEPARTURE - ONE ENGINE INOPERATIVE

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	6	- 785.7	836.3	6	1553.3	77.0
16000	8	-1007.0	706.6	8	1542.8	72.4
15000	8	- 957.5	639.8	8	1546.0	80.0
14000	10	- 899.1	569.7	10	1551.5	78.1
13000	10	-1028.1	621.6	10	1479.6	197.0
12000	12	- 876.3	431.1	12	1546.3	71.4
11000	12	- 818.8	422.7	12	1527.4	39.8
10000	14	- 768.7	338.2	14	1416.4	45.8
9000	14	- 704.6	288.8	14	1274.4	56.9
8000	13	- 615.2	298.8	13	1115.5	48.9
7000	13	- 529.3	13.0	13	969.8	32.0
6000	13	- 448.7	219.0	13	853.2	23.8
5000	14	- 372.6	190.8	14	693.7	22.1
4000	14	- 270.0	144.8	14	556.1	23.7
ALTITUDE (FT)					RANGE** (FT)	
200	14	- 58.6	54.5	14	1458.6	117.1
Low Point	14	19.6	60.8	14	331.1	385.8
200	14	261.9	348.9	14	-3037.8	1942.4
300	14	602.6	620.9	14	-5315.6	2147.9
400	14	1751.8	1239.5	14	-7224.6	2441.6
500	13	3229.2	1721.7	13	-7270.5	3226.4
600	8	3878.6	2171.8	8	-6892.5	3538.8
700	7	4817.0	2368.5	7	-6039.3	4362.4
800	5	5072.0	3061.5	5	-5873.6	4899.6
900	1	3396.0	0.	1	-4261.0	0.
1000	1	4055.0	0.	1	-4043.0	0.
Power Event 139	14	3.8	59.8	14	- 842.6	329.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** Negative (-) is the distance down the runway from threshold; positive is the distance before the runway threshold.

APPENDIX I

NIGHT APPROACHES USING ALL AVAILABLE AIDS

LIST OF TABLES

TABLE I-1. NIGHT APPROACHES - USING ALL AVAILABLE AIDS, 18000 FEET TO THRESHOLD (VFR)

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	-1655.0	0.	1	1169.0	0.
17000	4	-1109.8	853.1	4	1314.5	337.6
16000	5	- 828.0	813.7	5	1220.0	353.7
15000	5	- 675.7	719.3	5	1213.0	360.2
14000	7	- 567.2	561.7	7	1341.3	359.1
13000	9	- 337.9	601.7	9	1261.2	356.3
12000	12	- 243.6	483.2	12	1265.1	348.9
11000	15	- 177.3	411.3	15	1158.0	313.4
10000	19	- 155.3	332.8	19	1076.4	252.0
9000	21	- 175.1	271.3	21	1021.7	190.2
8000	23	- 136.4	252.2	23	949.4	129.2
7000	25	- 107.1	218.3	25	895.8	105.1
6000	26	- 56.2	179.8	26	800.7	73.4
5000	28	- 25.4	147.6	28	677.4	55.7
4000	29	- 28.1	106.4	29	539.0	44.8
3000	29	- 20.7	61.9	29	399.6	35.5
2500	29	- 13.4	44.1	29	332.8	31.0
2000	29	- 5.5	31.5	29	266.2	27.3
1500	27	0.6	18.9	27	201.0	23.1
1000	27	3.5	11.1	27	130.8	19.4
W.G.P.** 50	29	0.9	7.2	29	56.8	12.4
W.G.P. 35	30	0.4	6.6	30	45.1	11.2
1750	28	- 1.2	25.1	28	234.7	24.7
1335	26	3.0	15.8	25	177.4	22.2
1040	27	3.6	11.3	27	136.5	19.7
877	29	2.9	9.6	29	115.2	18.2
760	29	1.9	8.7	29	99.4	16.8
Threshold	29	- 1.2	5.3	29	16.5	6.9

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-2. NIGHT APPROACHES - USING VASI ONLY, 17000 FEET TO THRESHOLD (VFR)

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	1	141.0	0.	1	1690.0	0.
16000	1	115.0	0.	1	1674.1	0.
15000	1	129.0	0.	1	1654.0	0.
14000	1	156.0	0.	1	1671.0	0.
13000	2	-533.6	1028.8	2	1624.0	69.3
12000	2	-475.0	958.8	2	1599.0	45.3
11000	3	-225.0	603.8	3	1372.0	306.3
10000	4	-150.6	337.0	4	1174.0	355.7
9000	7	- 47.6	189.3	7	996.4	257.7
8000	9	- 39.6	155.3	9	918.6	184.6
7000	12	- 34.8	160.0	12	859.0	134.5
6000	12	- 38.3	159.3	12	775.0	122.5
5000	14	- 6.6	156.1	14	642.0	105.0
4000	14	- 4.6	106.5	14	515.1	79.4
3000	14	5.1	75.5	14	383.6	57.9
2500	14	4.9	61.5	14	317.9	47.4
2000	15	5.9	42.2	15	253.7	36.1
1500	15	3.7	23.6	15	194.4	28.7
1000	14	2.4	13.1	14	128.9	18.8
W.G.P.** 50	12	3.3	6.5	8	49.6	9.3
W.G.P. 35	8	2.8	6.6	8	38.3	8.3
1750	15	5.9	33.5	15	224.1	32.6
1335	13	5.7	16.5	13	171.0	26.4
1040	12	5.6	12.1	14	134.1	19.7
877	13	6.1	9.2	15	113.3	15.7
760	13	4.5	7.5	15	98.6	13.4
Threshold	12	1.5	5.8	14	14.7	4.0

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-3. NIGHT APPROACHES - USING NO AIDS, 17000 FEET TO THRESHOLD (VFR)

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	1	-77.0	0.	1	857.0	0.
16000	1	-47.0	0.	1	851.1	0.
15000	2	-41.0	1.0	2	932.5	142.1
14000	4	-40.3	36.3	4	920.3	74.6
13000	6	-182.2	302.4	6	931.2	67.7
12000	6	-98.7	215.0	6	922.2	79.8
11000	7	-25.4	136.6	7	916.3	73.5
10000	9	-23.8	103.1	9	902.2	62.4
9000	9	6.1	82.6	9	895.8	73.6
8000	11	- 9.6	90.9	11	828.2	116.2
7000	13	6.2	77.4	13	780.4	135.9
6000	15	- 3.3	71.9	15	676.2	122.3
5000	15	- 7.3	62.9	15	567.1	102.3
4000	16	8.4	89.9	16	450.1	79.6
3000	16	- 1.3	34.3	16	334.6	58.4
2500	16	- 1.3	26.5	16	278.4	48.9
2000	14	0.9	23.9	14	220.4	51.8
1500	15	2.3	12.8	15	166.7	30.2
1000	16	2.4	8.6	16	109.5	20.9
W.G.P.** 50	2	- 2.5	2.1	2	47.0	8.5
W.G.P. 35	2	- 1.0	1.4	2	37.0	7.1
1750	14	3.4	16.9	14	198.4	34.8
1335	15	2.9	11.8	15	147.9	26.6
1040	15	2.1	9.3	15	115.7	21.5
877	16	3.3	8.2	16	96.1	18.1
760	16	2.8	7.9	16	83.9	16.3
Threshold	17	- 0.3	6.5	17	14.5	4.8

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-4. NIGHT APPROACHES - 4° GLIDE SLOPE, SKEWED GUIDANCE WITH FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	3968.0	0.	1	794.0	0.
17000	8	- 618.9	149.9	8	816.4	30.9
16000	11	- 533.3	114.9	10	811.3	30.7
15000	14	- 496.6	75.4	14	793.1	49.1
14000	16	- 454.4	64.2	16	789.5	39.7
13000	15	- 422.1	83.0	15	783.8	31.5
12000	16	- 388.1	58.1	16	797.9	30.2
11000	17	- 359.9	60.0	17	791.0	24.4
10000	19	- 337.1	94.9	19	744.3	23.8
9000	19	- 304.3	87.5	19	675.6	21.9
8000	18	- 254.2	61.8	18	593.3	24.7
7000	18	- 225.4	39.0	18	521.7	21.3
6000	18	- 181.5	32.5	18	441.4	12.9
5000	18	- 129.3	30.3	18	363.8	12.0
4000	17	- 90.6	21.1	17	289.9	9.3
3000	18	- 53.4	17.0	18	217.7	7.6
2500	17	- 24.9	21.1	17	181.1	1.5
2000	18	- 4.3	21.9	18	146.3	8.9
1500	18	- 2.4	14.8	18	117.8	10.7
1000	18	- 5.2	19.4	18	81.0	8.4
W.G.P**. 50	17	- 12.2	28.6	17	57.5	8.5
W.G.P. 35	18	- 51.5	92.3	18	42.9	7.5
1750	17	1.4	12.5	18	134.0	10.6
1335	17	- 1.4	12.3	18	105.8	10.0
1040	15	1.5	9.2	18	83.9	8.5
877	15	0.1	10.6	18	71.9	7.9
760	15	- 1.4	13.2	18	63.3	8.4
Threshold	15	2.9	6.4	20	12.3	2.6

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-5. NIGHT APPROACHES - 6° GLIDE SLOPE, SKEWED GUIDANCE WITH FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	12	-972.3	474.2	12	1241.8	73.8
16000	15	-958.7	332.5	15	1247.7	60.2
15000	17	-915.6	160.9	17	1241.9	58.8
14000	18	-854.9	91.6	18	1235.3	71.8
13000	21	-808.0	102.6	21	1240.0	62.4
12000	21	-719.6	90.0	21	1233.9	59.3
11000	24	-629.8	91.5	24	1197.3	35.0
10000	24	-563.9	74.7	24	1114.7	37.2
9000	24	-529.5	46.5	24	999.0	27.2
8000	24	-472.3	31.6	24	877.9	23.0
7000	24	-402.8	34.0	24	760.3	21.0
6000	24	-339.4	30.9	24	648.4	18.9
5000	24	-256.8	25.3	24	540.0	17.2
4000	24	-184.7	19.4	24	435.5	12.7
3000	24	-114.6	20.3	24	330.1	8.1
2500	24	- 80.1	14.9	24	276.5	7.2
2000	24	- 42.0	13.6	24	221.3	6.6
1500	23	- 2.5	26.3	23	168.0	5.5
1000	24	7.6	21.5	24	119.3	7.6
W.G.P.** 50	24	2.9	9.3	24	59.7	8.4
W.G.P. 35	24	2.7	7.8	24	45.8	7.9
1750	23	- 24.8	13.0	23	194.6	6.3
1335	23	- 1.5	20.4	23	152.7	5.7
1040	24	7.3	22.1	24	123.1	7.3
877	24	7.0	18.8	24	107.1	8.8
760	24	6.0	15.9	24	94.7	9.7
Threshold	24	1.4	7.4	24	17.3	5.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-6. NIGHT APPROACHES - 7.5° GLIDE SLOPE, SKEWED GUIDANCE WITH FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	-1863.0	0.	1	1552.0	0.
17000	11	-1585.6	172.1	11	1584.8	65.4
16000	12	-1447.3	152.9	12	1580.5	67.2
15000	15	-1381.5	385.4	15	1578.3	59.5
14000	17	-1246.1	291.7	17	1572.2	60.6
13000	19	-1116.9	250.3	19	1567.8	62.3
12000	20	-1004.8	230.3	20	1557.6	56.4
11000	20	- 906.7	208.6	20	1516.7	32.1
10000	23	- 855.5	172.2	23	1396.0	43.7
9000	23	- 800.2	97.3	23	1250.7	49.2
8000	22	- 699.8	64.7	22	1099.3	48.1
7000	23	- 592.4	68.2	23	955.9	40.5
6000	24	- 509.9	68.2	24	818.4	31.9
5000	23	- 414.6	68.4	23	684.1	29.1
4000	24	- 311.9	44.0	24	554.0	19.5
3000	24	- 202.5	35.3	24	415.0	11.0
2500	24	- 153.6	27.1	24	347.7	6.3
2000	24	- 104.9	20.5	24	277.8	5.8
1500	24	- 50.2	14.4	24	210.1	6.0
1000	23	- 4.7	15.6	23	143.1	6.5
W.G.P.** 50	24	6.7	12.2	24	61.0	9.1
W.G.P. 35	24	4.7	10.6	24	47.0	9.0
1750	24	- 78.7	17.3	24	244.2	5.0
1335	24	- 33.0	14.2	24	191.1	11.8
1040	23	- 7.8	15.4	23	148.5	6.3
877	23	2.7	14.7	23	127.8	6.7
760	22	8.0	12.4	22	114.2	7.7
Threshold	24	0.3	7.0	24	20.3	5.4

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-7. NIGHT APPROACHES - 4° GLIDE SLOPE, SKEWED GUIDANCE WITHOUT FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	7	-1265.1	847.5	7	877.3	32.5
16000	8	-1080.5	679.5	8	872.1	49.2
15000	15	- 802.5	430.1	15	833.7	53.7
14000	19	- 689.7	243.4	18	822.4	45.2
13000	21	- 606.8	170.1	21	822.8	56.5
12000	23	- 509.2	160.4	23	819.7	50.9
11000	23	- 404.2	166.7	23	791.3	34.6
10000	23	- 371.4	133.5	23	735.2	42.9
9000	24	- 336.0	90.0	24	649.4	33.7
8000	25	- 313.7	78.4	25	579.4	29.2
7000	26	- 289.1	94.0	26	512.0	23.6
6000	24	- 226.5	59.8	25	443.2	23.0
5000	25	- 148.5	74.2	25	369.9	16.6
4000	25	- 108.2	47.9	25	299.5	20.0
3000	23	- 53.0	53.9	23	225.0	13.5
2500	23	- 33.9	45.8	23	187.1	15.8
2000	25	- 17.6	39.9	25	150.4	12.9
1500	21	- 5.2	30.5	23	117.2	12.5
1000	21	- 1.5	15.2	23	82.0	11.5
W.G.P.** 50	22	- 2.0	9.2	24	58.6	9.0
W.G.P. 35	22	- 1.3	6.5	24	43.7	7.2
1750	22	- 10.3	39.7	24	134.6	12.0
1335	22	- 5.0	24.9	24	105.8	12.7
1040	22	- 2.7	16.3	24	85.2	11.6
877	22	- 1.6	12.7	24	73.3	10.6
760	22	- 1.7	10.4	24	64.3	9.6
Threshold	22	- 0.3	4.1	24	12.3	3.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-8. NIGHT APPROACHES - 6° GLIDE SLOPE, SKEWED GUIDANCE WITHOUT FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	4	-1208.8	944.6	4	1278.8	45.0
16000	8	-1058.8	449.6	8	1260.4	35.5
15000	12	- 966.8	251.8	12	1257.4	36.7
14000	16	- 813.1	260.7	16	1241.1	46.0
13000	19	- 818.4	131.7	19	1235.5	55.8
12000	20	- 765.2	140.4	20	1234.3	51.4
11000	21	- 669.4	122.6	21	1206.0	40.0
10000	21	- 611.1	126.0	21	1226.9	34.3
9000	22	- 558.5	111.8	22	1004.2	32.8
8000	22	- 487.6	110.8	22	886.0	31.0
7000	23	- 425.6	101.6	23	773.5	32.2
6000	22	- 358.1	88.2	22	659.0	27.0
5000	22	- 285.9	63.4	22	549.5	26.0
4000	21	- 232.6	51.5	21	444.1	17.6
3000	22	- 149.4	56.0	22	336.7	17.1
2500	22	- 109.7	57.1	22	284.0	10.5
2000	22	- 75.5	57.7	22	229.0	11.2
1500	21	- 42.1	43.4	21	179.4	10.5
1000	21	- 2.4	34.8	22	120.9	8.8
W.G.P.** 50	21	7.3	21.2	22	60.1	7.0
W.G.P. 35	20	3.5	13.7	21	45.1	5.7
1750	22	- 62.2	50.4	22	204.6	11.3
1335	20	- 26.3	40.7	21	160.3	9.4
1040	21	- 4.3	36.0	22	125.2	9.3
877	21	0.6	31.6	22	107.4	9.0
760	21	1.5	28.0	22	95.0	9.0
Threshold	20	1.2	5.7	21	16.7	2.3

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-9. NIGHT APPROACHES - 7.5° GLIDE SLOPE, SKEWED GUIDANCE WITHOUT FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	7	-1466.1	427.4	7	1617.1	48.1
16000	9	-1299.5	414.5	8	1615.0	48.5
15000	9	-1299.9	257.6	9	1601.2	45.3
14000	11	-1308.1	220.4	12	1585.1	47.3
13000	14	-1252.4	218.8	14	1571.1	54.1
12000	17	-1163.4	186.0	17	1572.8	56.5
11000	18	-1082.6	210.8	18	1528.6	55.1
10000	19	-1006.6	202.3	19	1391.1	62.3
9000	20	- 920.7	157.4	20	1246.8	64.2
8000	20	- 818.4	105.4	20	1098.2	62.2
7000	20	- 680.6	70.6	20	964.0	59.8
6000	21	- 539.2	90.1	21	828.2	39.5
5000	21	- 439.6	89.7	21	692.7	18.8
4000	20	- 352.1	86.5	20	555.2	23.6
3000	20	- 245.9	53.7	20	419.2	19.7
2500	20	- 182.9	58.2	20	350.6	15.4
2000	21	- 120.1	69.1	21	282.5	15.9
1500	20	- 69.8	70.3	20	210.0	9.5
1000	20	- 30.4	60.8	20	144.6	12.1
W.G.P.** 50	21	- 2.7	21.3	21	60.0	10.5
W.G.P. 35	20	- 1.5	19.0	20	44.3	9.2
1750	21	- 93.5	70.5	21	244.6	13.2
1335	18	- 47.4	63.9	19	187.8	10.0
1040	19	- 25.7	54.8	20	150.1	12.0
877	19	- 15.7	47.5	20	127.7	11.8
760	18	- 17.9	48.5	19	113.0	11.1
Threshold	20	- 0.3	7.3	21	19.5	7.4

*Negative (-) is left of centerline; positive is right of centerline viewed from approach.

**W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-10. NIGHT APPROACHES - 6° GLIDE SLOPE, CENTERLINE GUIDANCE WITH FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
18000	1	-139.0	0.	1	1195.0	0.
17000	18	11.0	250.3	18	1260.4	56.4
16000	19	62.7	185.5	19	1271.8	52.8
15000	22	109.8	224.1	22	1267.0	54.5
14000	23	96.5	153.2	23	1267.0	60.1
13000	23	63.3	126.6	23	1262.7	70.5
12000	23	60.6	126.3	23	1250.8	66.0
11000	24	72.1	117.1	24	1182.0	58.1
10000	24	45.4	102.4	24	1085.0	52.1
9000	25	23.7	87.6	25	972.6	40.0
8000	25	5.0	65.7	25	854.7	34.1
7000	26	- 9.7	62.9	26	736.1	29.7
6000	26	- 10.0	41.5	26	620.9	27.1
5000	26	- 6.5	37.5	26	509.8	21.3
4000	26	- 2.3	30.6	26	402.5	17.0
3000	26	0.9	32.6	26	300.0	15.5
2500	26	- 4.6	28.4	26	248.7	11.8
2000	25	- 11.4	24.7	25	196.7	9.9
1500	25	- 4.4	23.1	25	147.4	9.8
1000	26	- 4.0	18.7	26	104.6	7.0
W.G.P.** 50	24	- 3.6	11.6	24	67.3	7.5
W.G.P. 35	22	- 1.9	9.0	22	54.5	6.8
1750	24	- 8.8	21.1	24	170.8	9.7
1335	26	- 3.5	24.3	26	132.7	8.0
1040	26	- 4.0	19.9	26	108.0	6.9
877	26	- 3.7	14.5	26	93.6	7.3
760	26	- 3.7	12.7	26	82.5	7.6
Threshold	24	- 0.8	6.0	24	15.1	3.3

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-11. NIGHT APPROACHES - 7.5° GLIDE SLOPE, CENTERLINE GUIDANCE WITH FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	16	69.8	264.1	16	1582.4	72.1
16000	20	63.3	294.0	20	1578.7	58.2
15000	21	99.1	261.9	21	1578.0	61.9
14000	23	93.4	210.5	23	1580.7	54.5
13000	24	65.5	144.6	24	1576.4	46.4
12000	24	51.8	157.9	24	1560.6	50.6
11000	24	64.0	153.5	24	1485.0	56.1
10000	27	34.6	110.8	27	1364.8	59.8
9000	29	-11.8	98.2	29	1216.2	56.3
8000	29	-22.2	75.8	29	1062.0	48.1
7000	29	- 9.8	70.3	29	910.5	42.1
6000	29	- 1.4	55.2	29	768.3	40.0
5000	29	- 0.3	44.8	29	634.1	35.6
4000	29	- 1.5	27.2	29	507.0	31.0
3000	29	- 4.6	35.5	29	378.5	27.7
2500	29	- 3.0	26.4	29	314.7	24.9
2000	29	1.4	24.2	29	250.1	22.2
1500	26	-10.4	35.8	26	186.5	16.7
1000	29	- 6.8	30.3	29	124.4	12.9
W.G.P.** 50	26	- 2.2	13.2	26	66.5	10.3
W.G.P. 35	28	- 0.8	10.3	28	54.0	10.1
1750	29	- 5.1	32.3	29	217.4	18.8
1335	28	-11.6	34.4	28	173.5	41.6
1040	29	- 7.8	31.4	29	129.2	13.4
877	29	- 5.6	26.8	29	110.4	12.1
760	29	- 4.8	22.5	29	96.7	11.4
Threshold	29	- 0.8	5.2	30	15.2	6.6

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-12. NIGHT APPROACHES - 6° GLIDE SLOPE, CENTERLINE GUIDANCE WITHOUT FLIGHT DIRECTOR

RANGE (FT)	LATERAL-DEVIATION SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	ALTITUDE SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	11	- 48.2	504.0	11	1293.5	25.2
16000	14	-132.6	450.8	14	1262.8	76.4
15000	16	-112.8	346.4	16	1259.3	87.9
14000	20	- 62.4	185.8	20	1254.8	57.8
13000	22	- 51.0	161.7	22	1262.6	61.2
12000	22	- 23.1	154.6	22	1251.1	54.0
11000	21	- 27.8	109.7	21	1178.7	63.3
10000	21	- 49.5	111.4	21	1075.7	55.2
9000	23	- 39.9	124.6	23	959.5	52.4
8000	23	- 34.5	112.7	23	850.6	45.8
7000	23	- 17.3	100.1	23	735.0	44.0
6000	23	- 6.3	69.4	23	632.3	34.6
5000	23	7.9	59.7	23	521.6	22.3
4000	23	- 9.7	59.8	23	415.3	15.6
3000	23	- 8.3	61.1	23	306.6	14.3
2500	23	- 4.9	57.6	23	251.6	13.1
2000	22	- 10.5	48.2	22	201.0	15.8
1500	20	- 16.4	31.2	20	148.3	11.2
1000	23	- 5.8	33.5	23	101.6	5.0
W.G.P.** 50	22	- 4.8	26.8	22	65.2	5.0
W.G.P. 35	20	- 2.8	16.8	21	52.8	5.1
1750	22	- 12.0	43.0	22	179.6	22.2
1335	22	- 10.5	40.9	22	131.7	8.2
1040	20	- 2.9	31.2	22	105.8	4.3
877	19	- 6.0	16.2	22	91.3	4.2
760	19	- 5.2	11.9	23	80.1	5.0
Threshold	21	- 0.4	5.0	23	14.8	4.4

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-13. NIGHT APPROACHES - 7.5° GLIDE SLOPE, CENTERLINE GUIDANCE WITHOUT FLIGHT DIRECTOR

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	9	48.9	131.8	9	1601.7	57.4
16000	11	- 32.9	215.2	11	1585.7	60.2
15000	13	- 95.8	190.7	13	1578.5	49.0
14000	15	119.6	191.8	15	1573.9	40.3
13000	15	21.7	201.4	15	1571.1	40.2
12000	18	- 0.7	179.8	18	1557.3	49.4
11000	17	- 32.5	162.8	17	1477.9	59.8
10000	18	- 41.8	135.7	18	1346.5	60.3
9000	19	- 3.2	138.2	19	1199.4	60.1
8000	21	- 29.2	119.8	21	1060.2	42.5
7000	20	- 30.6	103.2	20	919.6	39.9
6000	20	- 24.6	89.3	20	780.4	36.4
5000	20	- 16.9	84.8	20	644.0	37.1
4000	20	- 13.0	71.7	20	515.6	33.8
3000	20	- 17.9	43.0	20	386.6	23.2
2500	21	- 22.2	39.7	21	320.8	15.7
2000	21	- 21.8	39.0	21	254.1	16.5
1500	21	- 2.0	61.0	21	193.7	30.7
1000	21	- 0.5	34.2	21	126.3	11.4
W.G.P.** 50	19	- 1.6	19.2	20	69.0	10.7
W.G.P. 35	18	- 1.2	15.7	18	55.9	10.1
1750	20	- 13.1	40.8	21	220.8	14.2
1335	19	1.0	45.1	20	169.2	17.1
1040	19	1.4	35.3	21	131.0	11.8
877	19	4.7	28.6	21	111.9	11.4
760	19	3.8	24.8	21	98.0	11.6
Threshold	18	- 1.3	6.2	20	16.6	5.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 35-feet elevation.

TABLE I-14. NIGHT APPROACHES - 7.5° GLIDE SLOPE, CENTERLINE GUIDANCE WITHOUT FLIGHT DIRECTOR AND VASI

	LATERAL-DEVIATION			ALTITUDE		
RANGE (FT)	SAMPLE SIZE	AVERAGE* (FT)	STAND DEV (FT)	SAMPLE SIZE	AVERAGE (FT)	STAND DEV (FT)
17000	4	- 7.3	429.0	4	1569.8	50.6
16000	5	139.4	348.1	5	1564.0	51.9
15000	5	6.2	288.2	5	1555.2	83.6
14000	5	- 80.6	365.8	5	1541.4	109.3
13000	7	24.4	327.0	7	1546.6	125.0
12000	7	22.7	247.6	7	1533.7	159.4
11000	8	31.9	201.9	8	1451.0	144.6
10000	8	48.5	181.9	8	1318.0	125.5
9000	9	16.1	131.1	9	1190.6	109.2
8000	9	- 33.0	128.9	9	1041.9	92.4
7000	9	- 13.6	129.9	9	917.2	81.5
6000	9	- 20.2	89.7	9	779.0	62.8
5000	9	- 5.2	58.0	9	642.1	52.0
4000	9	- 11.7	69.0	9	514.2	51.3
3000	9	18.6	58.5	9	385.7	36.9
2500	9	13.4	37.1	9	322.9	32.7
2000	9	- 10.7	34.7	9	257.7	22.4
1500	7	11.1	32.7	7	189.9	17.7
1000	7	19.1	37.6	9	130.8	11.6
W.G.P.** 50	7	- 2.4	27.8	8	168.1	6.0
W.G.P. 35	6	4.5	10.3	8	56.6	5.2
1750	9	5.8	40.1	9	223.2	17.2
1335	5	24.2	28.3	7	194.6	67.5
1040	9	- 0.4	53.4	9	136.1	13.1
877	7	16.9	35.3	9	113.9	10.8
760	6	11.2	29.6	9	99.3	10.5
Threshold	6	- 0.3	5.5	9	18.0	4.1

* Negative (-) is left of centerline; positive is right of centerline viewed from approach.

** W.G.P. 50 = Where Glide Path is 50-feet elevation.
W.G.P. 35 = Where Glide Path is 50-feet elevation.

APPENDIX J

DIAGRAMS OF AIRCRAFT POSITION IN SPACE TO 1 STANDARD DEVIATION

LIST OF ILLUSTRATIONS

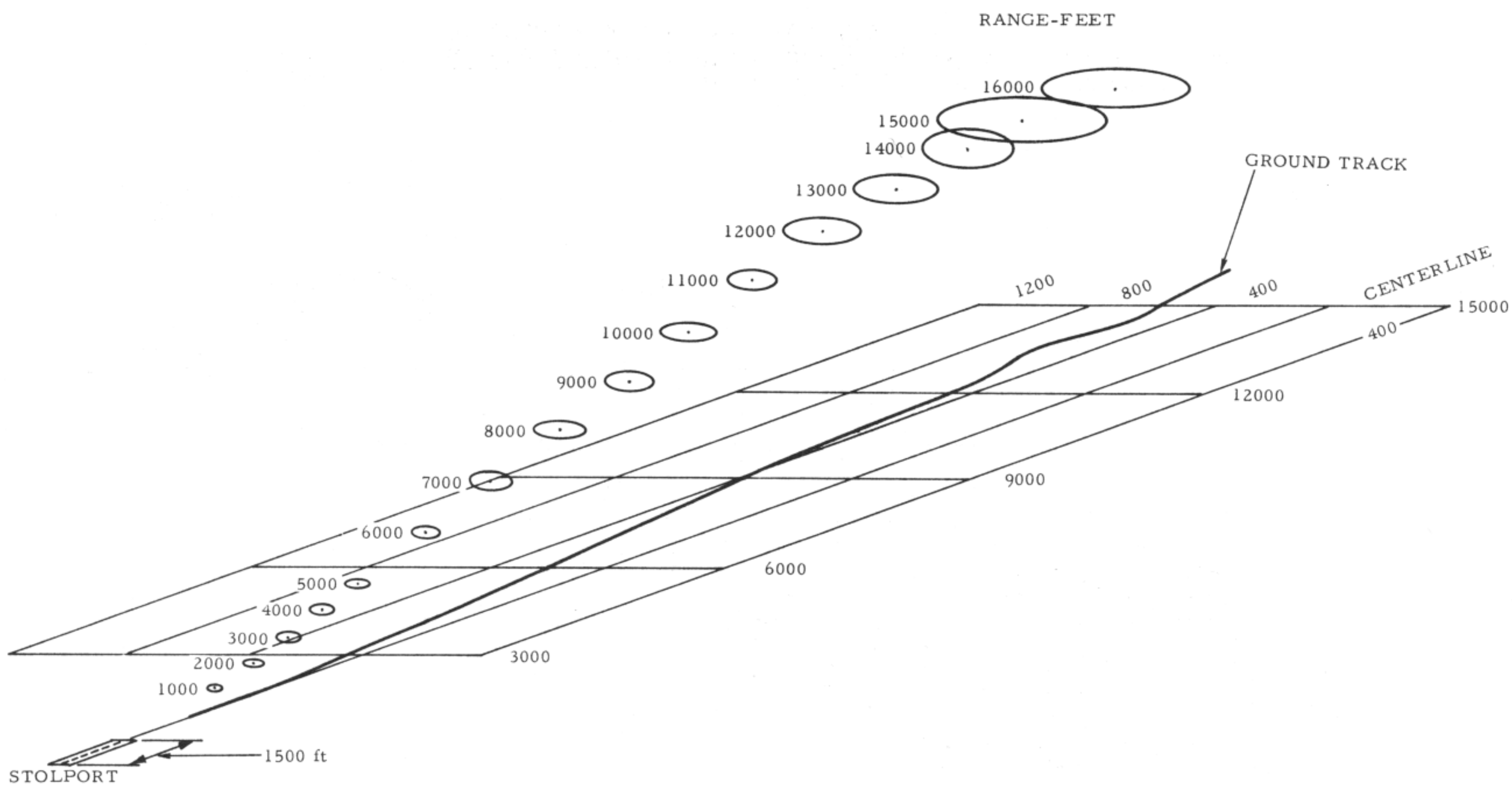


FIGURE J-1. 4° GLIDE SLOPE - DAY - SKEWED GUIDANCE - WITHOUT FLIGHT DIRECTOR

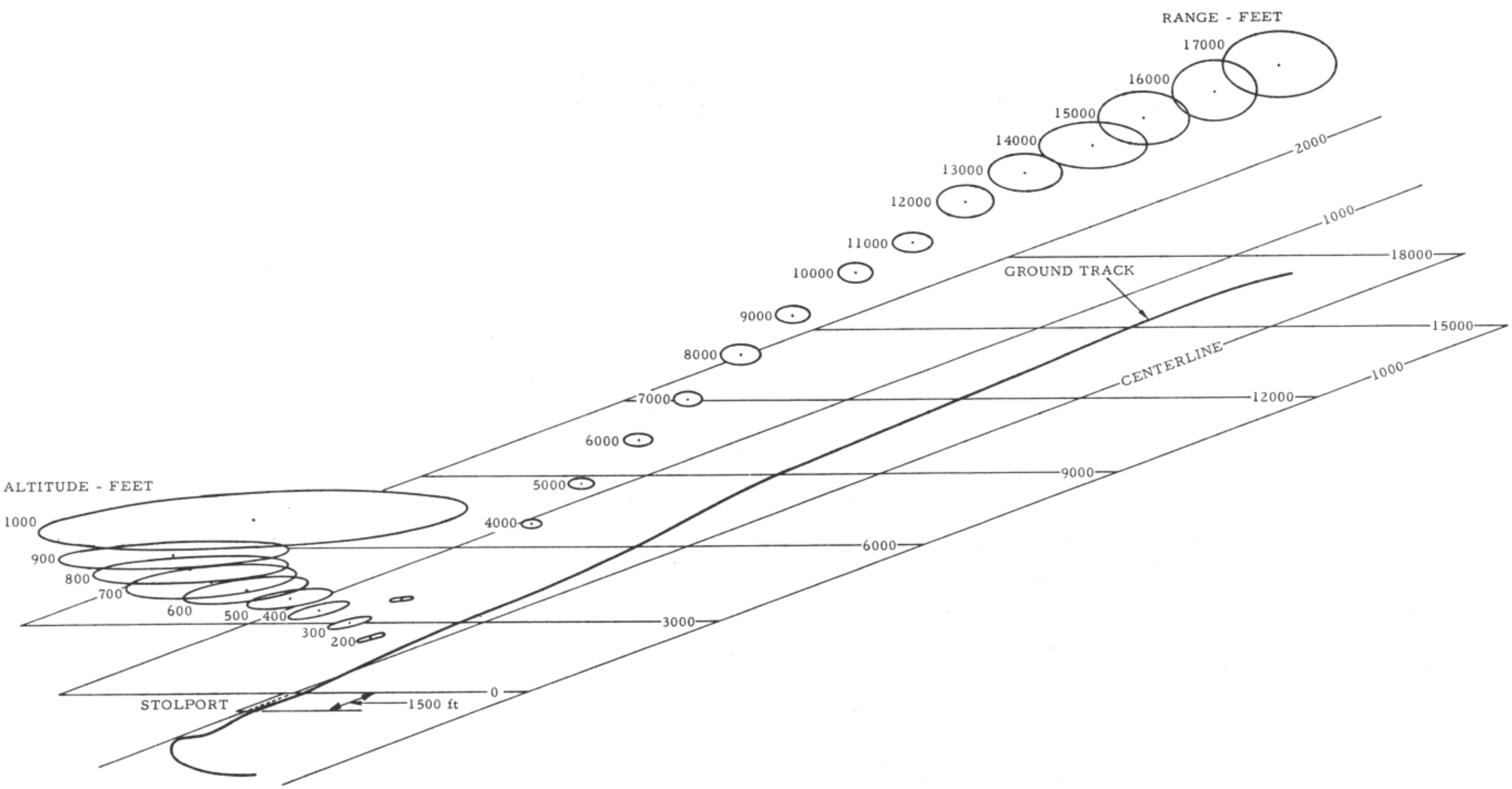


FIGURE J-2. 4° GLIDE SLOPE - DAY - SKEWED GUIDANCE - <u>WITHOUT</u> FLIGHT DIRECTOR - MISSED APPROACH STRAIGHT

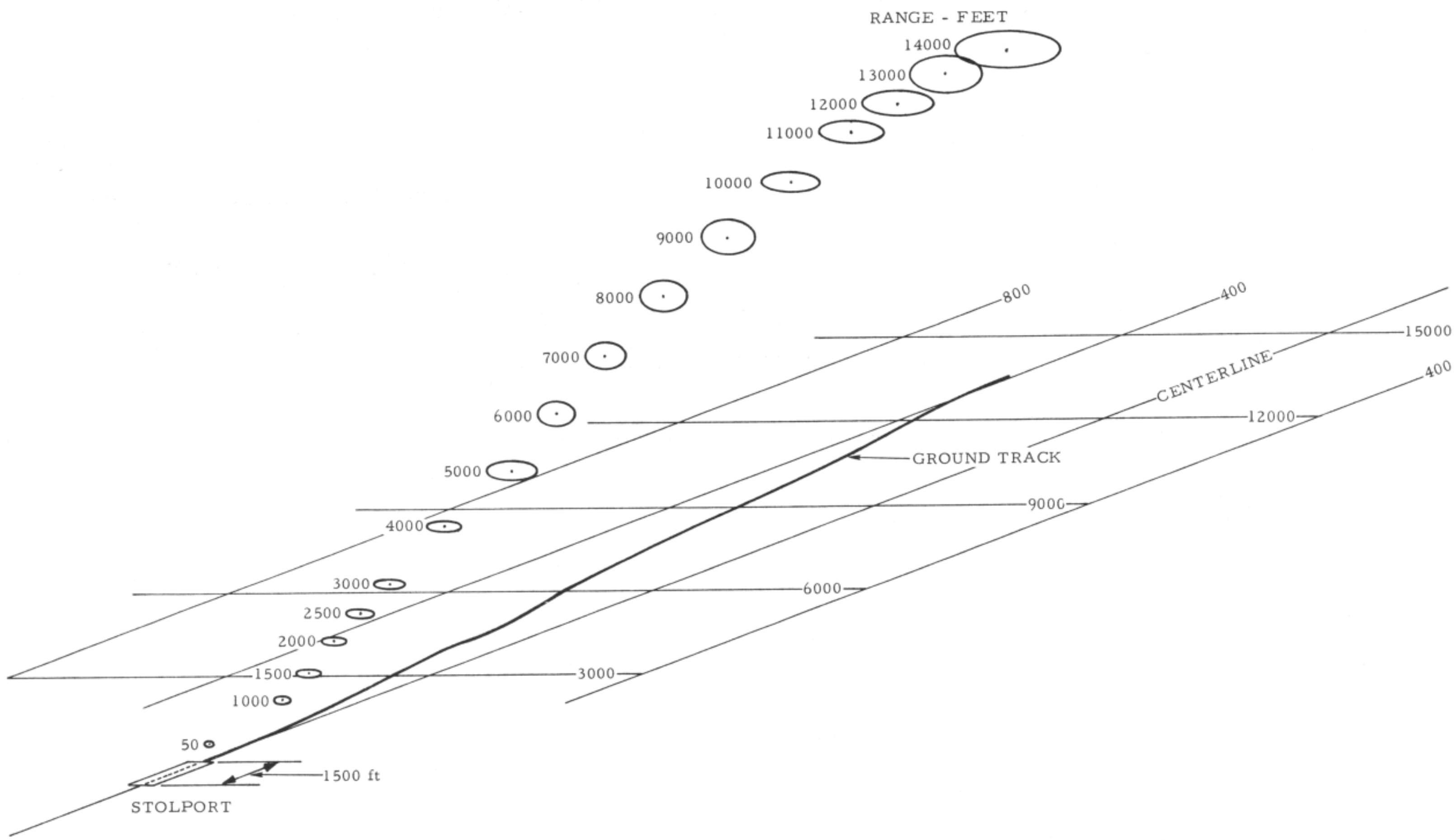


FIGURE J-3. 6° GLIDE SLOPE - DAY - SLEWED GUIDANCE - <u>WITHOUT</u> FLIGHT DIRECTOR

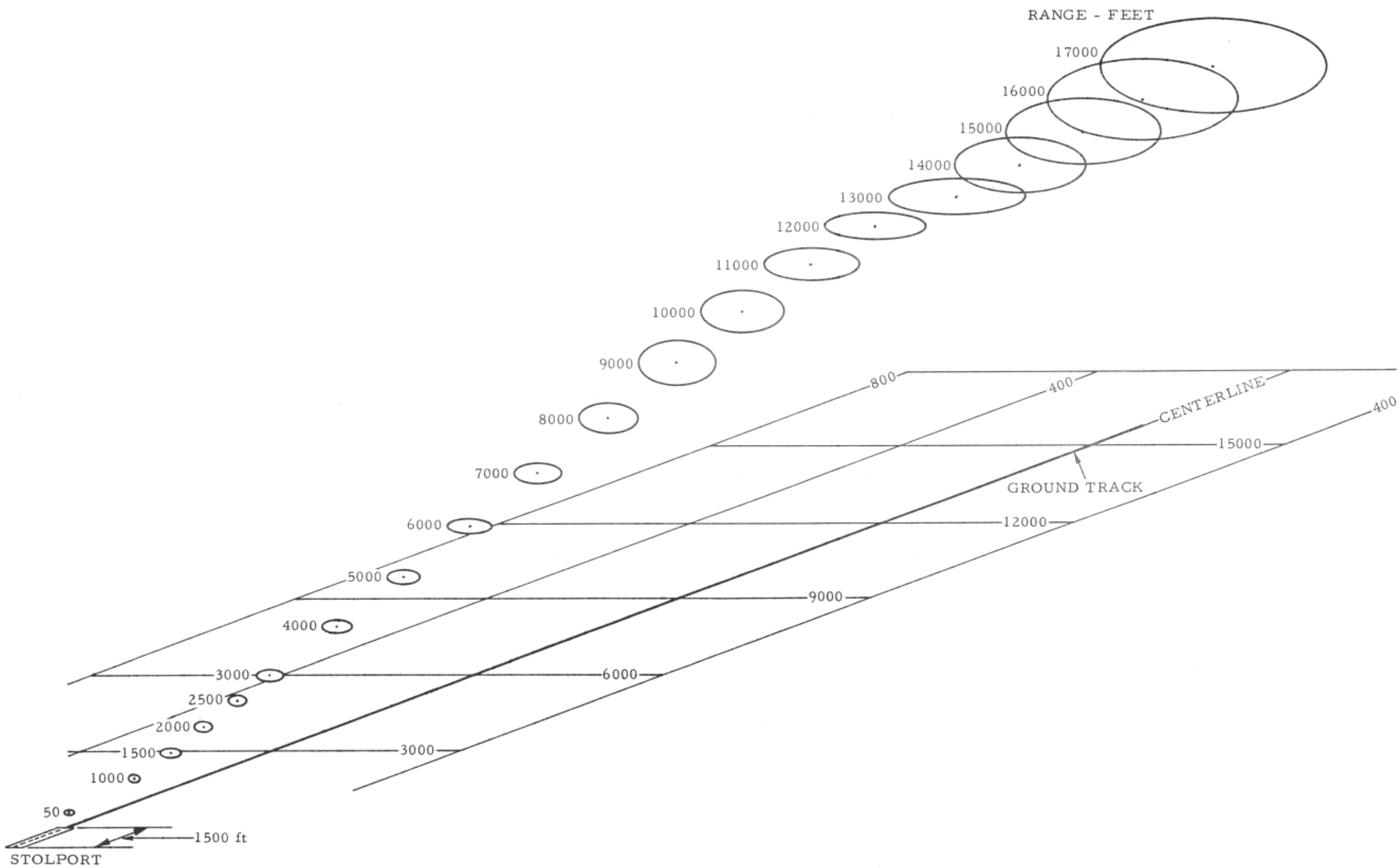


FIGURE J-4. 6° GLIDE SLOPE - DAY - CENTERLINE GUIDANCE - <u>WITH</u> FLIGHT DIRECTOR

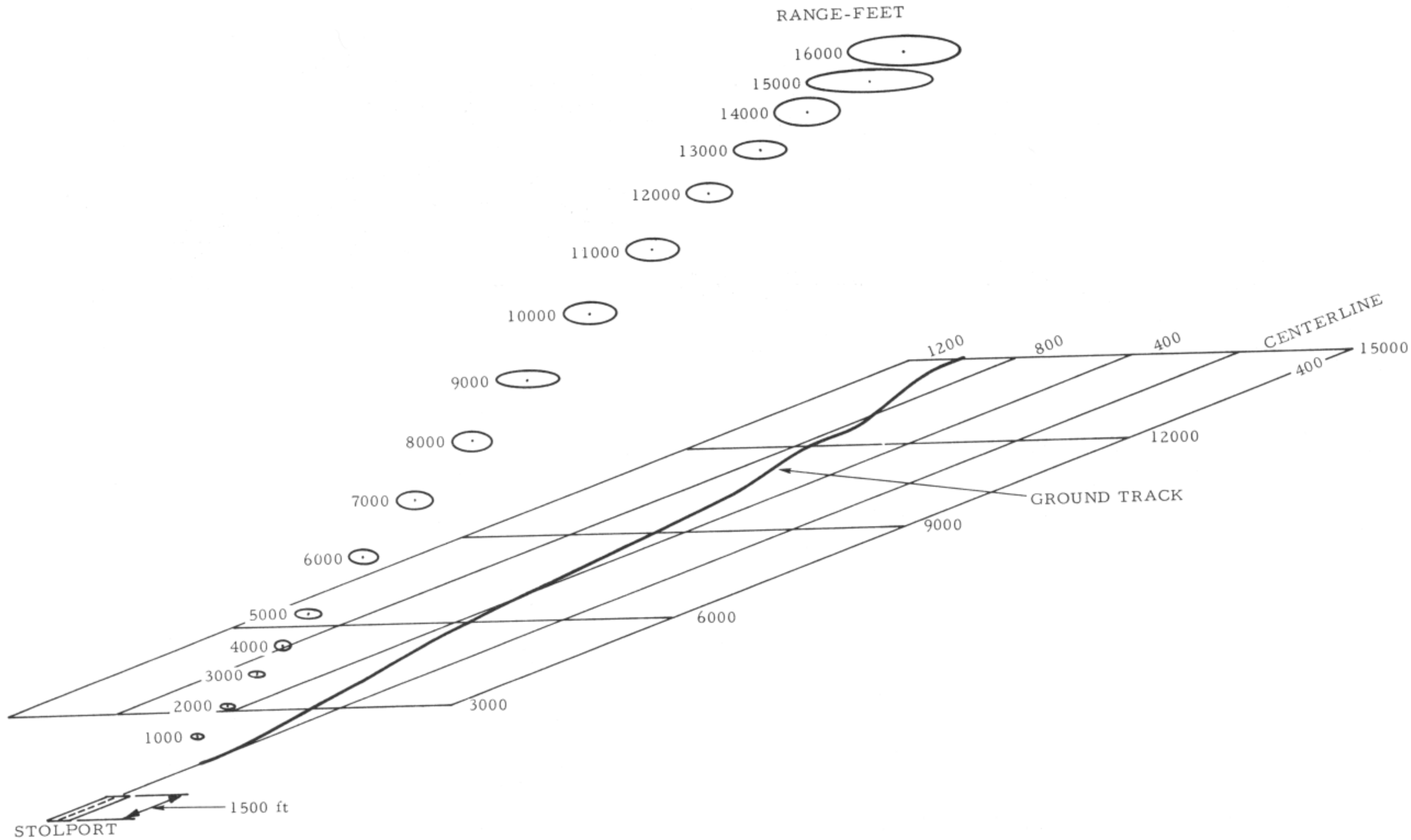


FIGURE J-5. 6° GLIDE SLOPE - DAY - SKEWED GUIDANCE - WITH FLIGHT DIRECTOR

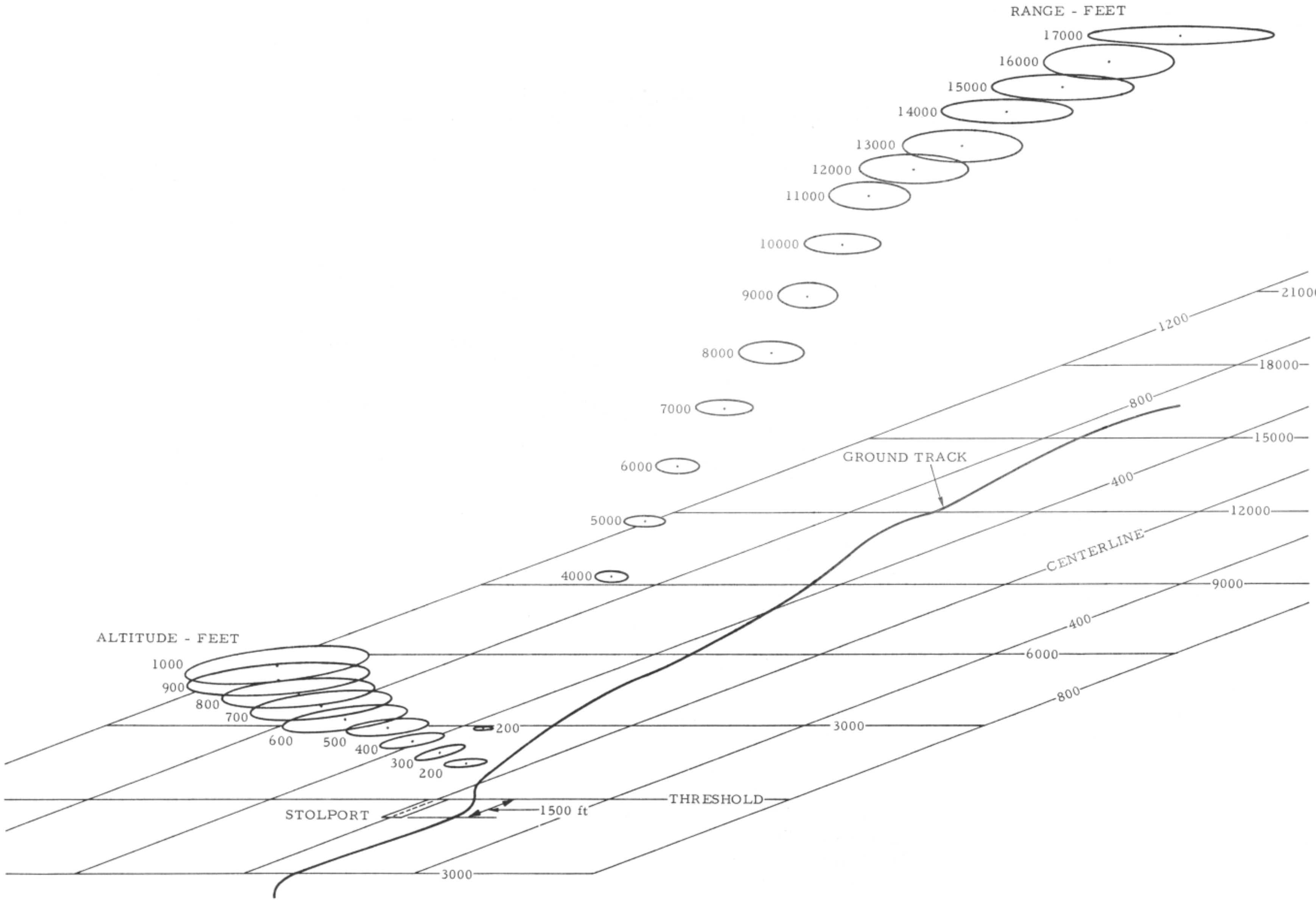


FIGURE J-6. 7.5° GLIDE SLOPE - DAY - SKEWED GUIDANCE - <u>WITHOUT</u> FLIGHT DIRECTOR - MISSED APPROACH - STRAIGHT DEPARTURE

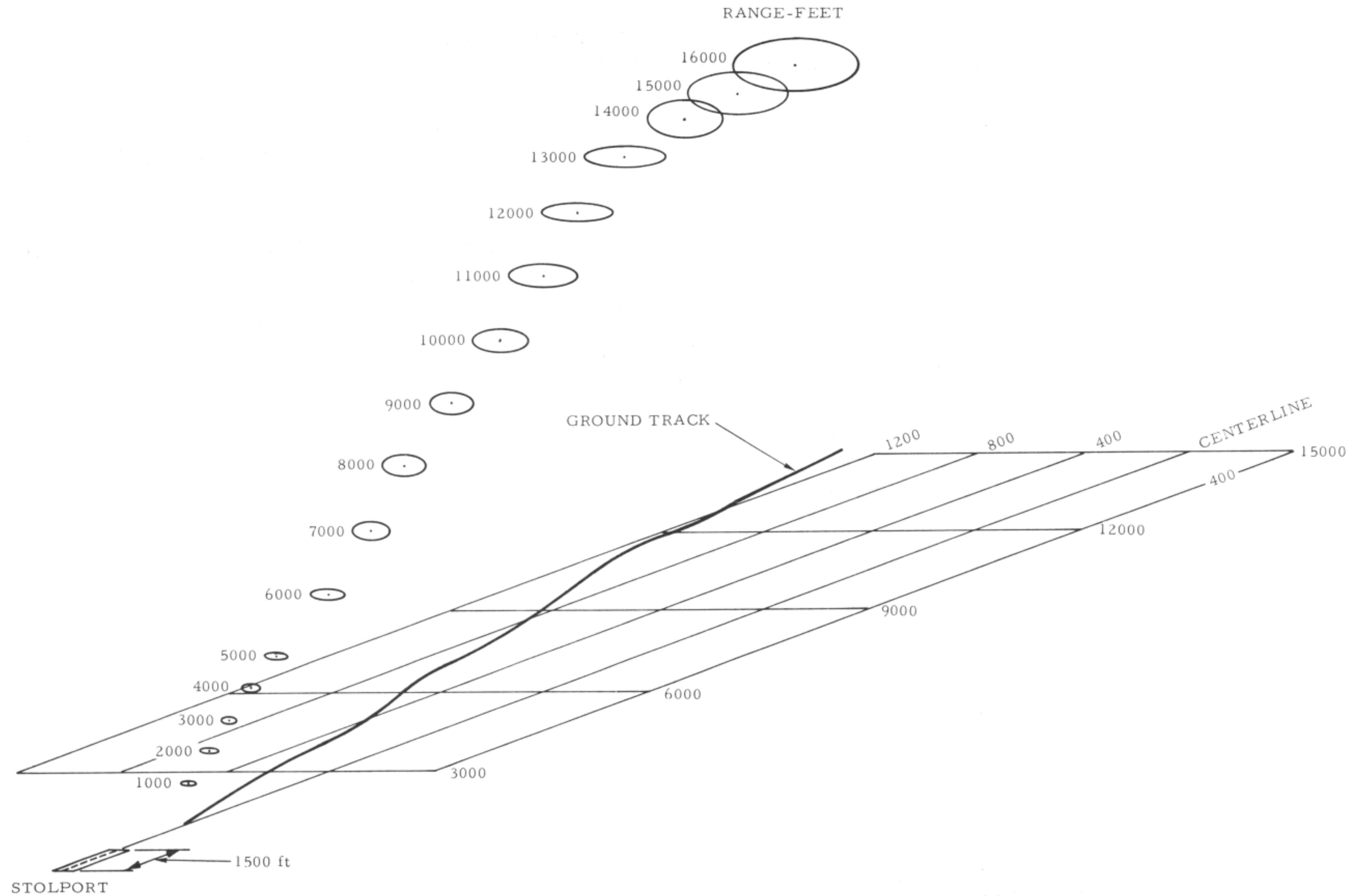


FIGURE J-7. 7.5° GLIDE SLOPE - DAY - SKEWED GUIDANCE - WITHOUT FLIGHT DIRECTOR

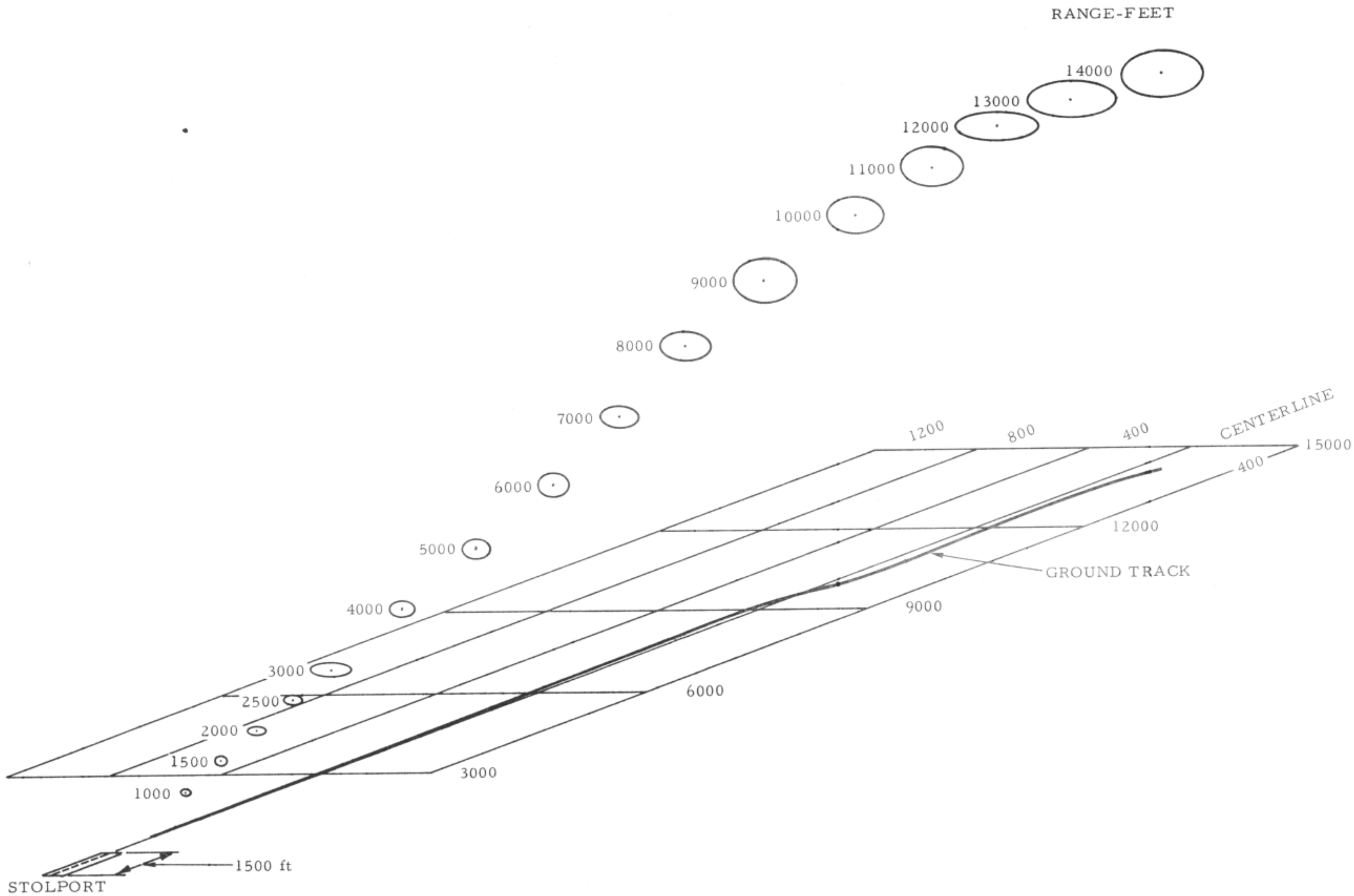


FIGURE J-8. 7.5° GLIDE SLOPE - DAY - CENTERLINE GUIDANCE - <u>WITH</u> FLIGHT DIRECTOR

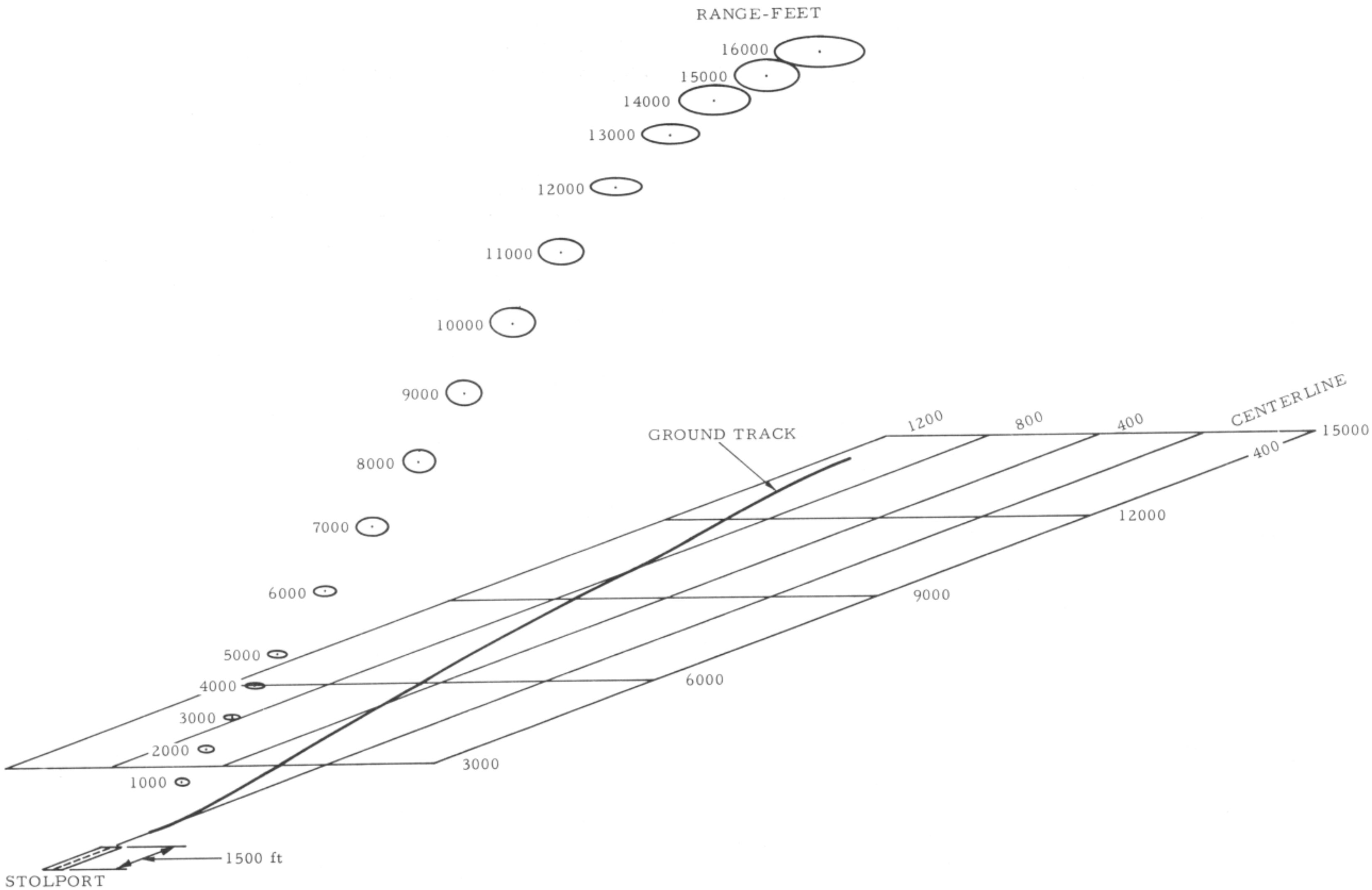


FIGURE J-9. 7.5° GLIDE SLOPE - DAY - SKEWED GUIDANCE - <u>WITH</u> FLIGHT DIRECTOR

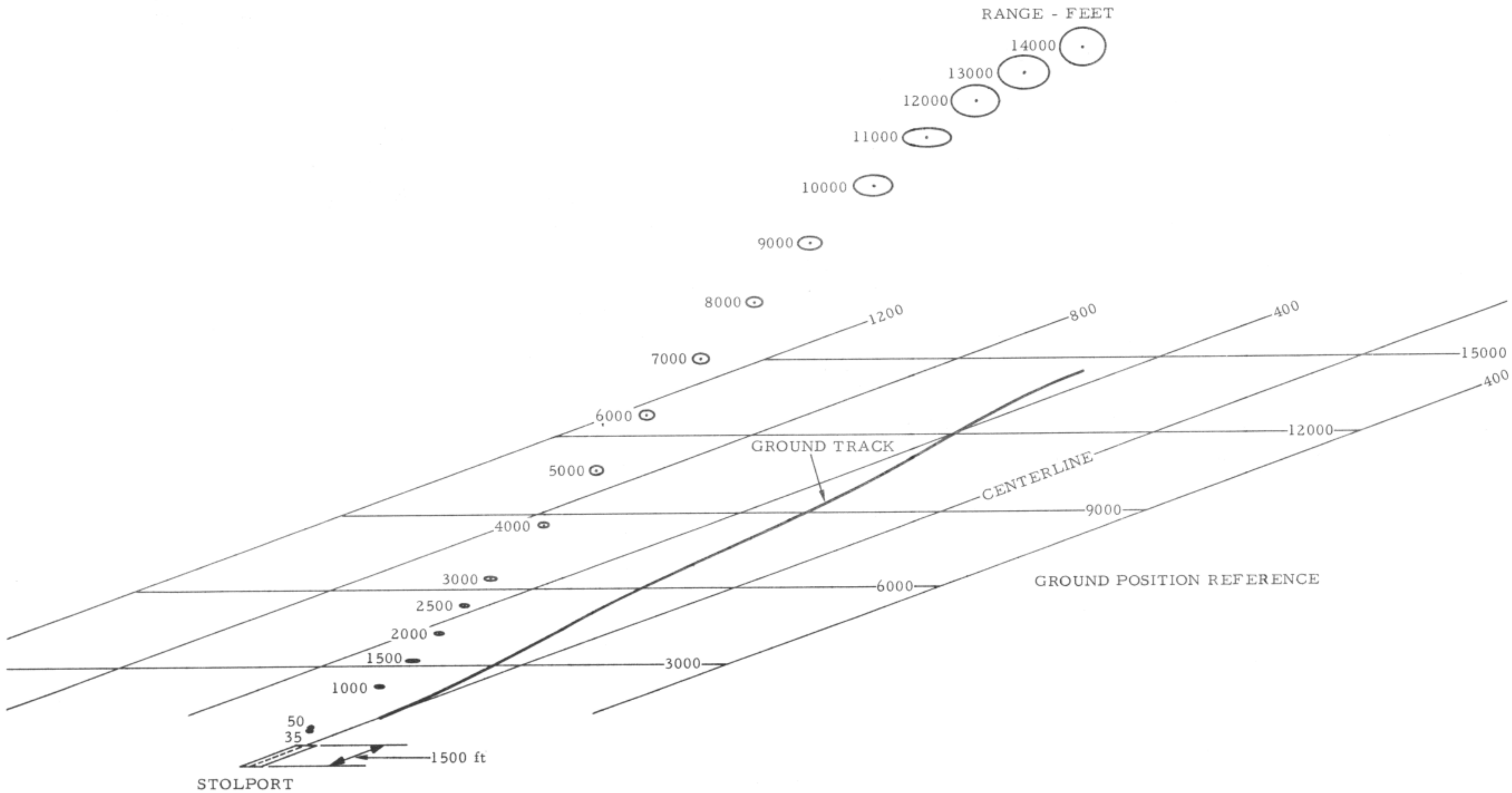


FIGURE J-10. 6° GLIDE SLOPE - NIGHT - SKEWED GUIDANCE - WITH FLIGHT DIRECTOR

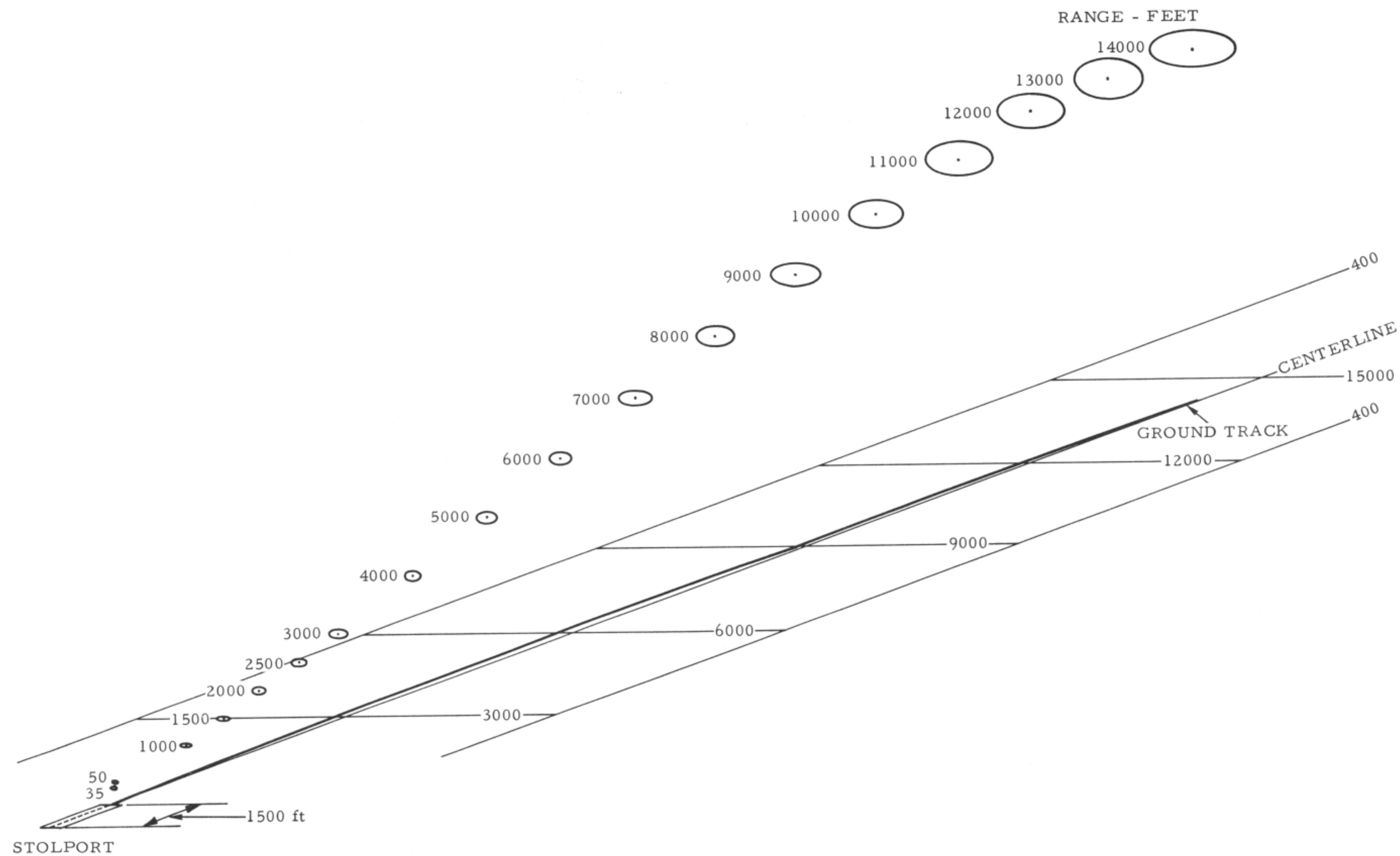


FIGURE J-11. 6° GLIDE SLOPE - NIGHT - CENTERLINE GUIDANCE - <u>WITH</u> FLIGHT DIRECTOR

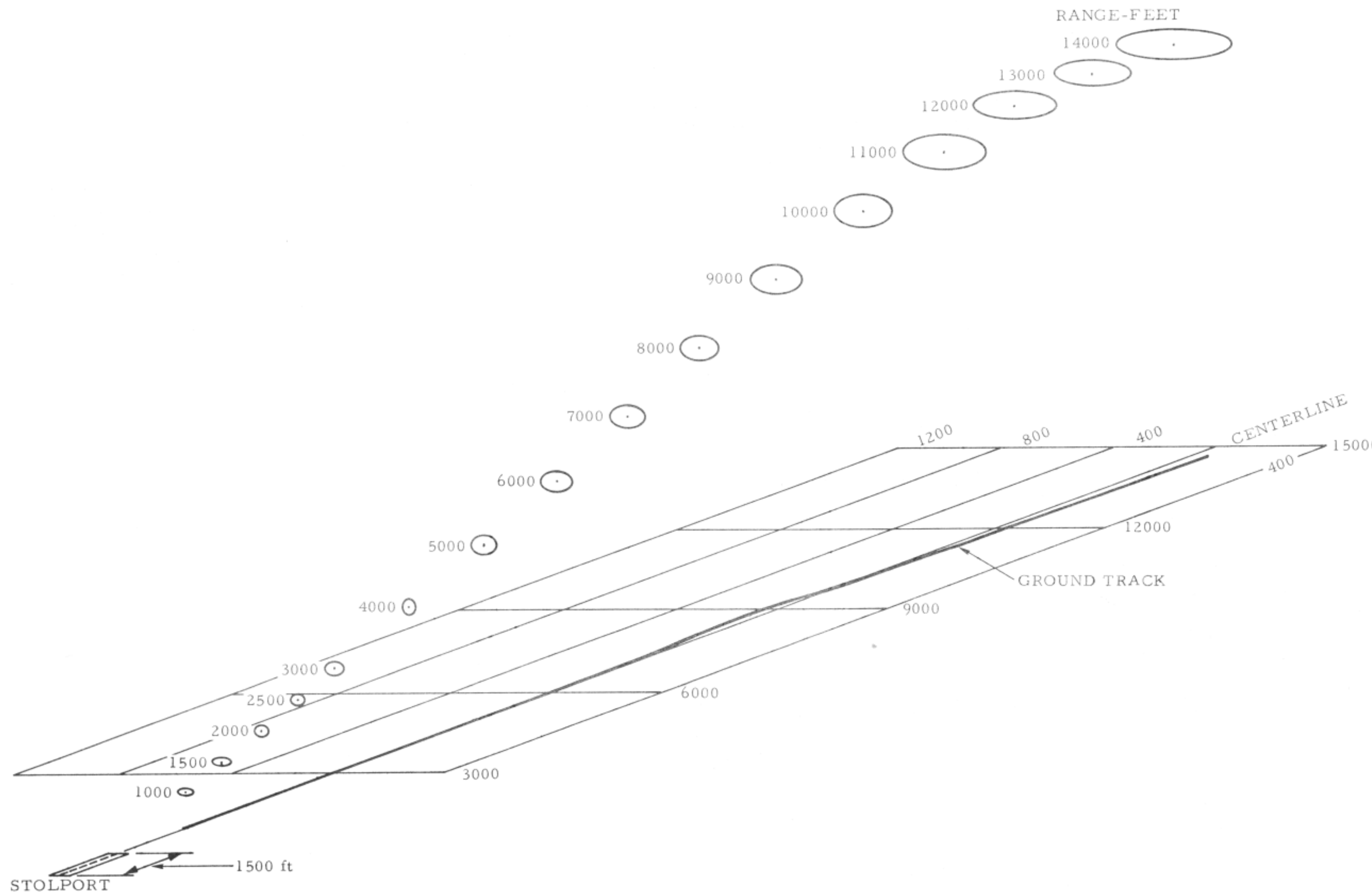


FIGURE J-12. 7.5° GLIDE SLOPE - NIGHT - CENTERLINE GUIDANCE - <u>WITH</u> FLIGHT DIRECTOR

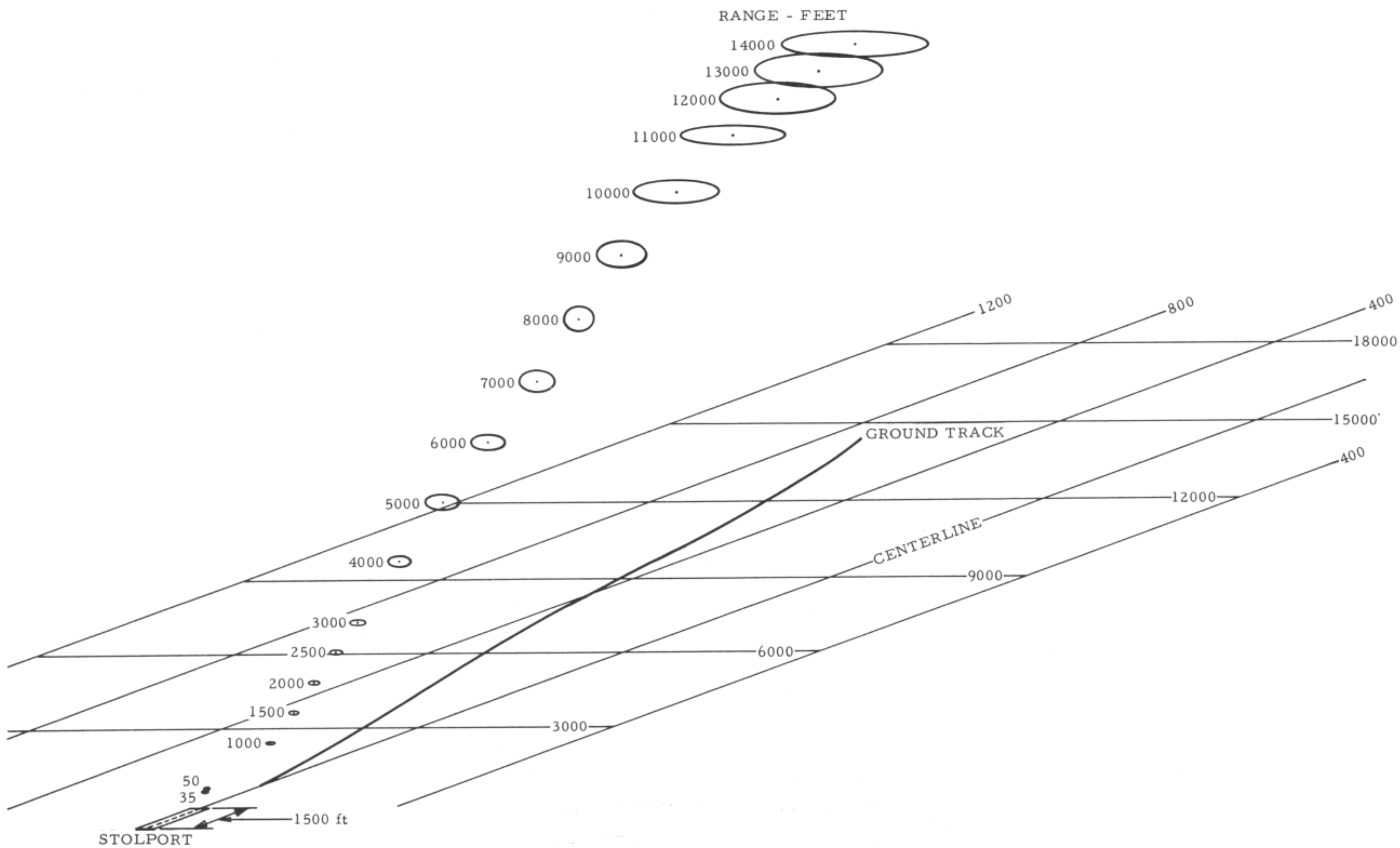


FIGURE J-13. 7.5° GLIDE SLOPE - NIGHT - SKEWED GUIDANCE - <u>WITH</u> FLIGHT DIRECTOR

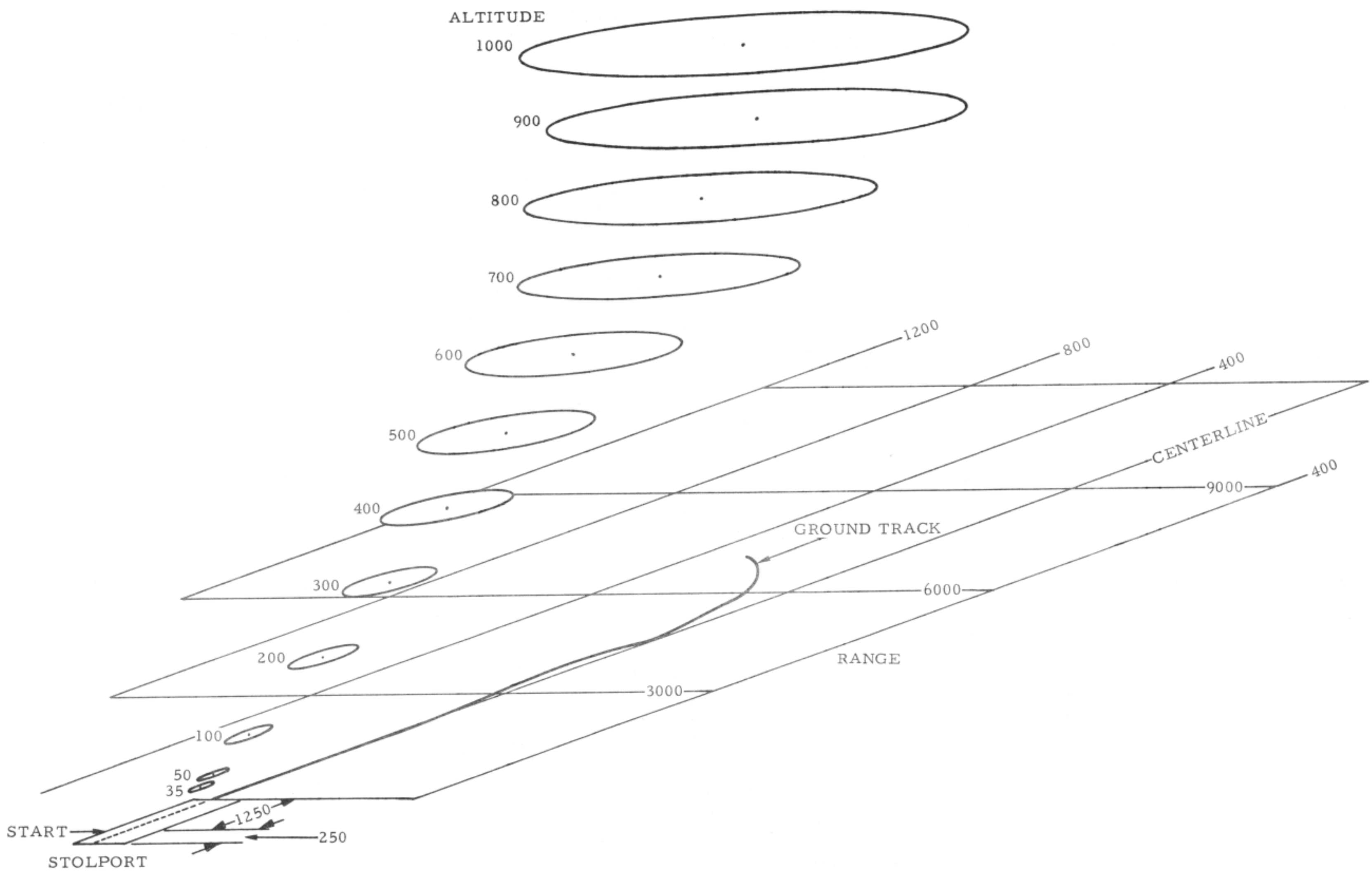


FIGURE J-14. DEPARTURE - DAY - STRAIGHT

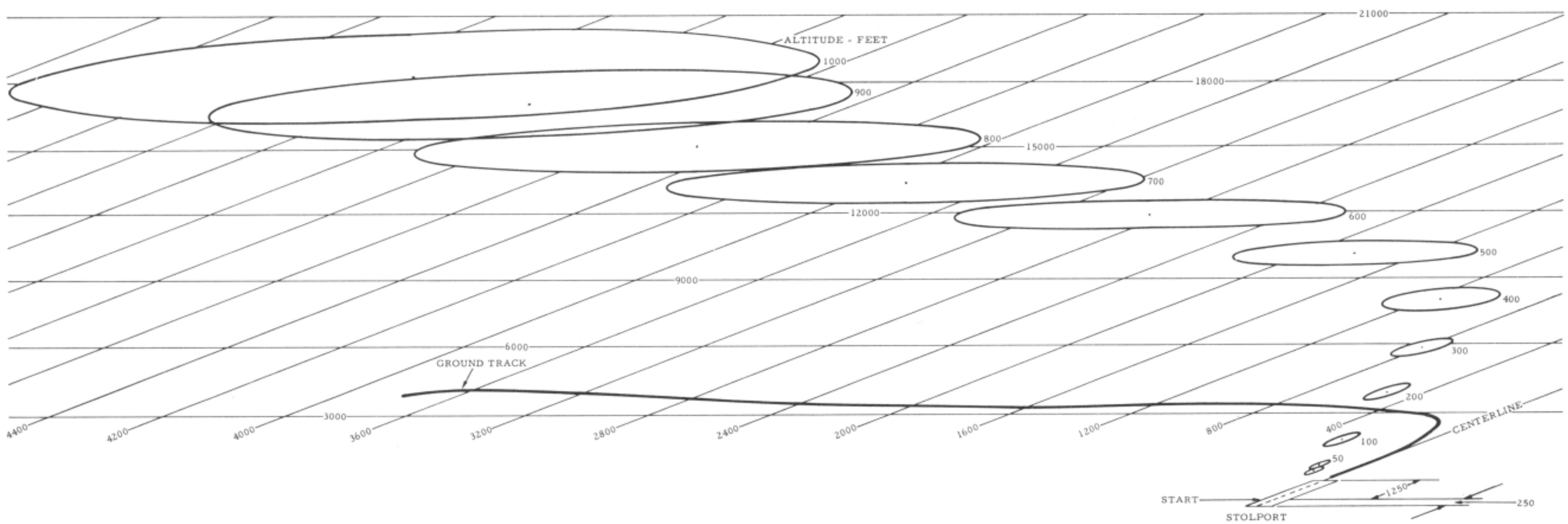


FIGURE J-15. DEPARTURE - DAY - TURNING

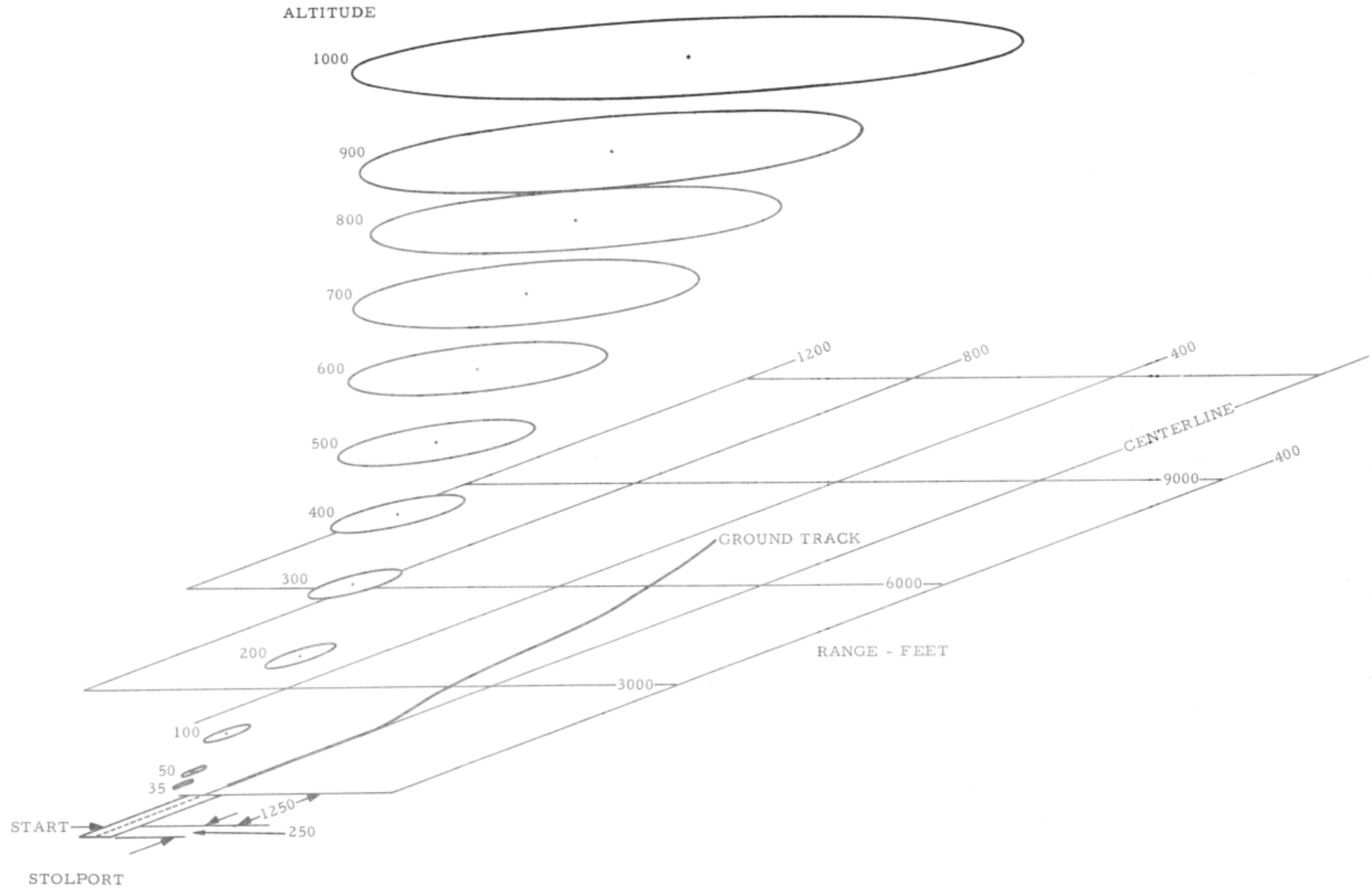


FIGURE J-16. DEPARTURE - NIGHT - STRAIGHT

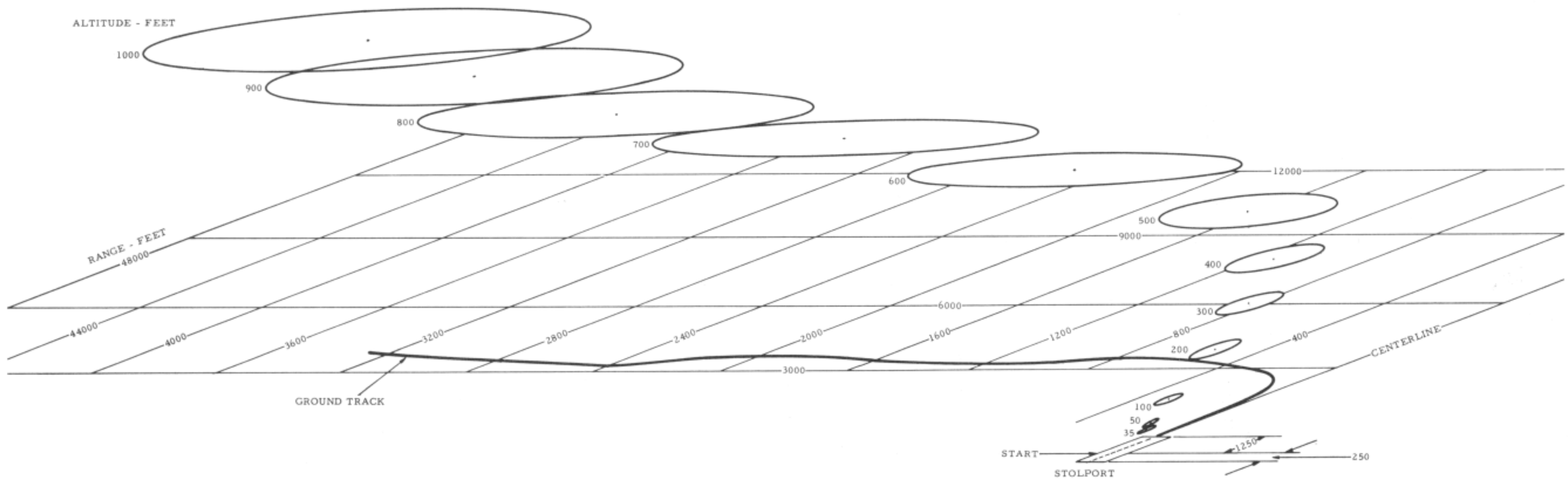


FIGURE J-17. DEPARTURE - NIGHT - TURNING