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LIGHTNING SWEPT-STROKE ATTACHMENT PATTERNS AND FLIGHT CONDITIONS FOR STORM HAZARDS '81

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SUMMARY

As part of the NASA Langley Research Center Storm Hazards Program, 111 thunderstorm penetrations were made in 1981 with an F-106B airplane in order to record direct-strike lightning data and the associated flight conditions. During these penetrations, the airplane received 10 direct lightning stikes; in addition, lightning transient data were recorded from 22 nearby lightning flashes. The tests were conducted with ground-based weather radar guidance by the NOAA-National Severe Storms Laboratory in Oklahoma, and the NASA Wallops Flight Facility (WFF) in Virginia.

This report contains the strike attachment patterns that were found and the flight conditions recorded at the time of each lightning event. This paper also contains a table in which the data in this paper are cross-referenced with the previously published lightning electromagnetic waveform data.

INTRODUCTION

The NASA Langley Research Center Storm Hazards Program is being conducted to improve the state of the art of severe storm hazards detection and avoidance, as well as protection of aircraft against those hazards which cannot reasonably be avoided. The primary emphasis of the program is being placed on lightning hazard research. The 1981 flight program is the fourth year of the research effort. The 1978, 1979, and 1980 programs are described in references 1-3, respectively. The purpose of this report is to present the lightning swept-flash attachment patterns for each of the 10 direct lightning strikes experienced by the NASA F-106B thunderstorm research airplane during 1981. The flight conditions recorded at the time of each direct strike and nearby flash are included also. The lightning transient waveform data associated with the data presented in this paper were published in reference 4, and the transient data from the 1980 program were published in reference 5. The lightning attachment patterns and the flight conditions from 1980 were reported in reference 3, and are analyzed along with the 1981 and 1982 data in reference 6.

TEST EQUIPMENT AND DATA REDUCTION

Test Equipment

F-106B research airplane.- A thoroughly instrumented F-106B "Delta Dart" airplane (fig. 1) is used to make thunderstorm penetrations in the Storm Hazards Program. Details on the F-106B airplane and the criteria used in choosing the airplane for this mission can be found in references 2, 3, and 7. The lightning hardening procedures and verification tests undertaken prior to each thunderstorm season are described in references 2 and 7.

Prior to the 1981 program, the paint was stripped from the top and bottom wing surfaces of the integral wing fuel tanks to reduce the lightning dwell times on those surfaces. This reduced the possibility of burn through of the aluminum skins covering the fuel cells.

Airborne instrumentation systems.- The F-106B airplane is equipped with a number of data systems to measure the electromagnetic and environmental characteristics of thunderstorms during penetrations. The direct-strike lightning instrumentation system (DLite) (refs. 8 and 9) documents the electromagnetic characteristics of

direct lightning strikes and nearby lightning flashes at normal airplane flight altitudes. It consists of electromagnetic sensors mounted on the surface of the airplane, a shielded recording system in the weapons bay, and a control panel in the aft cockpit. Lightning transients were detected by two sensors whose outputs were recorded by DLite and by an additional sensor whose output was recorded on a Boeing Data Logger system mounted in the weapons bay (see refs. 8 and 10). The three measurements made in 1981 were (see fig. 1 for sensor locations):

$\dot{D}_T$ time rate of change of electric flux density, D, by a flat-plate dipole antenna mounted on the left side of the vertical tail

$\dot{B}_L$ time rate of change of magnetic flux density, B, from nose-to-tail (longitudinal) strikes by a multigap loop antenna mounted on the right side of the fuselage above the wing

I_N total attachment current, I, to the nose boom by a current transformer located inside the radome. Output was recorded by the Boeing Data Logger system

Details on the $\dot{D}_T$ and $\dot{B}_L$ sensors may be found in reference 11. (The outputs of the $\dot{B}_L$ sensor were also recorded in 1980 (see ref. 5).)

An attempt was made to film lightning attachments to the airplane with two 16-mm color movie cameras (ref. 6 and fig. 1) running continuously during each penetration. One movie camera was installed forward of the windshield, focused on the nose boom. The second camera was mounted on the left side of the fuselage, looking aft. However, no lightning attachments were filmed during 1981. Environmental parameters and flight conditions were measured by the Aircraft Instrumentation System (AIS) and the Inertial Navigation System (INS). The descriptions of the lightning flashes and flight conditions by the flight crew were recorded by an onboard voice recorder which ran continually throughout the flight. The AIS and INS are described in references 3 and 6. The fifteen airborne experiments conducted on the F-106B airplane between 1980 and 1982 are summarized in reference 6.

Data Reduction

Definition of lightning events.- The lightning events experienced by the F-106B airplane are categorized as direct strikes or nearby flashes. A direct lightning strike in the Storm Hazards Program is defined as a lightning flash which has been confirmed to have hit the airplane based on lightning attachment points, cockpit voice comments, or direct strike waveforms on the onboard lightning data systems. A nearby flash is defined as a lightning flash which has triggered a sensor in the DLite system without attaching to the F-106B airplane.

Determination of lightning attachment points.- Following each flight in which there were direct lightning strikes, the lightning attachment points were located by careful inspection of the airplane surface. Using the procedure given in references 3 and 6 an attempt was made to postulate, based on the attachment points, sensor triggers, and flight crew observations, the probable direction from which each strike initially approached the airplane, the initial and final attachment points, the swept-flash path(s), and directions(s) from which the flash exited the airplane.

Determination of flight conditions.- Static temperature and pressure altitude were computed from parameters measured and recorded by the AIS. The values of

pressure altitude were determined from the static pressure values which were corrected for position error. The ambient temperature was determined from the total temperature measurement. The relative intensities of turbulence and precipitation at the times of the lightning strikes and nearby flashes were based on pilot observations as extracted from the cockpit voice transcripts.

DATA

The airplane flight conditions recorded during each of the direct strikes and nearby flashes that occurred in 1981 are summarized in table I. In table I, the lightning events are listed in chronological order along with the appropriate flight number, date (month and day), and time of occurrence (in Greenwich Mean Time). The data entry for each lightning event also includes: the pressure altitude, ambient temperature, true airspeed, pitch angle, bank angle, and the location of the airplane with respect to the NASA Wallops Flight Facility (WFF) at Wallops Island, Virginia. (No lightning events occurred during the test flights in Oklahoma.) The airplane locations listed in table I are plotted on maps of the test area in Virginia in figure 2. Where there are clusters of points in figure 2, the cluster is circled and the event numbers are listed adjacent to the circle.

The relative intensities of precipitation and turbulence are tabulated for each lightning event in table II. Most lightning events occurred in areas of the thunderstorms where the flight crew called negligible intensities of precipitation and turbulence. Although heavy precipitation and heavy turbulence were occasionally encountered, no lightning events occurred when both precipitation and turbulence were characterized simultaneously as being heavy in intensity.

The lightning attachment points and the swept-stroke scenarios for each direct strike are presented in figures 3-24. Three general categories of strike scenarios have been found in the lightning attachment point patterns from 1980 and 1981:

1. Flashes which initially enter the nose of the aircraft and subsequently "sweep" alongside it, reattaching at a succession of spots along the fuselage. In these cases, the initial and final exit point is usually the trailing edge of an extremity such as a wing or vertical fin tip. The final entry point is a trailing edge of the fuselage, because the flash is usually still alive by the time the aircraft has flown completely through it. Most of the twenty strikes displayed this pattern.

2. Similar to (1) except that the entry channel sweeps aft across the top or bottom wing surface instead of the fuselage. Three strikes meet this description, including strike 1 of 1981 (figs. 3 and 4), in which the channel swept back over the leading edge of the wing to the lower surface of the elevon with no apparent attachment points in the midspan area.

3. Strike in which the initial entry and exit points occur at the nose. In this case, the lightning flash appears to "touch" the aircraft nose but continues on from this point to another destination. The aircraft then flies through the flash, resulting in successive entry points along one side of the fuselage or wing and exit points along the other. Again, because the flash usually exists for a longer time than it takes the aircraft to fly its length, the final entry and exit points are located along trailing edges. Strike 3 of 1980 (ref. 3) is the sole example of this pattern.

The flight conditions from 1980 and 1981 are similar, with the lightning events in 1981 occurring between values of pressure altitude of 4540 m (14 895 ft) and 7609 m (24 965 ft), and values of ambient temperature between -4.7°C and -29.9°C. The lightning attachment point data and the flight condition data from the 1980-1982 programs are summarized in reference 6.

Table III lists the figure numbers of the lightning attachment points and lightning strike scenarios presented in this paper along with the figure numbers from reference 4 of the corresponding electromagnetic waveforms. As can be seen in table III, the 10 direct strikes and 22 nearby flashes resulted in a total of 26 electromagnetic transients. However, only the single waveform of nose boom current from the I_T sensor was associated with a direct strike; nine of the direct strikes have no corresponding electromagnetic data. The results of a statistical analysis of the electromagnetic data from 1980-1982 are reported in reference 8.

SUMMARY OF DATA

During the NASA Langley Research Center Storm Hazards Program, 111 thunderstorm penetrations were made in 1981 with an F-106B airplane in order to record direct-strike lightning data and the associated flight conditions. The lightning attachment point data and flight conditions data from 1981 may be summarized as follows:

1. The airplane received 10 direct lightning strikes; in addition, lightning transient data were recorded from 22 nearby flashes. Although 26 lightning electromagnetic transients were recorded, only 1 was associated with a direct strike.

2. The flight conditions from 1980 and 1981 are similar, with the 1981 strikes occurring between values of pressure altitude of 4540 m and 7609 m, corresponding to ambient temperatures between -4.7°C and -29.9°C.

3. Three general categories of scenarios were found in the swept-flash attachment patterns, with most strikes showing flashes which initially entered the nose of the aircraft, with the flash sweeping alongside the fuselage to the aft extremities.

REFERENCES

1. Fisher, Bruce D.; and Crabill, Norman L.: Summary of Flight Tests of an Airborne Lightning Locator System and Comparison With Ground-Based Measurements of Precipitation and Turbulence. 1980 Aircraft Safety and Operating Problems, Joseph W. Stickle, compiler. NASA CP-2170, Part 1, 1981, pp. 251-277.

2. Fisher, Bruce D.; Keyser, Gerald L., Jr.; Deal, Perry L.; Thomas, Mitchel E.; and Pitts, Felix L.: Storm Hazards '79 - F-106B Operations Summary. NASA TM-81779, Mar. 1980.

3. Fisher, Bruce D.; Keyser, Gerald L., Jr.; and Deal, Perry L.: Lightning Attachment Patterns and Flight Conditions for Storm Hazards '80. NASA TP-2087, Dec. 1982.

4. Pitts, Felix L.; and Thomas, Mitchel E.: 1981 Direct Strike Lightning Data. NASA TM-83273, Mar. 1982.

5. Pitts, Felix L.; and Thomas, Mitchel E.: 1980 Direct Stike Lightning Data. NASA TM-81946, Feb. 1981.

6. Fisher, Bruce D.; and Plumer, J. Anderson: Lightning Attachment Patterns and Flight Conditions Experienced by the NASA F-106B Airplane. Procs. Addendum, Eighth Inter. Aero. and Gnd. Conf. on Lightning and Static Elec., Ft. Worth, Texas, June 1983. DOT/FAA/CT-83/25(A), pp. 26-1 through 26-14.

7. Deal, Perry L.; Keyser, Gerald L.; Fisher, Bruce D.; and Crabill, Norman L.: Thunderstorm Hazards Flight Research - Program Overview. AIAA-81-2412, Nov. 1981.

8. Lee, Larry D.; Finelli, George B.; Thomas, Mitchel E.; and Pitts, Felix L.: Statistical Analysis of Direct-Strike Lightning Data (1980 to 1982). NASA TP-2252, Jan. 1984.

9. Thomas, M. E.: Direct-Strike Lightning Measurement System. AIAA-81-2513, Nov. 1981.

10. von Bokern, Greg J.: In-Flight Lightning Data Measurement System for Fleet Applications-Flight Test Results. Proc., National Aero. and Elec. Conf., Dayton, Ohio, vol. 1, May 1982, pp. 25-31.

11. Trost, Thomas F.; and Zaepfel, Klaus P.: Broadband Electromagnetic Sensors for Aircraft Lightning Research. Lightning Technology, NASA CP-2128, FAA-RD-80-30, 1980, pp. 131-152.

Table I. - Airplane Flight Conditions During Direct Strikes and Nearby Flashes In 1981

Event		Flight 81-	Date	Time, GMT	Pressure altitude		Ambient temperature, °C	True airspeed		Pitch angle, deg (a)	Bank angle, deg (b)	Distance from NASA WFF, km(c)	
					m	ft		m/sec	knots			North	East
Nearby	1	026	July 1	18:09:34.5	4558	14 953	-6.2	196.5	382.0	4.9	-4.9	-68	-110
	2			18:09:40.1	4557	14 951	-6.1	193.1	375.4	4.2	-18.7	-69	-109
	3			18:09:54.6	4555	14 945	-4.9	198.7	386.2	3.8	-8.1	-71	-108
	4			18:10:01.2	4540	14 895	-5.4	199.8	388.4	6.0	-2.2	-72	-107
	5			18:10:17.7	4542	14 900	-4.7	193.9	376.9	3.0	-12.4	-74	-105
	6			18:13:03.0	4655	15 271	-6.1	193.4	375.9	3.5	-18.1	-72	-102
	7			18:16:58.5	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)
	8			18:17:04.4	4551	14 932	-5.6	208.3	404.9	2.9	-4.8	-69	-110
	9			18:17:14.7	4533	14 871	-5.3	198.3	385.5	6.0	-0.6	-68	-108
	10			18:17:36.0	4564	14 972	-5.4	193.9	376.9	3.8	-1.2	-68	-103
Strike	1	036	July 21	19:24:38.0	4709	15 450	-5.3	185.8	361.2	3.7	8.5	11	-21
	2	039	July 29	19:41:14.0	5913	19 400	-8.4	193.6	376.4	6.7	-9.0	-172	-110
	3	040		22:03:45.0	6630	21 752	-13.0	199.8	388.4	6.2	-4.5	-206	-70
	4			22:12:30.0	6457	21 187	-10.7	199.9	388.7	8.0	-3.3	-213	-56
	5			22:17:06.0	6491	21 297	-11.1	218.6	425.0	7.1	0.2	-208	-53
	6			22:21:30.0	6425	21 080	-11.3	205.7	399.9	4.6	-7.6	-212	-46
Nearby	11	041	Aug. 6	14:36:44.0	5208	17 086	-4.8	189.5	368.3	7.4	23.1	-85	-69
	12	041	Aug. 6	14:41:00.0	5219	17 123	-5.8	188.8	367.0	5.2	18.0	-84	-70
	13	042	Aug. 11	21:58:04.2	5837	19 150	-7.9	213.4	414.8	2.2	5.5	-178	-70
Strike	7	042	Aug. 11	21:58:21.0	5827	19 117	-8.5	218.8	425.3	1.2	-18.7	-176	-73
Nearby	14	043	Aug. 16	19:16:28.5	7614	24 980	-19.7	212.9	414.0	3.2	-5.9	-144	-92
Strike	8			19:16:29.0	7614	24 980	-19.7	212.9	414.0	3.2	-5.9	-144	-91
Nearby	15			19:26:07.3	7653	25 108	-21.8	237.3	461.3	2.7	14.9	-145	-72
	16			19:30:48.5	7622	25 007	-26.5	230.8	448.6	3.6	3.6	-137	-120
	17			19:38:22.5	7595	24 919	-20.4	234.1	455.2	4.2	12.8	-145	-64
Strike	9			19:38:05.6	7627	25 023	-19.3	221.9	431.3	-1.5	2.7	-146	-68
Nearby	18	045	Sept. 8	19:22:31.0	7094	22 276	-18.6	225.1	437.6	0	-11.5	-116	-86
	19			19:22:36.0	7082	23 237	-26.6	229.8	446.7	0	4.9	-117	-85
	20			19:29:12.0	7006	22 986	-18.9	241.2	468.8	1.5	- 2.4	-118	-79
	21			19:33:36.0	7021	23 037	-17.9	220.2	428.0	3.5	-7.3	-118	-104
	22			19:49:56.0	7094	23 274	-24.8	222.2	432.0	-.2	9.6	-112	-70
Strike	10	046		23:05:10.0	7609	24 965	-29.9	228.8	444.8	3.9	-6.4	-2	12

Notes: (a) Positive for nose up.
(b) Positive for right wing down.
(c) Positive for North and East.
(d) Data not available.

Table II. - Relative Precipitation and Turbulence Intensities During Lightning Events In 1981

Event		Flight 81-	Relative Precipitation Intensity	Relative Turbulence Intensity
Nearby	1	026	Negligible	Negligible
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
Strike	1	036	Heavy	Moderate
	2	039	Light	Light
	3	040	Negligible	Negligible
	4			Moderate
	5			Negligible
	6			
Nearby	11	041		
	12	041		
	13	042		Light
Strike	7	042		Negligible
Nearby	14	043		Moderate
Strike	8			Moderate
Nearby	15			Negligible
	16		Heavy	Negligible
	17		Moderate	Heavy
Strike	9		Negligible	Heavy
Nearby	18	045	Heavy	Negligible
	19		Heavy	Negligible
	20		Negligible	Negligible
	21		Negligible	Moderate
	22		Negligible	Negligible
Strike	10	046	Heavy	Negligible

Table III.- 1981 Lightning Data Cross-Reference Table

Event		Flight 81-	Date	Figure number for -		Figure number from ref. 4 for -		
				Attach. Pts.	Scenario	$\dot{D}_T$	$\dot{B}_L$	I_N
Nearby	1	026	July 1		1			
	2	↓	↓			2, 3		
	3					4		
	4					5		
	5					6	7	
	6					8		
	7					9		
	8					10	11	
	9					12	13	
	10					14	15	
Strike	1	036	July 21	3	4			
	2	039	July 29	5, 6	7			
	3	040	↓	5, 8	9			
	4	↓		5, 10	11			
	5			5, 12	13			
	6			5, 14	15			
Nearby	11	041	Aug. 6				16	
	12	041	Aug. 6				17	
	13	042	Aug. 11				18	
Strike	7	042	Aug. 11	16	17			
Nearby	14	043	Aug. 16				19, 33	
Strike	8	↓	↓	18, 19	20			28, 33
Nearby	15						20	
	16						21	
	17						22	
Strike	9			18, 21	22			
Nearby	18	045	Sept. 8				23	
	19	↓	↓				24	
	20						25	
	21						26	
	22						27	
Strike	10	046	↓	23	24			
Totals:	10 strikes 22 nearby flashes					9	16	1
						26 transients		

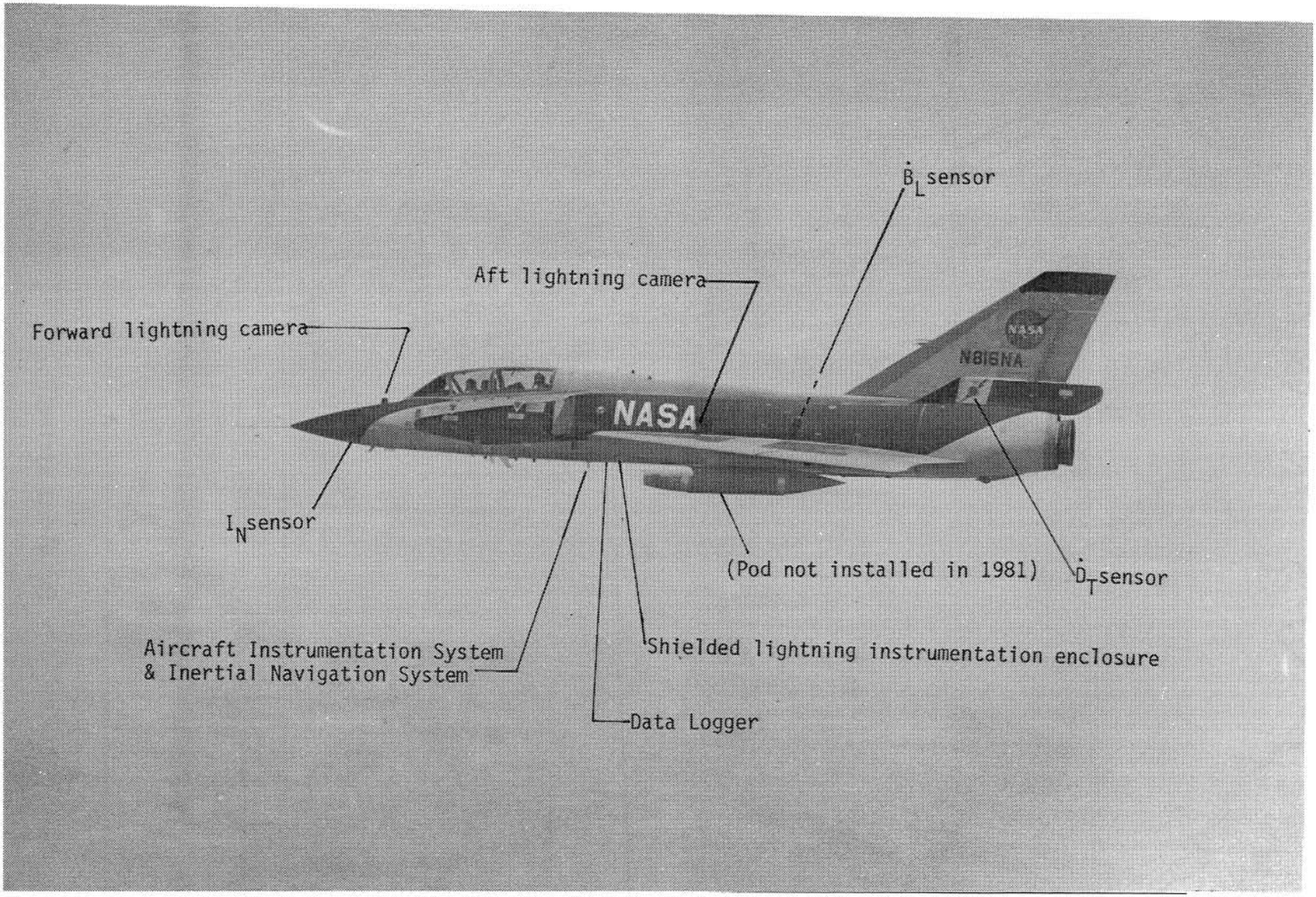
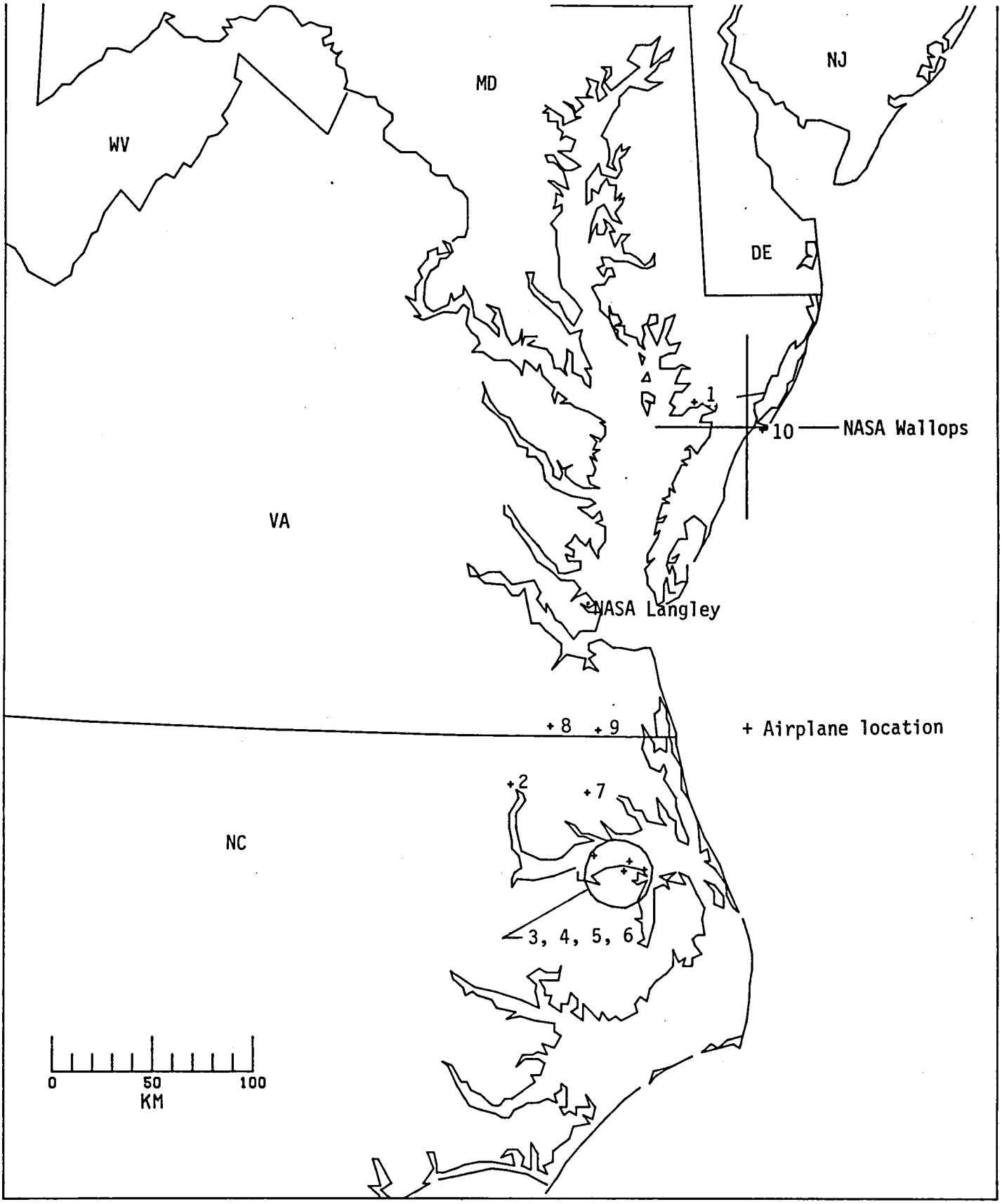
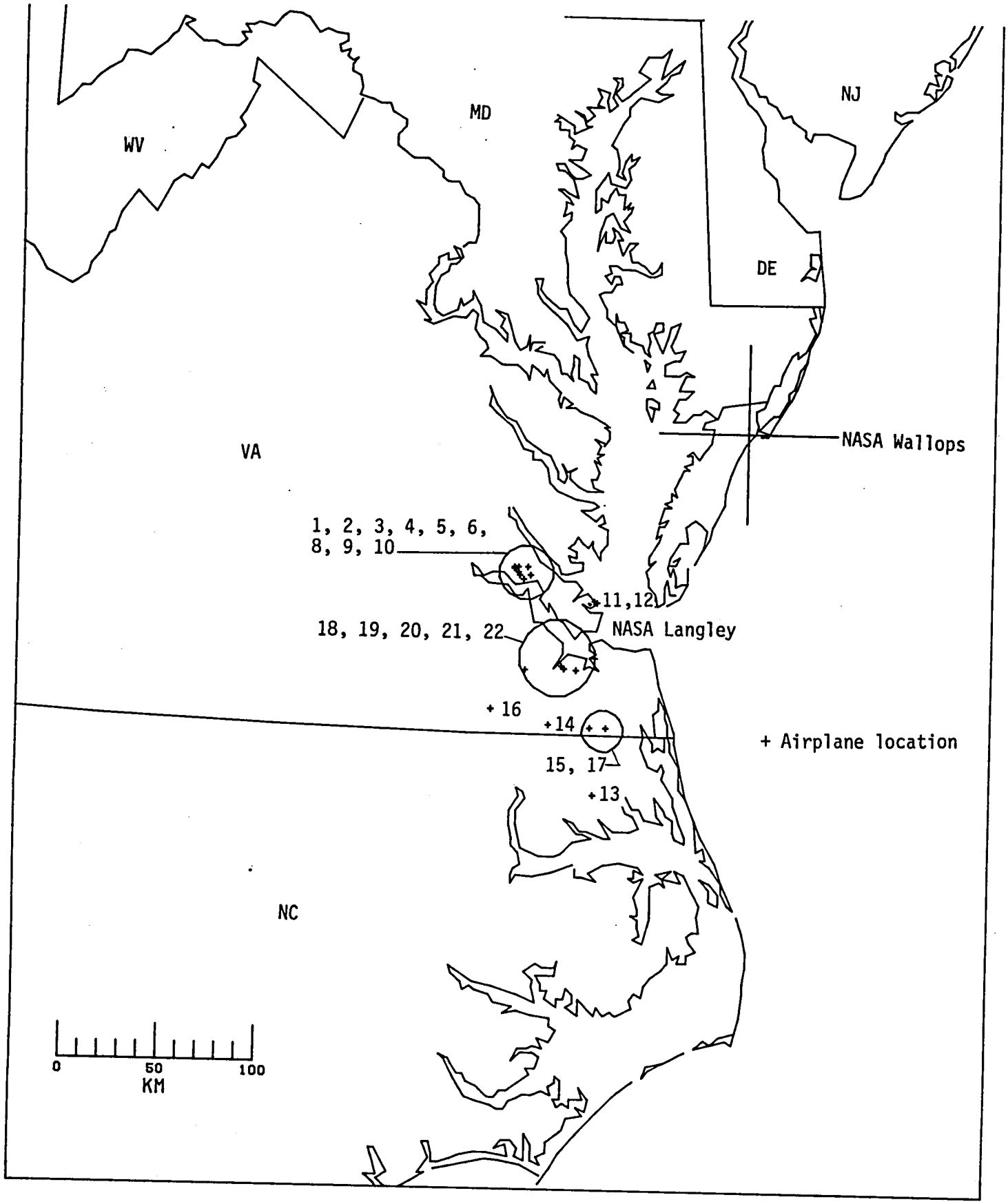


Figure 1.- NASA Langley Research Center Storm Hazards '81 research vehicle.



(a) Direct strikes.

Figure 2.- Location of airplane at time of each lightning event in 1981.



(b) Nearby flashes.

Figure 2.- Concluded.

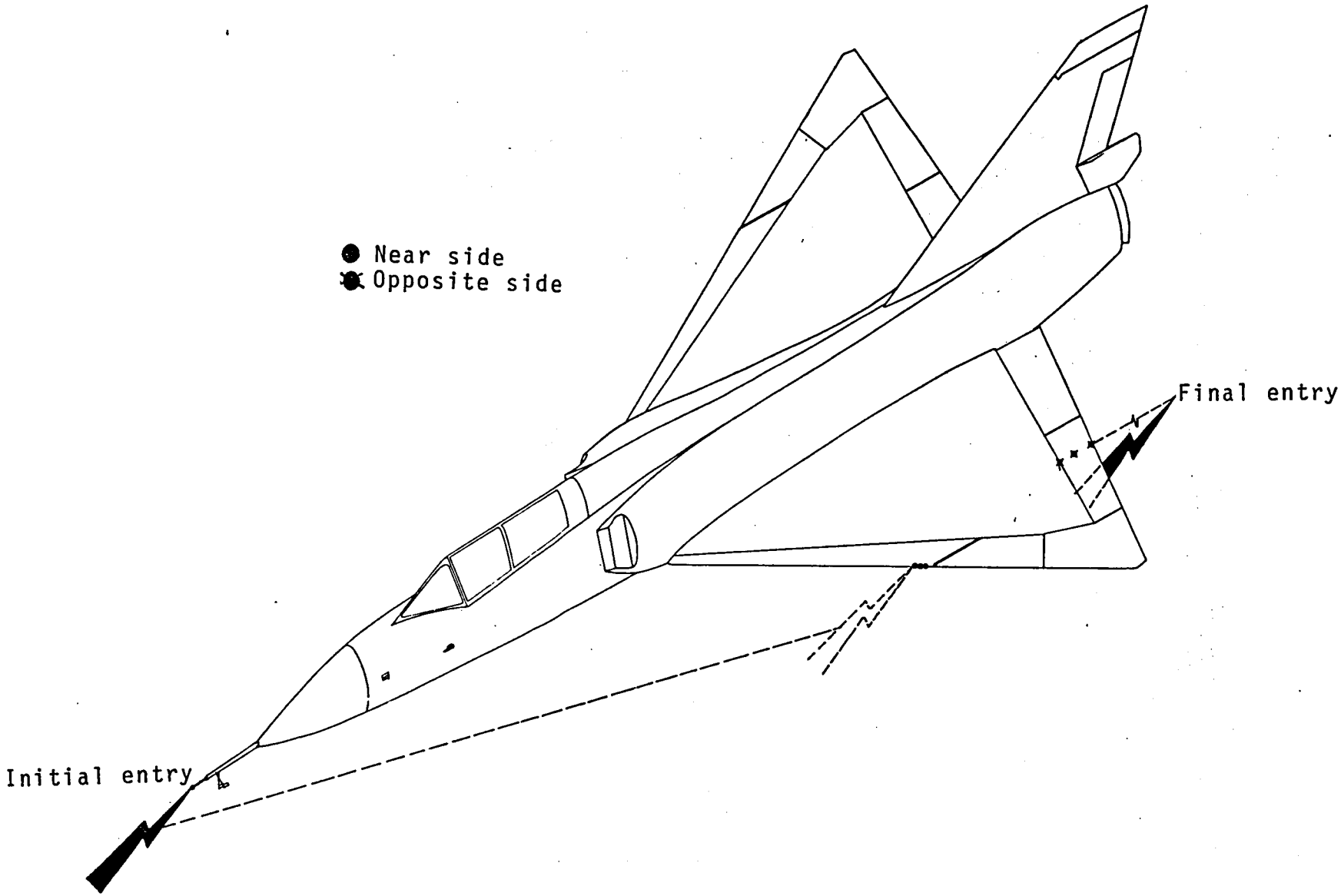
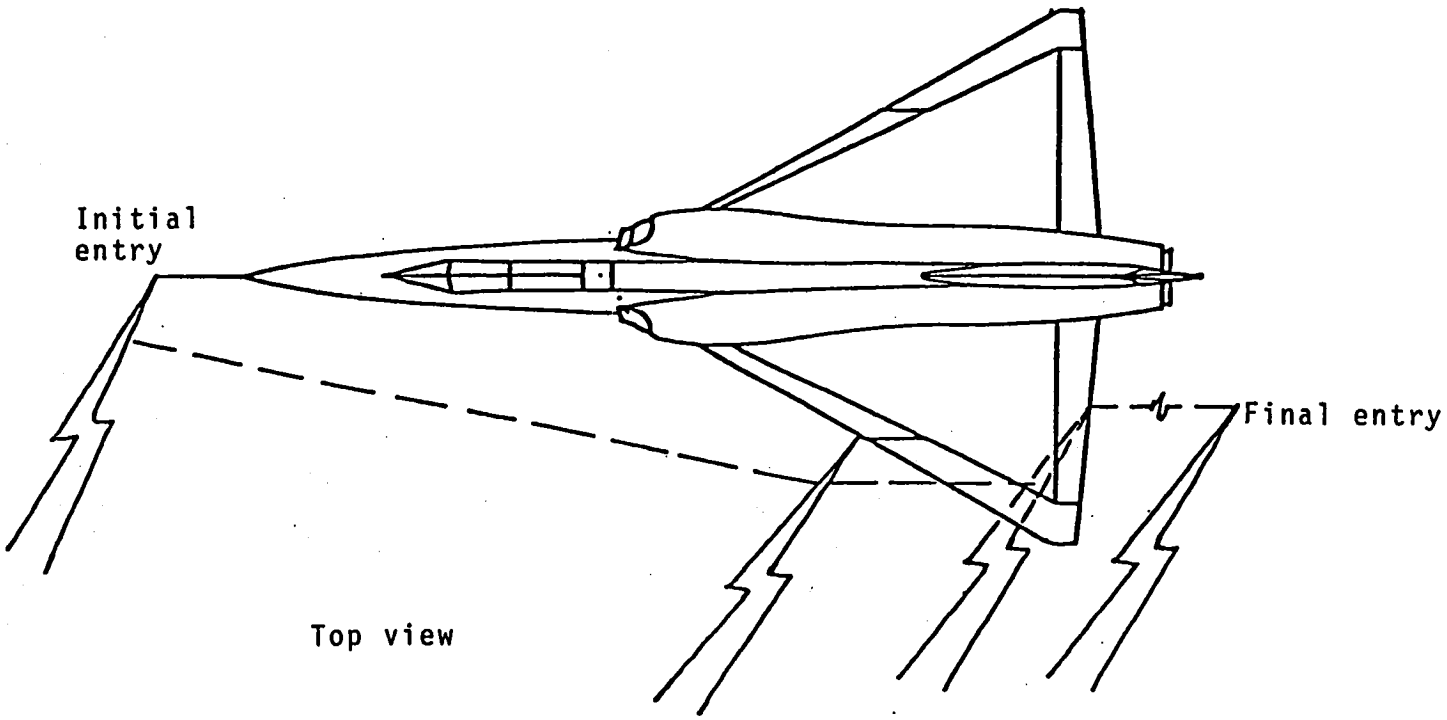


Figure 3.- Lightning attachment points and scenario for strike 1 of 1981, Flight 81-036, July 21, 1981. (Exit location unknown.)



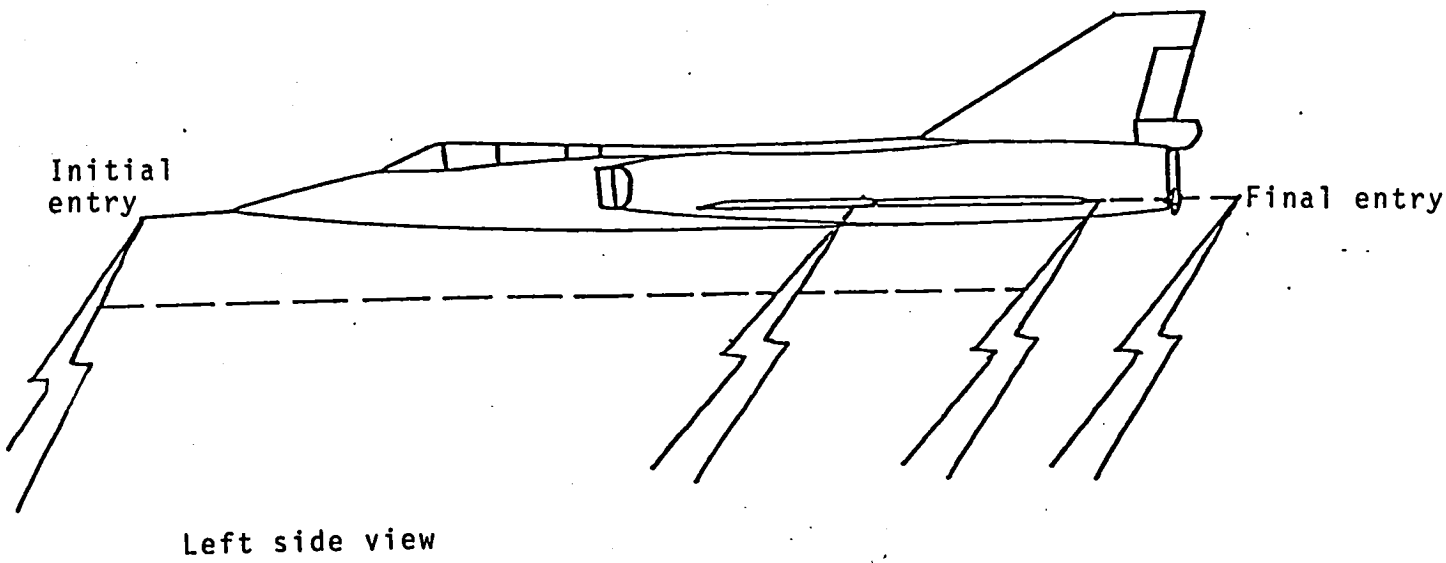


Figure 4.- Lightning strike scenario for strike 1 of 1981, Flight 81-036, July 21, 1981. (Exit location unknown.)

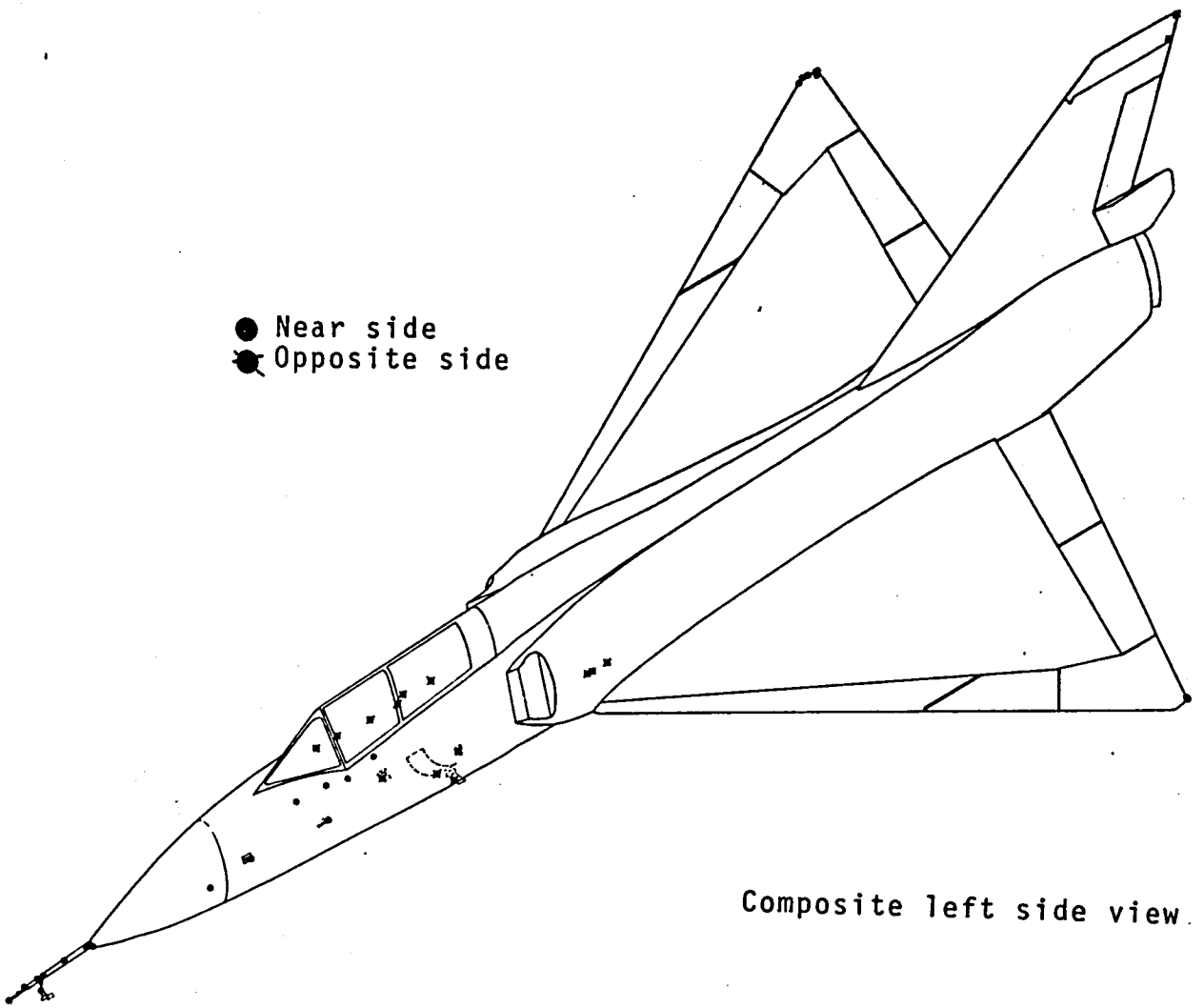


Figure 5.- Lightning attachment points for strikes 2-6 of 1981, Flights 81-039 and 81-040, July 29, 1981.

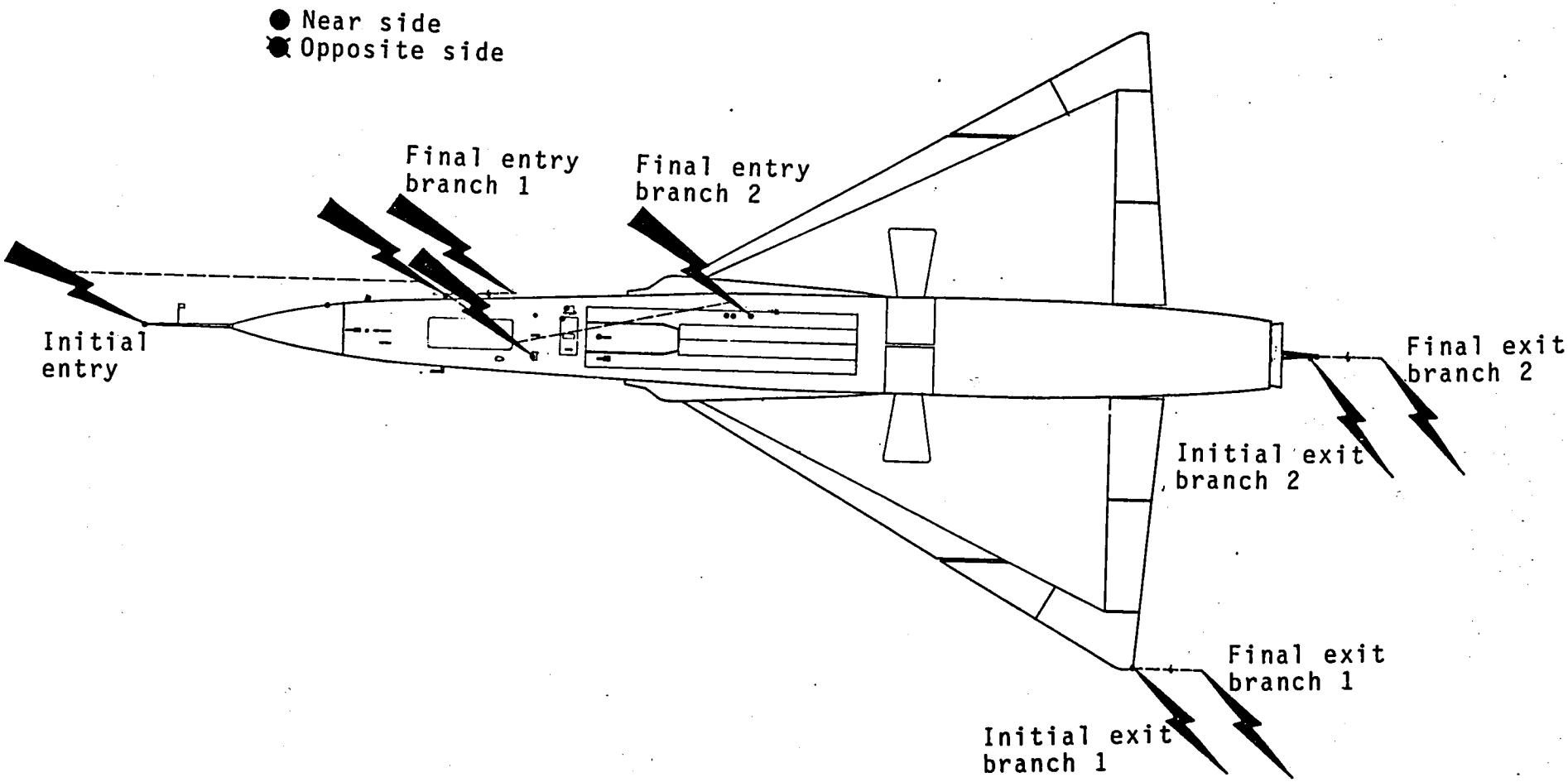


Figure 6.- Lightning attachment points and scenario for strike 2 of 1981, Flight 81-039, July 29,1981. Bottom view.

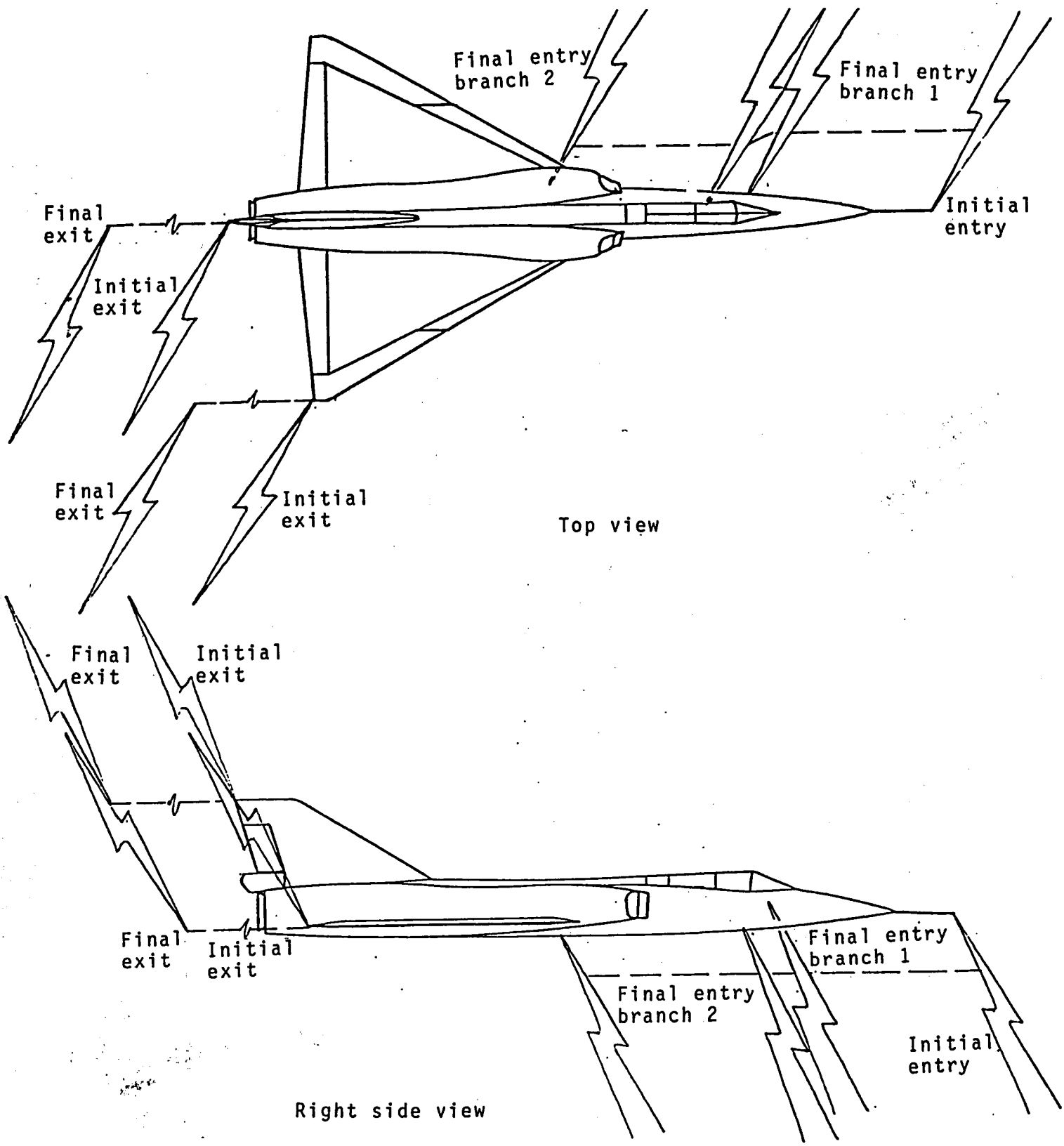


Figure 7.- Lightning strike scenario for strike 2 of 1981, Flight 81-039, July 29, 1981.

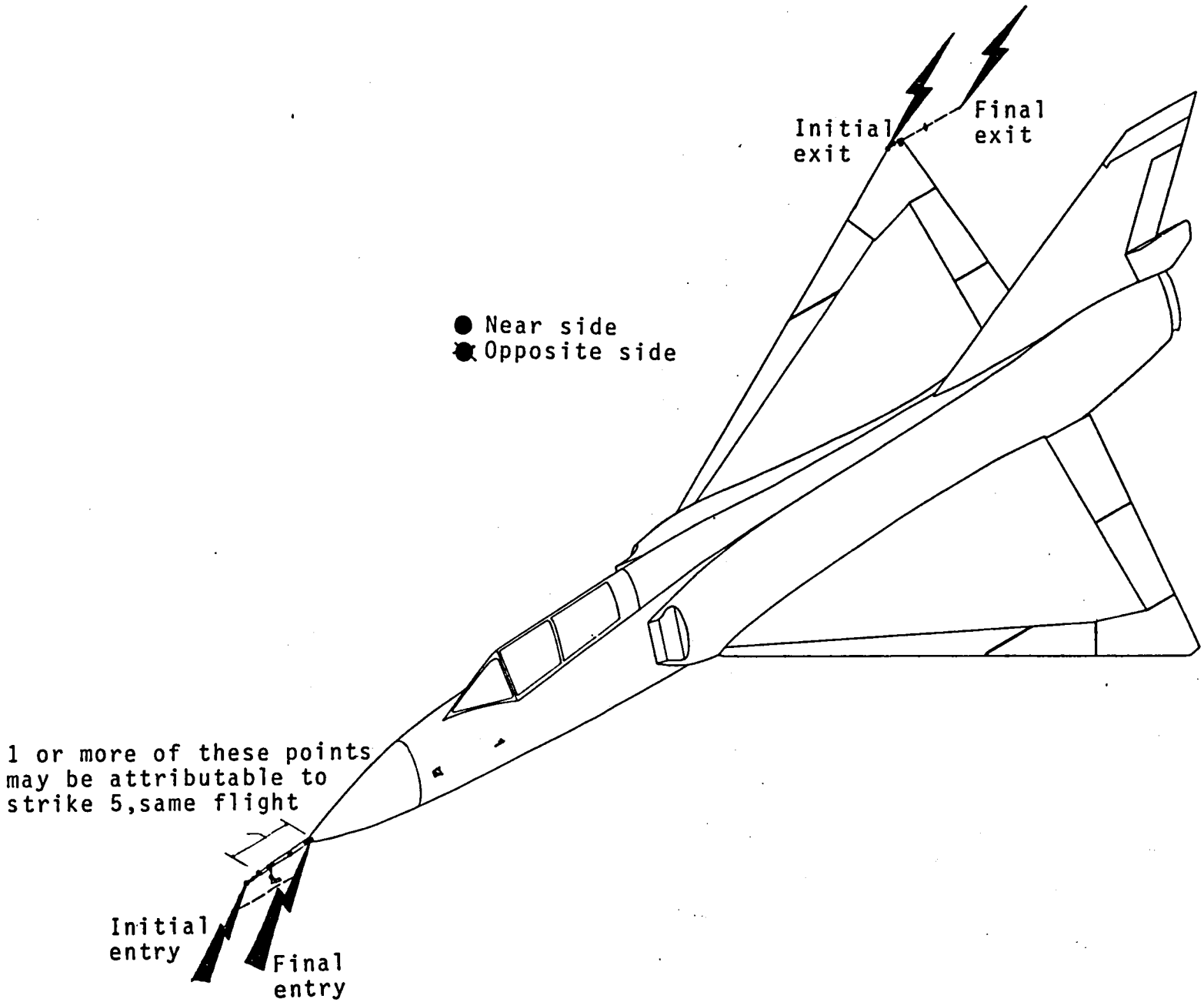


Figure 8.- Lightning attachment points and scenario for strike 3 of 1981, Flight 81-040, July 29, 1981.

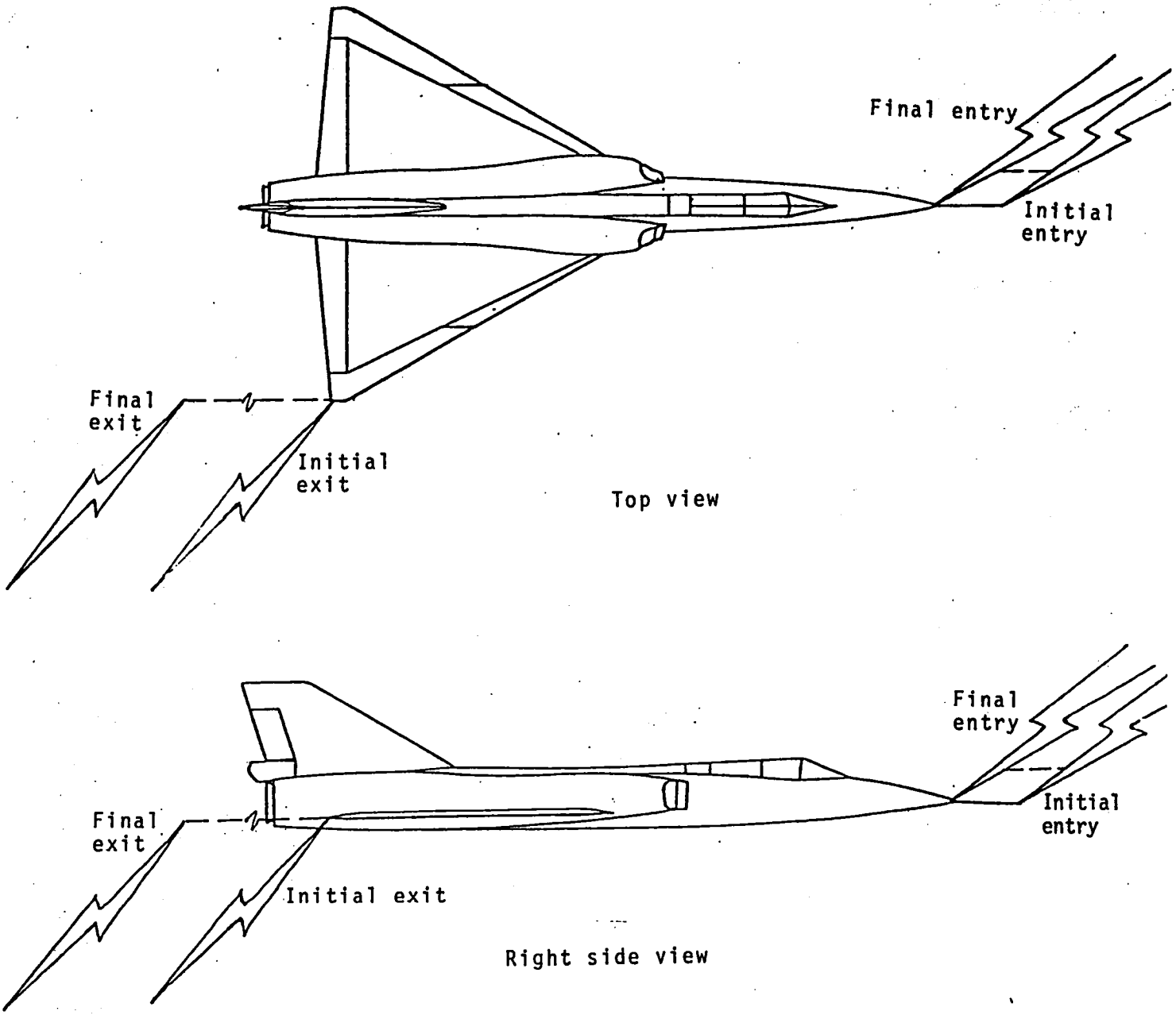


Figure 9.- Lightning strike scenario for strike 3 of 1981, Flight 81-040, July 29,1981.

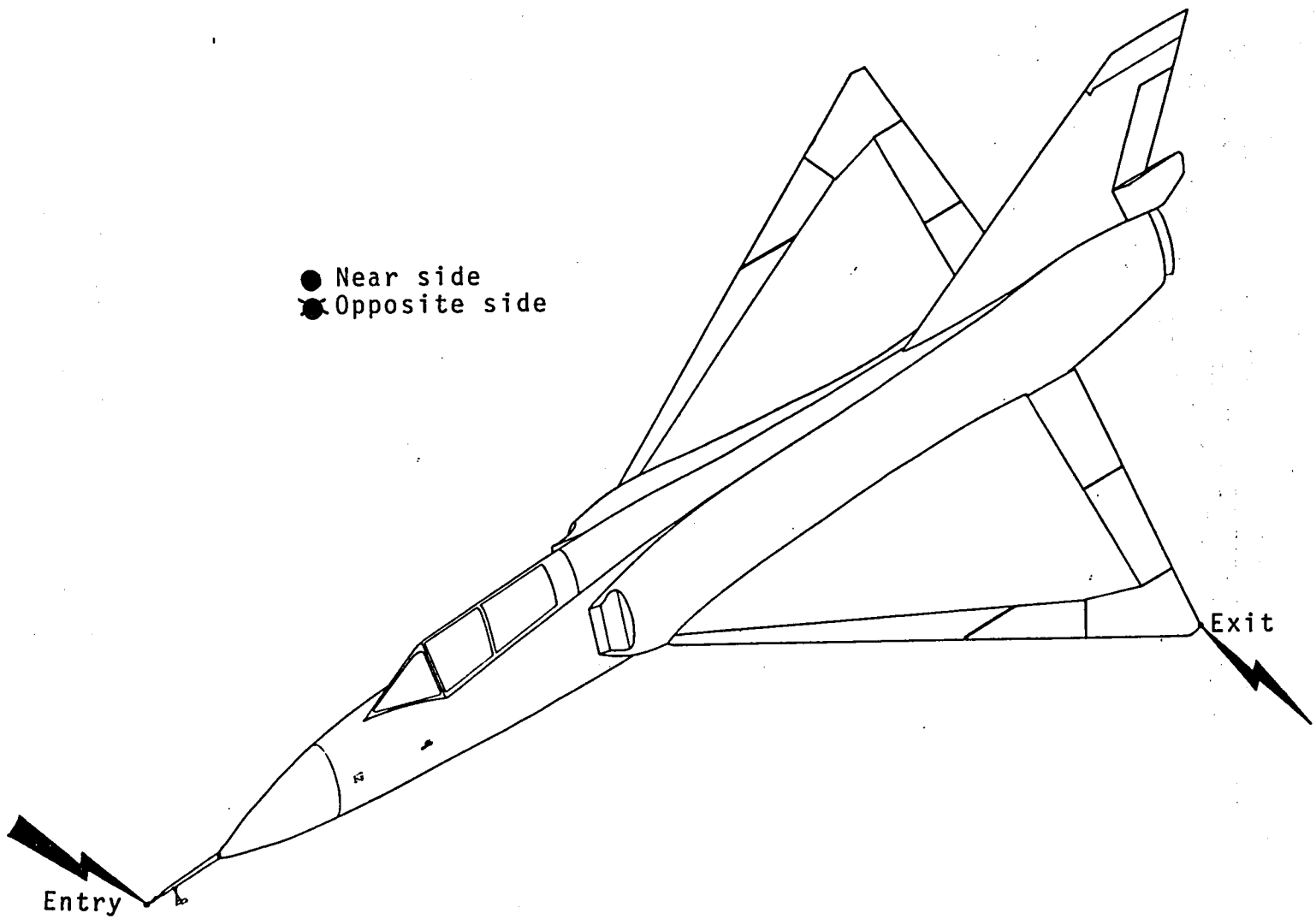


Figure 10.- Lightning attachment points and scenario for strike 4 of 1981, Flight 81-040, July 29, 1981.

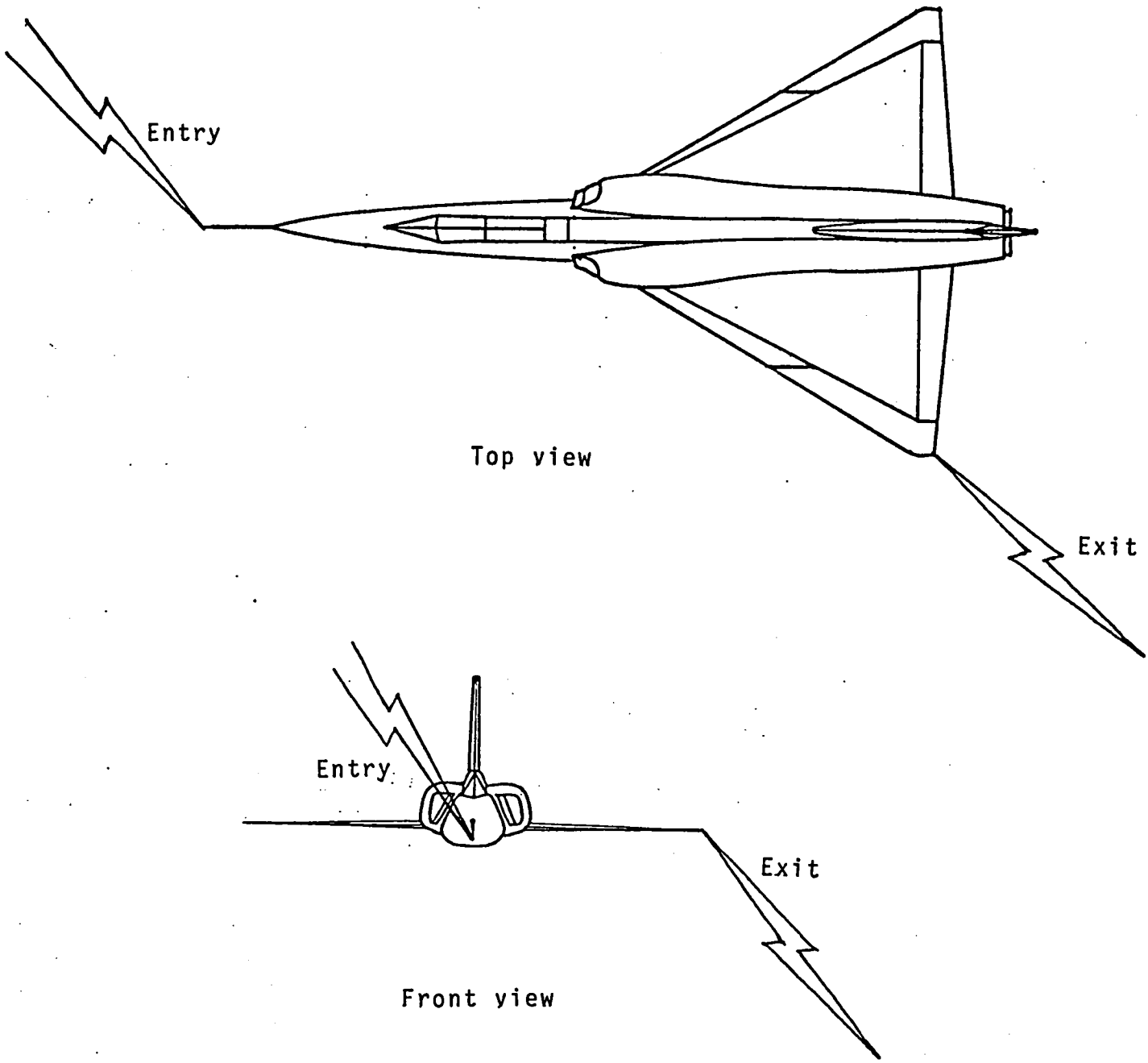


Figure 11.- Lightning strike scenario for strike 4 of 1981, Flight 81-040, July 29, 1981.

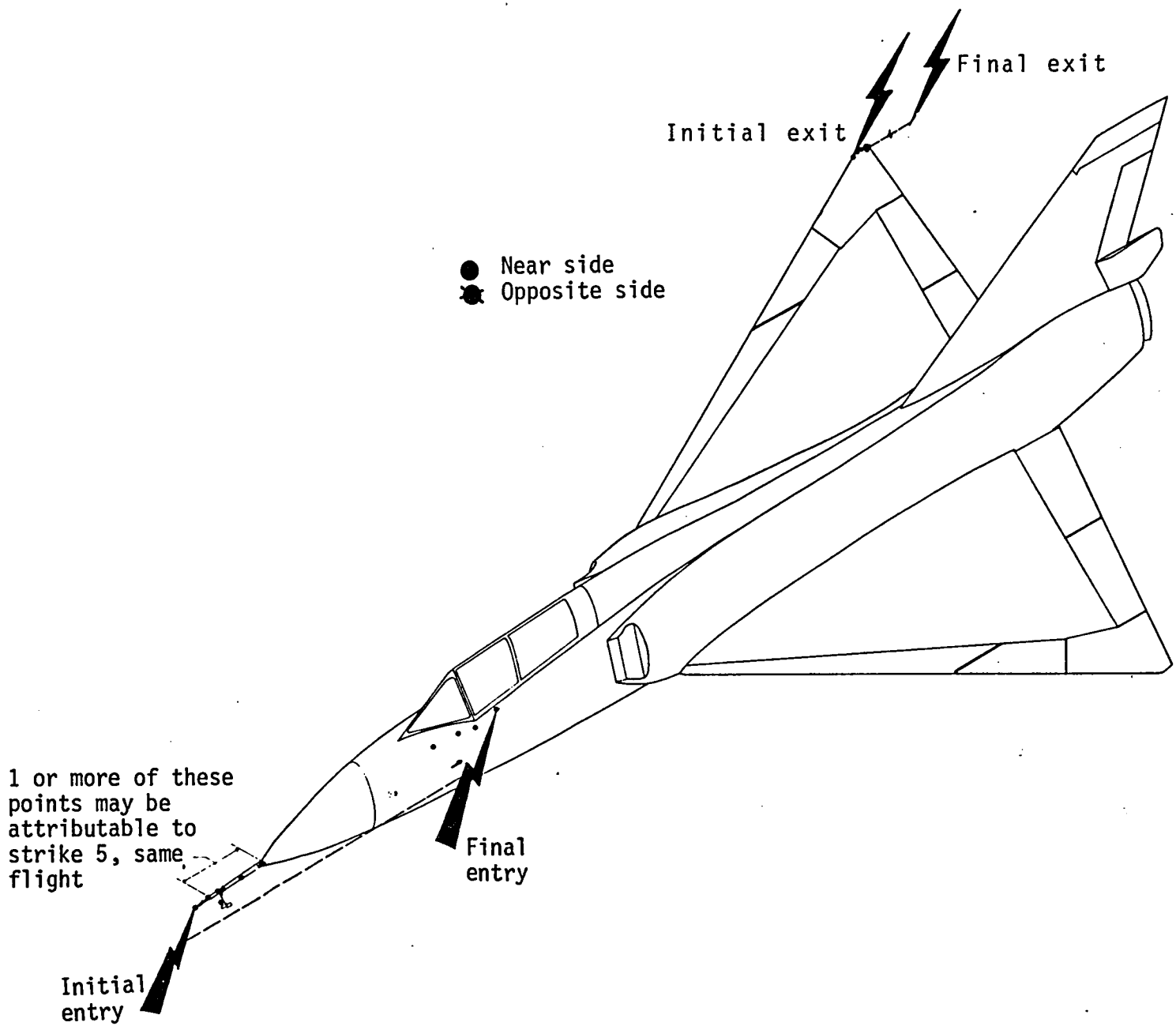
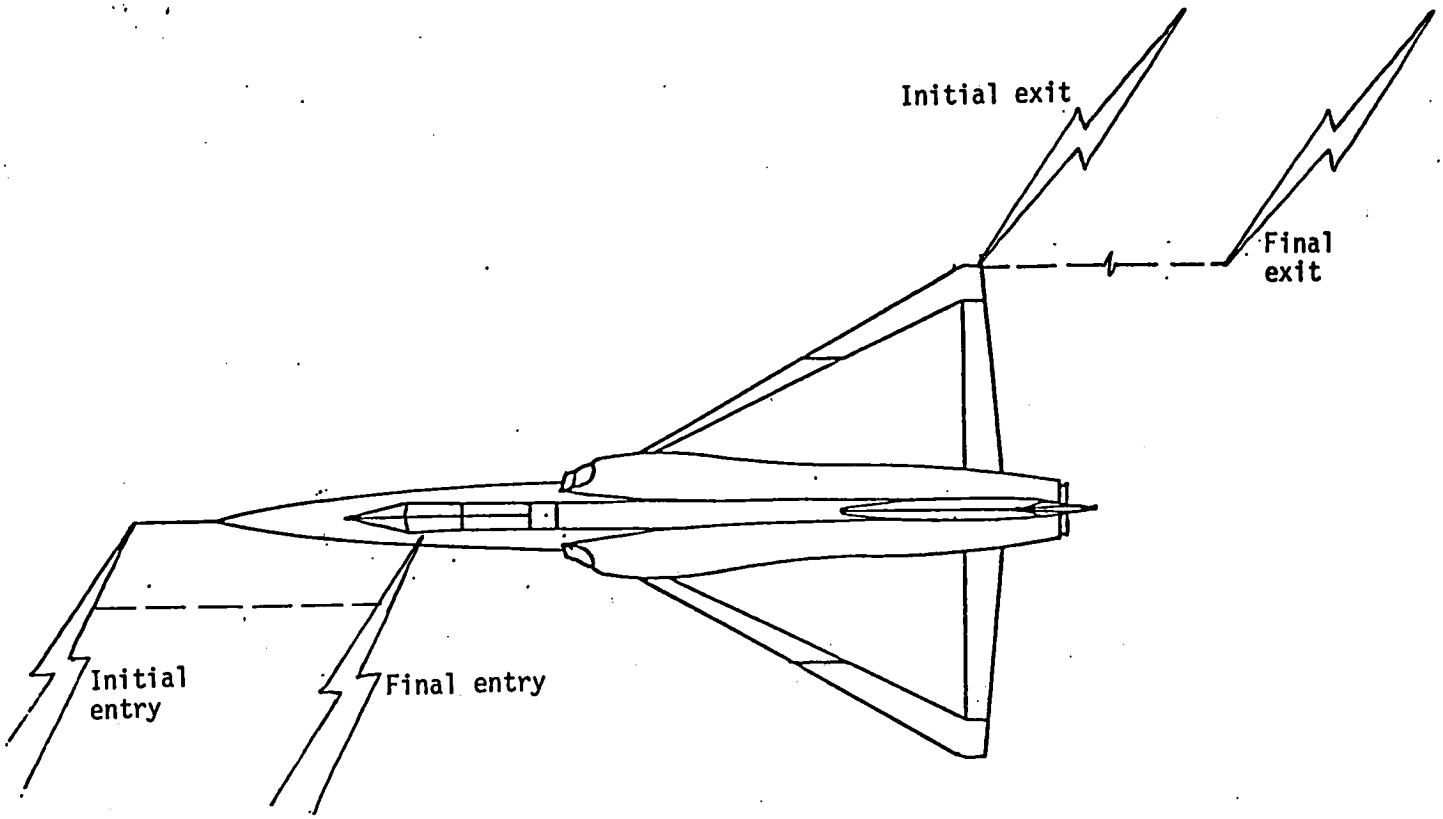
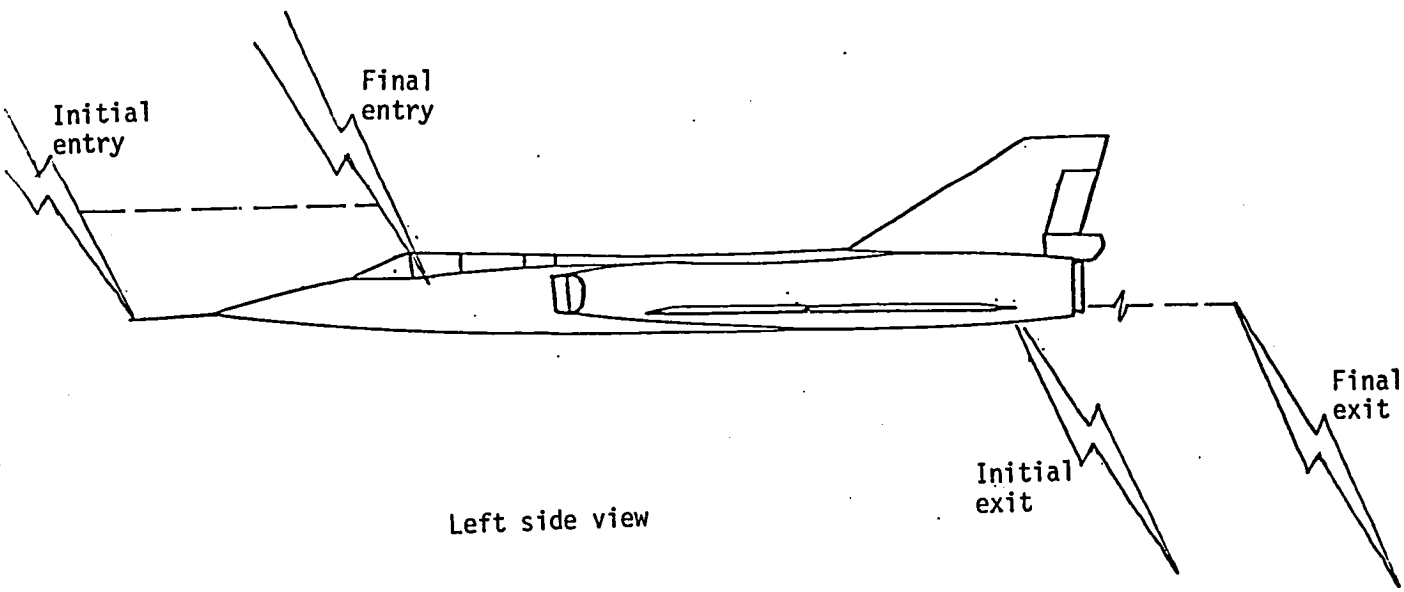


Figure 12.- Lightning attachment points and scenario for strike 5 of 1981, Flight 81- 040, July 29, 1981.



Top view



Left side view

Figure 13.- Lightning strike scenario for strike 5 of 1981, Flight 81-040, July 29,1981.

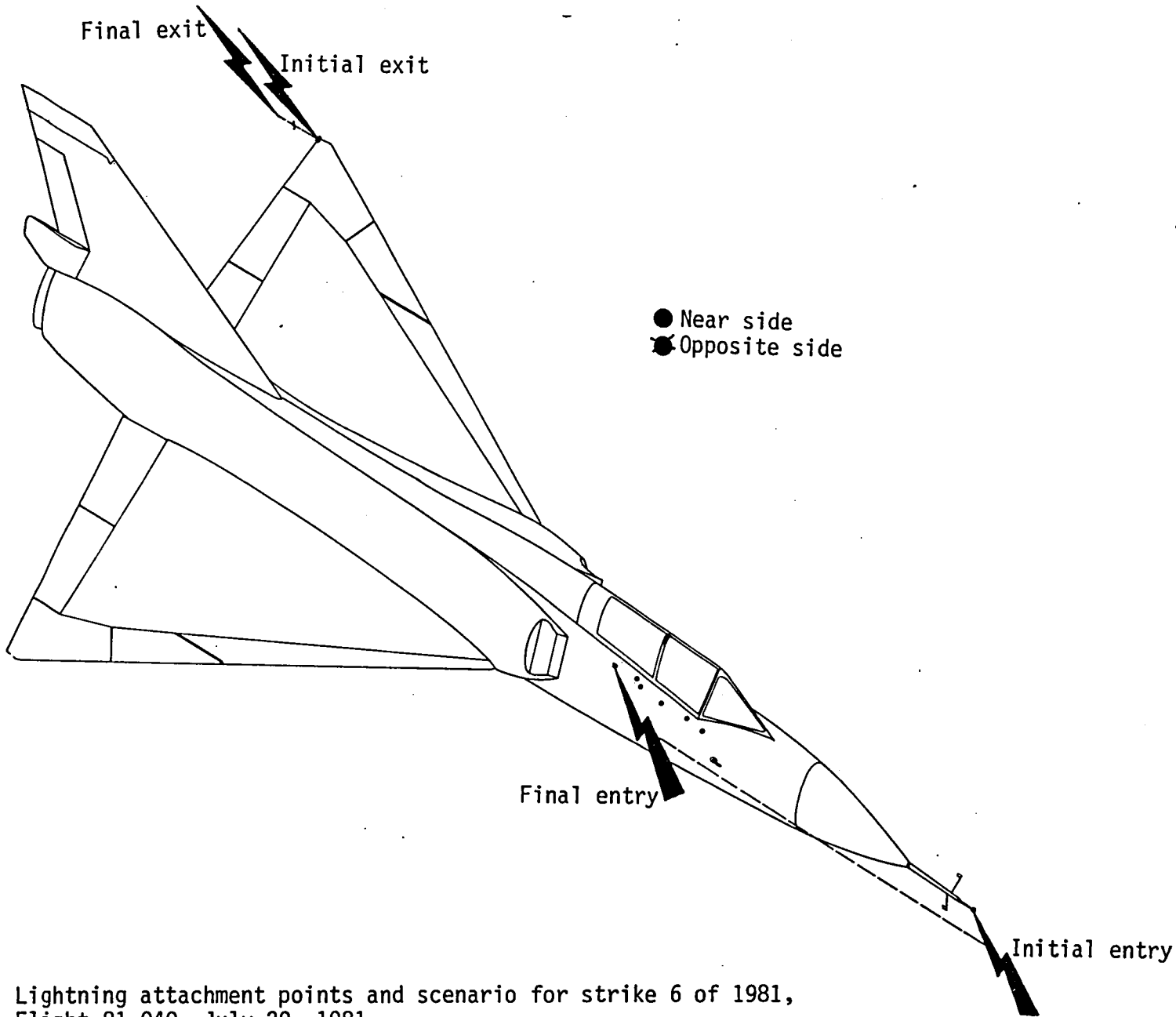


Figure 14.- Lightning attachment points and scenario for strike 6 of 1981, Flight 81-040, July 29, 1981.

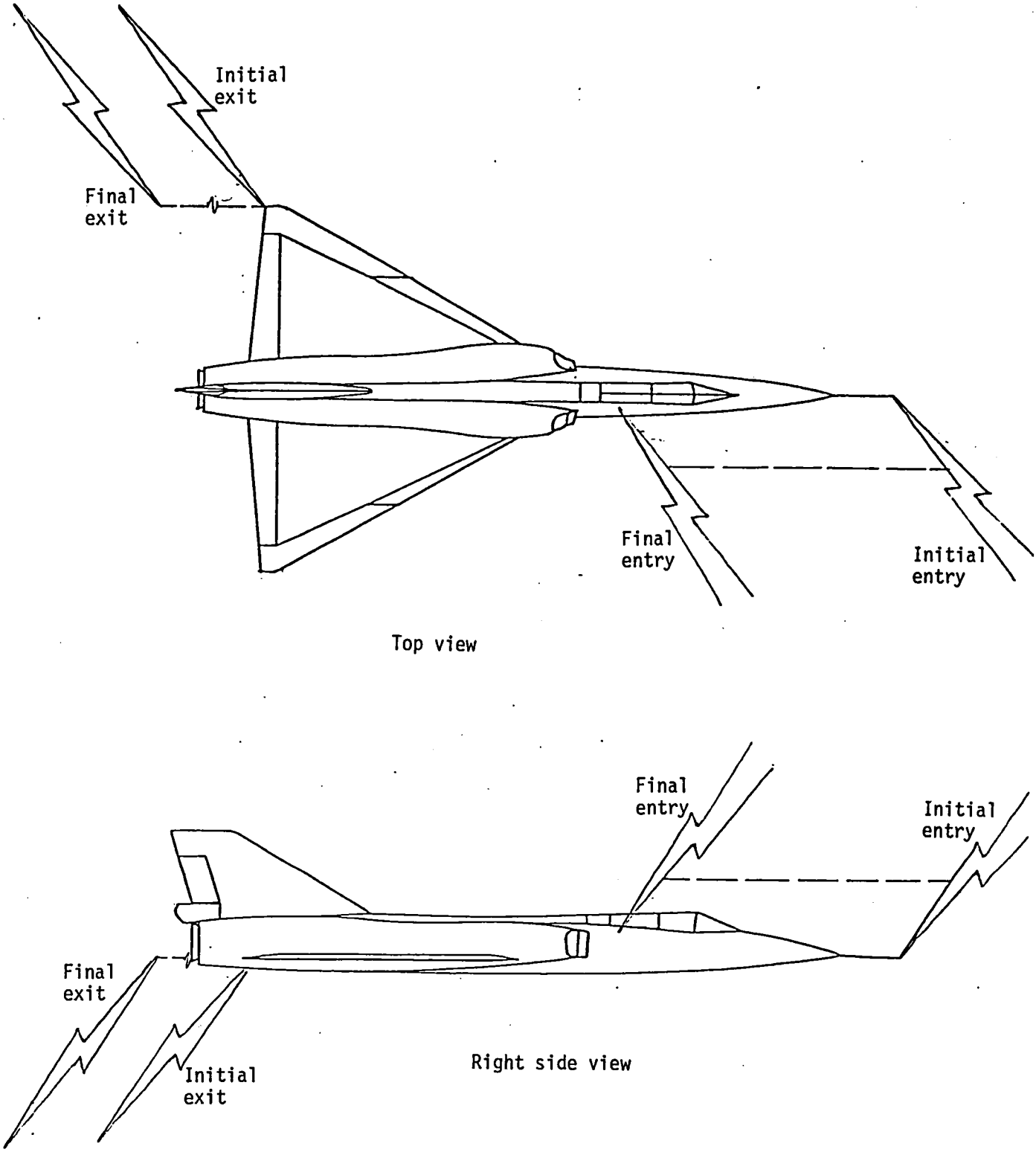


Figure 15.- Lightning strike scenario for strike 6 of 1981, Flight 81-040, July 29, 1981.

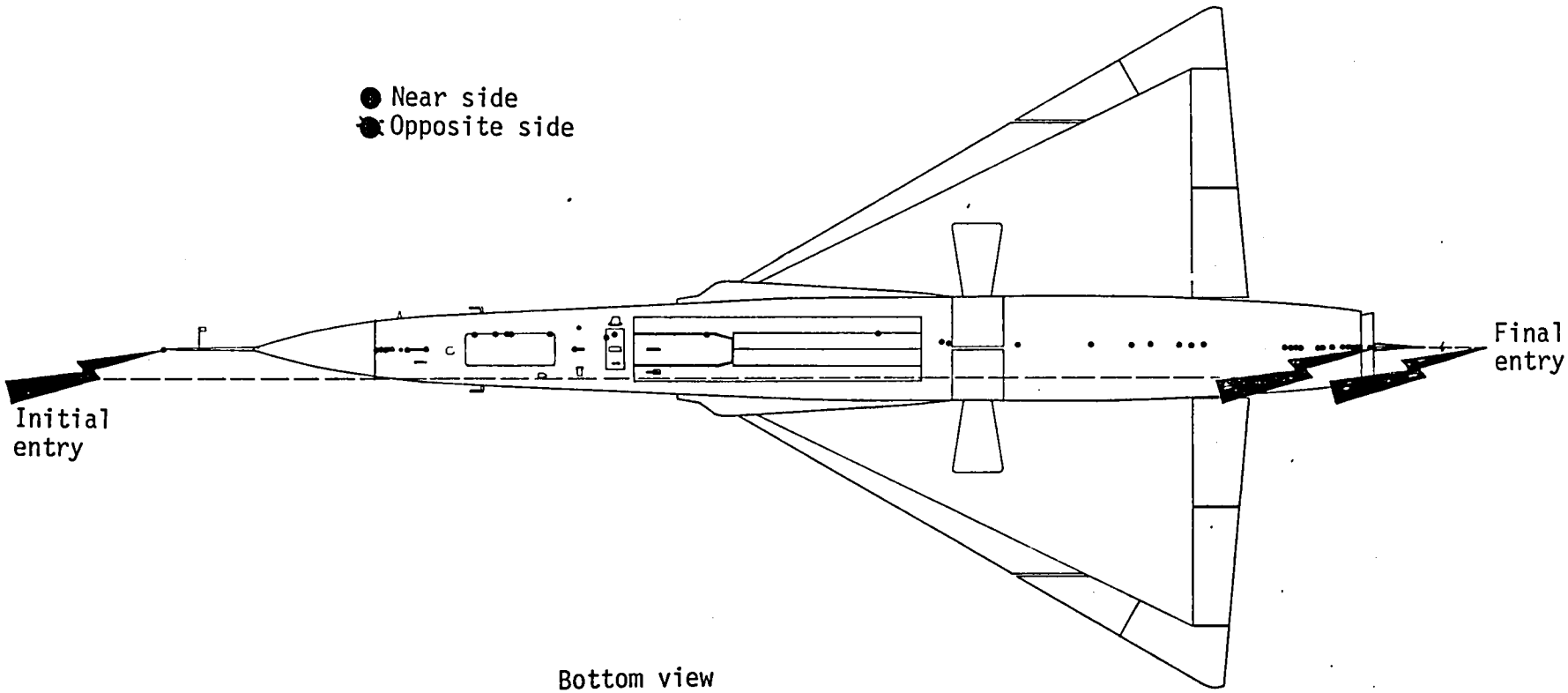


Figure 16.- Lightning attachment points and scenario for strike 7 of 1981, Flight 81-042, August 11, 1981.

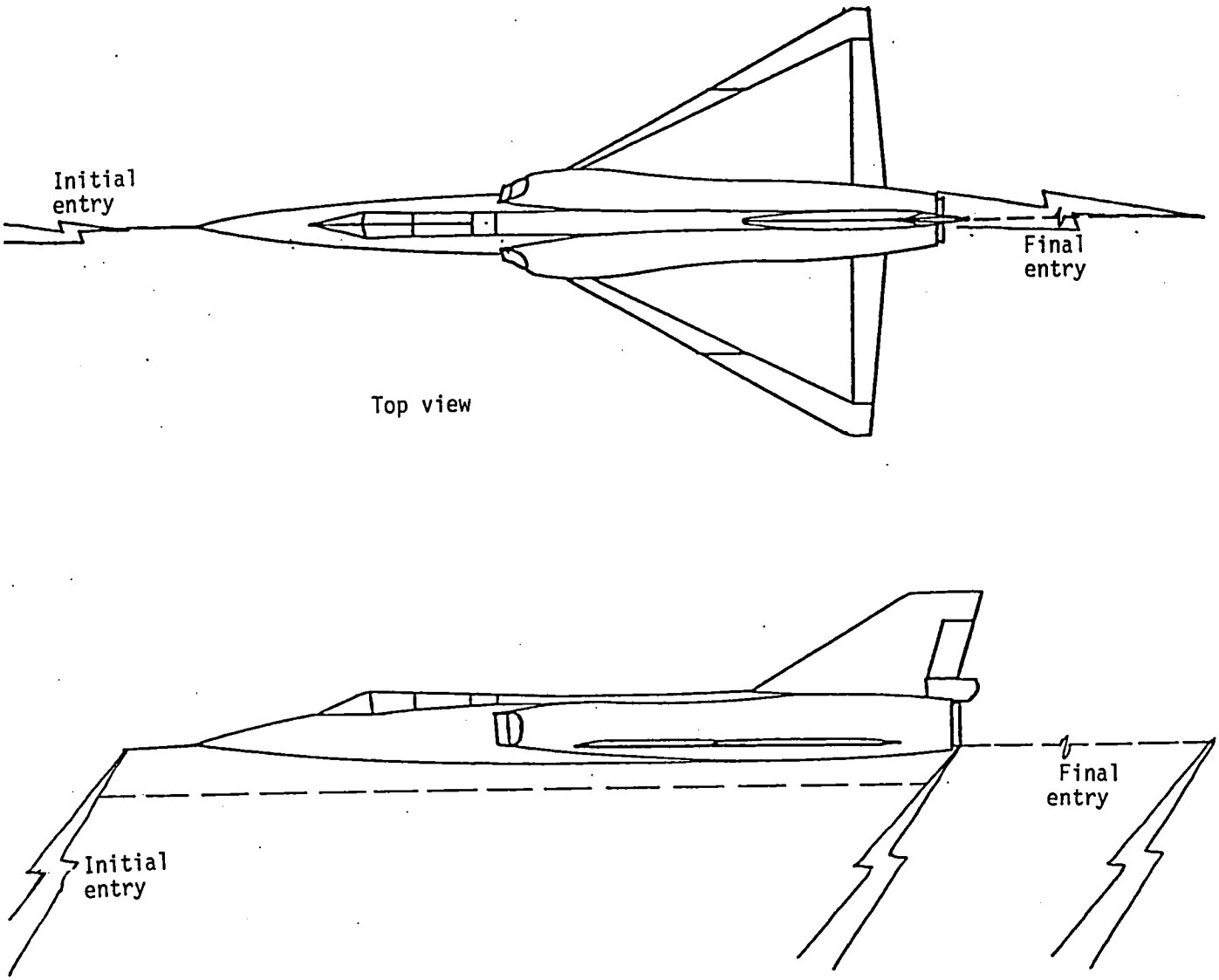


Figure 17.- Lightning strike scenario for strike 7 of 1981,
Flight 81-042, August 11, 1981. (Exit location unknown.)

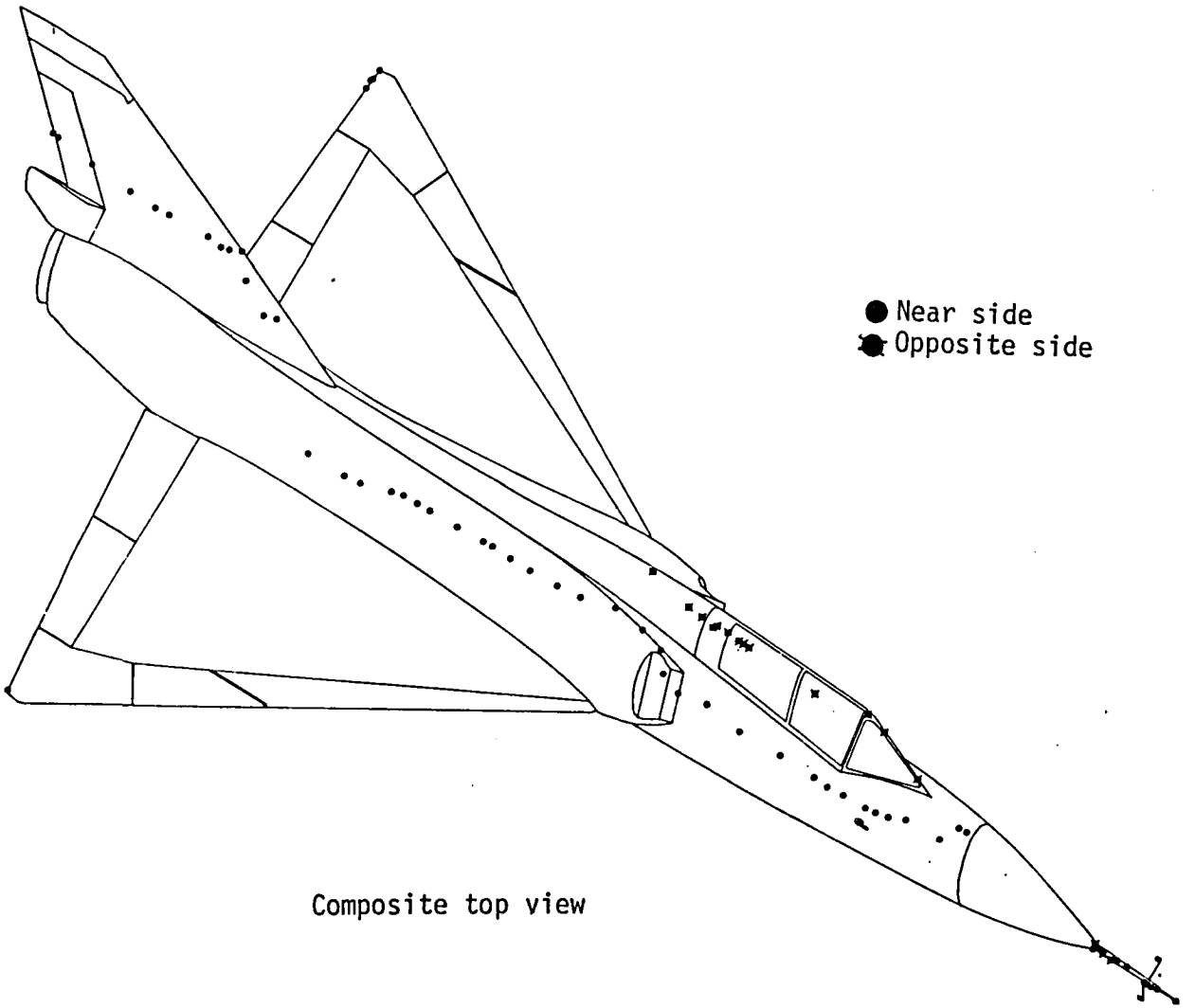


Figure 18.- Lightning attachment points for strikes 8 and 9 of 1981, Flight 81-043, August 16, 1981.

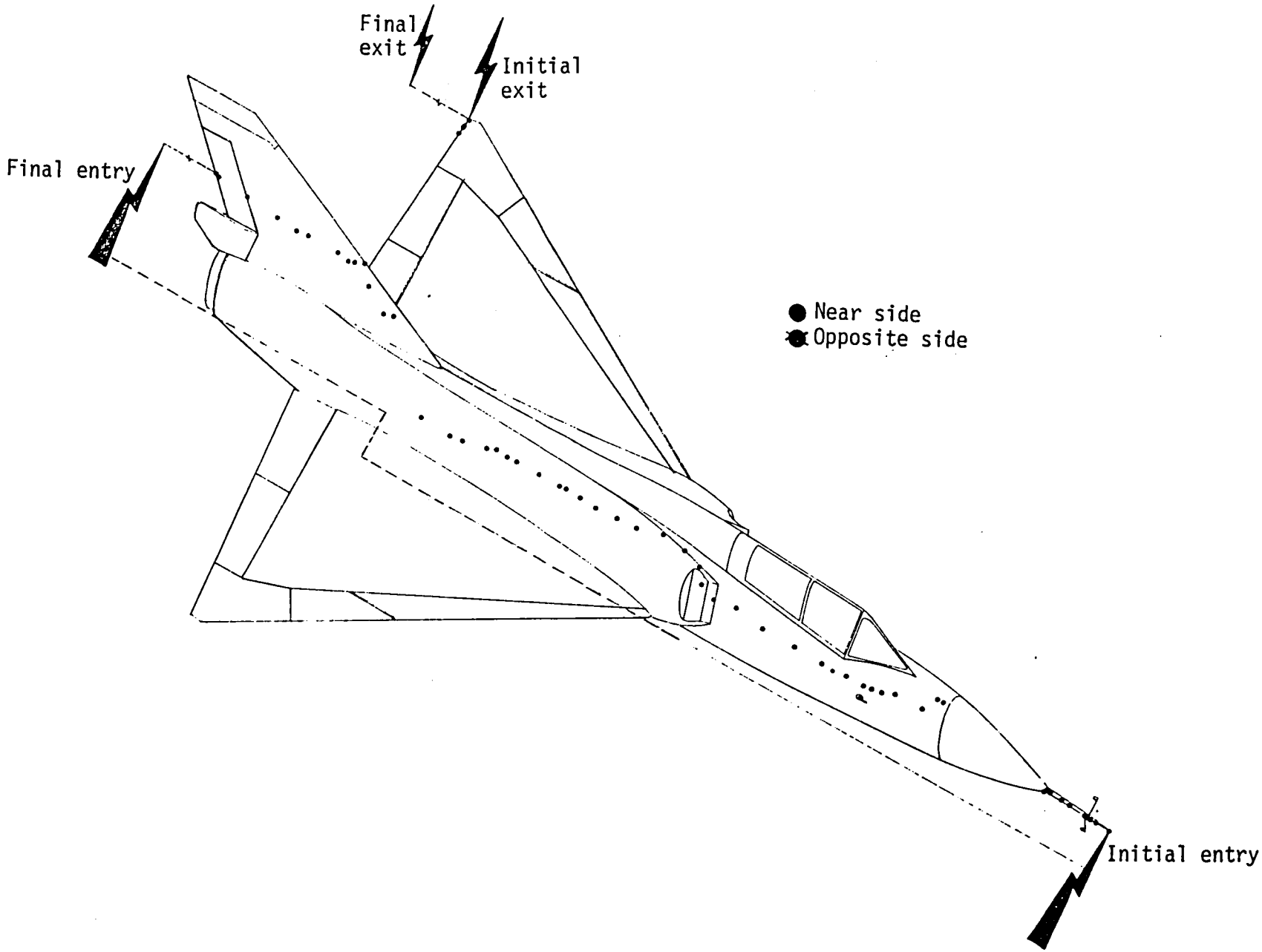


Figure 19.- Lightning attachment points and scenario for strike 8 of 1981, Flight 81-043, August 16, 1981.

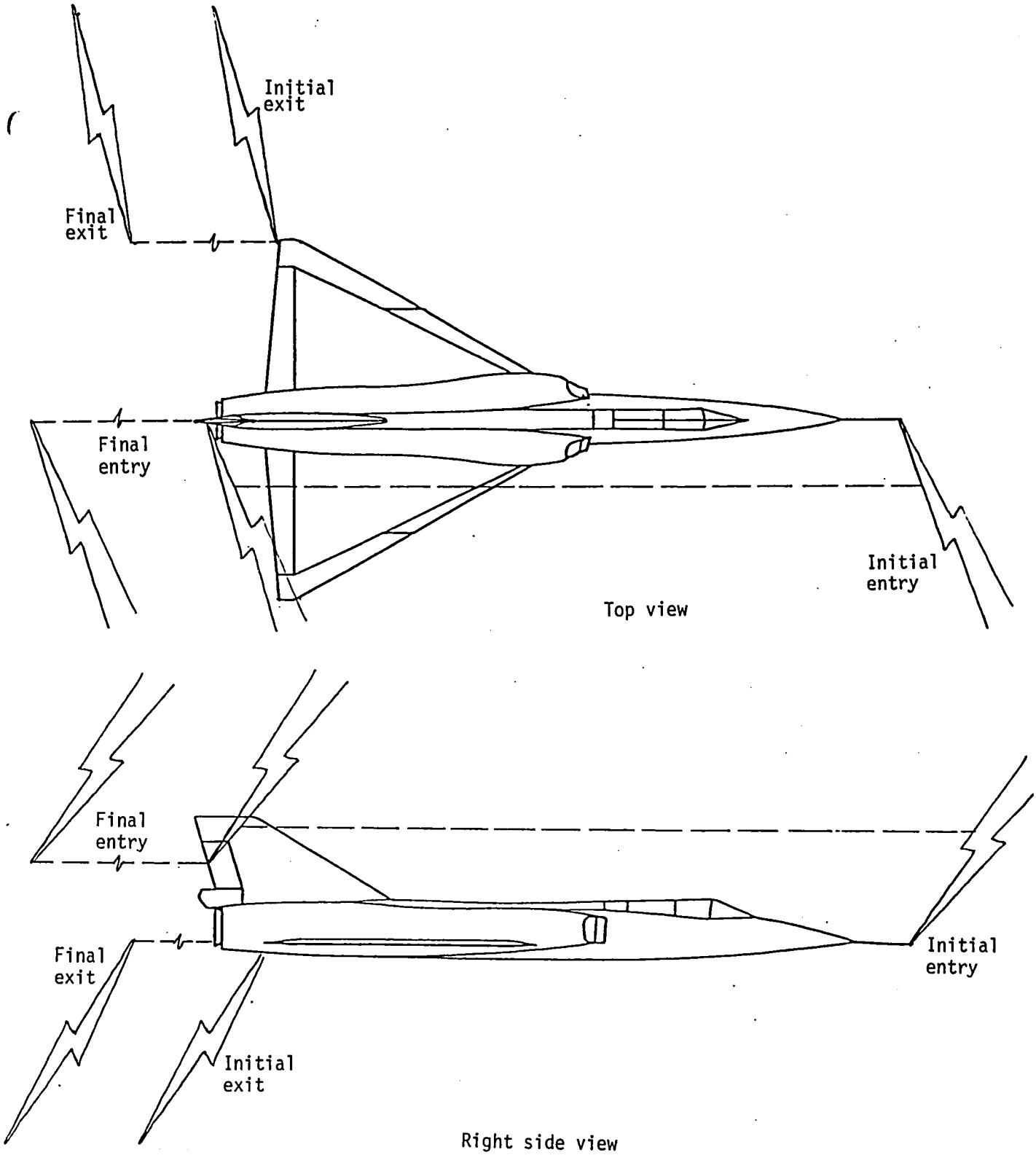


Figure 20.- Lightning strike scenario for strike 8 of 1981, Flight 81-043, August 16, 1981.

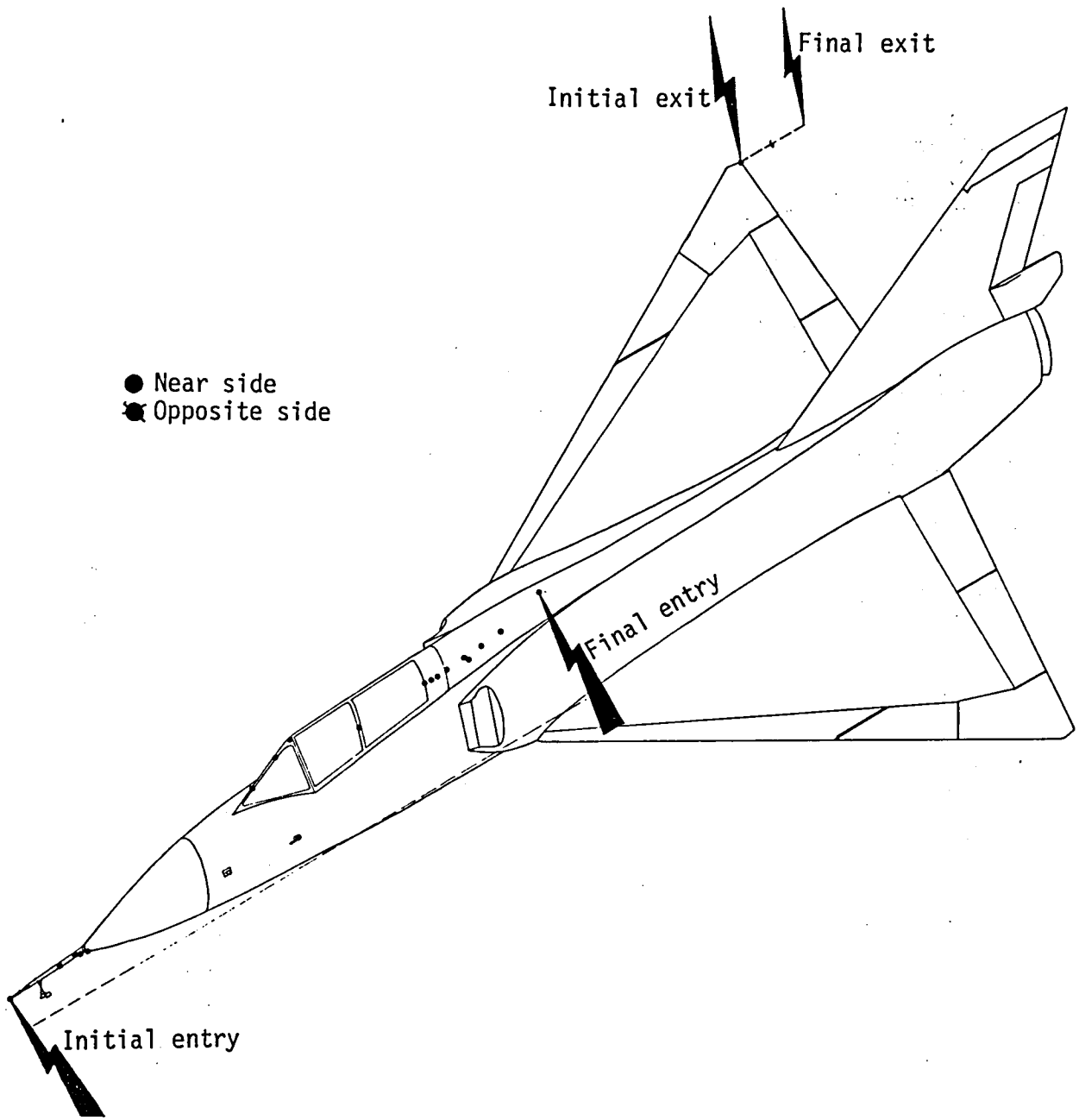
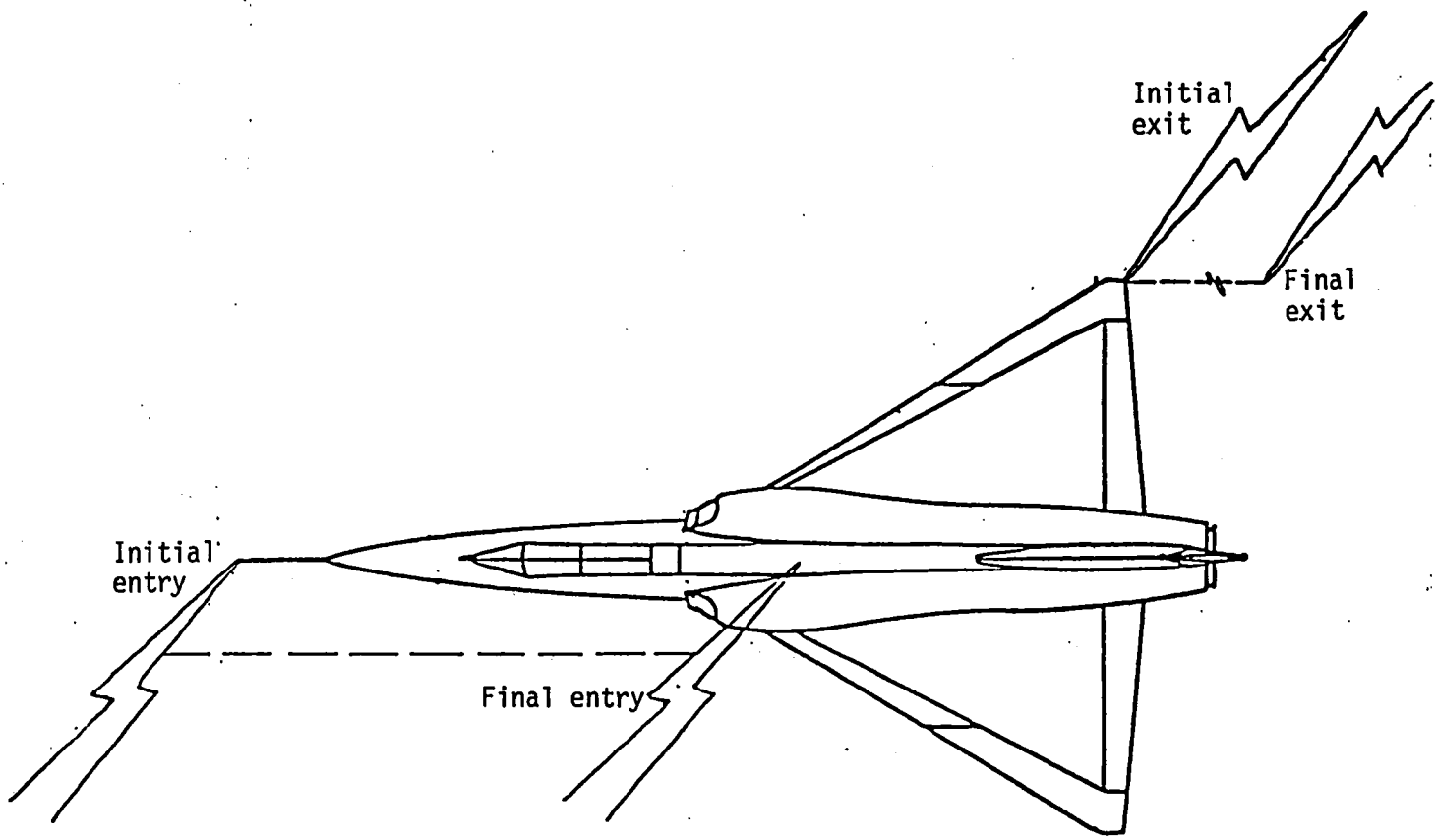
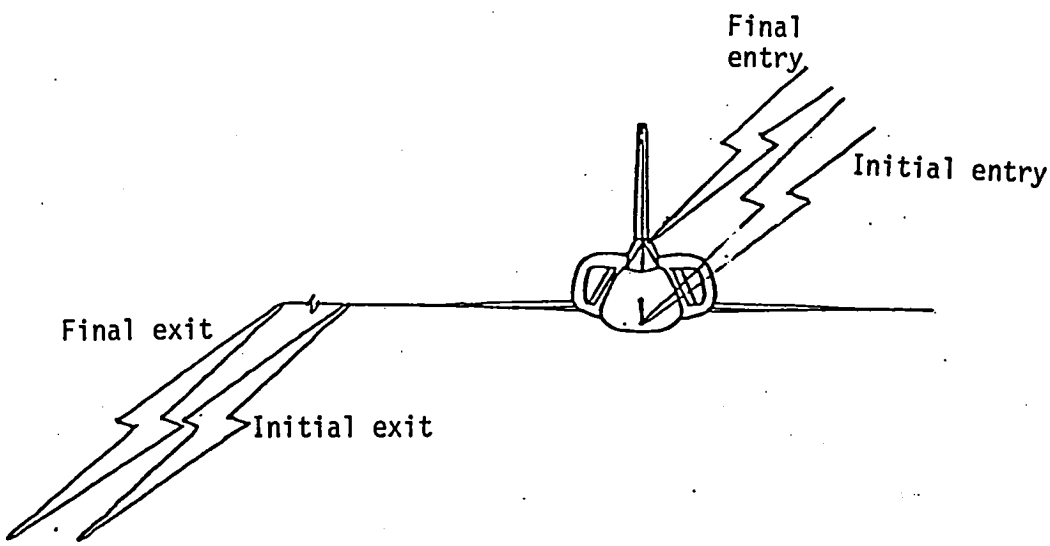


Figure 21.- Lightning attachment points and scenario for strike 9 of 1981, Flight 81-043, August 16,1981.



Top view



Front view

Figure 22.- Lightning strike scenario for strike 9 of 1981, Flight 81-043, August 16, 1981.

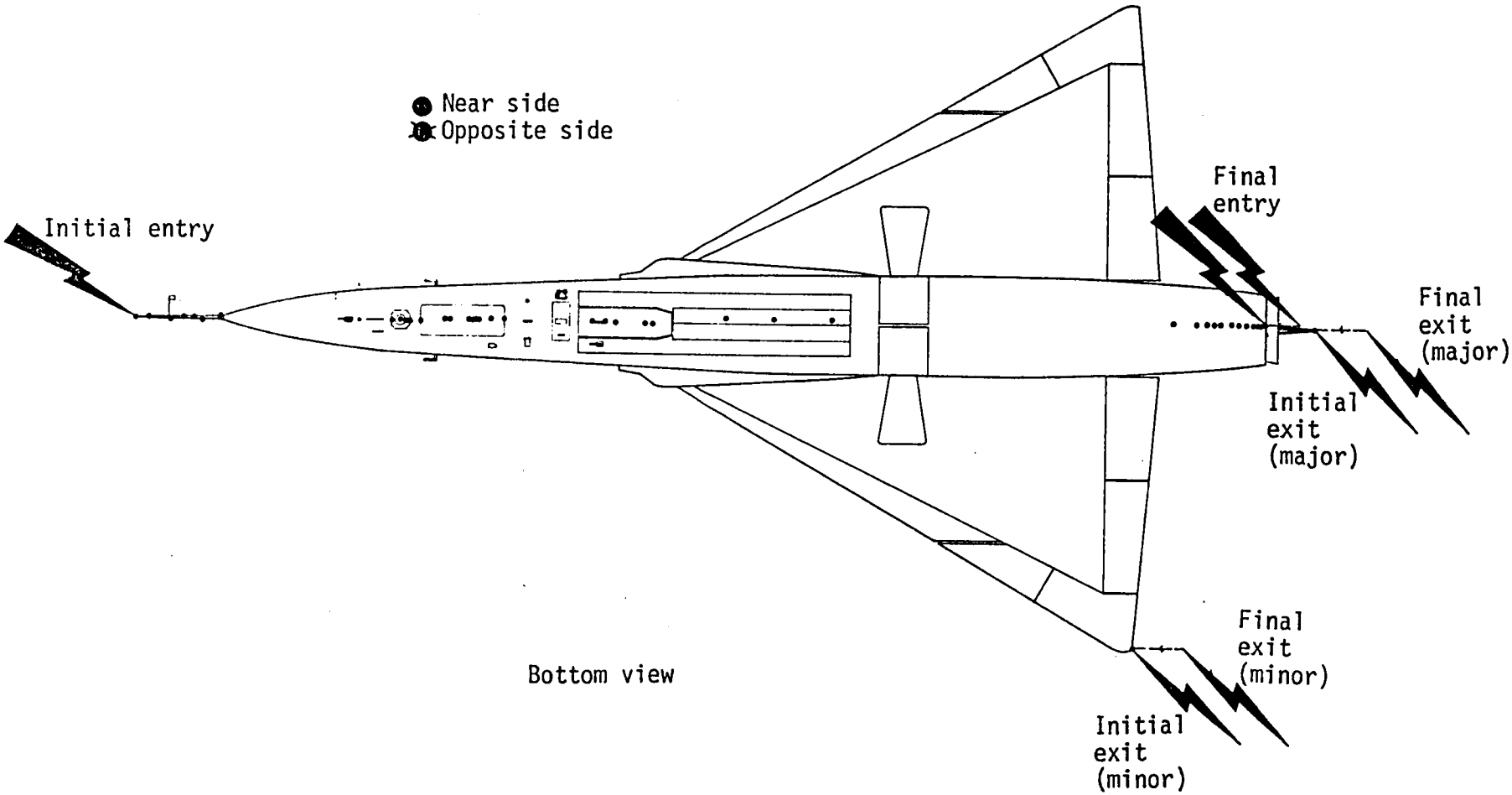


Figure 23.- Lightning attachment points for strike 10 of 1981, Flight 81-046, September 8,1981.

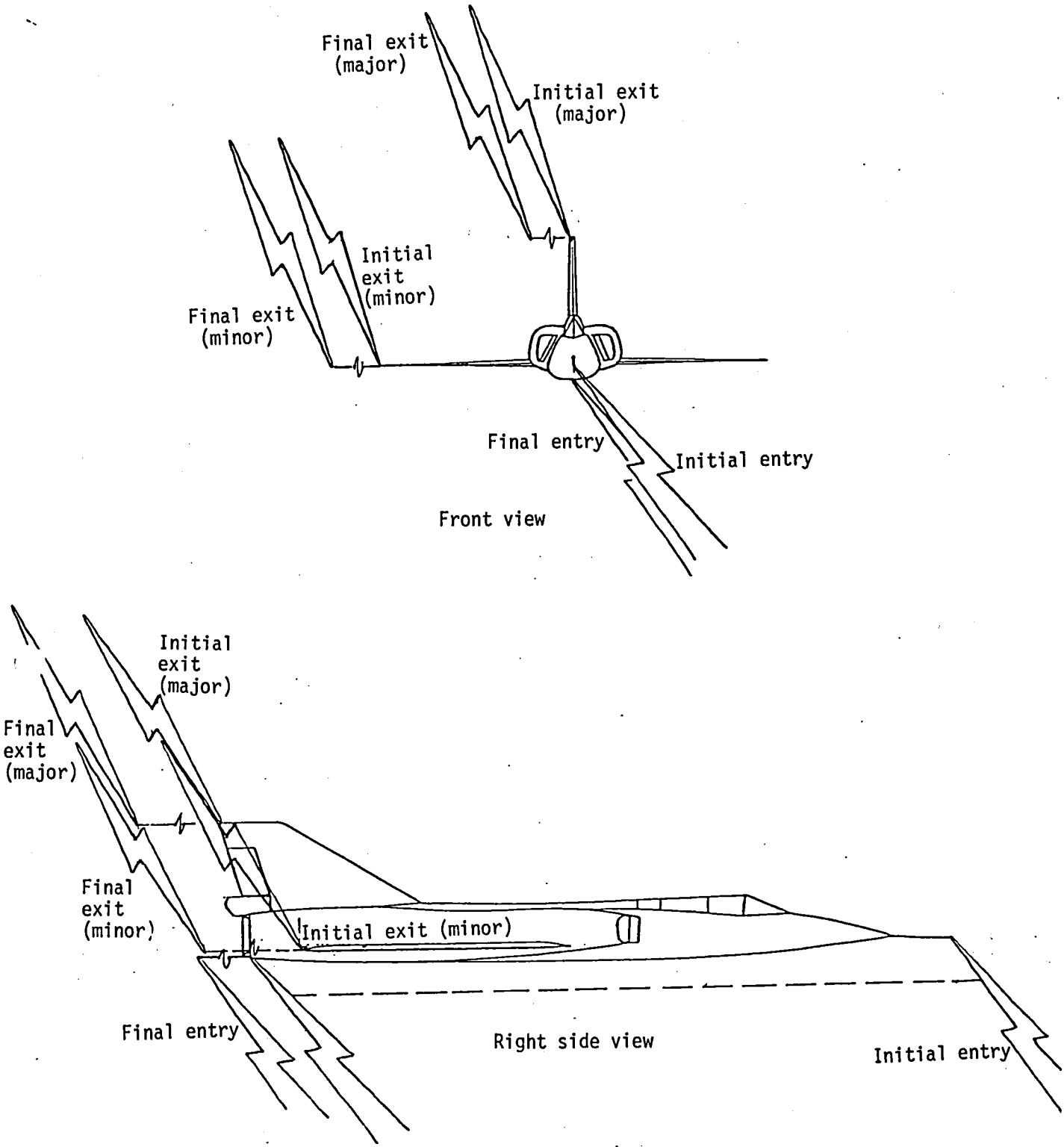


Figure 24.- Lightning strike scenario for strike 10 of 1981, Flight 81-046, September 8, 1981.

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15. Supplementary Notes

Lightning scenarios developed with assistance of Lightning Technologies, Inc., under NASA Contract NAS1-15884.

16. Abstract

As part of the NASA Langley Research Center Storm Hazards Program, 111 thunderstorm penetrations were made in 1981 with an F-106B airplane in order to record direct-strike lightning data and the associated flight conditions. Ground-based weather radar measurements in conjunction with these penetrations were made by NOAA National Severe Storms Laboratory in Oklahoma and by NASA Wallops Flight Facility in Virginia. In 1981, the airplane received 10 direct lightning strikes; in addition, lightning transient data were recorded from 22 nearby flashes. Following each flight, the airplane was thoroughly inspected for evidence of lightning attachment, and the individual lightning attachment points were plotted on isometric projections of the airplane to identify swept-flash patterns. This report shows the strike attachment patterns that were found, and tabulates the flight conditions at the time of each lightning event. Finally, this paper contains a table in which the data in this report are cross-referenced with the previously published electromagnetic waveform data recorded onboard the airplane.

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