CID FLIGHT/IMPACT

Russ Barber
Ames Dryden Flight Research Facility
Moffett Field, California

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I am going to describe as best I can what happened during the impact of the C.I.D., as well as discuss the planned versus the actual impact.

The scenario that we were attempting to conduct is identified on figure 1. The scenario here represents almost a year or year and a half of negotiations among the project participants. There was a lot of interest in how this impact would take place. The aircraft manufacturing industry and the participating government organizations all had input to the desired scenario. We were changing this right up to the last week prior to the C.I.D. mission. The FAA knew that they wanted a survivable accident. In order to do that it seemed clear that we needed to have the landing gear retracted so that the fuselage would not fracture aft of the wing because of the high sink rate. The longitudinal velocity and gross weight were relatively easy to achieve. The difficulty came with the longitudinal impact window. That was primarily driven by the crashworthiness people wanting to have 75 milliseconds of time after ground impact, but prior to impact with the wing openers. The AMK people did not want the airplane to land too long and therefore be going too slow by the time that it impacted the wing openers. So the last change that was made to the scenario was the addition of 50 feet on the longitudinal envelope. The concern was that we would not be able to impact the airplane that precisely with the control and guidance system we had. In fact, that did turn out to be the case.

The approach to accomplish the objectives was to remotely control the vehicle to an impact site prepared on the dry lakebed at Edwards as depicted in figure 2. We utiliized many of the systems that we had utilized in the remote control of the HiMAT, DAST, and spin research vehicles that we had flown remotely at Dryden previously. The control system that was developed is illustrated in figures 3 and 4. The airborne and the ground portions of the control system are respectively depicted. We primarily used the autopilot that was in the airplane (Bendix PB-20) to provide control of the airplane. In addition to the control functions that the autopilot performed it was necessary to mechanize several housekeeping functions to actuate things like flaps, landing gear, shutting the engines down, and so forth. The system had a separate and independent terminate system that had the capability of causing the airplane to dive into the ground if we were to lose control of the vehicle through the single string autopilot and airborne control system. The ground-based system had almost a totally dualized control capability. It had dual computational capability going into the ground-based cockpit. Several radars received the data and brought it into the ground computers so that it could be processed and displayed to the pilot. The system had a dual transmitting capability up to the airplane. Figure 4 also shows the independent ground-based terminate system. Basically the control concept was single string with the terminate safety relief in case of loss of control through the single string system.

Having a terminate system required a sterile area in which the airplane could be terminated and not impact any property or lives. Figure 5 depicts the sterile area. The photographers had to be located outside this sterile area, which made their task more difficult. The terminate profile was identified and we knew that if we terminated the airplane anywhere along the flight path, that it would impact in a sterile area. The airplane took off on lakebed runway 17 and flew the profile. There was no go-around accomplished on the C.I.D. mission so the flight profile was as shown. Figure 6 illistrates the crash site. A rockbed 1200 feet long and 300 feet wide of coarse railroad gravel was laid to provide a friction ignition source.

An aiming fence was prepared to enable the pilot to have better guidance longitudinally. Figure 7 depicts the wing openers that were installed to open the wings after impact.

Figure 8 summarizes the manned flight development of these systems. The airplane was flown 14 times with a crew on board. The development flights totaled about 30 hours of flight time. About 52 percent of that time was devoted to RPV control system development. The airplane accomplished 9 takeoffs and 13 landings under remote control and about 69 approaches to the C.I.D. site down to altitudes between 150 and 200 feet. That was the lowest altitude from which a safe go-around could be effected since the landing gear was retracted for the actual impact. The day of impact timeline is shown in figure 9. It looks like a 9:13 takeoff time is pretty leisurely, but we were actually out there about 4:00 in the morning preparing for this. The mission from brake release to impact was something on the order of 9 minutes with a very short interval of time between the initial impact of the no. 1 engine and the fuselage impact. The telemetered data stayed on for a significant period of time after the impact and total data failure occurred at 09:22:12.8.

The weight and balance for the C.I.D. mission are shown in figure 10. The mission used 8000 pounds of fuel during the flight profile. The fuel used was obtained by integrating the fuel flow meters. All of that fuel came out of the center wing tank. All the fuel boost punps were on so the center wing override boost pump was predominant. The airplane had 76,000 pounds of AMK on for the final mission.

Figure 11 shows the wreckage distribution. This figure was provided by the FAA's Accident Investigation Team. It shows that the airplane impacted fairly close to the center line. Several areas of impact definition are still confusing and I will address that a little bit later. The airplane slid into the wing openers with a relatively large skew angle and then debris scattered throughout an area about 1500 feet long. The airplane came to rest with the right wing over the left side of the fuselage.

The data that has been obtained on impact is compared with the goals set out prior to the impact on figure 12. The actual sink rate was very close to the desired sink rate. The airspeed was right on. The fuselage hit 281 feet long of the impact envelope and the wing hit 410 feet long. The data showed the lateral deviation was 34 feet to the right of the centerline. The roll attitude was the variable that was probably the furthest off; it was -12^{o} rather than the desired wings-level attitude. The heading angle we have not totally defined yet. We are trying to get some additional photographs to enable us to evaluate this.

Figures 13a, 13b, 13c, and 13d are a sequence of photographs that show the airplane just prior to impact. They show the no. 1 engine impacting first and then the fuselage. It is interesting to note that the engines on the left wing are really distorted.

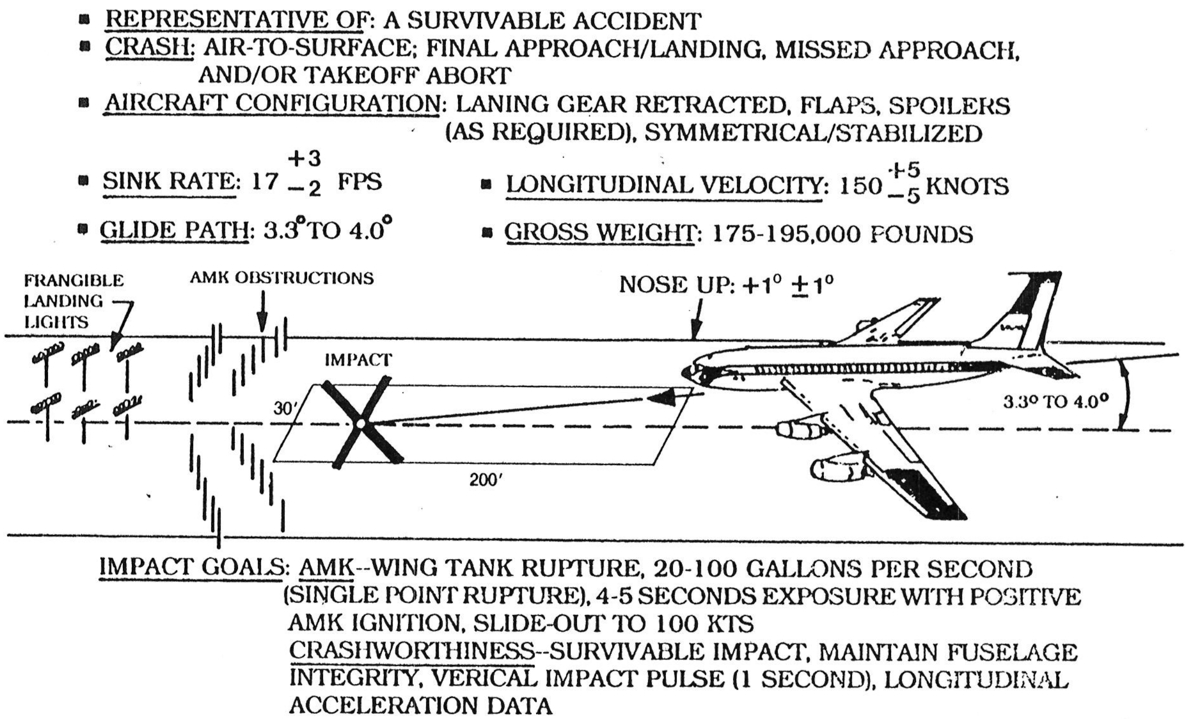


Figure 1. Planned CID impact scenario.

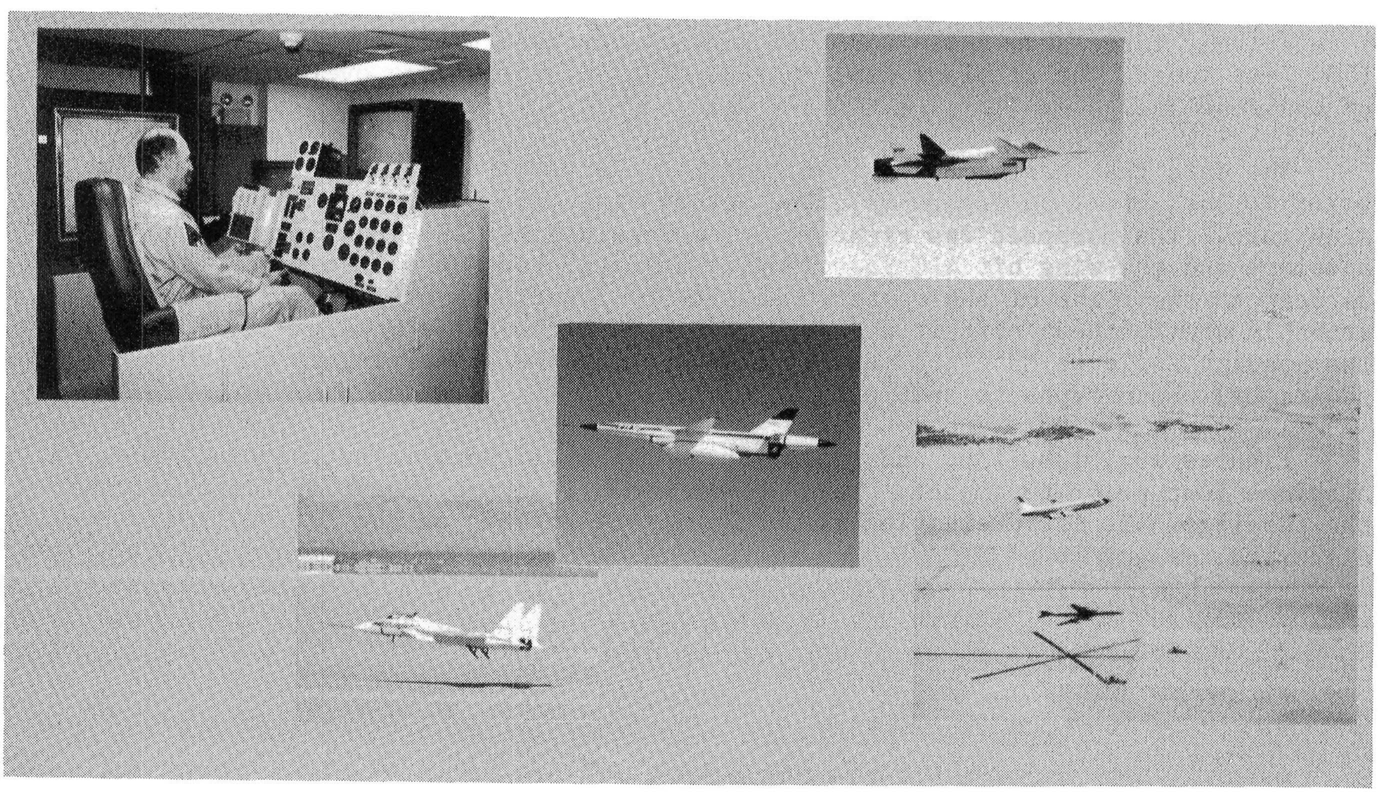


Figure 2. CID technical approach.

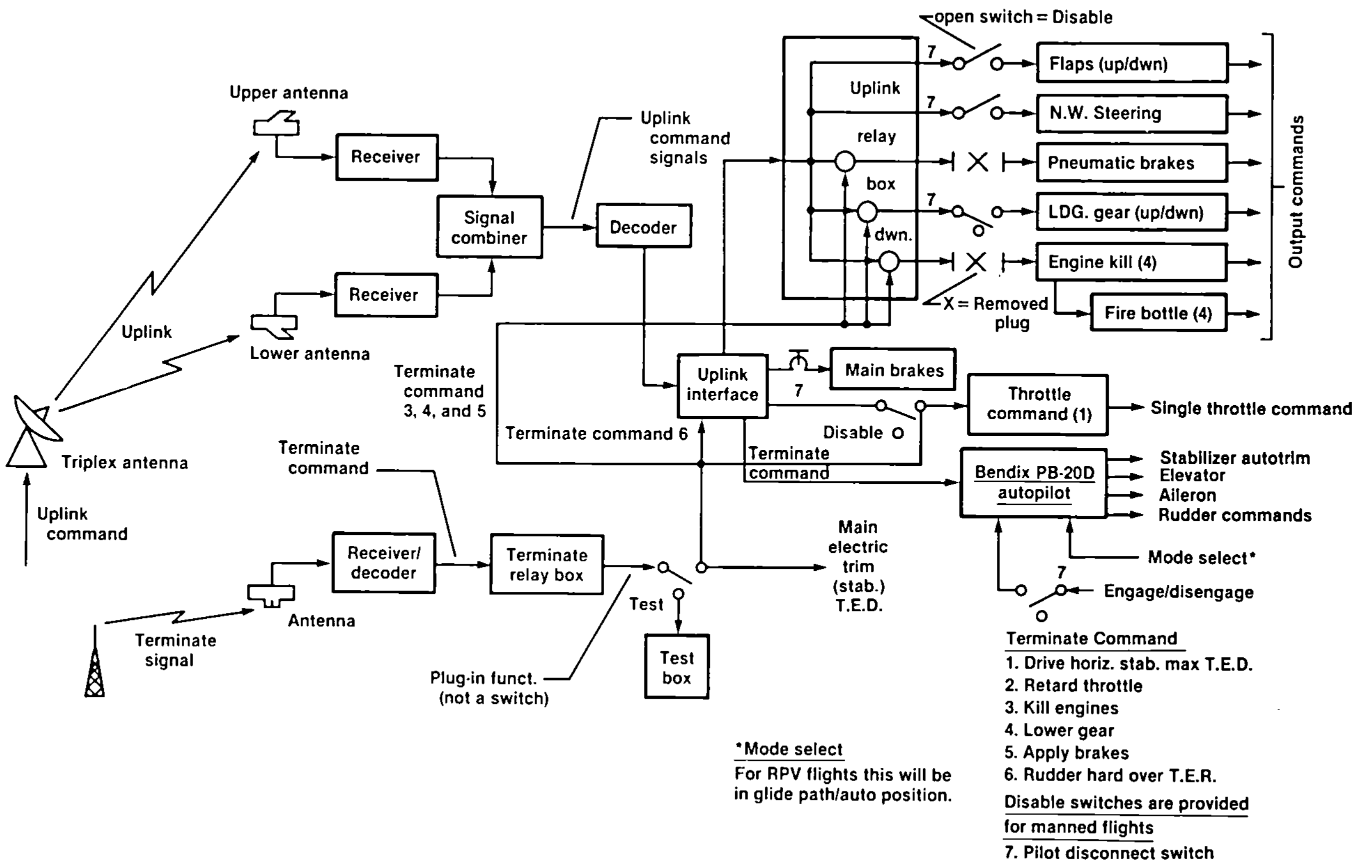


Figure 3. CID airborne RPV control system.

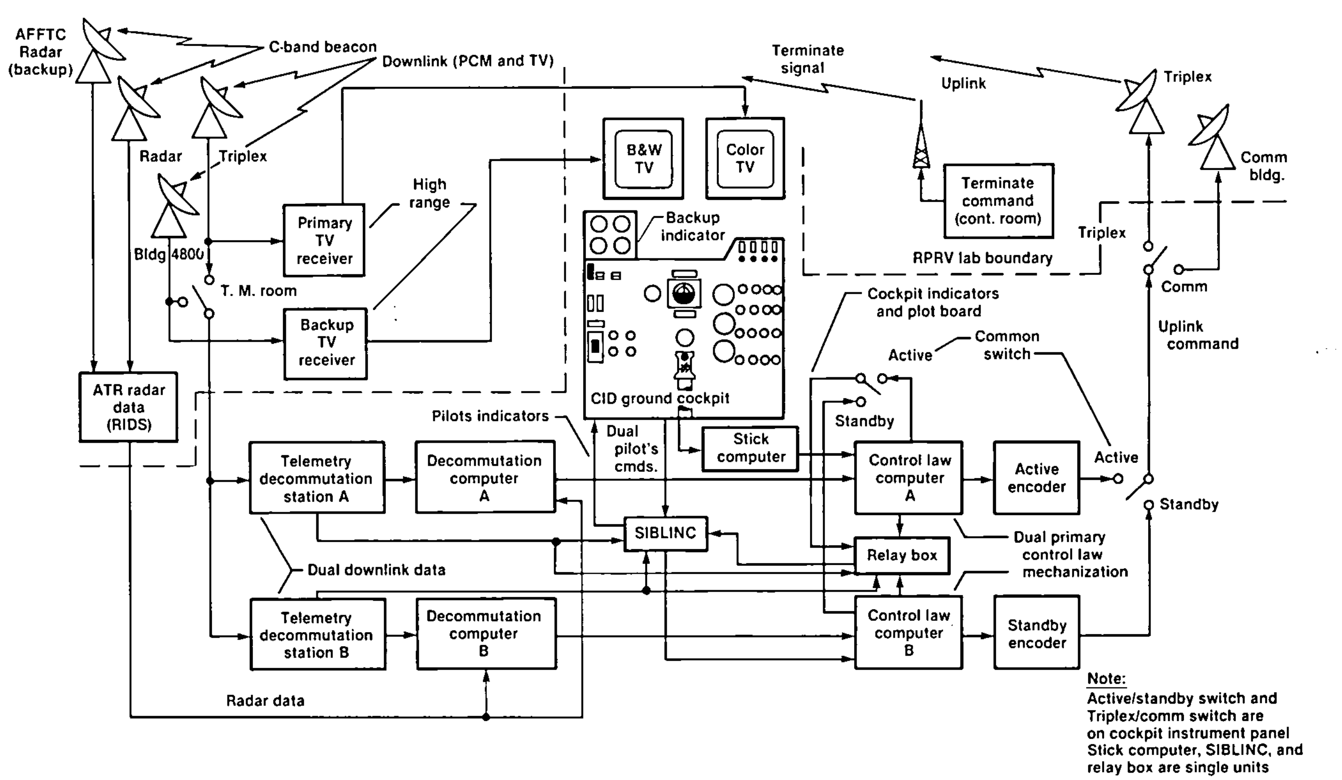


Figure 4. CID ground-based RPV control system.

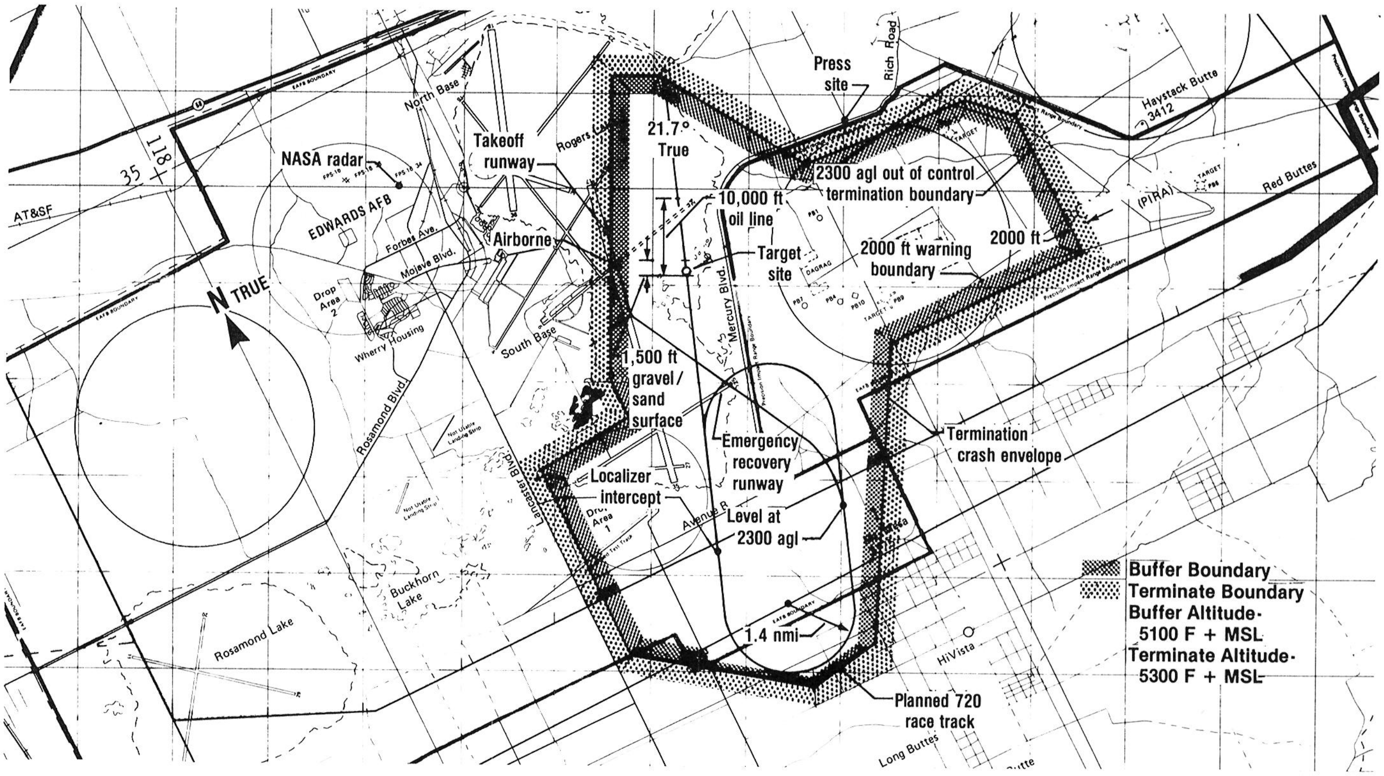


Figure 5. CID impact profile.

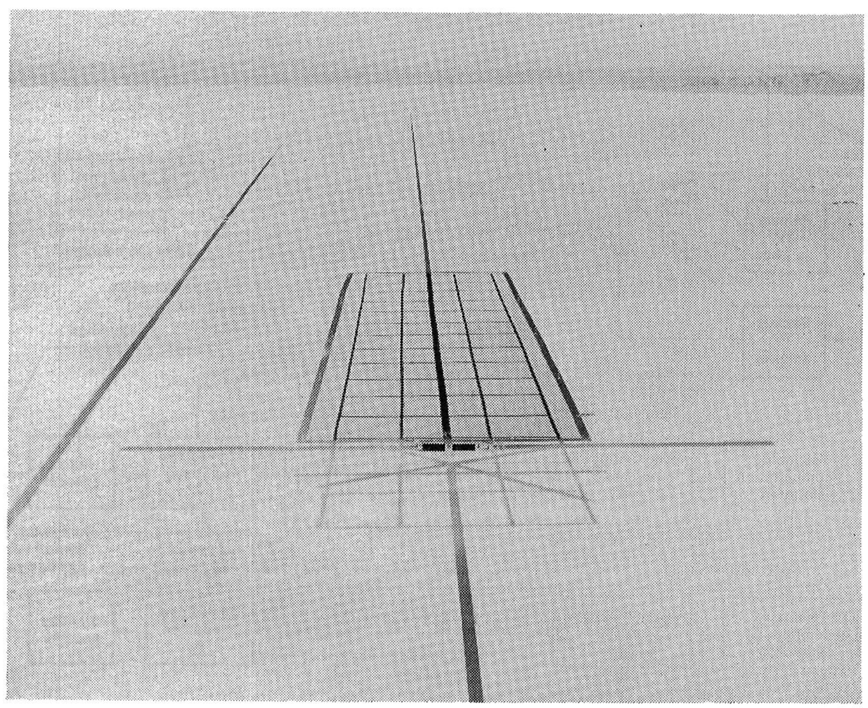


Figure 6. CID crash site.

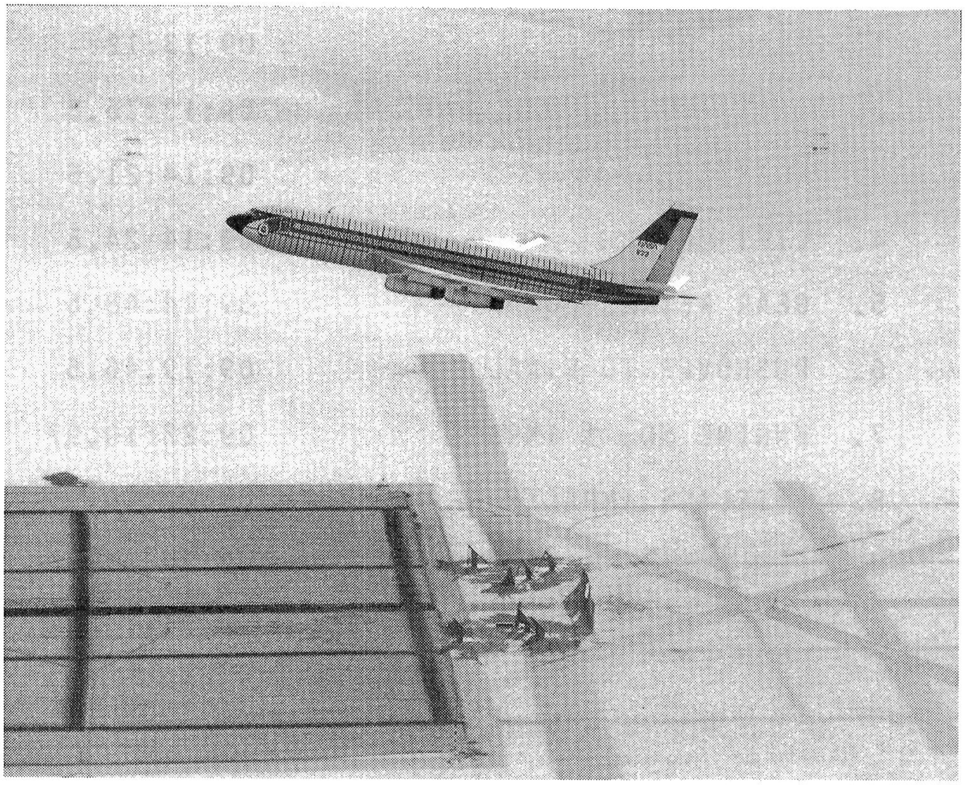


Figure 7. CID wing openers.

- 14 manned flights flown
  - Total flight time 31.4 h
  - Total RPV time was 52.2 percent of total
  - 9 RPV takeoffs and 13 RPV landings
  - 69 CID approaches to altitudes between 150 and 200 ft

Figure 8. CID manned flight summary.

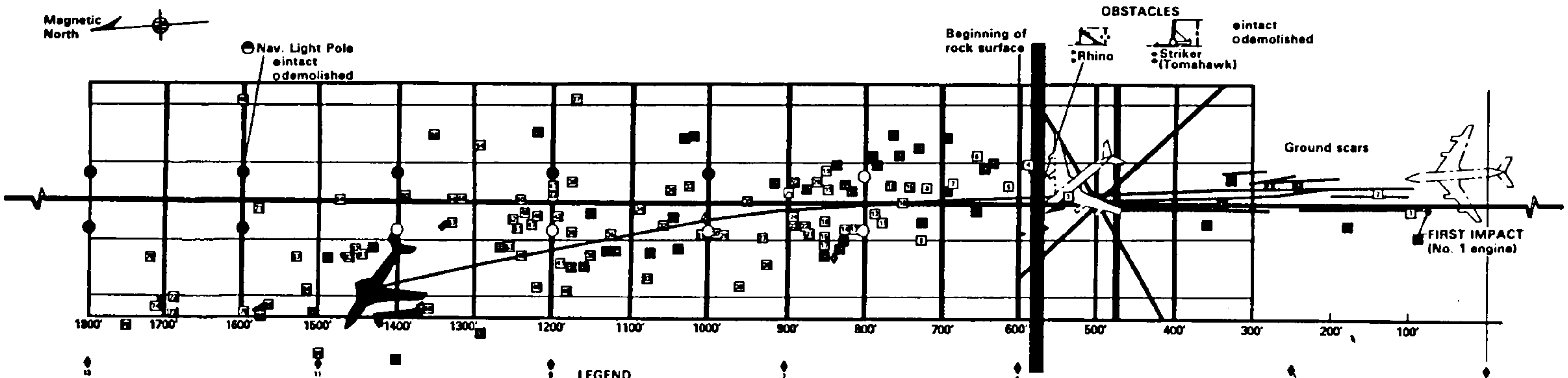
1.	BRAKE RELEASE	09:13:12
2.	INITIAL ROLL	09:13:16.8
3.	ROTATION	09:14:21.5
4.	LIFT OFF	09:14:24.5
5.	GEAR RETRACTED	09:14:48.5
6.	PUSHOVER TO FINAL	09:19:46.5
7.	ENGINE NO. 1 IMPACT	09:22:10.97
8.	FUSELAGE IMPACT	09:22:10.99
9.	PCM POWER FAIL	09:22:11.00
10.	TOTAL DATA FAIL	09:22:12.8

Figure 9. CID mission timeline.

PRE ENGINE START	GROSS WT 200,455 LBS C.G. 22.6% MAC
FUEL USED FROM C.W. TANK	8,072 LBS
IMPACT	GROSS WT 192,383 C.G. 24.2% MAC

76,058 LBS OF AMK WAS LOADED FOR THE CID MISSION

Figure 10. CID mission weight and balance.



LEGEND

AIRFRAME COMPONENTS

1. Engine Lower Cowl
2. Engine Cowl
3. Engine Cowl Segment (2'×2')
4. Landing Gear Door
5. Engine Cowl
6. Engine Strut Trailing Edge
7. Engine Cowl Segment (3'×3')
8. Cowling
9. Engine Cowl Segment (6'×3½')
10. Engine Cowl Segment (2'×3')
11. Not Identified
12. Not Identified
13. Engine Cowling Door
14. Cowling
15. Engine Cowl Segment (3'×4')
16. Engine Cowl Segment (4'×4')
17. Control Surface (?)
18. Cowling
19. Engine Ducting
20. Engine Cowling
21. Cowling
22. Cowling
23. Pylon
24. Throttle Linkage
25. Lower Fuselage Antenna Panel
26. Pylon Part
27. Engine Cowling
28. Engine Cowling
29. Lower Fuselage Structure
30. Landing Gear Door (?)
31. Heat Exchanger
32. Engine Inlet Cowling
33. Door
34. Fire Bottle
35. Tube Structure
36. Engine Inlet Cowl
37. Air Conditioning Heat Exchanger
38. Fire Bottle
39. Fuselage Keel Beam
40. Nose Cowl
41. Door
42. Engine Pylon
43. Landing Gear Door
44. Heat Exchanger
45. Pylon Fairing
46. Right Wing Section
47. Engine Inlet Cowl
48. Tire
49. Tire & Wheel

MISCELLANEOUS

1. Striker Pole
2. Light Pole

ENGINE COMPONENTS

1. Fuel degrader piece
2. Gear box section
3. Section of reverser
4. DC Armature
5. Reverser Cascades
6. DC Generator
7. Reverser Actuator
8. 12" Section LPC blades
9. Tach Generator
10. Engine Starter
11. Oil System Comp. & Line
12. Reverser Actuator
13. Reverser Clamshell Door
14. Oil Cooler
15. Exhaust Duct
16. Oil Pump
17. Inlet Pressure Transducer
18. Oil Tank
19. EPR Transmitter
20. Oil Presser Switch
21. CSD Housing Segment
22. EPR Transmitter
23. Igniter Unit
24. Igniter Unit
25. Engine Exhaust Section
26. Engine Oil Tank
27. Tach Generator
28. Turbine Rear Bearing Sdpt.
29. Filter
30. Reverser Act. Track
31. Engine Starter
32. CSD Oil Tank
33. Oil Filter
34. Engine Fuel Control
35. Oil Cooler Core
36. Engine Fuel Control
37. Starter Housing
38. Engine Oil Regulator
39. 7th Stage Comp. Dish
40. Fuel Pump
41. 10 inch Stator Segment
42. Ignitor Box
43. Engine Starter
44. Generator
45. Oil Pump
46. Generator
47. 7th Stage Dish Rim/Blades
48. Generator Winding
49. Compressor Blade Seg.
50. Generator Case
51. 7th Stage Comp. Spacer
52. Thrust Reverser Housing
53. Ignitor Unit
54. Pressure Switch
55. Nose Cone
56. Roller Bearing Cage
57. No. 2 Engine
58. Fuel Control Shaft
59. No. 1 Engine
60. Constant Speed Drive Unit
61. 1st Stage Outer Shroud/Vanes
62. Vane Section
63. No. 3 Engine LPC Sect.
64. Thrust Reverser Door
65. Ignition Unit
66. Inner Shroud/Vane Sect.
67. Tachometer
68. No. 4 Engine LPC Sect.
69. No. 4 Engine HPC-Turb
70. CSD and Generator
71. Fuel Pump
72. CSD and Generator
73. 17 pieces Blades & Vanes
74. No. 3 Engine HPC/Turb
75. Oil Pump Housing
76. Oil Tank

Figure 11. CID wreckage distribution.

THE TARGET CONDITIONS IN TERMS OF DESIRED AND ACCEPTABLE RANGES, TOGETHER WITH THE MEASURED VALUES, ARE AS FOLLOWS:

	DESIRED	ACCEPTABLE	MEASURED
SINK RATE (FPS)	15-17	15-20	17.3
LONGIT. VEL. (KTS)	150-155	145-155	151.5
PITCH ATTITUDE (DEG)	1	0-2	0
LONGIT. DEVIATION (FT)	-75 TO +75	-125 TO +75	-128 NOTE 1 OR -410 NOTE 2
LATERAL DEVIATION (FT)	-15 TO +15	-15 TO +15	+45 NOTE 1
ROLL ATTITUDE (DEG)	-1 TO +1	-1 TO +1	-12 NOTE 2
HEADING ANGLE (DEG)	-1 TO +1	-1 TO +1	NOTE 3

NOTE 1. MEASURED AT A POINT WHERE FUSELAGE MADE INITIAL CONTACT.

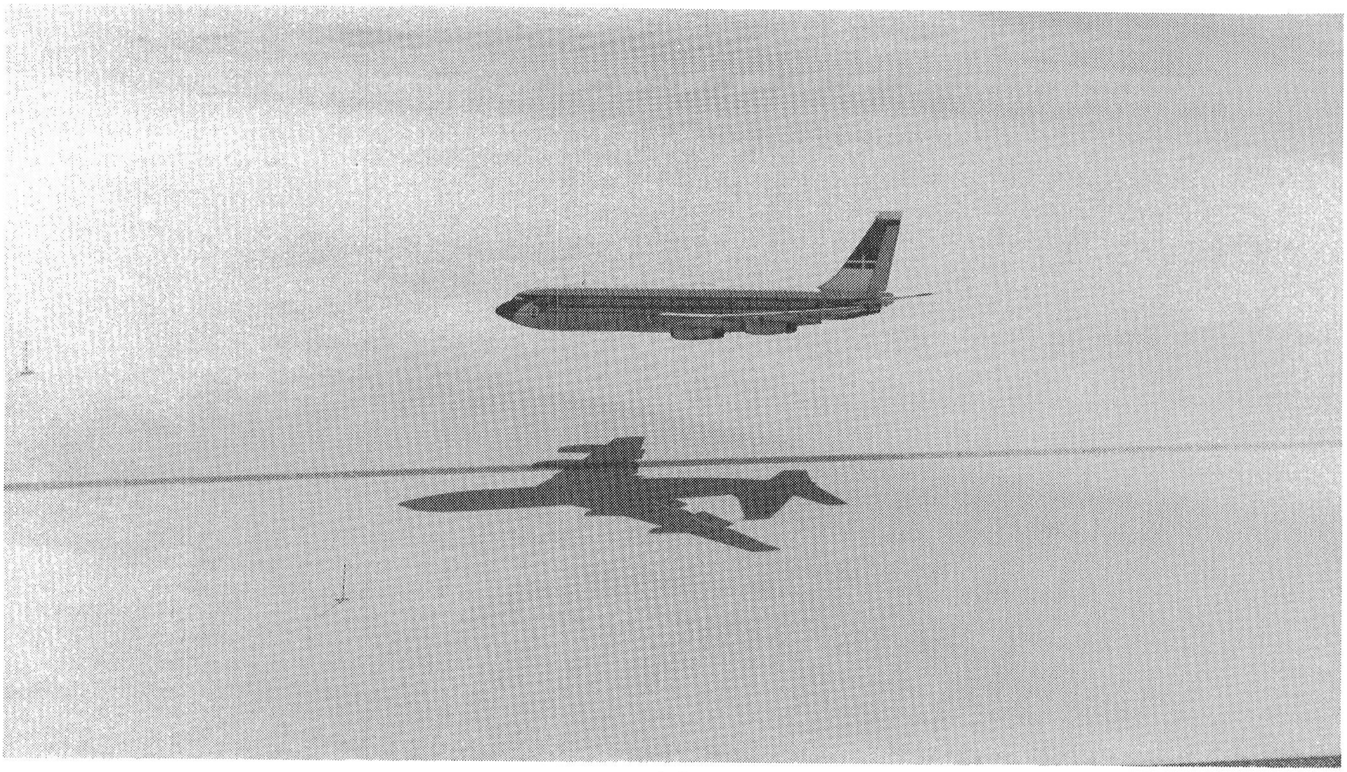
NOTE 2. MEASURED AT POINT OF INITIAL GROUND CONTACT (WHERE NUMBER 1 ENGINE IMPACTED THE GROUND).

NOTE 3. OVERHEAD PHOTOS ARE NEEDED TO DETERMINE VALUE. PHOTOS NOT YET RELEASED TO NASA.

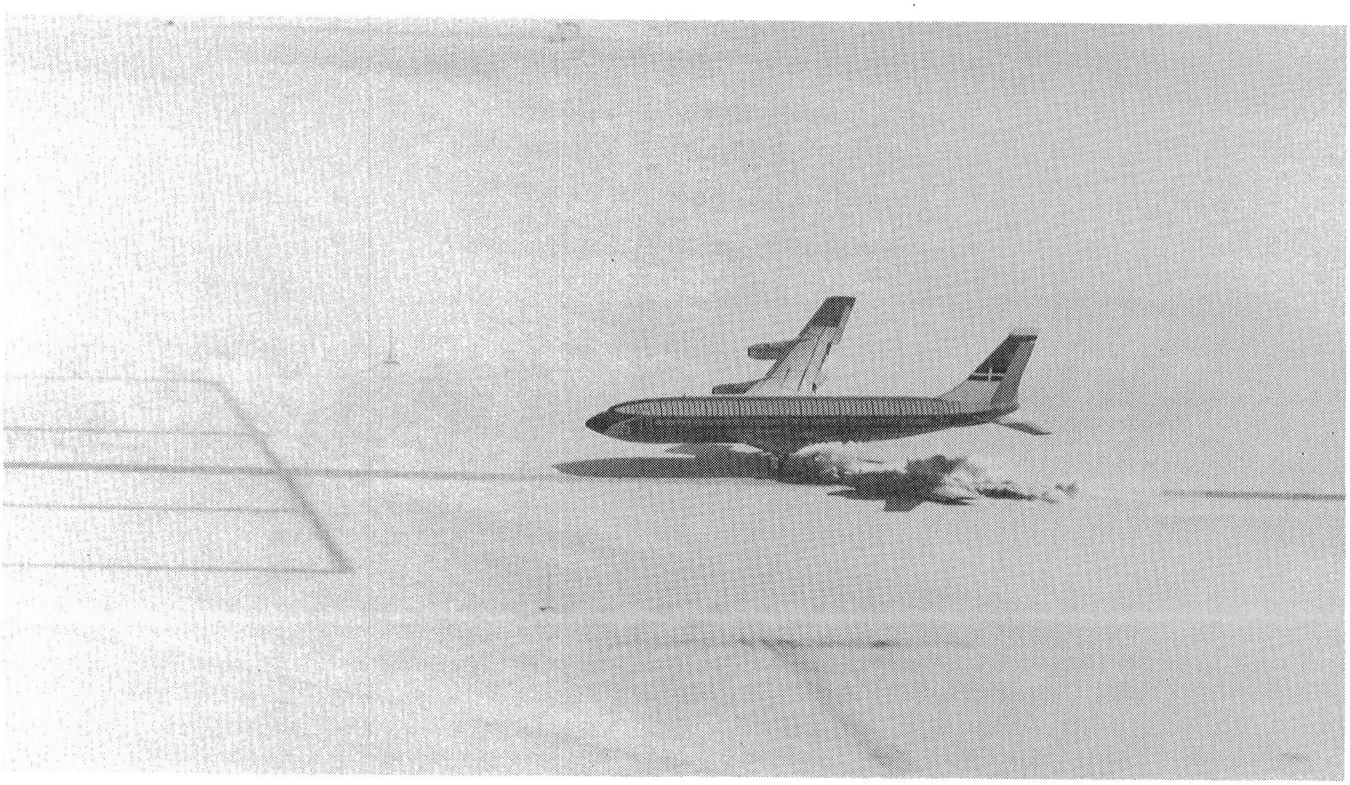
o ASSUMED AIRCRAFT WOULD BE STABILIZED AT IMPACT.

o AT 200 FT THE CID PROFILE WAS NOMINAL LONGITUDINALLY, OFF NOMINAL LATERALLY.

Figure 12. CID actual impact scenario.

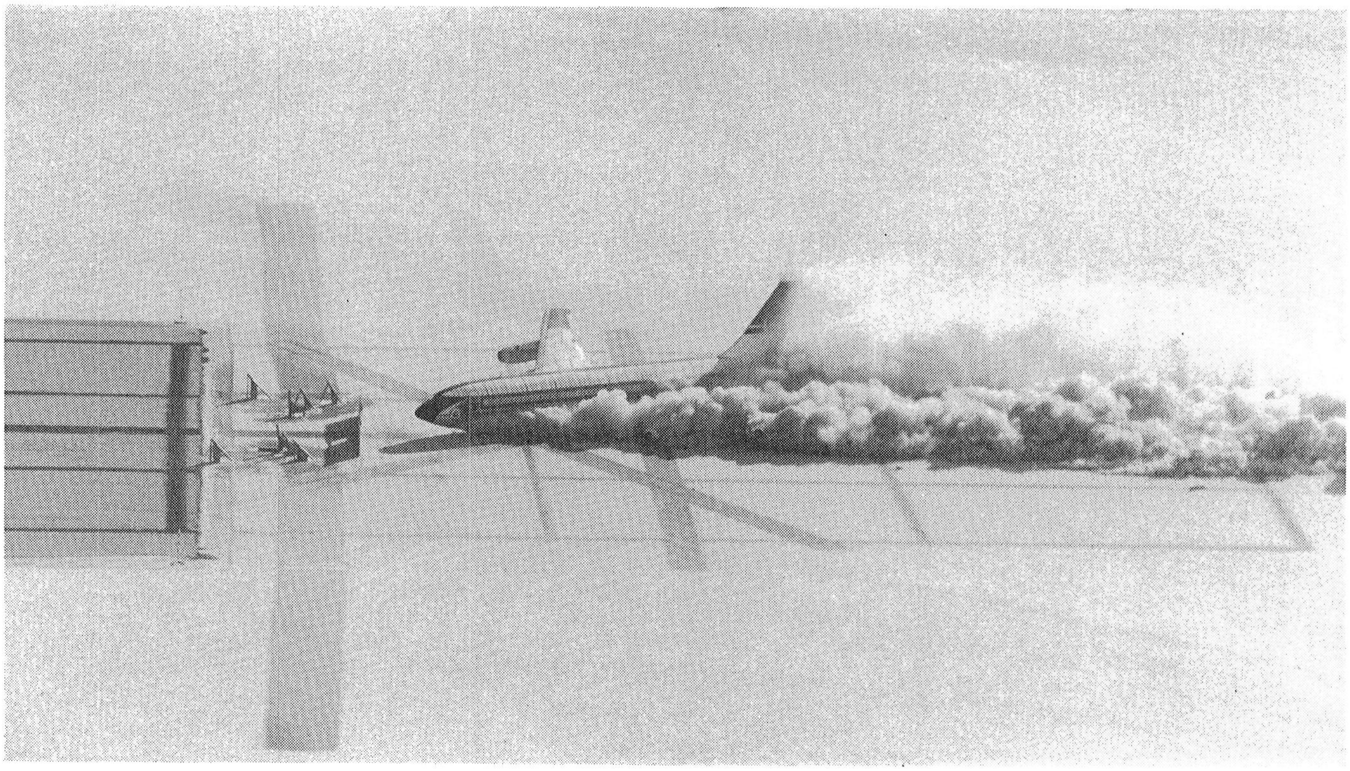


(a)

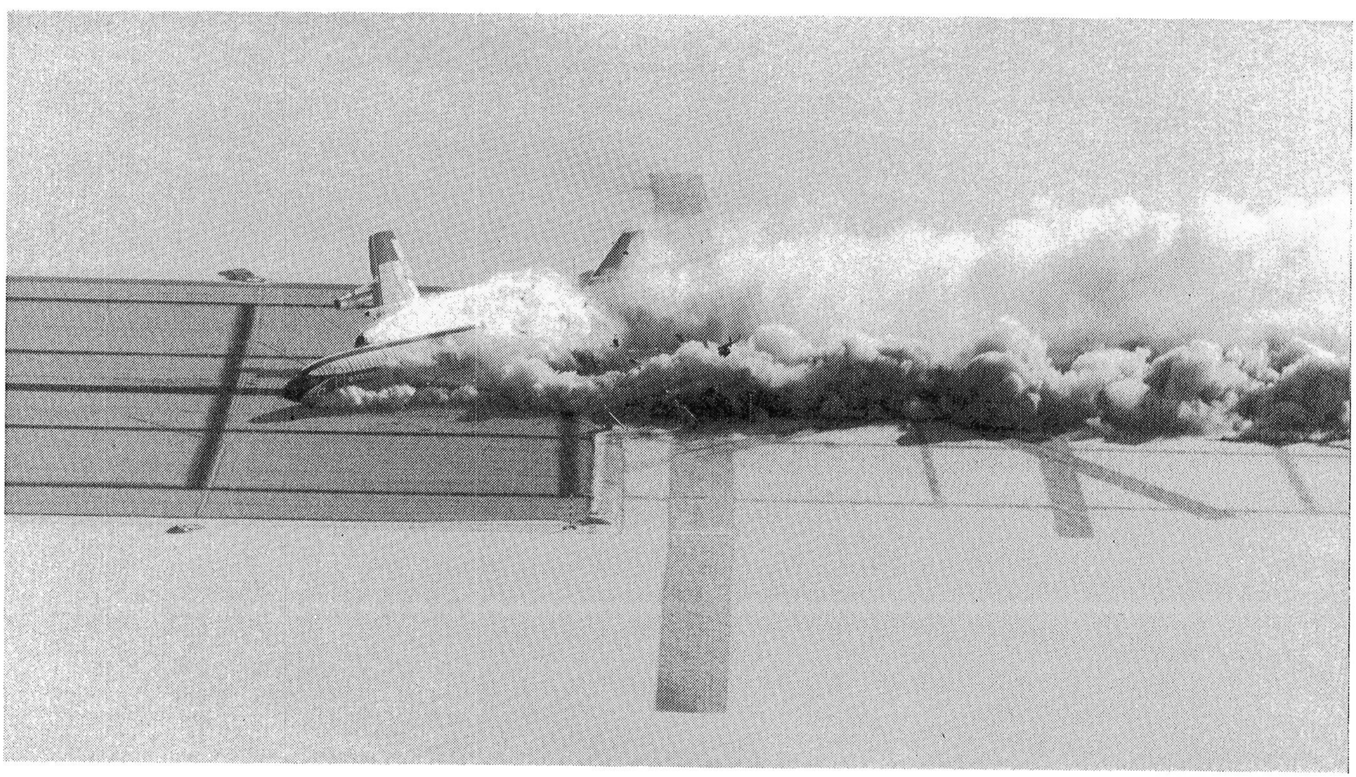


(b)

Figure 13. CID impact.



(c)



(d)

Figure 13. Concluded.