NASA TECHNICAL NOTE

N73-30026

NASA TN D-7300

NASA TN D-7300

CASE FILE COPY

AIRPORT-AREA AIRSPACE USED IN SIMULATED OPERATIONS WITH AN EXPERIMENTAL POWERED-LIFT STOL AIRPLANE

by Norman S. Silsby and Richard H. Sawyer

Langley Research Center
Hampton, Va. 23665

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • SEPTEMBER 1973

1. Report No. NASA TN D-7300	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle AIRPORT-AREA AIRSPACE USED IN SIMULATED OPERATIONS WITH AN EXPERIMENTAL POWERED-LIFT STOL AIRPLANE		5. Report Date September 1973
		6. Performing Organization Code
7. Author(s) Norman S. Silsby and Richard H. Sawyer		8. Performing Organization Report No. L-8869
9. Performing Organization Name and Address NASA Langley Research Center Hampton, Va. 23665		10. Work Unit No. 768-81-04-00
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		13. Type of Report and Period Covered Technical Note
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Simulation tests were made using an experimental powered-lift STOL airplane to help define airport-area airspace requirements for STOL operations. The operational feasibility and airspace used in take-offs followed by climbing turns, offset (bent localizer) approaches, missed approaches, and two-segment (bent glide-slope) approaches were studied. Flight-director guidance was provided for the approach maneuvers.

17. Key Words (Suggested by Author(s))		18. Distribution Statement	
Airport-area airspace Experimental powered-lift airplane STOL		Unclassified – Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 27	22. Price* Domestic, $3.00 Foreign, $5.50

*For sale by the National Technical Information Service, Springfield, Virginia 22151

AIRPORT-AREA AIRSPACE USED IN SIMULATED OPERATIONS WITH AN EXPERIMENTAL POWERED-LIFT STOL AIRPLANE

By Norman S. Silsby and Richard H. Sawyer
Langley Research Center

SUMMARY

Simulation tests were made using an experimental powered-lift STOL airplane (augmentor-wing modification of a Buffalo) to help define airport-area airspace requirements for STOL operations. The operational feasibility and airspace used in take-offs followed by climbing turns, offset (bent localizer) approaches, missed approaches, and two-segment (bent glide-slope) approaches were studied. Flight-director guidance was provided for the approach maneuvers. Smooth air conditions were used in the tests.

In general, offset approaches at intercept angles up to 60° were considered feasible by the pilots when a 1.0-n. mi. straight final-approach segment was provided. With a 0.5-n. mi. straight final-approach segment, the consensus of pilot opinion was that an intercept angle of 25° was operationally feasible, but that higher angles (45° and 60°) would be questionable in rough air conditions. In the offset approaches with turn anticipation provided in the flight-director guidance, the average deviations from localizer centerline (overshoots) at the transition to the final-approach course were always within the half width of the localizer beam.

In missed approach operations, minimum, maximum, and average distances beyond the glide-slope ground intercept at which turns considered operationally feasible were initiated were 122, 1280, and 671 m (400, 4200, and 2200 ft), respectively, for a decision height of 61 m (200 ft) and 823, 1646, and 1067 m (2700, 5400, and 3500 ft), respectively, for a decision height of 15 m (50 ft). All the pilots indicated that the missed-approach procedure from the 61-m (200-ft) decision height was marginally acceptable because of the low stability characteristics of the airplane. If only airplane performance was considered, however, the missed-approach procedure was generally rated as feasible even at a decision height of 15 m (50 ft).

In the take-offs, the minimum, maximum, and average distances from start of ground roll to the point at which turns considered operationally feasible were initiated were about 732, 1524, and 1036 m (2400, 5000, and 3400 ft), respectively.

Although the flight-director guidance was not optimum, the pilots agreed that the two-segment glide-slope concept for transition altitudes of 91, 61, and 30 m (300, 200, and 100 ft) were all easily accomplished.

INTRODUCTION

Previous studies concerning the integration of short take-off and landing (STOL) airplane operations with conventional take-off and landing (CTOL) operations (refs. 1 and 2) have indicated that independent STOL runways and approach and departure paths are a requirement in order to maintain efficient operations on the CTOL runways. Operations of the STOL and CTOL traffic to and from the same runways results in a large loss in number of flights because of the differences in operating speeds of the two types of aircraft and the resulting large increases in separation required.

For independent STOL terminal operations, knowledge of the airspace requirements for take-off, approach, and missed-approach maneuvers is needed for designing STOL port configurations and STOL runway locations relative to the CTOL runways in order to insure at least standard separation of airplanes during the integrated operations.

In order to provide some of the information required, tests have been made using a flight simulator programed to represent an experimental powered-lift STOL airplane. Take-offs followed by climbing turns, offset (bent localizer) approaches, missed approaches, and two-segment (bent glide-slope) approaches were evaluated. Five government pilots participated in the tests.

The results include lateral overshoot deviations at the bend in offset approaches, distances traveled before turning in missed approaches, minimum altitudes at which turns were initiated in take-offs and missed approaches, altitude loss in missed approaches, vertical deviations from glide slope in the two-segment approaches, and pilot comments.

Values are given in both SI and U.S. Customary Units. The measurements and calculations were made in U.S. Customary Units.

EQUIPMENT

A fixed-base airplane flight simulator (see fig. 1) was used to represent the experimental powered-lift STOL airplane – the augmentor-wing research-airplane modification of a Buffalo airplane (ref. 3). The airplane as modified has two split-flow turbofan engines replacing the turboprop engines. Augmented lift is obtained by exhausting the cold air from the front fans through a slotted-flap arrangement. The hot gas flow exits through nozzles whose orientation can be adjusted in flight to provide control of the thrust vector through a vertical angle of 98°.

The airplane simulated had a mass of 18 140 kg (40 000 lbm) for both the take-off and the landing-approach conditions. The wing loading was 2210 N/m^2 (46.2 lb/ft^2). The maximum (hot) thrust-mass ratio was about 0.31 for both the take-off and missed-approach conditions. The engine acceleration characteristics were such that approach thrust could be increased to take-off thrust in less than 2 sec. The nozzles could be rotated from the approach to the take-off setting in about 1 sec. The flap actuation rate was from 1 to 2 deg/sec.

Conventional flight controls were used with a thumb switch on the control column for pitch trim. A single throttle lever was used to control both engines. Another was used to control the angle of the adjustable nozzles. Longitudinal, lateral, and directional stability augmentation systems were employed. However, the pilots generally rated the airplane as having low lateral and longitudinal stability characteristics.

In addition to conventional flight instrumentation, a flight-director system with an attitude director indicator (ADI) and a horizontal situation indicator were provided. Both command steering and deviation indicators for localizer and glide-slope guidance were included on the ADI. A dual pointer-type indicator on the engine instrument panel was used to show the vertical angle of each nozzle.

TEST PROCEDURES

All the tests were performed using the flight instruments for guidance. No external visual cues were available. Only smooth air conditions were simulated. The approaches were started on course at 3.5 or 4 n. mi. from glide-slope ground intercept at 701-m (2300-ft) altitude and 90 knots calibrated airspeed (KCAS). The airplane was slowed to final approach speed (65 KCAS) prior to glide-slope intercept which occurred at about 3.0 n. mi.

The offset (bent localizer) approaches were made along a single-segment glide slope (7.5°). In these approaches, localizer-course changes of 25°, 45°, and 60° were investigated for both left and right turns to final-approach course. The localizer-course transition was made at either 0.5 or 1 n. mi. from glide-slope ground intercept. For the majority of the offset-approach tests, the flight-director bank-angle command indicator was activated a few seconds before the airplane was due to arrive at the localizer-course transition point, providing turn anticipation in order to reduce overshoot of final-approach course. The turn-anticipation times used were 7 sec for the 25° and 45° localizer-course changes and 9 sec for the 60° localizer-course changes. A few tests were made with a turn-anticipation time of zero for comparison.

The offset approaches were either carried through to a landing or missed-approach procedures were effected. The missed approaches were initiated at altitudes of either

61 or 15 m (200 or 50 ft). The procedure followed was to advance the throttle for maximum thrust, retract the flaps from full down to an intermediate position, raise the nozzles from near vertical to about 60° from horizontal, and, after airspeed had increased to at least 75 KCAS and a positive rate of climb had been established, raise the flaps to 15° and the nozzles to full up. The initial climbout was made at or above 75 KCAS. A 45° turn to the right or left was made as soon as considered operationally feasible by the pilot. The airplane was accelerated to 120 KCAS in the climb with the test ending at an altitude of 457 m (1500 ft). Missed approaches were made using the ADI for a climbout pitch-attitude reference.

The two-segment (bent glide-slope) approaches were made along a straight localizer course. In these approaches, the transition from the 7.5° to the 3° glide slope was investigated at each of three altitudes: 91, 61, and 30 m (300, 200, and 100 ft). The two-segment approaches were carried through to a landing.

For both the offset and two-segment approaches, a constant-width localizer beam of 152 m (500 ft), and an angular glide-slope beam of 4° were used. The glide-slope ground intercept point was at 305 m (1000 ft) down the runway from the runway threshold.

In the take-offs, rotation was at about 65 KCAS with initial climbout at 76 KCAS or above. Turns of either 45° or 90° were made as soon as considered operationally feasible by the pilot. The airplane was accelerated to 120 KCAS in the climbs with the tests ending at about a 457-m (1500-ft) altitude for the 45° turns and at a 914-m (3000-ft) altitude for the 90° turns.

RESULTS AND DISCUSSION

Offset Approaches

The maximum and average lateral deviations from the localizer centerline Y_{max} and Y_{av}, during the turn in the offset-approach tests for the three localizer-course changes $\Delta\psi$ for turns both with and without turn anticipation (t.a.) provided in the flight-director guidance, are summarized below:

$\Delta\psi$, deg	Y_{max}, m (ft)		Y_{av}, m (ft)	
	With t.a.	Without t.a.	With t.a.	Without t.a.
25	53 (175)	107 (350)	18 (60)	88 (288)
45	122 (400)	183 (600)	49 (162)	152 (500)
60	259 (850)	--- ----	38 (124)	--- ----

These data include those from tests made at both 0.5- and 1.0-n. mi. localizer-course transition. Results are not shown for $\Delta\psi = 60^{\circ}$ without turn anticipation as only one test was made for this condition.

The results show in general, as would be expected, an increase in the Y_{max} and Y_{av} values with increase in $\Delta\psi$. The reduction in Y_{av} for $\Delta\psi = 60^{\circ}$ compared to that for $\Delta\psi = 45^{\circ}$ is an exception and is believed due to the increased turn-anticipation time used (9 instead of 7 sec). The large value of Y_{max} for $\Delta\psi = 60^{\circ}$ occurred as the result of a blunder by the pilot.

Comparison of the results with and without turn anticipation indicates that the lack of turn anticipation increased the Y_{max} and Y_{av} values from 1.5 to nearly 5 times. With turn anticipation provided, the localizer centerline overshoots on the average were well within 76 m (250 ft), the half width of the localizer beam. The maximum deviations, however, all exceeded the half width of the localizer beam except for the $\Delta\psi = 25^{\circ}$ case with turn anticipation. Without turn anticipation, the average deviations were always greater than the half width of the localizer beam.

With regard to the operational feasibility of the offset approaches, all the pilots agreed that the 25° offset approaches for both the 0.5- and 1.0-n. mi. transitions were feasible with flight-director guidance having turn-anticipation logic. Without turn anticipation, the guidance was considered to be marginal. For the 45° offset approaches, the workload was increased. Some pilots questioned the acceptability of 0.5-n. mi. transitions even with turn anticipation in these approaches. For the 60° offset approaches with turn anticipation, the 1.0-n. mi. transitions were generally considered marginally acceptable, but the 0.5-n. mi. transitions were considered unacceptable by all the pilots. These results of the operational feasibility of the offset approaches were obtained without turbulence input to the simulator. In the opinion of the pilots, the task difficulty would be increased by turbulence to an unacceptable level for those offset-approach conditions rated questionable or marginal.

Missed Approach

Ground tracks of offset approaches from which missed-approach procedures were initiated using flight-director guidance at decision heights of either 61 or 15 m (200 or 50 ft), are given in figures 2 to 5. The airspeeds and altitudes at which each test was ended are presented in table I.

Distance to turn initiation.- The differences shown in the distances beyond the glide-slope ground intercept point at which the 45° turn initiation occurred result from different operational techniques used by the pilots. In general the pilots did not initiate the turn following the missed approach until an altitude of at least 122 m (400 ft) was gained. One pilot did not initiate the turn until at an altitude of about 183 m (600 ft). These were the minimum altitudes considered safe for being in such a maneuver with this airplane in the event of a one-engine power loss.

The minimum, maximum, and average distances to turn initiation d_{min}, d_{max}, and d_{av} for the two decision heights h_d used are summarized below:

h_d, m (ft)	d_{min}, m (ft)	d_{max}, m (ft)	d_{av}, m (ft)
61 (200)	122 (400)	1280 (4200)	671 (2200)
15 (50)	823 (2700)	1646 (5400)	1067 (3500)

Because of time limitations, the pilots were given only a minimum of training in the missed-approach maneuver. However, the lack of training may have been offset to some degree by the knowledge that a missed approach was to be executed.

Altitude loss.- Because approach thrust could be increased to take-off thrust in less than 2 sec, and the nozzles could be rotated from approach setting to a setting providing both direct lift and acceleration in about 1 sec, the altitudes lost in the missed-approach procedure were generally small. In all cases, positive rate of climb was attained in less than 3 sec after initiation of the missed-approach procedure.

The minimum, maximum, and average altitude losses Δh_{min}, Δh_{max}, and Δh_{av} for the two decision heights used are summarized below:

h_d, m (ft)	Δh_{min}, m (ft)	Δh_{max}, m (ft)	Δh_{av}, m (ft)
61 (200)	3 (10)	23 (75)	9 (30)
15 (50)	5 (15)	14 (45)	8 (25)

Pilot comments.- As performed (without flight-director guidance), the missed-approach maneuver from a 61-m (200-ft) decision height was considered marginally acceptable by all the pilots with the task being described as too demanding because of the low lateral and longitudinal stability characteristics of the airplane. One pilot indicated he believed that if flight-director-heading, missed-approach, and altitude-hold modes were available, the maneuver would probably be considered quite satisfactory. From a decision height of 15 m (50 ft), the missed-approach maneuver was rated as feasible (from an airplane performance standpoint only) by three of four pilots. For the 15-m (50-ft) decision height two of the pilots conditioned their feasible ratings by noting that in the tests the pilot was planning a missed approach instead of a landing. In the real world, when trying to optimize the corrections to flight path for landing, the pilot might not respond quickly enough which could result in unintended ground contact.

Take-offs

Ground tracks of the take-offs followed by either 45° or 90° climbing turns to altitudes of about 457 and 914 m (1500 and 3000 ft), respectively, are given in figure 6. The altitude and airspeed at which each test was ended are presented in table II.

Only three pilots participated in the take-off tests, and the average altitudes at which they initiated turns varied between only 104 and 122 m (340 and 400 ft). Consequently, there were no significant differences among the pilots in the distance to turn initiation measured from the start of ground roll. For all the take-offs, the maximum distance measured was about 1524 m (5000 ft), the minimum distance was 732 m (2400 ft), and the average distance was about 1036 m (3400 ft).

Two-Segment Glide-Slope Approaches

Vertical profile tracks of the two-segment glide-slope approaches with transition from the 7.5° to the 3° glide slope at altitudes of 91, 61, and 30 m (300, 200, and 100 ft) are given in figure 7. Flight-director steering command information was provided for both vertical and lateral guidance in these approaches.

The results show that the vertical-path tracking performance in general was very good. There was, however, a consistent deviation above the glide path at intercept, and a tendency to deviate below the glide path in the transition to the 3° glide slope. The deviations at intercept were from 15 to 43 m (50 to 140 ft) in altitude and were not difficult to correct. The deviations in the transition were from 1.5 to 15 m (5 to 50 ft) in altitude and generally appeared correctable. These deviations from glide slope indicate that the flight-director-guidance logic was not optimum for the intercept and transition maneuvers.

Although the flight-director guidance provided was not optimum, the pilots agreed that the two-segment glide-slope concept was easily accomplished for all three transition altitudes. Feasibility of the concept for routine operations would depend on development of guidance information permitting smooth transitions with no deviation below glide slope.

CONCLUDING REMARKS

Simulation tests were made using an experimental powered-lift STOL airplane (augmentor-wing modification of a Buffalo) to help define airport-area airspace requirements for STOL operations. The operational feasibility and airspace used in take-offs followed by climbing turns, offset (bent localizer) approaches, missed approaches, and two-segment (bent glide-slope) approaches were studied. Flight-director guidance was provided for the approach maneuvers. Smooth air conditions were used in the tests.

In general, offset approaches at intercept angles up to 60° were considered feasible by the pilots when a 1.0-n. mi. straight final-approach segment was provided. With a 0.5-n. mi. straight final-approach segment, the consensus of pilot opinion was that an intercept angle of 25° was operationally feasible, but that higher angles (45° and 60°) would be questionable in rough air conditions. In the offset approaches with turn anticipation provided in the flight-director guidance, the average deviations from localizer centerline (overshoots) at the transition to the final-approach course were always within the half width of the localizer beam.

In missed-approach operations, minimum, maximum, and average distances beyond the glide-slope ground intercept at which turns considered operationally feasible were initiated were 122, 1280, and 671 m (400, 4200, and 2200 ft), respectively, for a decision height of 61 m (200 ft) and 823, 1646, and 1067 m (2700, 5400, and 3500 ft), respectively, for a decision height of 15 m (50 ft). All the pilots indicated that the missed-approach procedure from the 61-m (200-ft) decision height was marginally acceptable because of the low stability characteristics of the airplane. If only airplane performance was considered, however, the missed-approach procedure was generally rated as feasible even at a decision height of 15 m (50 ft).

In the take-offs, minimum, maximum, and average distances from start of ground roll to the point at which turns considered operationally feasible were initiated were about 732, 1524, and 1036 m (2400, 5000, and 3400 ft), respectively.

Although the flight-director guidance was not optimum, the pilots agreed that with the two-segment glide-slope concept, transitions at altitudes of 91, 61, and 30 m (300, 200, and 100 ft) were all easily accomplished.

Langley Research Center,
National Aeronautics and Space Administration,
Hampton, Va., June 5, 1973.

REFERENCES

1. Barriage, J. B.; Douglass, L. N.; and Conway, R. C.: STOL and VTOL Operations in the National Airspace System. AIAA Paper No. 68-1099, Oct. 1968.

2. Petersen, Paul; Sawyer, Richard H.; and McLaughlin, Milton D.: Integration of STOL Airplanes Into the ATC System. STOL Technology, NASA SP-320, 1972, pp. 291-306.

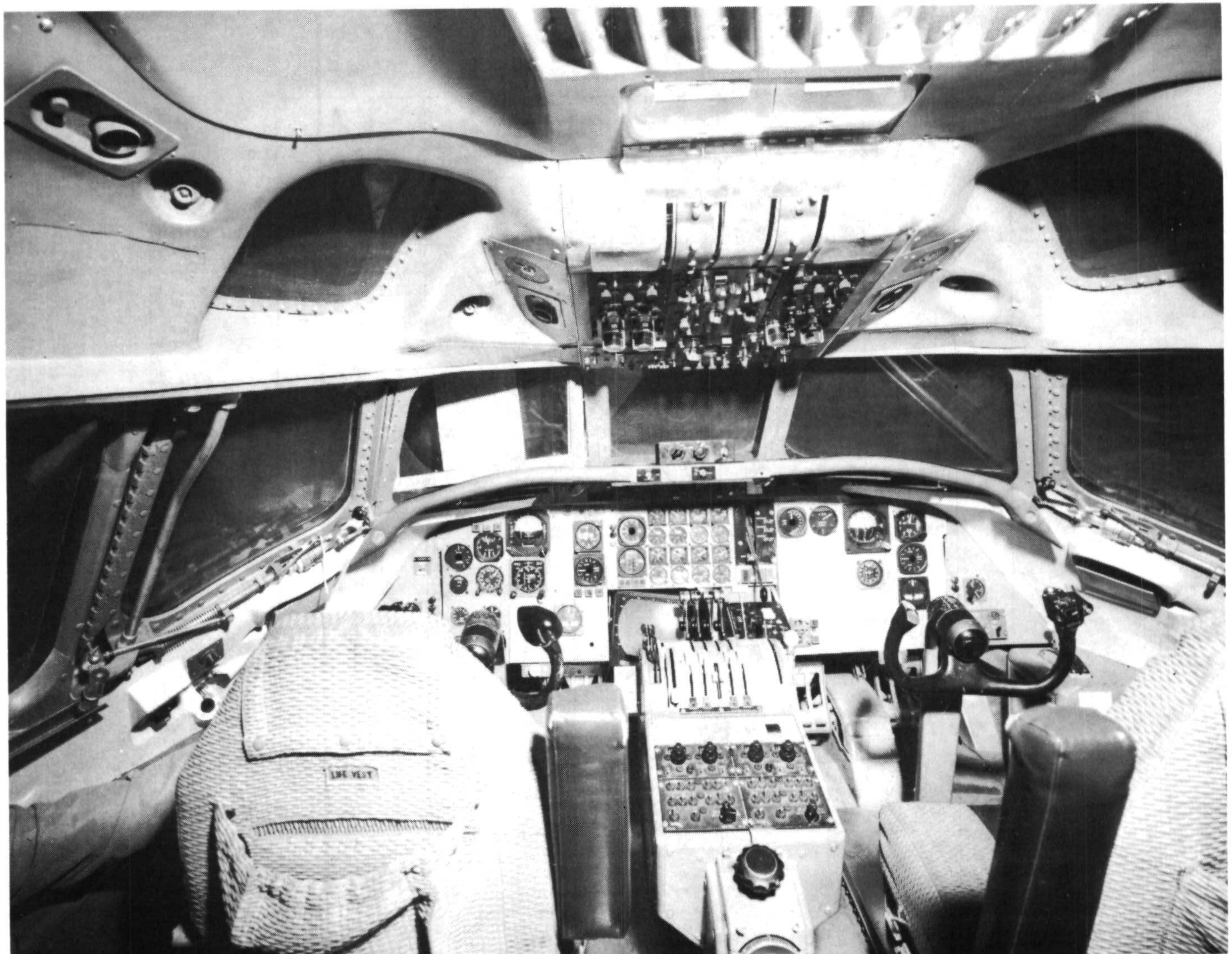
3. Quigley, Hervey C.; Sinclair, S. R. M.; Nark, Theodore C., Jr.; and O'Keefe, Jack V.: A Progress Report on the Development of an Augmentor Wing Jet STOL Research Aircraft. [Preprint] 710757, Soc. Automot. Eng., Sept. 1971.

TABLE I.- TEST CONDITIONS FOR MISSED-APPROACH MANEUVERS

Figure	Run	Course change, deg	Turn-anticipation time, sec	Decision height, m (ft)	Conditions at end of test	
					Altitude, m (ft)	Airspeed, knots
2	1	25	7	61 (200)	314 (1030)	118
	2	25	7	61 (200)	282 (925)	123
	3	45	7	61 (200)	312 (1025)	122
	4	45	7	61 (200)	317 (1040)	124
	5	60	9	61 (200)	332 (1090)	114
	6	60	9	61 (200)	320 (1050)	116
3	1	25	7	61 (200)	491 (1610)	140
	2	45	7	61 (200)	509 (1670)	140
	3	60	9	61 (200)	437 (1435)	127
	4	60	9	61 (200)	515 (1690)	112
	5	45	0	61 (200)	456 (1495)	120
	6	25	0	61 (200)	453 (1485)	120
	7	25	7	61 (200)	303 (995)	127
	8	25	7	61 (200)	280 (920)	115
	9	45	7	61 (200)	314 (1030)	122
	10	45	7	61 (200)	318 (1045)	130
	11	60	9	61 (200)	334 (1095)	126
	12	60	9	61 (200)	348 (1140)	119
	13	25	7	61 (200)	367 (1205)	161
	14	25	7	61 (200)	250 (820)	126
	15	45	7	61 (200)	160 (525)	121
	16	45	7	61 (200)	655 (2150)	120
	17	60	9	61 (200)	472 (1550)	111
4	1	60	9	15 (50)	434 (1425)	122
	2	60	9	15 (50)	478 (1570)	121
5	1	25	0	15 (50)	436 (1430)	112
	2	45	0	15 (50)	459 (1505)	131
	3	60	0	15 (50)	468 (1535)	108
	4	25	7	15 (50)	378 (1240)	110
	5	45	7	15 (50)	439 (1440)	122
	6	60	9	15 (50)	508 (1665)	112
	7	25	7	15 (50)	457 (1500)	117
	8	45	7	15 (50)	488 (1600)	114
	9	60	9	15 (50)	456 (1495)	120

TABLE II.- TEST CONDITIONS FOR TAKE-OFFS

Figure	Run	Conditions at end of test	
		Altitude, m (ft)	Airspeed, knots
6	1	468 (1535)	127
	2	478 (1570)	129
	3	878 (2880)	123
	4	913 (2995)	117
	5	471 (1545)	94
	6	492 (1615)	121
	7	818 (2685)	123
	8	924 (3030)	128
	9	901 (2955)	142
	10	910 (2985)	121
	11	856 (2810)	142
	12	457 (1500)	129



L-72-3813

Figure 1.- Cockpit of fixed-base airplane flight simulator.

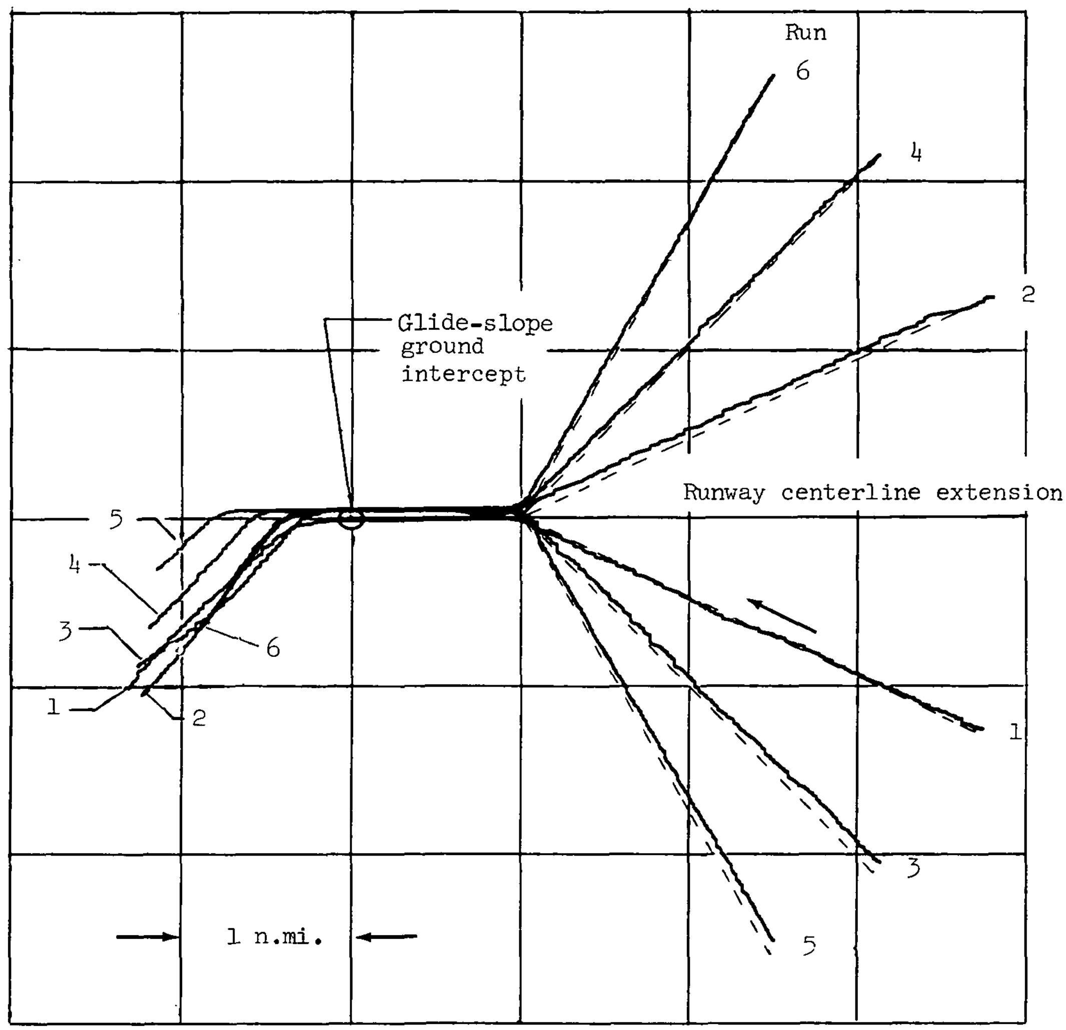
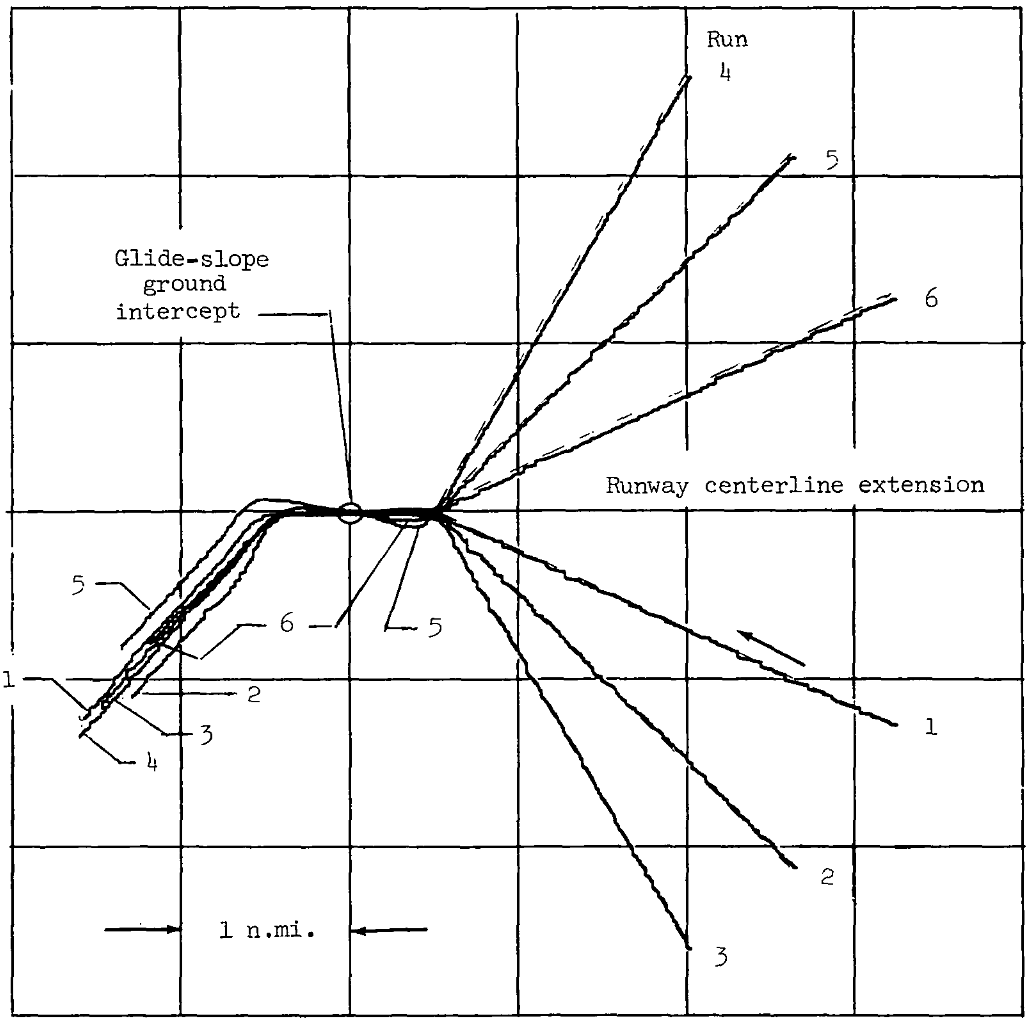
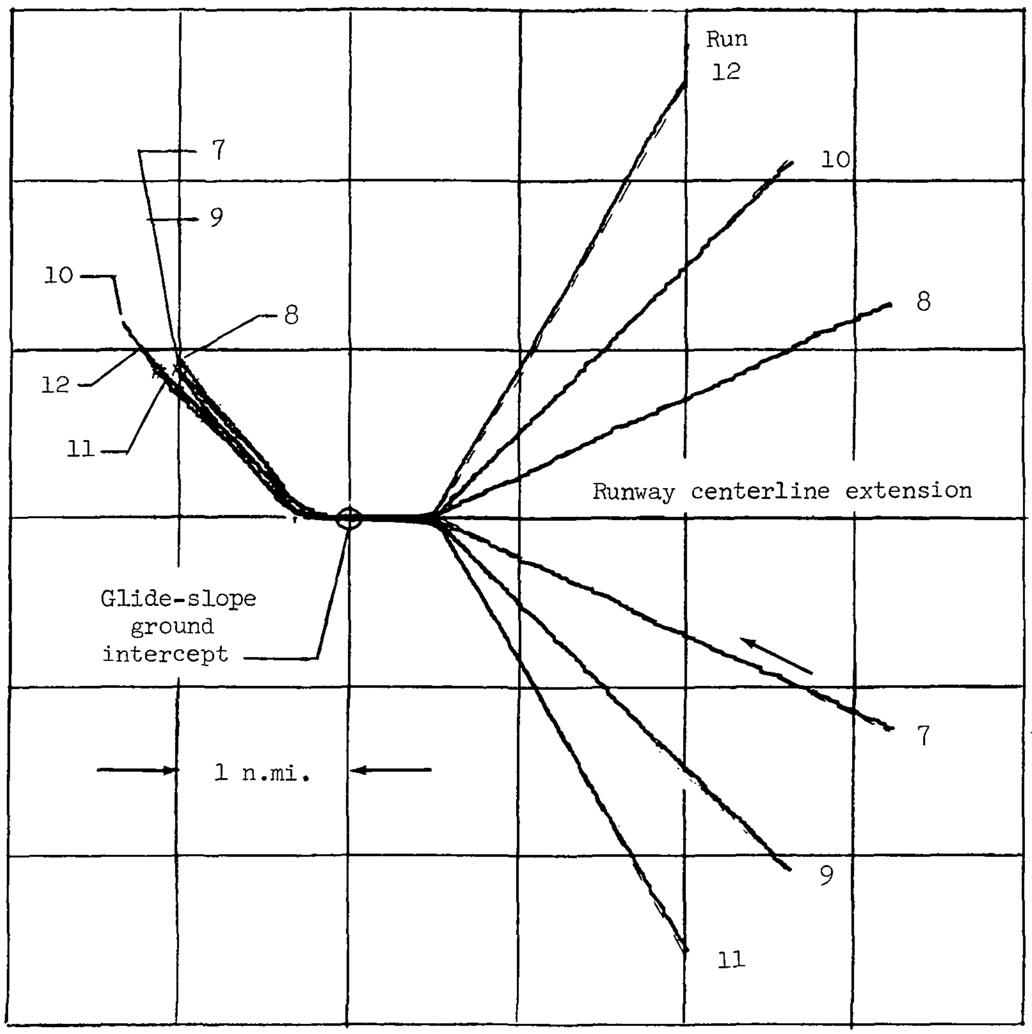


Figure 2.- Ground tracks of offset approaches followed by missed-approach procedure. Final-approach-course transition at 1 n. mi. Decision height = 61 m (200 ft). Conditions at end of test given in table I.



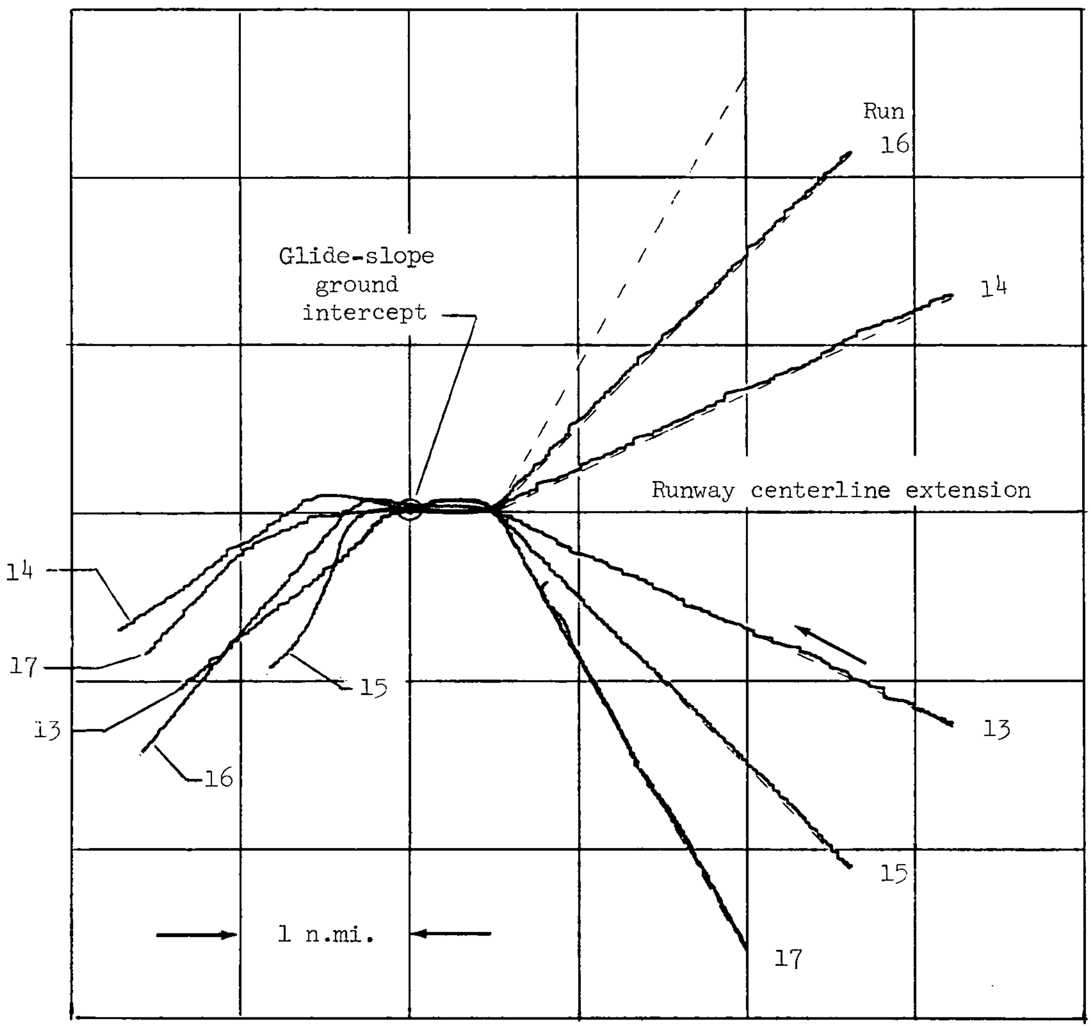
(a) Runs 1 to 6.

Figure 3.- Ground tracks of offset approaches followed by missed-approach procedure. Final-approach-course transition at 0.5 n. mi. Decision height = 61 m (200 ft). Conditions at end of test given in table I.



(b) Runs 7 to 12.

Figure 3.- Continued.



(c) Runs 13 to 17.

Figure 3.- Concluded.

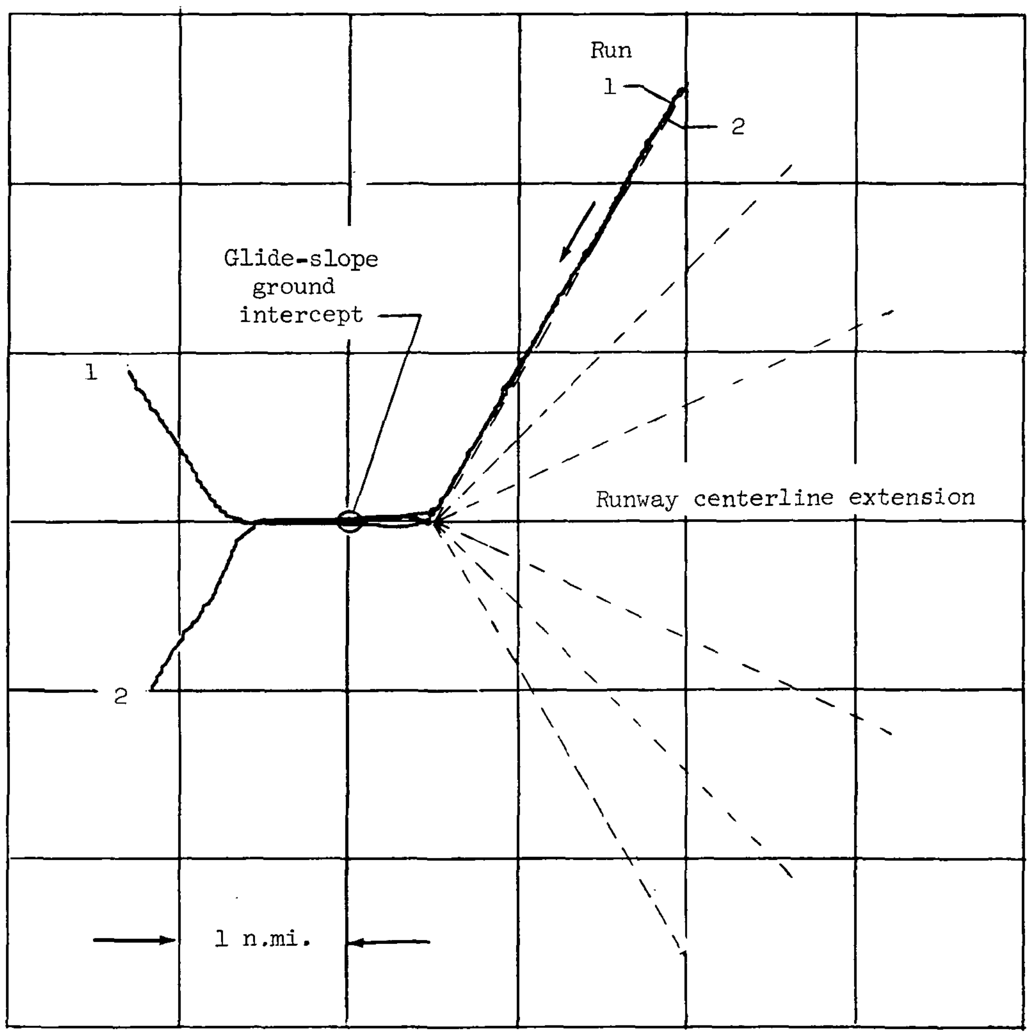
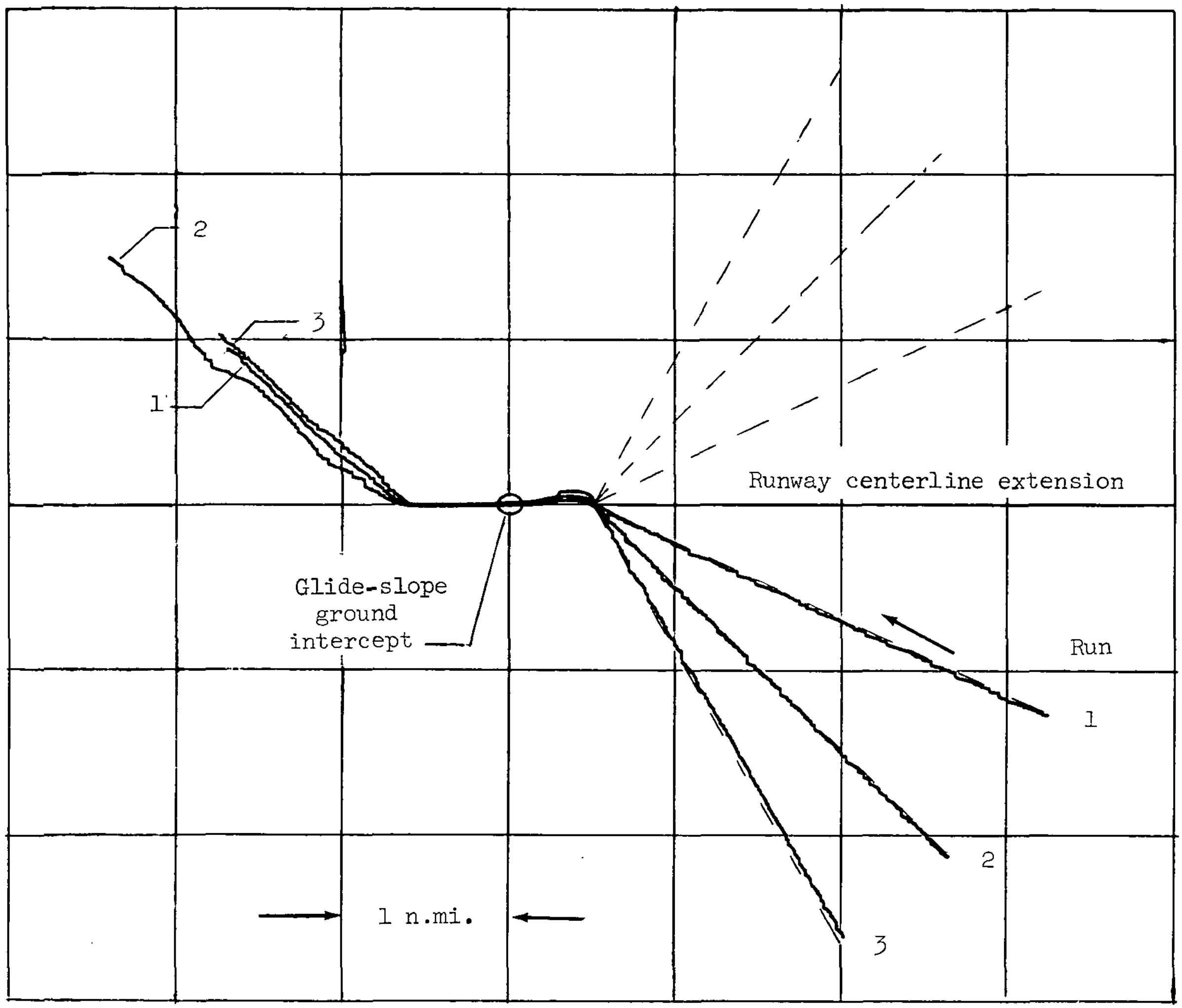
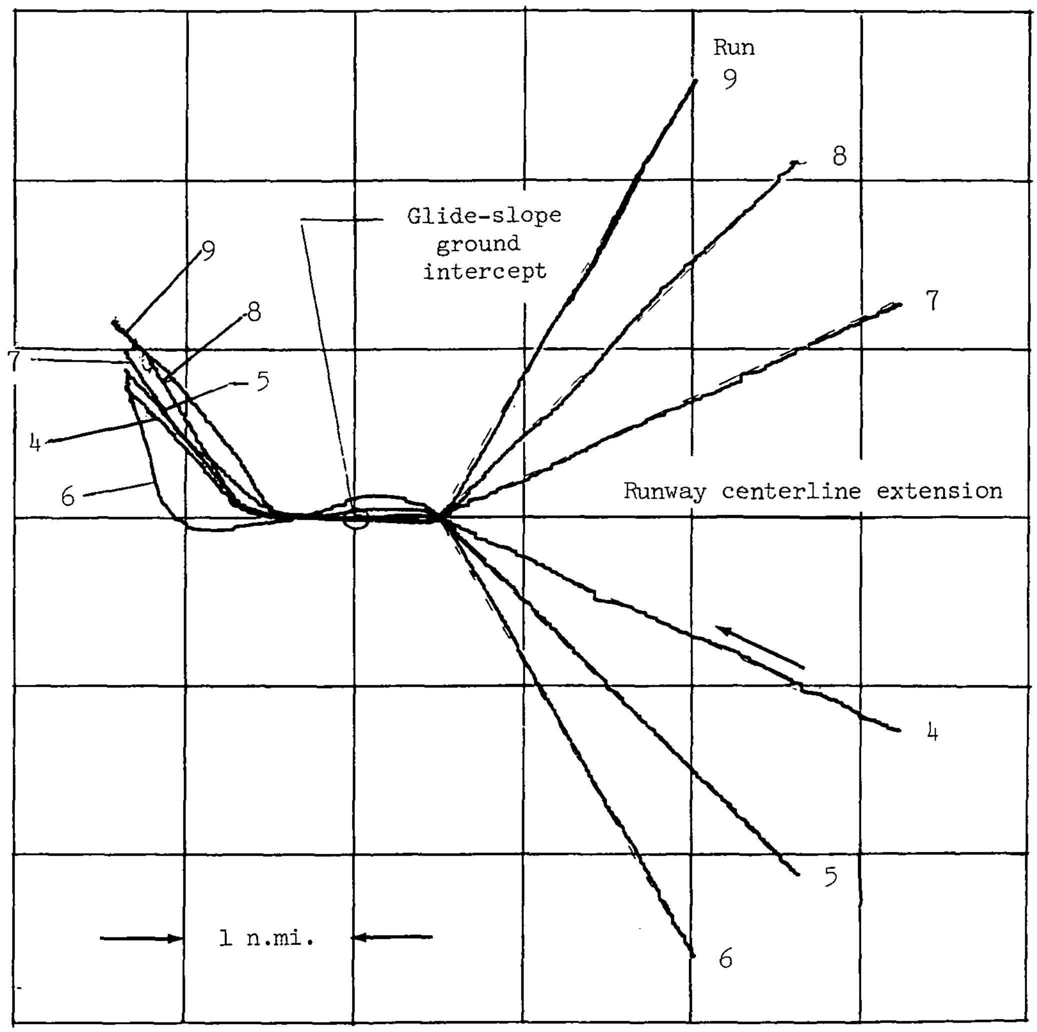


Figure 4.- Ground tracks of offset approaches followed by missed-approach procedure. Final-approach-course transition at 0.5 n. mi. Decision height = 15 m (50 ft). Conditions at end of test given in table I.



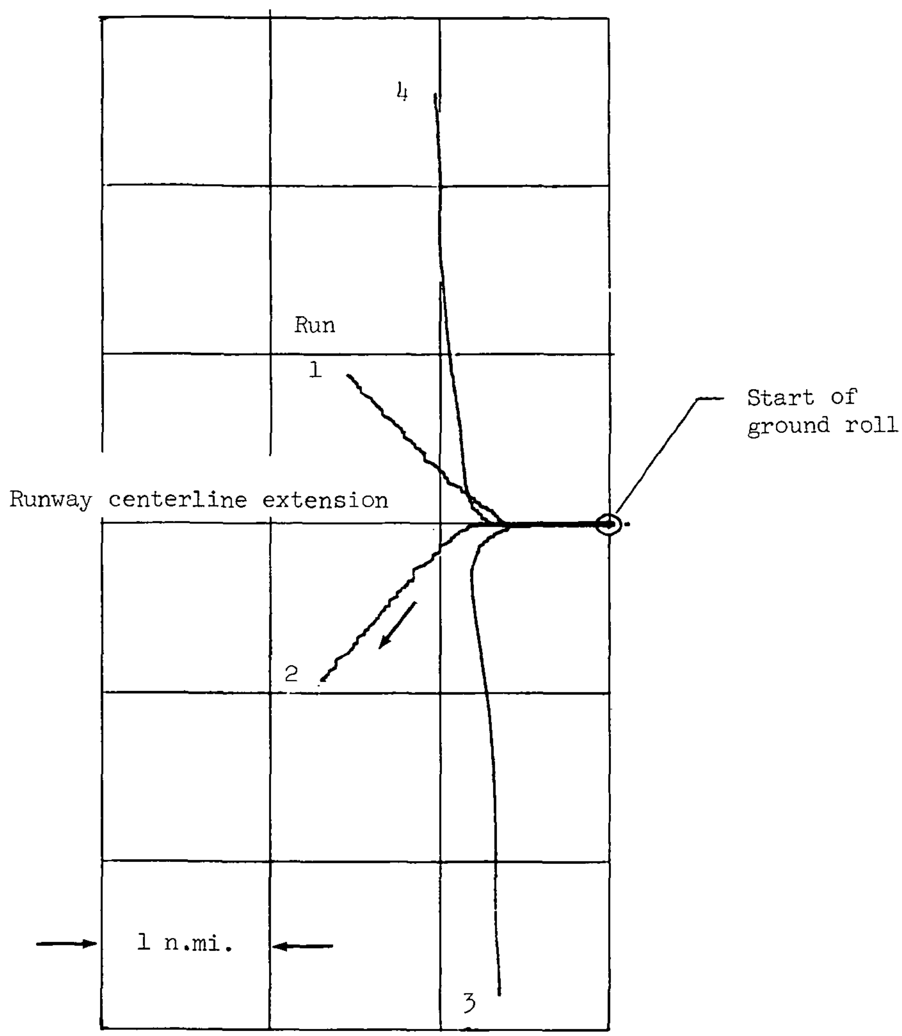
(a) Runs 1 to 3.

Figure 5.- Ground tracks of offset approaches followed by missed-approach procedure. Final-approach-course transition at 0.5 n. mi. Decision height = 15 m (50 ft). Conditions at end of test given in table I.



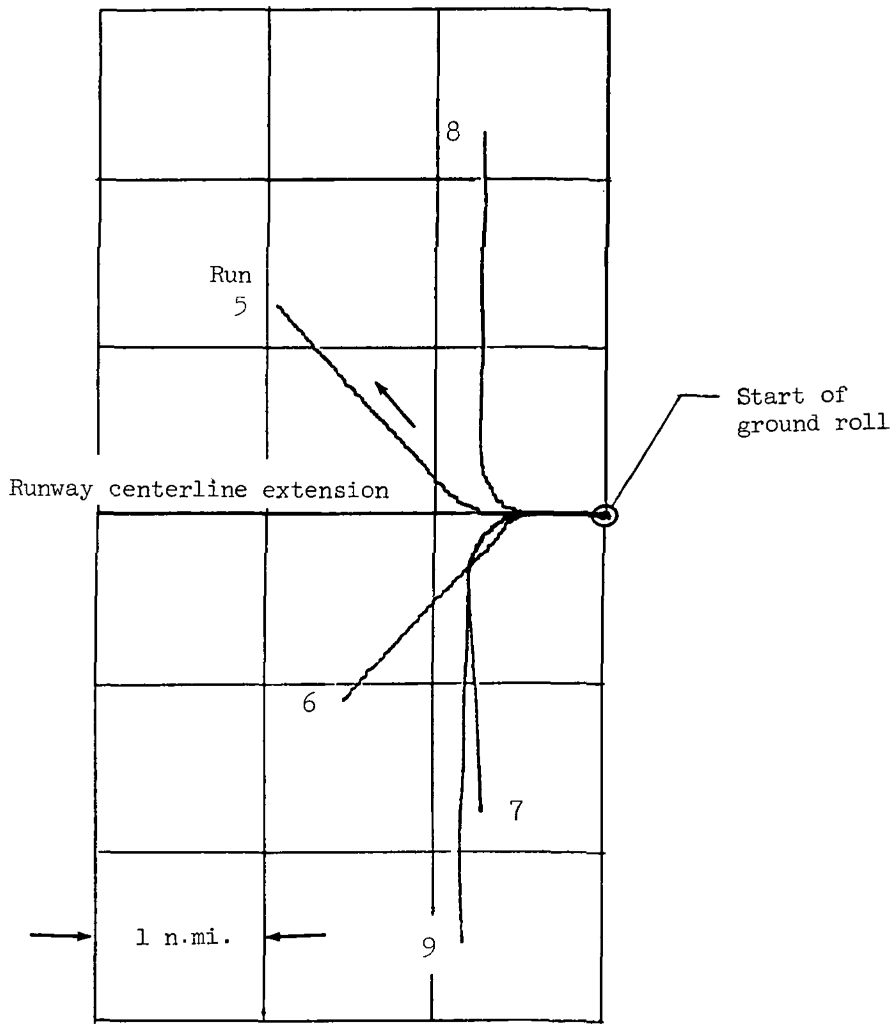
(b) Runs 4 to 9.

Figure 5.- Concluded.



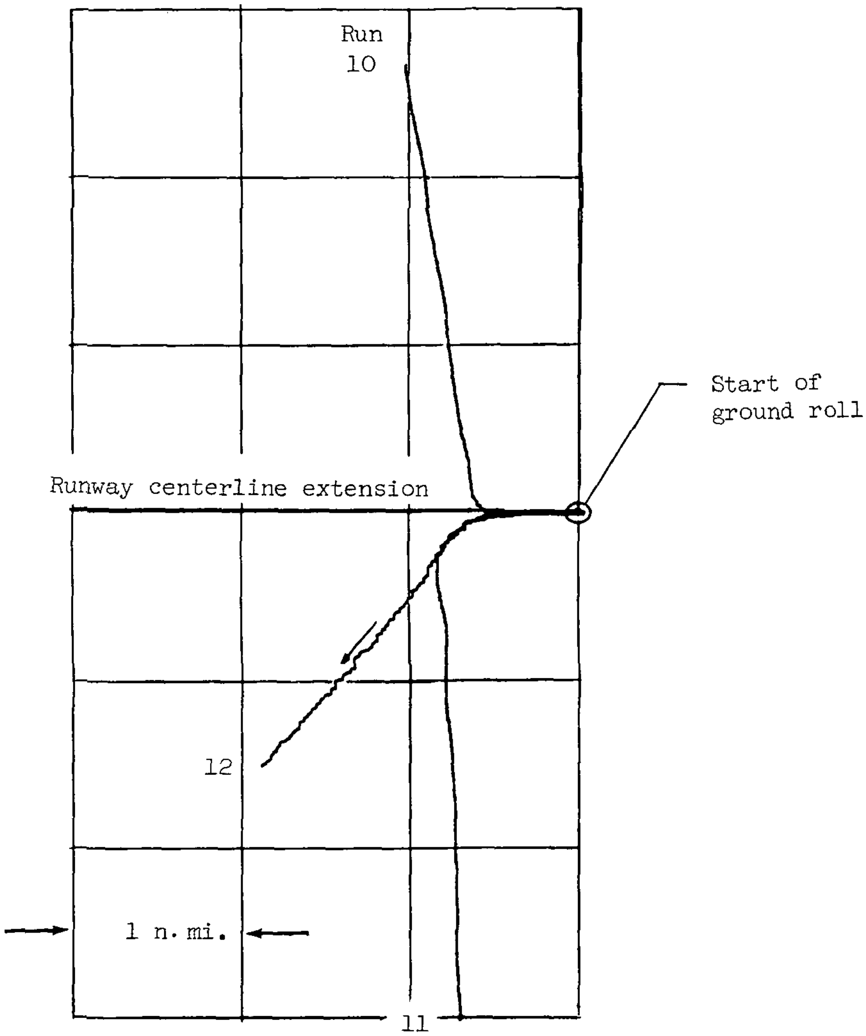
(a) Runs 1 to 4.

Figure 6.- Ground tracks of take-offs followed by 45° or 90° climbing turns to altitudes of about 457 and 914 m (1500 and 3000 ft), respectively. Conditions at end of test given in table II.



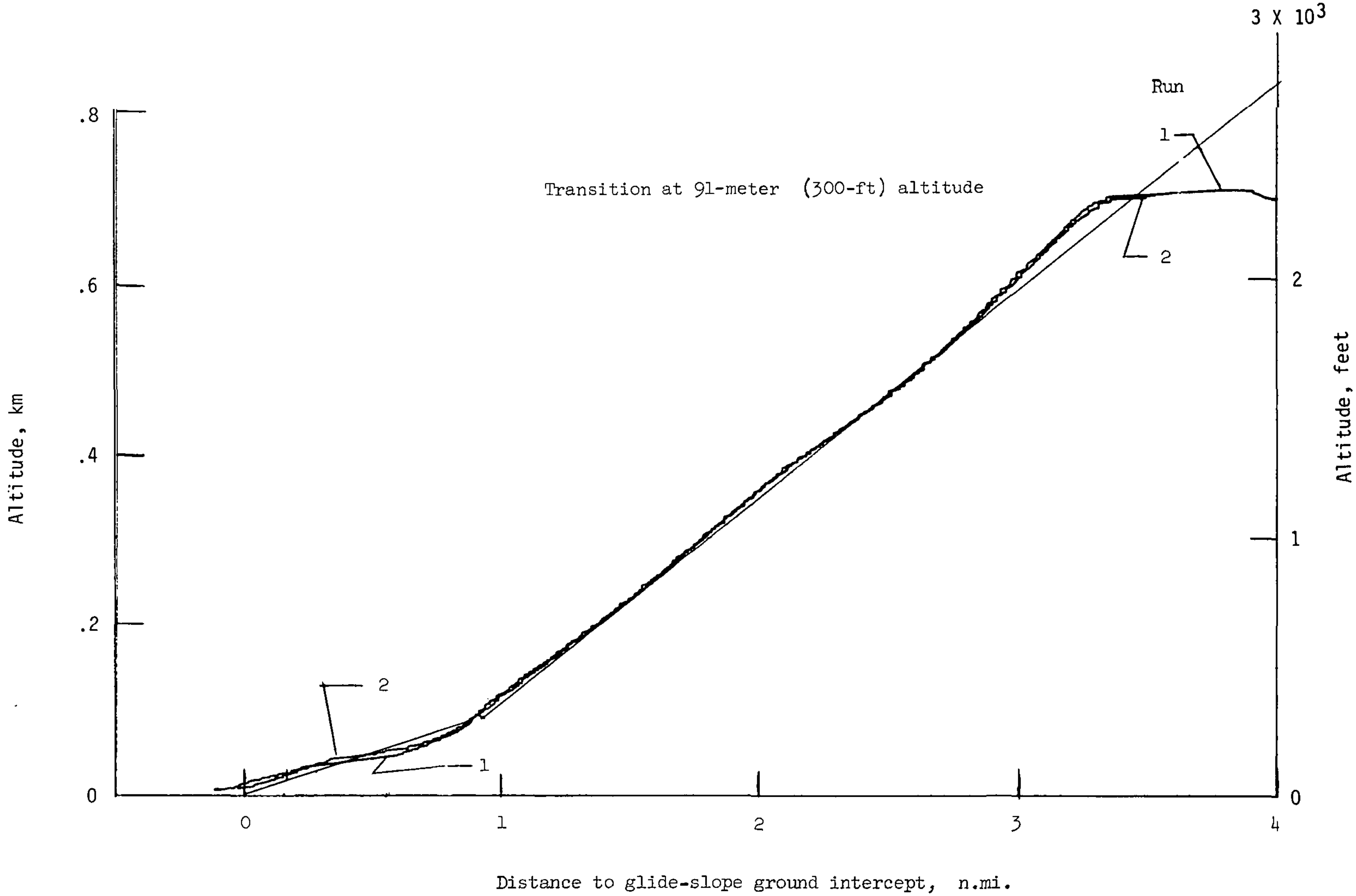
(b) Runs 5 to 9.

Figure 6.- Continued.



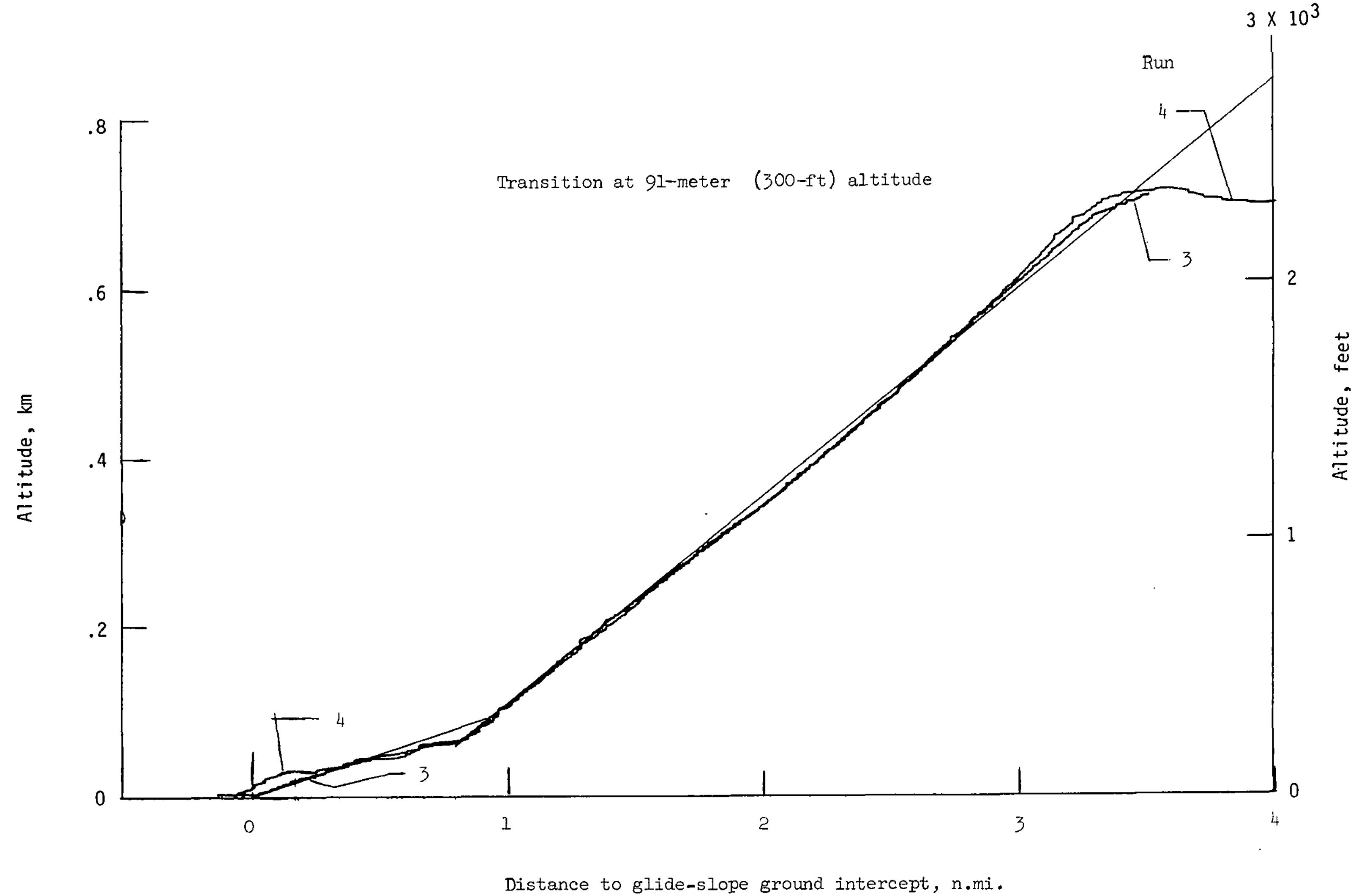
(c) Runs 10 to 12.

Figure 6.- Concluded.



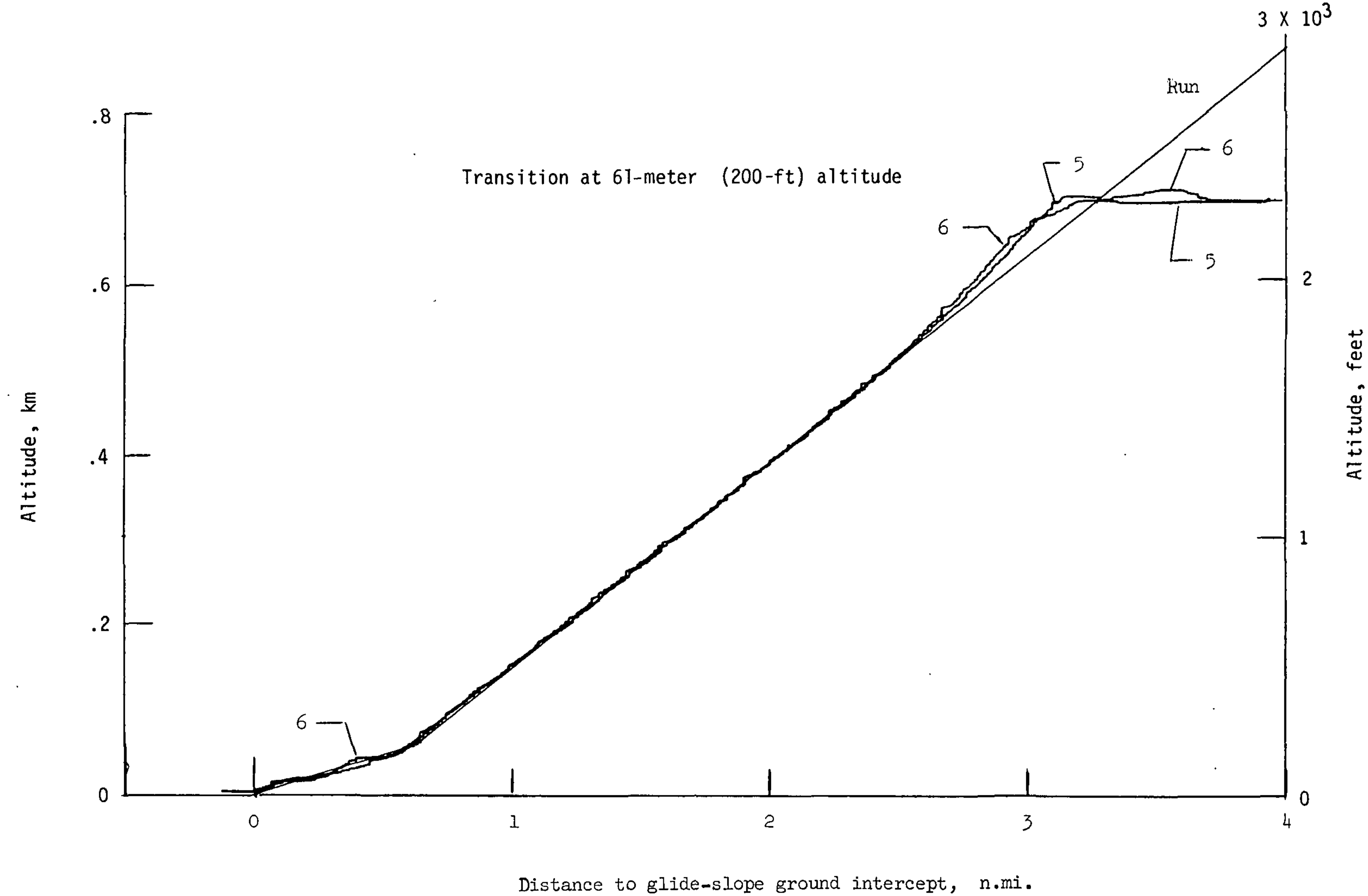
(a) Runs 1 and 2.

Figure 7.- Vertical profile tracks of two-segment glide-slope approaches.



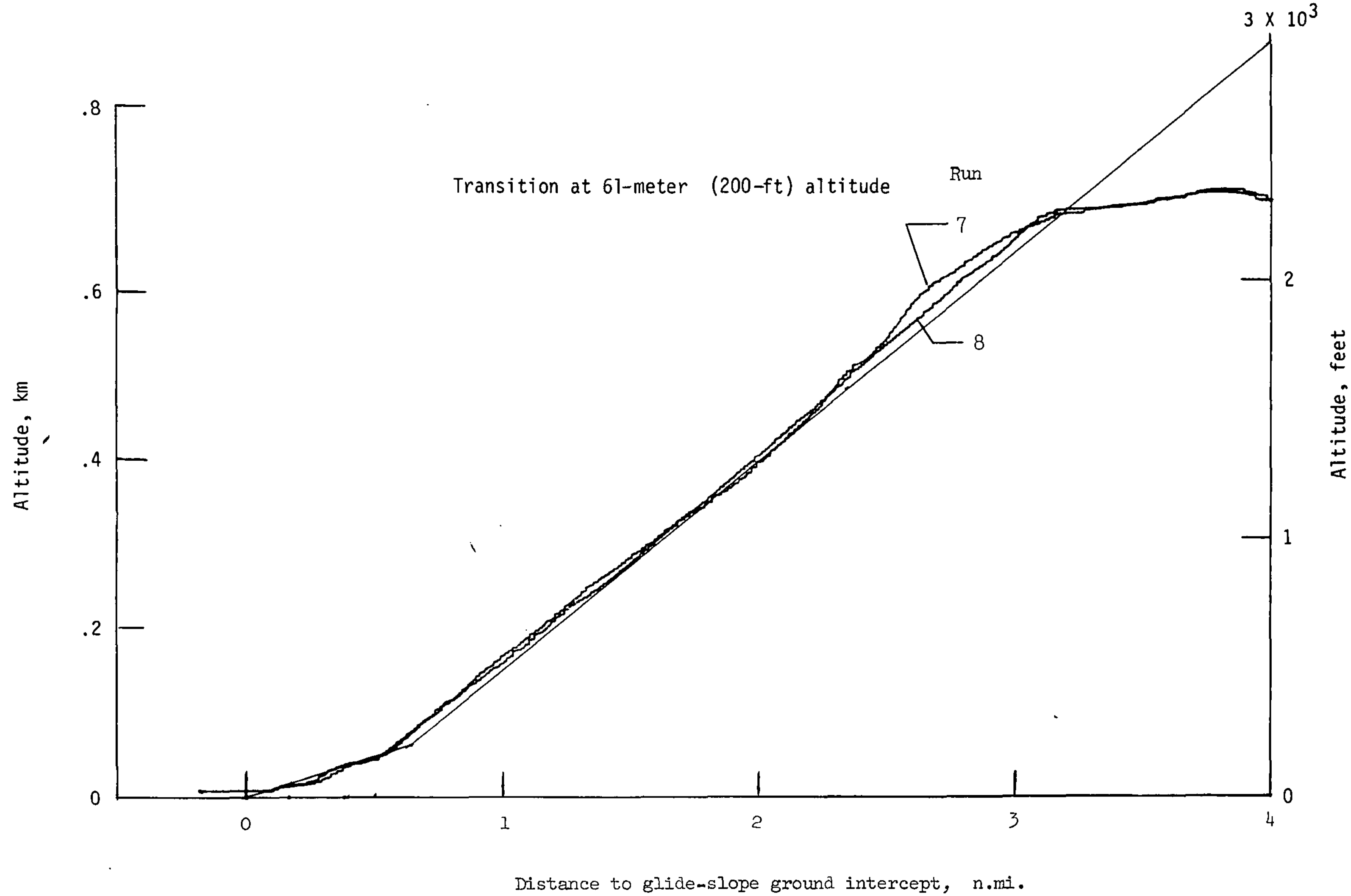
(b) Runs 3 and 4.

Figure 7.- Continued.



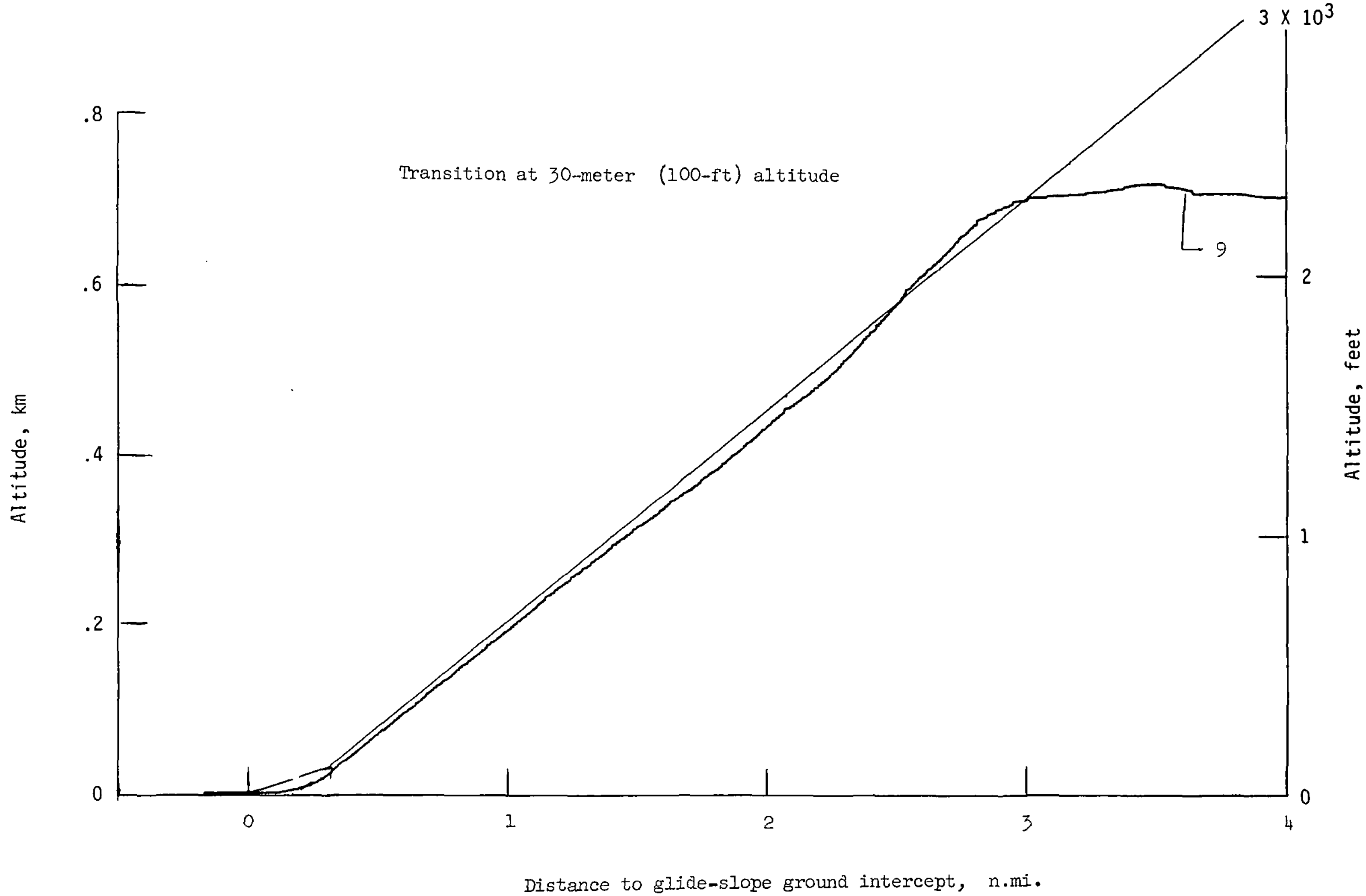
(c) Runs 5 and 6.

Figure 7.- Continued.



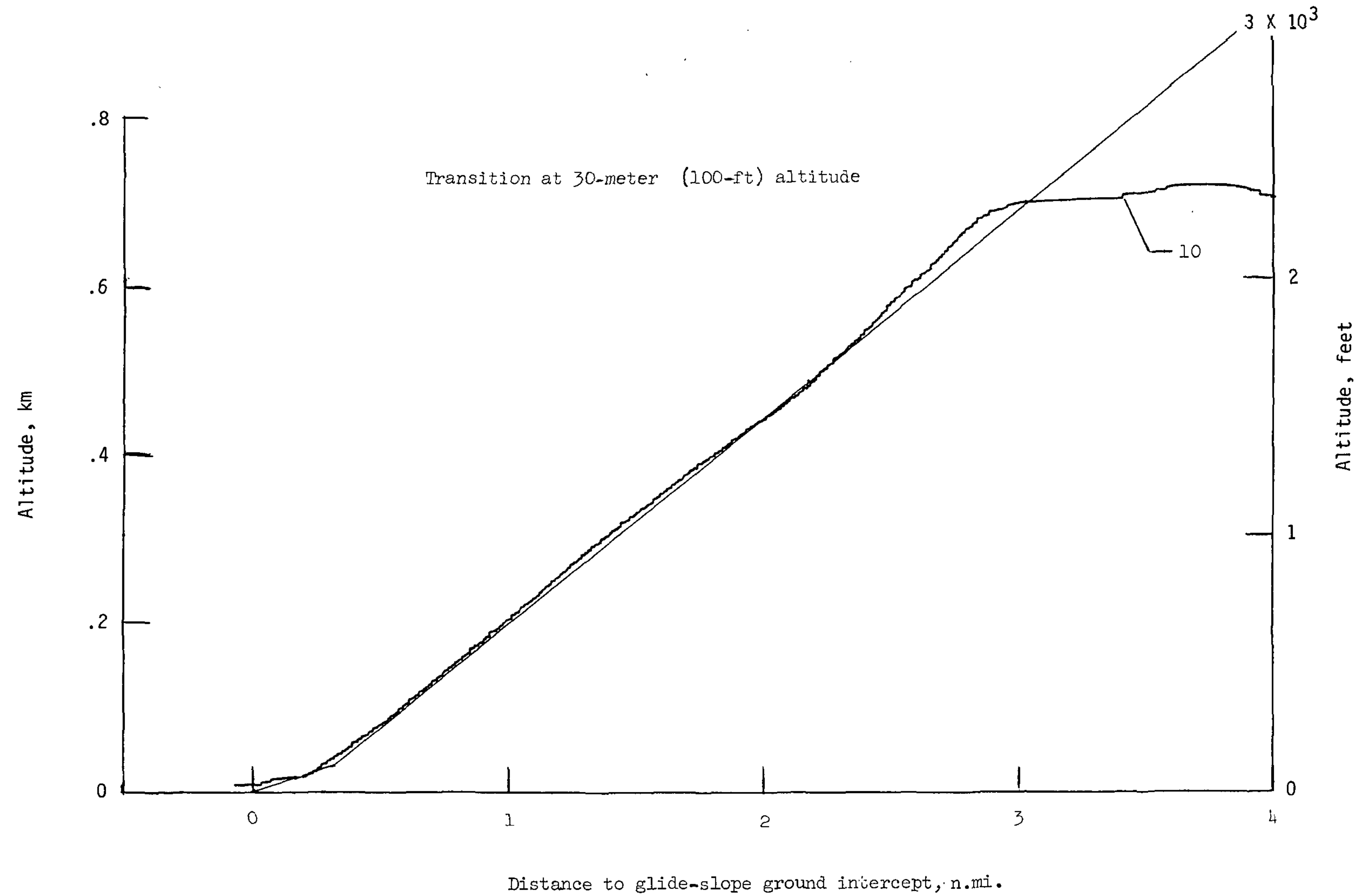
(d) Runs 7 and 8.

Figure 7.- Continued.



(e) Run 9.

Figure 7.- Continued.



(f) Run 10.

Figure 7.- Concluded.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

SPECIAL FOURTH-CLASS RATE
BOOK

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
451

U.S.MAIL

POSTMASTER : If Undeliverable (Section 158 Postal Manual) Do Not Return

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons. Also includes conference proceedings with either limited or unlimited distribution.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include final reports of major projects, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. 20546