12/04/2003

"WING "D-1"

NTPS

Brief of Accident

Adopted 10/27/2005

LAX04FA057
File No. 18490 | 12/4/2003 | Rosamond, CA | Aircraft Reg No. N8602J | Time (Local): 08:54 PST

Make/Model: Wing Aircraft / D-1
Engine Make/Model: Lycoming / IO-320-B1C
Aircraft Damage: Destroyed
Number of Engines: 2
Operating Certificate(s): None
Type of Flight Operation: Instructional
Reg. Flight Conducted Under: Part 91: General Aviation

	Fatal	Serious	Minor/None
Crew	2	0	0
Pass	0	0	0

Last Depart. Point: Mojave, CA
Destination: Local
Airport Proximity: Off Airport/Airstrip

Condition of Light: Day
Weather Info Src: Weather Observation Facility
Basic Weather: Visual Meteorological Cond
Lowest Ceiling: None
Visibility: 10.00 SM
Wind Dir/Speed: Unk/Nr
Temperature (°C): 6
Precip/Obscuration: No Obscuration; No Precipitation

Pilot-in-Command Age: 59

Certificate(s)/Rating(s)
Airline Transport; Commercial; Multi-engine Land; Single-engine Land
Instrument Ratings
Airplane

Flight Time (Hours)

Total All Aircraft: 5763
Last 90 Days: 51
Total Make/Model: 122
Total Instrument Time: Unk/Nr

Following maneuvers during an instructional flight under visual meteorological conditions, the airplane departed from controlled flight, stalled, and entered a spin. In the uncontrolled descent, the airplane impacted desert terrain and was destroyed by impact forces. Wreckage was located over a 65-foot-wide, 122-foot-long north-northeasterly path less than 1/4-mile from the last radar recorded location. A circular area around the airplane was devoid of vegetation. The airplane was examined on-scene and following its recovery. Fuselage and cockpit structure was found partially collapsed in a downward direction. The continuity of the flight control system was confirmed, and no evidence of preimpact mechanical malfunction was found. The purpose of the flight was for the flight school's instructor to provide initial training to a foreign student pilot, who was an instructor pilot in military aircraft, and to familiarize him with the flight characteristics of the airplane prior to the student's enrollment in a test pilot program. The foreign pilot was not qualified to act as pilot-in-command of the accident airplane. The flight school's instructor was current in the accident airplane. The syllabus for the planned 1-hour-long familiarization flight included stalls, with the landing gear and wing flaps retracted and extended, in addition to velocity minimum control demonstrations. The instructor pilot was to demonstrate a maneuver followed by the student performing the maneuver. A review of radar data indicated that the airplane was maneuvered through a series of stalls from 0847 until 0853. At 0853:20, the airplane's altitude indicated 5,900 feet. At 0853:49, the altitude indicated 3,500 feet, and the groundspeed decreased to 60 knots, where it remained until the airplane disappeared from radar at 0853:54. The airplane's radar position remained relatively constant during the final seconds of recorded flight, as the airplane descended at 5,000 feet per minute until impacting 2,600 foot mean sea level (msl) terrain. It was not determined whether one or both of the pilots were handling the controls at the time the spin commenced. Flight records from the test pilot school indicated that the student had accrued one flight in a multiengine airplane, with a flight time of 1.2 hours. His total flight time was about 1,531 hours with the majority of his flight time accrued in F16 type military aircraft. The instructor, who was the director of flight operations and the flying safety officer for the school, had a total flight time of about 5,767 hours. An estimated 122 hours had been accumulated in the accident make and model airplane, with 27.4 of those hours accumulated in the past year. The weight and balance data was found to be within acceptable limits for the flight. The airplane flight manual prohibited the performance of spins. No determination could be made as to which pilot may have been manipulating the controls at the time of the departure from controlled flight.

LAX04FA057
File No. 18490 12/4/2003 Rosamond, CA Aircraft Reg No. N8602J Time (Local): 08:54 PST

Occurrence #1: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: MANEUVERING

Findings
1. STALL - PERFORMED - FLIGHTCREW
2. (C) AIRCRAFT CONTROL - NOT OBTAINED - PILOT IN COMMAND
3. (C) STALL/SPIN - INADVERTENT - FLIGHTCREW

Occurrence #2: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
4. TERRAIN CONDITION - GROUND

Findings Legend: (C) = Cause, (F) = Factor

The National Transportation Safety Board determines the probable cause(s) of this accident as follows.
The flying pilot's failure to obtain/maintain control of the airplane during practice stalls, which resulted in the inadvertent entry into a spin.

National Transportation Safety Board FACTUAL REPORT AVIATION	NTSB ID: LAX04FA057	Aircraft Registration Number: N8602J
	Occurrence Date: 12/4/2003	Most Critical Injury: Fatal
	Occurrence Type: Accident	Investigated By: NTSB

Location/Time

Nearest City/Place	State	Zip Code	Local Time	Time Zone
Rosamond	CA	93560	0854	PST

Airport Proximity: Off Airport/Airstrip	Distance From Landing Facility:	Direction From Airport:

Aircraft Information Summary

Aircraft Manufacturer	Model/Series	Type of Aircraft
Wing Aircraft	D-1	Airplane

Sightseeing Flight: No **Air Medical Transport Flight:** No

Narrative

Brief narrative statement of facts, conditions and circumstances pertinent to the accident/incident:

HISTORY OF FLIGHT

On December 4, 2003, at 0854 Pacific standard time, a Wing Aircraft, D-1, N8602J, collided with desert terrain while maneuvering about 11 nautical miles (nm) west-southwest of Rosamond, California. The National Test Pilot School (NTPS), located in Mojave, California, operated the airplane under the provisions of 14 CFR Part 91. The multiengine airplane was destroyed by impact forces. The airline transport pilot, who was acting as a flight instructor, and the student were fatally injured. Visual meteorological conditions prevailed, and a company flight plan was in effect. The instructional familiarization flight originated from runway 26 at the Mojave Airport, approximately 0832.

Prior to initiating the accident flight, the instructor briefed the student using a lesson plan. The specific stall and Vmc maneuvers to be performed were listed on a document, which the NTPS termed a "flight card." The anticipated length of the familiarization flight was 1 hour.

Recorded radar data indicates that the Mode C (altitude encoding) transponder equipped airplane departed from the Mojave Airport in a westerly direction. Thereafter, the airplane proceeded in a southwesterly direction and flew toward the area where the accident was to occur, with a ground speed between 100 and 140 knots. No altitude data was recorded by radar until about 0846, at which time the airplane's altitude indicated 6,000 feet. At 0849, after reversing course, the airplane's altitude decreased from 5,900 feet to 5,200 feet, with a groundspeed of about 80 knots. Thereafter, the airplane regained altitude. About 0850, the airplane's altitude decreased from 6,000 feet to 5,600 feet, with a ground speed of 80 knots within a matter a seconds. At 0853:20, the airplane's altitude indicated 5,900 feet. The airplane's position remained relatively constant on the radarscope during the final seconds of its recorded flight. At 0853:49, the altitude indicated 3,500 feet, and the groundspeed decreased to 60 knots, where it remained until the target disappeared from radar at 0853:54, at an altitude of 3,100 feet. The estimated location of the airplane when last observed on radar was about 34 degrees 50.600 minutes north latitude by 118 degrees 23.383 minutes west longitude. During the last 5 seconds of the radar track, the target depicted a left turn.

PERSONNEL INFORMATION

[redacted]nstructor.

A review of Federal Aviation Administration (FAA) airman records revealed the instructor held an airline

(Continued on next page)

Narrative (Continued)

transport pilot certificate with an airplane single engine rating. He also held a commercial pilot certificate with a multiengine land rating. His second-class medical certificate was issued on January 9, 2003. It had the limitations that the pilot must wear corrective lenses for near and distant vision. An examination of the instructor's logbook indicated he had accumulated an estimated 1,711 hours of civilian flight time. He had logged 52.2 hours in the last 90 days, and 18.9 in the last 30 days. He had an estimated 122 hours in the accident make and model airplane, with 27.4 hours over the past year. His total multiengine flight time was approximately 387 hours. NTPS management reported that the instructor was current in the accident airplane and authorized to provide the familiarization flight to the student.

The instructor was a graduate of the United States Air Force test pilot school. He served as the Director of Flight Operations, and as the Flying Safety Officer for the NTPS. He had an estimated total flying time of 5,767 hours. The majority of the instructor's flight time was in an F-4 (2,700 hours). The instructor had 400 hours of flight time in an E-8A/C (a modified Boeing 707). He had 1,600 hours of flight time as an instructor pilot in F-4 aircraft, 75 hours in an F-16, and 50 hours in other aircraft.

Student.

The student was a pilot for the Korean Air Force. He did not hold any FAA airman certificates; however, he was rated as an instructor pilot by the Korean Air Force. He maintained both F16 and instrument flying authorizations.

Based on flight time records submitted by the Korean Embassy, certified January 8, 2004, the student had an estimated total flying time of 1,531 hours, with 1,237 hours as pilot-in-command. He had been flying for the past 12 years. The majority of his total flight time, approximately 962 hours, was in F16C/D and KF16C/D (the Korean equivalent to the F16) aircraft. Most of his remaining flight time was in F5E/F aircraft (416 hours) and T37C airplanes (122 hours). The flight times submitted by the Korean Embassy did not include NTPS flights.

The NTPS's Deputy Director reported to the National Transportation Safety Board's investigator-in-charge (IIC) that the student was enrolled in the school's 6 week-long pre-Professional Test Pilot course (pre-TPS), in preparation for commencement of the 11-month-long test pilot program. The pre-TPS course provides, in pertinent part, familiarization training in the flight characteristics of the fuel injected, normally aspirated, reciprocating propeller-equipped airplane. The curriculum includes stalls, with the landing gear and wing flaps retracted and extended. The course also exposes the student to various maneuvers including velocity minimum control (Vmc) demonstrations with both the left (critical) engine and the right engine operating at reduced power

The student began his training at the NTPS in October 2003. He was preparing to enter the Professional Pilot course in January 2004. His flight time records at the school indicated that the first two flights were in helicopters, with a total flight time of 2.5 hours on November 17. On December 2, the pilot flew twice in single engine propeller airplanes, accumulating a total flight time of 2.0 hours. On December 3, he made one flight in a multiengine propeller airplane, with a flight time of 1.2 hours, and one flight in a single engine propeller airplane, logging 0.9 hours of flight time.

AIRPLANE INFORMATION

The accident airplane was a Wing D-1, serial number 9. The airplane was manufactured by Derringer.

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Narrative (Continued)

Emerald Enterprises LTD currently holds the type certificate. The Wing D-1 is a low-wing, multiengine airplane, with conventional propellers. A review of the airplane's logbooks revealed a total airframe time of 927.9 hours at the last 100-hour annual inspection. An annual inspection was completed on May 15, 2003. The Hobbs hour meter was placarded inoperative.

The airplane had a Textron Lycoming IO-320-B1C engine, serial number L-5782-55A, installed on the left side. Total time on the engine at the last 100-hour annual inspection was 355.9 hours.

The airplane had a Textron Lycoming IO-320-B1C engine, serial number L-5781-55A, installed on the right side. Total time on the engine at the last 100-hour annual inspection was 355.9 hours.

A review of the airframe, engine, and propeller maintenance records by the Safety Board IIC did not reveal evidence of any anomalies or uncorrected maintenance issues prior to the flight.

Fueling records at the East Kern Airport District established that the airplane was last fueled on December 2, 2003, with the addition of 5.7 gallons of 100LL octane aviation fuel. The flight departed with 60 gallons of fuel on board.

The airplane's approved flight manual (AFM) states that the stall speeds for the airplane are 80 miles per hour (mph) indicated airspeed in the clean configuration, and 72 mph with the gear and flaps extended. Aerobatic maneuvers, including spins, are prohibited. A stall speed chart indicated that the stall speeds increase as the angle of bank increases. The chart specified the following stall airspeeds:

Flaps Up (Power off)

0 degrees Angle of Bank	at	80 mph, IAS
15 degrees Angle of Bank		81 mph
30 degrees Angle of Bank		86 mph
45 degrees Angle of Bank		95 mph
60 degrees Angle of Bank		113 mph

Flaps Down (Power off)

0 degrees Angle of Bank	at	72 mph, IAS
15 degrees Angle of Bank		73 mph
30 degrees Angle of Bank		77 mph
45 degrees Angle of Bank		86 mph
60 degrees Angle of Bank		102 mph

WRECKAGE AND IMPACT INFORMATION

The Safety Board IIC, an FAA inspector, a Lycoming representative, and a representative from Flight Research, Inc., examined the wreckage at the accident scene on December 5, 2003. The airplane impacted level desert 2,600-foot mean sea level (msl) terrain less than 1/4-mile from the last location at which it was observed on radar. The wreckage was found at the following approximate global positioning satellite coordinates: 34 degrees 50.682 minutes north latitude by 118 degrees 23.299 minutes west longitude. A circular area around the airplane was devoid of vegetation. The wreckage was distributed in an area approximately 65 feet wide and 122 feet long. The nose of the airplane came to rest facing a

(Continued on next page)

Narrative (Continued)

north-northeasterly direction. Fuselage and cockpit structure was found partially collapsed in a downward direction.

Flight control continuity was established through the aileron, rudder, and elevator control systems, to the cockpit area. The left and right aileron cables were intact to the cockpit area. The right rudder cable displayed "broomstrawing" at its breaking point.

The elevator was controlled through a series of push-pull tubes. The rear push-pull tube was found separated at the belly mounted pivot follower. A 3-inch end section that attached the rear push-pull tube to the follower was not recovered. The attachment to the follower displayed a smeared surface on one side; the other displayed a grainy appearance, broken at a 45-degree angle. A bolt attachment to the forward follower was sheared. The control tube was bowed at the fuel selector location.

No control stop deformation, bending, or over-travel evidence consistent with flight control surface flutter was detected.

The cockpit area was examined. The mixture controls were found in the full-forward position. The propeller controls were in the full-forward position and curled right. The throttle controls were in the aft position. The left and right magnetos' switches were in the both position and clicked when turned to the off position. The landing gear selector was in the down position and displaced slightly right. Both control yokes were in the full aft position and bent downward. The left yoke vertical grip on the right side was not attached. Neither of the right yoke vertical grips were attached.

The flap actuators indicated that the flaps were symmetrically extended in a down position. The elevator trim position indicated neutral. The rudder and aileron trim setting was not determined.

The canopy was found on the left side of the airplane, aft of the left wing, in an inverted position. The latches were found in the deformed fuselage structure with the actuator control rods broken. The canopy seal did not display any over-travel signatures.

The oleo struts on the left and right main landing gear were oriented perpendicular to the fuselage. The wheels were bent aft. The nose gear was deformed back and upward.

The engines and propellers were examined. The left engine crankshaft was rotated. Fuel was present throughout the system. The flow divider was examined, the gaskets were intact, and no perforations or holes were found. The spark plug electrodes were gray in color, which corresponded to normal operation according to the Champion Aviation Check-A-Plug AV-27 Chart. The left propeller remained attached to the left engine. Blade 1 was undamaged. Blade 2 was bent slightly aft. Chordwise striations were found on the cambered surface, and none were found on the face. There was no evidence of leading edge gouging.

The right engine crankshaft was rotated. Fuel was present throughout the system. The flow divider was examined, the gaskets were intact, and no perforations or holes were found. The top spark plug electrodes were dark and sooty, which corresponded to rich operation according to the Champion Aviation Check-A-Plug AV-27 Chart. The bottom spark plugs, excluding cylinder number 4 (which could not be removed), were white in color, which corresponded to lean operation according to the Champion Aviation Check-A-Plug AV-27 Chart. The number 3 and number 4 cylinders were borescoped. Their coloration was consistent with normal

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Narrative (Continued)

operation. The right propeller hub was found detached and forward of the right engine. Blade 1 did not display any torsional deformation. Chordwise striations were found on both the cambered and face side. There was no evidence of leading edge gouging. Blade 2 was undamaged.

Fuel was found in desert soil beneath both wings. Fuel was also detected in the airplane's fuel lines.

METEROLOGICAL INFORMATION

The closest aviation weather observation station to the accident site was at Mojave (MHV), 17 nm northeast of the accident site. The elevation at MHV is 2,791 feet msl. A routine aviation weather report (METAR) for Mojave was issued at 0845. It stated: skies clear; visibility 40 miles; winds calm; temperature 16 degrees Fahrenheit; altimeter 30.20 InHg.

MEDICAL AND PATHOLOGICAL

The Kern County Coroner completed autopsies on the instructor and the student. They also performed toxicological tests which were negative for drugs of abuse and alcohol.

The FAA Toxicology and Accident Research Laboratory performed toxicological testing of specimens from the instructor and the student. According to the postmortem toxicology report, results for the student were negative for carbon monoxide, cyanide, ethanol and screened drugs. The toxicology report for the instructor was negative for carbon monoxide, cyanide, and screened drugs. The instructor's toxicological test results were positive for the following:

10 mg/dL, mg/hg ETHANOL detected in Blood
33 mg/dL, mg/hg ACETALDEHYDE in Blood.

The report indicated that the ethanol found in this case was from postmortem ethanol formation and not from the ingestion of ethanol.

TESTS AND RESEARCH

The airplane was recovered from the accident scene and was reexamined on December 8, 2003. The upper right leg of the cockpit's flight control Y was observed bent and broken. The vertical portion of the control Y exhibited a bending break consistent with an over-travel in the direction it was observed bent.

The NTSB Materials Laboratory examined fore and aft portions of the left rudder control cable. The Supervisory Metallurgist concluded that all features on the cable pieces were typical of an overstress separation. There was no evidence of corrosion or wear.

The elevator control tube was severed at the follower assembly, and a 3-inch section that attached the aft elevator control tube to the follower was not recovered. The airplane representative examined the sections of elevator control tube involved in the accident and the elevator control assembly of a sister ship. By design, the attachments of both the fore and aft elevator tubes are fixed at both ends. The tube moves along a follower assembly. With the elevator in the full aft position, the aft control tube attachment rests against the follower assembly. The representative opined that the aft elevator tube was sheared just aft of the attachment

(Continued on next page)

Narrative (Continued)

as ground impact occurred.

According to FAA personnel, air traffic control did not assign the accident airplane a discrete transponder squawk code. A review of recorded airport surveillance radar, from the High Desert Terminal Radar Approach Control facility located at the Edwards Air Force Base, was undertaken for the flight tracks of all aircraft departing runway 26 and disappearing over the crash site. Only one radar track matched the accident airplane's projected flight track. Safety Board investigators reviewed the flight track for this airplane during a real-time replay event at the Edwards Air Force Base facility in order to determine the flight path.

A Safety Board Research and Engineering specialist also reviewed the radar hits and the airplane's projected flight path. The entry speed into the final maneuver was calculated to be 92 mph, and the descent rate increased to more than 5,000 feet per minute. The flight path indicated by the final radar returns described a left spiral.

The Director of the NTPS performed an analysis of the radar data using the accident airplane's performance and flying qualities in conjunction with the flight test card. He had flown with the instructor pilot on numerous occasions and was familiar with the operating characteristics of the accident airplane. The assumed test sequence was the instructor pilot demonstrating the flight test technique (FTT) and the student pilot performing the FTT. The exception to the sequence would be the climb and level flight stabilized data points.

The Director associated the radar data with the estimated flight times it would take to perform the flight card requirements. The stall series was calculated to occur from 0847 until 0853. Based on the Director's calculations, the last stall to be performed was a "Level Flight Power Approach (PA) Configuration Stall." From the performance calculations, the Director concluded that the instructor first demonstrated the maneuver, and then control of the airplane was handed to the student. Recover from the initial stall appeared to have been straight ahead, and then the airplane stalled again at which time the airplane turned to the right. Following recovery, the airplane stalled again. It was at this point that the airplane presumably departed controlled flight. The Director concluded that the airplane entered a spin in the power approach (PA) configuration at approximately 6,000 feet and impacted the ground after approximately seven turns in a flat spin.

WEIGHT AND BALANCE

The weight and balance data for the flight was reviewed. The total takeoff weight was 2,896 pounds. The maximum takeoff weight for the airplane was 3,100 pounds. The center of gravity (CG) was 90.9 inches aft of the datum. The maximum forward CG for the airplane was 89.5 inches aft of datum and the maximum aft CG was 93.0 inches aft of datum.

ADDITIONAL INFORMATION

The airplane was released to the owner's representative on March 4, 2004.

National Transportation Safety Board
FACTUAL REPORT
AVIATION

NTSB ID: LAX04FA057

Occurrence Date: 12/4/2003

Occurrence Type: Accident

Landing Facility/Approach Information

Airport Name	Airport ID:	Airport Elevation	Runway Used	Runway Length	Runway Width
		Ft. MSL	NA		

Runway Surface Type: Unknown

Runway Surface Condition: Unknown

Type Instrument Approach: NONE

VFR Approach/Landing: None

Aircraft Information

Aircraft Manufacturer	Model/Series	Serial Number
Wing Aircraft	D-1	9

Airworthiness Certificate(s): Normal

Landing Gear Type: Retractable - Tricycle

Homebuilt Aircraft? No	Number of Seats: 2	Certified Max Gross Wt. 3050 LBS	Number of Engines: 2

Engine Type:	Engine Manufacturer:	Model/Series:	Rated Power:
Reciprocating	Lycoming	IO-320-B1C	160 HP

- Aircraft Inspection Information

Type of Last Inspection	Date of Last Inspection	Time Since Last Inspection	Airframe Total Time
Annual	05/2003	7.4 Hours	936.6 Hours

- Emergency Locator Transmitter (ELT) Information

ELT Installed? Yes	ELT Operated? Yes	ELT Aided in Locating Accident Site? No

Owner/Operator Information

	Street Address	City	State	Zip Code
Registered Aircraft Owner: DAC Holdings, Inc.	802 N. West Street	Wilmington	DE	19801
Operator of Aircraft: National Test Pilot School	1039 Flightline #72	Mojave	CA	93501

Operator Does Business As:

Operator Designator Code:

- Type of U.S. Certificate(s) Held: None

Air Carrier Operating Certificate(s):

Operating Certificate:

Operator Certificate:

Regulation Flight Conducted Under: Part 91: General Aviation

Type of Flight Operation Conducted: Instructional

National Transportation Safety Board
FACTUAL REPORT
AVIATION

NTSB ID: LAX04FA057
Occurrence Date: 12/4/2003
Occurrence Type: Accident

First Pilot Information

Name	City	State	Date of Birth	Age
On File	On File	On File	On File	59

Sex: M | Seat Occupied: Right | Principal Profession: Occupational Pilot | Certificate Number: On File

Certificate(s): Airline Transport; Commercial

Airplane Rating(s): Multi-engine Land; Single-engine Land

Rotorcraft/Glider/LTA: None

Instrument Rating(s): Airplane

Instructor Rating(s): None

Type Rating/Endorsement for Accident/Incident Aircraft? | Current Biennial Flight Review? 01/2003

Medical Cert.: Class 2 | Medical Cert. Status: Valid Medical--w/ waivers/lim. | Date of Last Medical Exam: 01/2003

Flight Time Matrix	All A/C	This Make and Model	Airplane Single Engine	Airplane Mult-Engine	Night	Instrument Actual	Instrument Simulated	Rotorcraft	Glider	Lighter Than Air
Total Time	5763	122	1693	4070	1146					
Pilot In Command(PIC)	4685	121	1376	3309	1136					
Instructor	2985	100	865	2120	593					
Last 90 Days	51	24	27	24						
Last 30 Days	18	5	4	14						
Last 24 Hours	1			1						

Seatbelt Used? Yes | Shoulder Harness Used? Yes | Toxicology Performed? Yes | Second Pilot? Yes

Flight Plan/Itinerary

Type of Flight Plan Filed: Company VFR

Departure Point	State	Airport Identifier	Departure Time	Time Zone
Mojave	CA	MHV	0832	PST

Destination	State	Airport Identifier
Local Flight		MHV

Type of Clearance: None

Type of Airspace: Class G

Weather Information

Source of Briefing: Unknown

Method of Briefing: Unknown

National Transportation Safety Board FACTUAL REPORT AVIATION	NTSB ID: LAX04FA057
	Occurrence Date: 12/4/2003
	Occurrence Type: Accident

Weather Information

WOF ID	Observation Time	Time Zone	WOF Elevation	WOF Distance From Accident Site	Direction From Accident Site
WJF	0856	PDT	2348 Ft. MSL	10 NM	239 Deg. Mag.

Sky/Lowest Cloud Condition: Clear Ft. AGL		Condition of Light: Day	
Lowest Ceiling: None Ft. AGL	Visibility: 10 SM	Altimeter: 30.19 "Hg	
Temperature: 6 °C	Dew Point: -6 °C	Wind Direction:	Density Altitude: Ft.
Wind Speed: 0	Gusts: 0	Weather Condtions at Accident Site: Visual Conditions	
Visibility (RVR): Ft.	Visibility (RVV) SM	Intensity of Precipitation:	

Restrictions to Visibility: No Obscuration; No Precipitation

Type of Precipitation:

Accident Information

Aircraft Damage: Destroyed	Aircraft Fire: None	Aircraft Explosion None

[redacted]ssification: U.S. Registered/U.S. Soil

- Injury Summary Matrix	Fatal	Serious	Minor	None	TOTAL
First Pilot					
Second Pilot					
Student Pilot	1				1
Flight Instructor	1				1
Check Pilot					
Flight Engineer					
Cabin Attendants					
Other Crew					
Passengers					
- TOTAL ABOARD -	2				2
Other Ground					
- GRAND TOTAL -	2				2

NTSB ID:	LAX04FA057
Occurrence Date:	12/4/2003
Occurrence Type:	Accident

Administrative Information

Investigator-In-Charge (IIC)

Wayne Pollack

Additional Persons Participating in This Accident/Incident Investigation:

Frank Motter
Aviation Safety Inspector
Federal Aviation Administration
16501 Sherman Way, Suite 330
Van Nuys, CA 91406

Dan Chandler
Flight Research, Inc.
1062 Flight Line, Hangar 161
Mojave, CA 93501

John Butler
Air Safety Investigator
Lycoming
Arlington, TX 76014

National Transportation Safety Board

Docket Contents

Project Information

Project ID (mkey)	Mode	Location
58431	Aviation	
NTSB Accident ID	**Occurrence Date**	**Location**
LAX04FA057	Dec 04, 2003	Rosamond, CA, United States

Docket Information

Creation Date	Last Modified	Public Release Date & Time
Apr 13, 2004	Aug 02, 2005 16:54	Aug 02, 2005 13:58

Comments

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FORM APPROVED FOR USE THROUGH 7/31/96 BY OMB NO.3147-0001.

NATIONAL TRANSPORTATION SAFETY BOARD
PILOT/OPERATOR AIRCRAFT ACCIDENT REPORT
This form To Be Used For Reporting Civil Aircraft Accidents Involving Commercial and General Aviation Aircraft

Location

Nearest City/Place, State, Zip Code	Date of Accident	Local Time (24 HOUR CLOCK)	Zone	Elevation At Accident Site
ROSAMOND, CA, 93560	4 Dec 2003	0912	PST	2650 Feet MSL; Feet MSL

If The Accident Occurred On Approach, Takeoff or Within 3 Miles of An Airport, Complete The Following Information N/A

Proximity To Airport
1.☐ On Approach 3.☐ Within 1/2 Mile 5.☐ Within 1 Mile 7.☐ Within 3 Miles
2.☐ Within 1/4 Mile 4.☐ Within 3/4 Mile 6.☐ Within 2 Miles 8.☑ Beyond 3 Miles

Airport Name	Airport Ident	Runway/Landing Surface Conditions:
		1.☐ Direction: 2.☐ Length: 3.☐ Width: 4.☐ Surface: 5.☐ Condition:

Phase Of Operation:
1.☐ Standing 3.☐ Takeoff 5.☐ Cruise 7.☐ Approach 9.☑ Hover/Maneuver
2.☐ Taxi 4.☐ Climb 6.☐ Descent 8.☐ Landing 10.☐ Altitude Of In-Flight Occurrence 3100 Feet MSL

Aircraft Information

Registration Mark	Aircraft Manufacturer	Aircraft Type/Model	Serial Number	Cert Max Gross WT
N8602J	WING AIRCRAFT CO.	Derringer D-1	009	3050 #

Type Of Aircraft
1.☑ Airplane 2.☐ Helicopter 3.☐ Glider 4.☐ Balloon 5.☐ Blimp/Dirigible 6.☐ Ultralight 7.☐ Gyroplane 8.☐ Specify

Type Of Airworthiness Certificate
1.☑ Normal 2.☐ Utility 3.☐ Acrobatic 4.☐ Transport 5.☐ Restricted 6.☐ Limited 7.☐ Experimental 8.☐ Specify

Amateur Built
1.☐ Yes 2.☑ No

Landing Gear
1.☐ Tricycle—Fixed 2.☑ Tricycle—Retractable 3.☐ Tailwheel—Fixed 4.☐ Tailwheel—Retractable 5.☐ Tailwheel—Retractable Mains 6.☐ Amphibian 7.☐ Skid 8.☐ Limited 9.☐ Specify

No. Of Seats
Flight/Cabin Crew 2
Pax 0

Stall Warning System Installed
1.☑ Yes 2.☐ No

IFR Equipped
1.☑ Yes 2.☐ No

Engine Type
1.☐ Reciprocating—Carburetor 2.☑ Reciprocating—Fuel Injected 3.☐ Turbo Prop 4.☐ Turbo Jet 5.☐ Turbo Fan 6.☐ Turbo Shaft

Engine Manufacturer	Engine Model/Series	Engine Rated Power	Type Of Fire Extinguishing System Used
LYCOMING	IO-320-B1C	each, 1. 160 Horsepower; 2. Lbs Thrust	1. None; 2. Specify

Engine(s)	Date of Mfg.	Mfg. Serial No.	Total Time	Time Since Inspection	Time Since Overhaul
Engine No. 1		L-5782-55A	936.6 Hours	7.4 Hours	579.4 Hours
Engine No. 2		L-5781-55A	936.6 Hours	7.4 Hours	579.4 Hours
Engine No. 3			Hours	Hours	Hours
Engine No. 4			Hours	Hours	Hours

Type Of Maintenance Program
1.☐ Annual 2.☐ Manufacturer's Inspection Program 3.☐ Other Approved Inspection Program(AAIP) 4.☐ Continuous Airworthiness 5.☑ Specify 100 Hr.

Type Of Last Inspection
1.☑ Annual 2.☐ 100 Hours 3.☐ AAIP 4.☐ Continuous Airworthiness

Date Last Inspection Performed May 15 2003 (M/D/Y)
Time Since Last Inspection 7.4 Hours
Airframe Total Time 936.6 Hours

Emergency Locator Transmitter (ELT)	ELT Manufacturer	Model/Series	Serial Number	Battery Date
	NARCO	ELT 10	74607	(M/D/Y) 2-21-02

Switch: 1.☐ On 2.☐ Off 3.☑ Armed
Operated: 1.☑ Yes 2.☐ No
Aided In Accident Location: 1.☐ Yes 2.☑ No

Registered Aircraft Owner
DAC HOLDINGS INC.
Address 802 N. WEST ST
WILMINGTON DE. 19801-1526

Operator Of Aircraft
1.☐ Same As Registered Owner
2. Name NATIONAL TEST PILOT SCHOOL
3. DBS:

Address
1.☐ Same As Registered Owner
2. 1039 FLIGHTLINE #72
MOJAVE CA 93501

Owner / Operator Information (cont.)

Operator (Certificate Number)	Operator Designator (4 Letter Designator)
N/A	N/A

Purpose Of Flight And Type Of Operation

Regulation Flight Conducted Under
- 1. [x] FAR91 (only) 4. [ ] FAR 121 7. [ ] FAR 133
- 2. [ ] FAR91D 5. [ ] FAR 125 8. [ ] FAR 135
- 3. [ ] FAR 103 6. [ ] FAR 129 9. [ ] FAR 137

Purpose of Flight
- 1. [ ] Personal 6. [ ] Aerial Observation
- 2. [x] Business 7. [ ] Other Work Use
- 3. [ ] Educational 8. [ ] Public Use
- 4. [ ] Executive/Corporate 9. [ ] Ferry
- 5. [ ] Aerial Application 10. [ ] Positioning

Operator Authority
- FAR121: 1. [ ] Domestic 2. [ ] Flag 3. [ ] Supplemental
- FAR 135: 4. [ ] On Demand 5. [ ] Commuter
- FAR 133: 6. [ ] Rotorcraft External Load
- FAR125: 7. [ ] Large Aircraft
- FAR 129: 8. [ ] Foreign

FAR 121, 125, 127, 129, 135 Revenue Operations
- 1. [ ] Scheduled
- 2. [ ] Non Scheduled
- 3. [ ] Domestic
- 4. [ ] International
- 5. [ ] Passenger
- 6. [ ] Cargo
- 7. Specify______

Pilot Information

Pilot Name	Pilot Certificate No.	Address	Nationality
Ronald Gay Bradley	[redacted]	[redacted] Lake Havasu City, AZ 86406	U.S.

Certificate (s)
- 1. [ ] Student 3. [x] Commercial 5. [ ] Flight Instructor 7. [ ] Military 9. [ ] None
- 2. [ ] Private 4. [x] Airline Transport 6. [ ] Flight Engineer 8. [ ] Foreign 10. Specify______

Rating (s)
- 1. [ ] None 6. [ ] Helicopter
- 2. [x] Single Engine Land (ATP) 7. [ ] Glider
- 3. [ ] Single Engine Sea 8. [ ] Free Balloon
- 4. [x] Multiengine Land (Comm) 9. [ ] Airship
- 5. [ ] Multiengine Sea 10. [ ] Gyroplane

Instrument Rating (s)
- 1. [x] None
- 2. [ ] Airplane
- 3. [ ] Helicopter

Instructor Rating (s)
- 1. [x] None 6. [ ] Instrument Airplane
- 2. [ ] Airplane S.E. 7. [ ] Instrument Helicopter
- 3. [ ] Airplane M.E. 8. [ ] Ground Instructor
- 4. [ ] Helicopter 9. [ ] Specify______
- 5. [ ] Glider

Type Ratings/Student Endorsements: B-707 B-737 B-720

Date Of Biennial Flight Review or Equivalent (M/D/Y): 01/27/03

BFR Aircraft
1. Make: Beech
2. Model: Be-33

Medical Certificate
- 1. [ ] None 3. [x] Class 2
- 2. [ ] Class 1 4. [ ] Class 3

Date Of Last Medical (M/D/Y): 01/09/03

Limitations: Holder shall wear corrective lenses for distant + near vision

Waivers: —

Date Of Birth (M/D/Y): [redacted]

Degree Of Injury
- 1. [ ] None
- 2. [ ] Minor
- 3. [ ] Serious
- 4. [x] Fatal

Seat Occupied
- 1. [ ] Left 4. [ ] Front
- 2. [x] Right 5. [ ] Rear
- 3. [ ] Center

Person At Controls At Time Of Accident
- 1. [x] Pilot In Control 4. [ ] Non-Pilot
- 2. [ ] Second Pilot 5. [ ] No One
- 3. [ ] Both Pilots

Seat Belt Available
- 1. [x] Yes
- 2. [ ] No

Seat Belt Used
- 1. [x] Yes
- 2. [ ] No

Shoulder Harness Available
- 1. [x] Yes
- 2. [ ] No

Shoulder Harness Used
- 1. [x] Yes
- 2. [ ] No

Source Of Pilot Flight Time Information
- 1. [x] Pilot Logbook 4. [ ] Company
- 2. [x] Operators Estimate 5. [ ] Specify______
- 3. [ ] FAA Records

Flight Time	All A/C	This Make & Model	Airplane Single Engine	Airplane Multiengine	Night	Instrument Actual	Instrument Simulated	Rotorcraft	Glider	Lighter Than Air
Total Time	5763	122	1693	4070	1146	300 total				
Pilot In Command (PIC)	4685	121	1376	3309	1136	unknown				
Instructor	2985	100	865	2120	593	unknown				
This Make & Model	[redacted]				—	—		[redacted]		
Last 90 Days	57	24	27	24	—	—				
Last 30 Days	18	5	4	14	—	—				
Last 24 Hours	1	—	—	1	—	—				

Second Pilot Information

Second Pilot Responsibilities At The Time Of Accident
- 1. [ ] Co-Pilot 2. [x] Dual Student 3. [ ] Safety Pilot 4. [ ] Check Pilot 5. [ ] None (Pilot-Rated Passenger)

Pilot Name	Pilot Certificate No.	Address	Nationality
Major Cheongin Kim	Korean Air Force Military	[redacted] Sachencity, Jesung apt. 12-502	Korean

Certificate (s)
- 1. [ ] Student 3. [ ] Commercial 5. [ ] Flight Instructor 7. [x] Military 9. None______
- 2. [ ] Private 4. [ ] Airline Transport 6. [ ] Flight Engineer 8. [x] Foreign 10. Specify______

} Korean Air Force

Second Pilot Information (cont.)

Rating (s)
1.☐ None
2.☐ Single Engine Land
3.☐ Single Engine Sea
4.☐ Multiengine Land
5.☐ Multiengine Sea
6.☐ Helicopter
7.☐ Glider
8.☐ Free Balloon
9.☐ Airship
10.☐ Gyroplane

Instrument Rating (s)
1.☐ None
2.☑ Airplane
3.☐ Helicopter
Korean Air Force F-16 Instrument Rating

Instructor Rating (s)
1.☐ None
2.☐ Airplane S.E.
3.☐ Airplane M.E.
4.☐ Helicopter
5.☐ Glider
6.☐ Instrument Airplane
7.☐ Instrument Helicopter
8.☐ Ground Instructor
9.☑ Specify Korean Air Force F-16 Instructor

Type Ratings/Student Endorsements
F-16 Korean Air Force

Date Of Biennial Flight Review or Equivalent (M/D/Y) As Req'd by Korean Air Force

BFR Aircraft
1. Make N/A
2. Model

Medical Certificate
1.☐ None
2.☐ Class 1
3.☐ Class 2
4.☐ Class 3
Korean Air Force

Date Of Last Medical (M/D/Y)
Unknown
Korean Air Force

Limitations —

Waivers —

Date Of Birth (M/D/Y) [redacted]

Degree Of Injury
1.☐ None
2.☐ Minor
3.☐ Serious
4.☑ Fatal

Seat Occupied
1.☑ Left
2.☐ Right
3.☐ Center
4.☐ Front
5.☐ Rear

Seat Belt Available
1.☑ Yes
2.☐ No

Seat Belt Used
1.☑ Yes
2.☐ No

Shoulder Harness Available
1.☑ Yes
2.☐ No

Shoulder Harness Used
1.☑ Yes
2.☐ No

1.☐ Pilot Logbook
2.☐ Operators Estimate
3.☐ FAA Records
4.☐ Company
5.☑ Specify Student Background Info Sheet

Flight Time	All A/C	This Make & Model	Airplane Single Engine	Airplane Multiengine	Night	Instrument Actual	Instrument Simulated	Rotorcraft	Glider	Lighter Than Air
Total Time	1545	—	1003	542	Unknown (Korea)					
Pilot In Command (PIC)	Unknown	—	Unknown (Kor)							
Instructor	Unknown	—	Unknown (Kor)							
This Make & Model										
Last 90 Days	F-16 Kor	—	F16 Kor	1.2						
Last 30 Days	4.1	—	2.9	1.2						
Last 24 Hours	2.1	—	0.9	1.2						

Other Personnel N/A

	Name	Seat	Address (City & State)	Crew	Non-Revenue	Revenue	Non-Occupant	FAA	Fatal Serious Minor None
1.									
2.									
3.									
4.									
5.									
6.									

Flight Itinerary Information

Last Departure Point
1. Airport ID KMHV
2. City/Place Mojave
3. State California

Time Of Departure
1. Time 0832 (L)
2. Time Zone PST

Destination
1. Airport ID KMHV
2. City/Place Mojave
3. State California

Flight Plan Filed
1.☑ None
2.☐ VFR
3.☐ IFR
4.☐ VFR/IFR
5.☐ Company (VFR)
6.☐ Military (VFR)

If Weather Was Involved, State If Weather Briefing Was Obtained or If Weather Reports Were Checked And How It Was Accomplished
Weather not a factor: Clear, vis 25 miles +, no turbulence

Fuel On Board At Last Takeoff
60 Gallons
or
Pounds

Fuel Type
1.☐ 80/87
2.☑ 100 Low Lead
3.☐ 100/130
4.☐ 115/145
5.☐ Jet A
6.☐ Automotive
7.Specify

Other Services, If Any, Prior to Departure
N/A

Weather Information At The Accident Site Same as in flight

Source Of Weather Information (Pilot/Operator, Weather Observation)
Pirep

Light Condition
1.☐ Dawn
2.☑ Daylight
3.☐ Dusk
4.☐ Bright Night
5.☐ Dark Night

Visibility 25+ Miles

Temp (°F) 60

Weather Information At The Accident Site (cont.)

Dew Point	Altimeter Setting	Sky/Lowest Cloud Condition
30 (°F)	30.21 "Hg	1.☑ Clear; 2.☐ Scattered ____ Feet AGL; 3.☐ Broken ____ Feet AGL; 4.☐ Overcast ____ Feet AGL; 5.☐ Partial Obscuration; 6.☐ Obscured

Wind Information	Restriction To Visibility	Type Precipitation	Intensity Of Precipitation
1. Direction Calm; 2. Velocity ____ Kts; 3. Gusts ____ Kts	none	none	1.☐ Light; 2.☐ Moderate; 3.☐ Heavy; 4. Specify ____

Turbulence (Multiple Entry)
1.☑ None 2.☐ Light 3.☐ Moderate 4.☐ Severe 5.☐ Extreme 6.☐ Clean Air 7.☐ In Clouds

Damage To Aircraft And Other Property no damage to property on ground.

Degree Of Aircraft Damage
1.☐ None 2.☐ Minor 3.☐ Substantial 4.☑ Destroyed

Fire
1.☐ Yes 2.☑ No 3.☐ In-Flight 4.☐ On Ground

Description Of Damage To Aircraft And Other Property
Aircraft appeared to impact ground in a flat spin. Wreckage relatively intact.

Mechanical Malfunction Failure
1.☑ No
2.☐ Yes List The Name Of The Part, Manufacturer, Part No., Serial No. And Describe The Failure

Preliminary investigation revealed no apparent mechanical failure.

Total Time	
On Part ____ Hours	At Overhaul ____ Hours

Collision Accident N/A

If Collision Accident Occurred, Complete The Information For Other Aircraft

Registration Mark	Aircraft Manufacturer	Aircraft Type/Model	Degree Of Aircraft Damage
			1.☐ Destroyed 2.☐ Substantial 3.☐ Minor 4.☐ None

Registered Aircraft Owner	Address

Pilot Name	Address	Pilot Certificate No.

Evacuation Of Aircraft N/A

Assistance Received
1.☐ Outside Person (s) 2.☐ Auxiliary Lighting 3.☐ Slide 4.☐ Rope 5.☐ Ladder 6.☐ Specify ____

Method Of Exit (State Approximate Number Of Persons Using Each Of The Following
1. Main Door ____ 2. Auxiliary Door ____ 3. Emergency Exit ____

Recommendation (How Could This Accident Have Been Prevented)

Operator/Owner Safety Recommendation (Optional Entry)

Additional Flight Crew Members: N/A

For Each Additional Flight Crew Member, Exclusive Of Cabin Attendants Complete The Following Information

Name	FAA Certificate No.	Address	Title

Certificate(s)
1. ☐ Student
2. ☐ Private
3. ☐ Commercial
4. ☐ Airline Transport
5. ☐ Flight Instructor
6. ☐ Flight Engineer
7. ☐ Foreign
8. Specify ______

Ratings/Endorsements	Total Flight Time	Flight Time This Accident

Name	FAA Certificate No.	Address	Title

Certificate(s)
1. ☐ Student
2. ☐ Private
3. ☐ Commercial
4. ☐ Airline Transport
5. ☐ Flight Instructor
6. ☐ Flight Engineer
7. ☐ Foreign
8. Specify ______

Ratings/Endorsements	Total Flight Time	Flight Time This Accident

Name	FAA Certificate No.	Address	Title

Certificate(s)
1. ☐ Student
2. ☐ Private
3. ☐ Commercial
4. ☐ Airline Transport
5. ☐ Flight Instructor
6. ☐ Flight Engineer
7. ☐ Foreign
8. Specify ______

Ratings/Endorsements	Total Flight Time	Flight Time This Accident

Narrative History Of Flight

Describe What Occurred In Chronological Order, The Circumstances Leading To The Accident And The Nature Of The Accident. Describe The Terrain and Include a Sketch Of Wreckage Distribution If Pertinent. Attach Extra Sheets If Needed. State Point Of Departure, Time Of Departure, Intended Destination And Services Obtained.

At 08:32 local time on December 4, 2003, Ron Bradley, a National Test Pilot School instructor, and Major Cheongon Kim, a Korean Air Force student test pilot, took off from Mojave Airport in a twin-engine Derringer aircraft. Their flight was planned for one hour with a return to Mojave. It was Major Kim's first flight in the Derringer- a familiarization flight. The flight profile consisted of climb performance, cruise performance, level and turning stalls in the clean configuration, a level stall in the landing configuration, a VMCA demonstration, a single-engine climb performance demonstration and landings. At approximately 0912, their radar track disappeared from Joshua Approach radar at an indicated altitude of 3100 feet MSL. The ground elevation at that location was 2650 feet MSL. They had not been in contact with Joshua Approach and there was no distress call heard by other aircraft or ground stations. No witnesses reported seeing the aircraft. The aircraft was found approximately three hours later by a fixed wing aircraft and a helicopter search aircraft from NTPS. The helicopter landed and the first crewmember to reach the Derringer found both pilots with fatal injuries. The aircraft crashed in an uninhabited area of the desert. It was relatively intact and appeared to have been in a flat spin at impact. The aircraft apparently departed controlled flight during one of the familiarization maneuvers and entered a spin, possibly a flat spin, from which recovery was impossible. Spins are prohibited in the Derringer. Parachutes were not worn nor were they required.

I Hereby Certify That The Above Information Is Complete And Accurate To The Best Of My Knowledge

Date Of This Report	Signature Of Pilot/Operator
December 16, 2003	J. E. Solski, Director of Operations, National Test Pilot School

Signature Of Person Filing Report Other Than Pilot/Operator

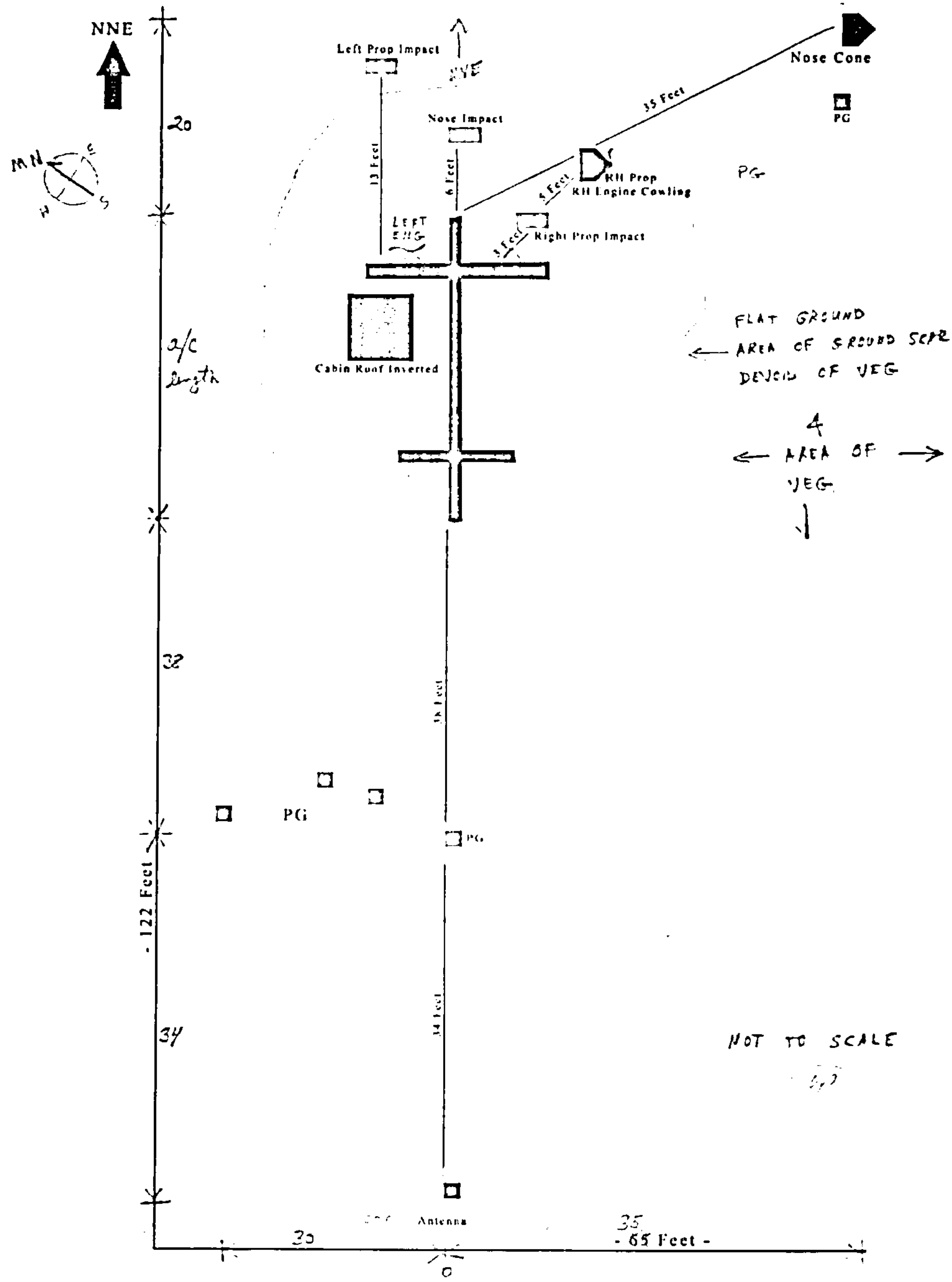
1. Signature ____________________

2. Type Or Print Name ____________________

3. Title ____________________

For NTSB Use Only

NTSB Accident No.	Reviewed By NTSB Office Located At	Name Of Investigator	Date Report Received
LAX04FA057	LAX	WAYNE POLLACK	12/18/03


NNE
Left Prop Impact
Nose Impact
Nose Cone
35 Feet
PG
13 Feet
6 Feet
RH Prop
RH Engine Cowling
5 Feet
3 Feet
Right Prop Impact
LEFT ENG
20
a/c length
Cabin Roof Inverted
FLAT GROUND
AREA OF GROUND SCAR
DEVOID OF VEG
AREA OF VEG
32
34
34 Feet
- 122 Feet -
Antenna
20
35
- 65 Feet -
0
NOT TO SCALE

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

April 13, 2004

MATERIALS LABORATORY FACTUAL REPORT — Report No. 04-038

A. ACCIDENT

Place	: Rosamond, California
Date	: December 4, 2003
Vehicle	: Wing D-1
NTSB No.	: LAX04FA057
Investigator	: Kristi Dunks

B. COMPONENTS EXAMINED

Two pieces of rudder control cable.

C. DETAILS OF THE EXAMINATION

The o pieces of cable contained a mating fracture. The other ends of the pieces had been cut in order to facilitate removal and shipment to the Materials Laboratory.

Visual examination of the broken individual wire ends at the fracture with a bench binocular microscope revealed that some of the wire ends had a slant fracture surface and others exhibited a cup or cone appearance. The individual wires were necked down (plastically elongated) adjacent to the fractures. All features on the cable pieces were typical of overstress separation. There was no evidence of corrosion or wear.

James F. Wildey II
Supervisory Metallurgist

Dunks Kristi

From: Eick Donald
Sent: Friday, December 12, 2003 3:45 AM
To: Eick Donald; Dunks Kristi
Subject: RE: LAX04FA057 Mojave, CA

-----Original Message-----
From: Eick Donald
Sent: Thursday, December 11, 2003 4:19 PM
To: Dunks Kristi
Subject: LAX04FA057 Mojave, CA

Upper Air Data
The closest upper air data I was able to obtain was from San Diego/Miramar (KMYF), located approximately 120 miles southeast of the accident site. The 1200Z sounding on December 4, 2003 provided the following data:

Altitude (ft -msl)	Wind (deg/kts)	T (C)	Td (C)
1,000	135/03	10.7	7.4
2,000	115/04	14.8	-4.6
3,300	080/04	16.1	-15.7
4,000	060/04	15.1	-20.0
5,000	040/05	13.8	-25.1
5,700	020/05	12.4	-30.3
6,600	345/06	12.0	-33.0
7,400	315/08	12.0	-34.6

The sounding basically indicated winds light and variable below 6,000 feet with winds below 10 knots through 8,000 feet. I also looked at Vandenburg AFB and they also agreed, however I could not print them out due to formatting errors in their reports.

Surface Observations
The nearest observations to the accident site was General William J. Fox Airfield, in Lancaster, California, at an elevation of 2,348 feet msl. The airport was equipped with an Automated Surface Observation System (ASOS) and reported the following conditions surrounding the time of the accident. Winds calm, visibility unrestricted, and skies clear below 12,000 feet, and temperatures above freezing ranging from 2 to 10 degrees Celsius.

METAR KWJF 041556Z 00000KT 10SM CLR 02/M06 A3017 RMK AO2 SLP230 T00171056 FZRANO

METAR KWJF 041656Z 00000KT 10SM CLR 06/M06 A3019 RMK AO2 SLP236 T00561056

METAR KWJF 041756Z 00000KT 10SM CLR 10/M06 A3019 RMK AO2 SLP234 T01001056 10100 21028 51010

If any additional information is needed please advise.

Don Eick

Observations for MOJAVE, CA (MHV)

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KMHV 041751Z 00000KT 40SM FEW200 16/ A3021
KMHV 041645Z 00000KT 40SM FEW200 12/ A3020
KMHV 041550Z 00000KT 40SM FEW200 10/ A3019
KMHV 041450Z 00000KT 40SM FEW200 08/ A3017
KMHV 040050Z 00000KT 40SM BKN200 16/ A3010 RMK LAST
KMHV 032345Z 06005KT 40SM BKN200 17/ A3010
KMHV 032245Z 00000KT 40SM BKN200 17/ A3010
KMHV 032150Z 04010KT 40SM BKN200 17/ A3012
KMHV 032045Z 03010KT 40SM BKN200 16/ A3014
KMHV 031952Z 03010KT 40SM BKN200 16/ A3016
KMHV 031846Z 02008KT 40SM BKN200 14/ A3020
KMHV 031746Z 00000KT 40SM BKN200 13/ A3022
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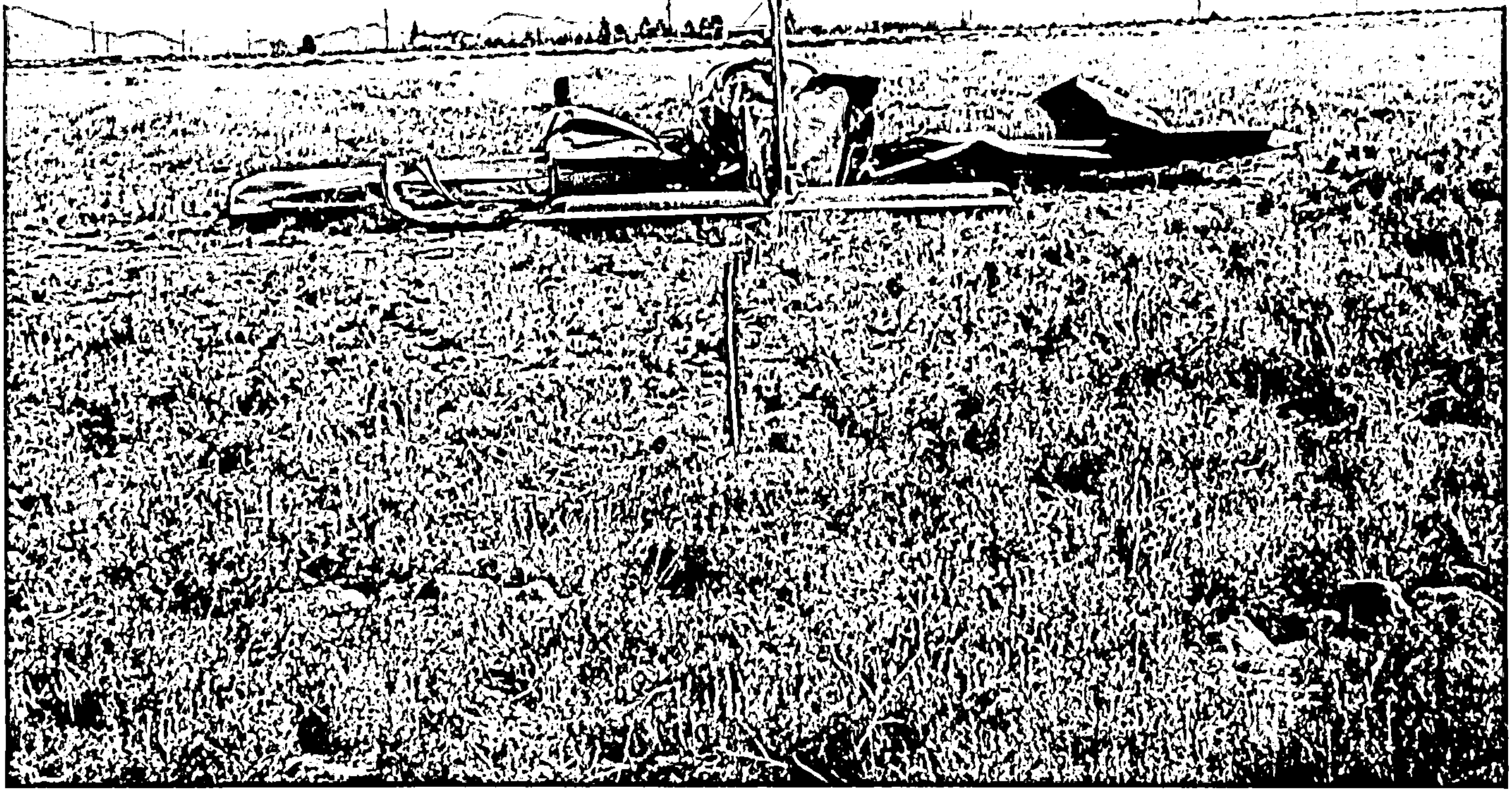


Photo 1 - Acft aft view

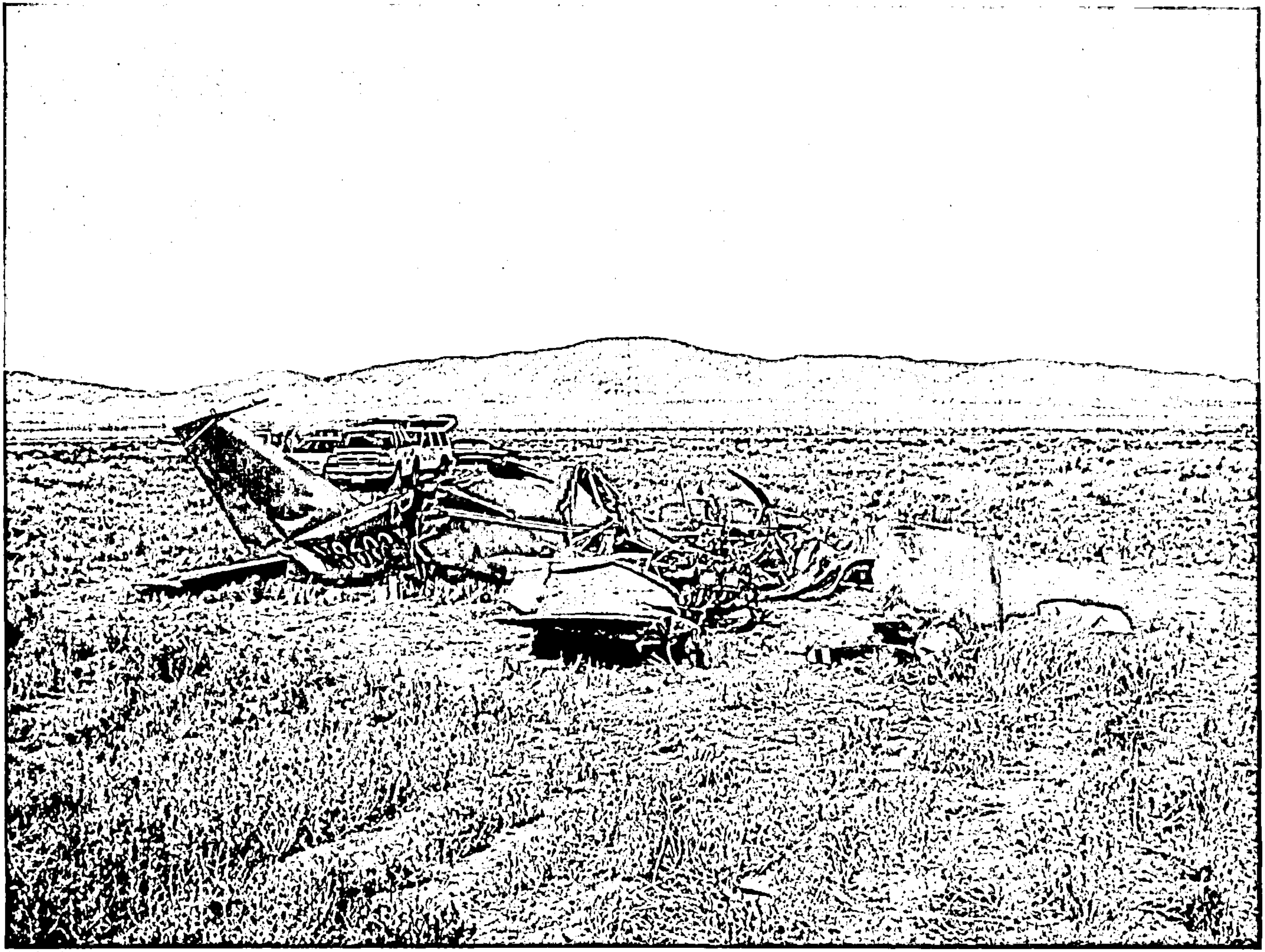


Photo 2 - Acft right side

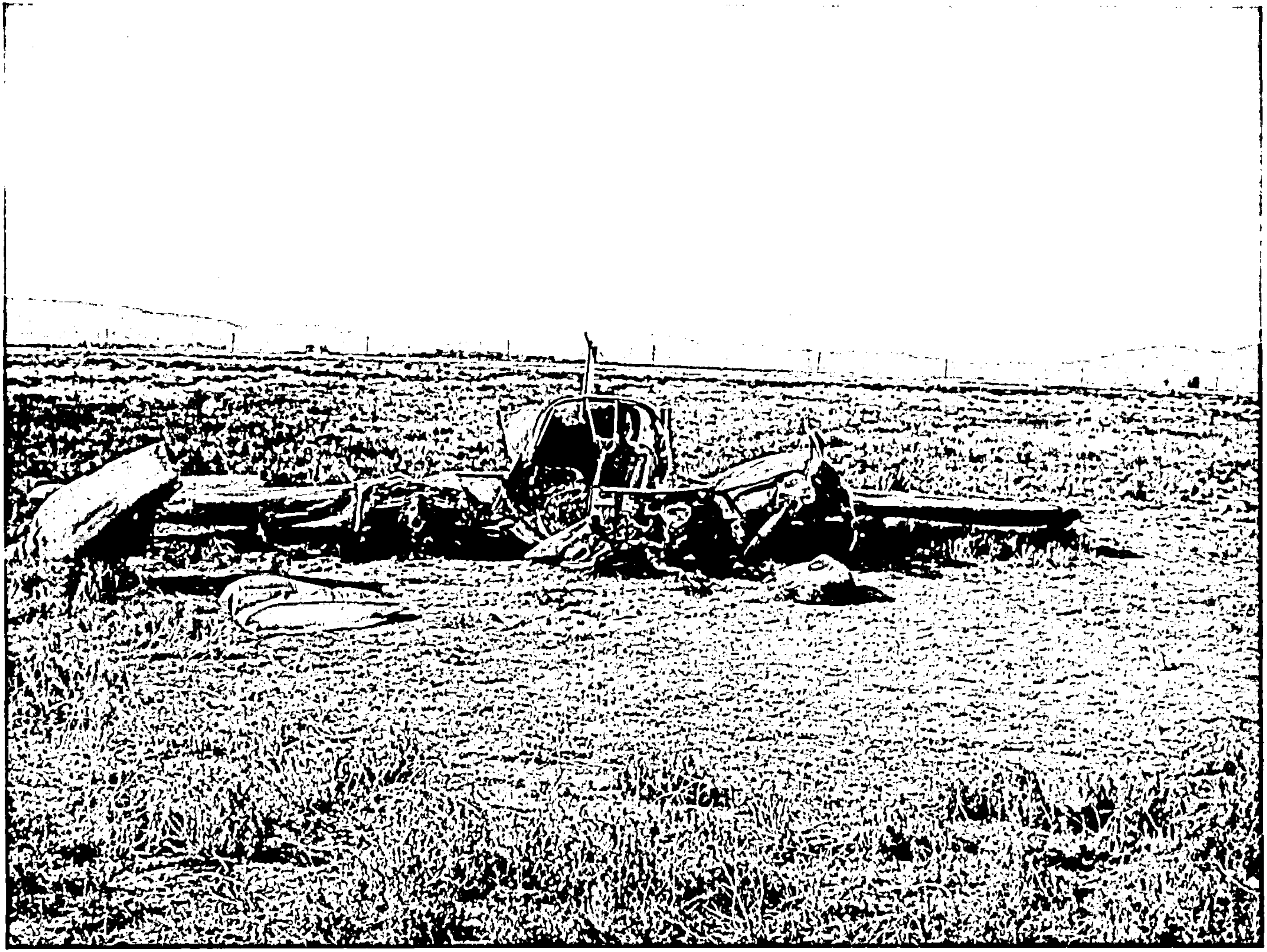


Photo 3 - Acft front view

Photo 4 - Acft left side

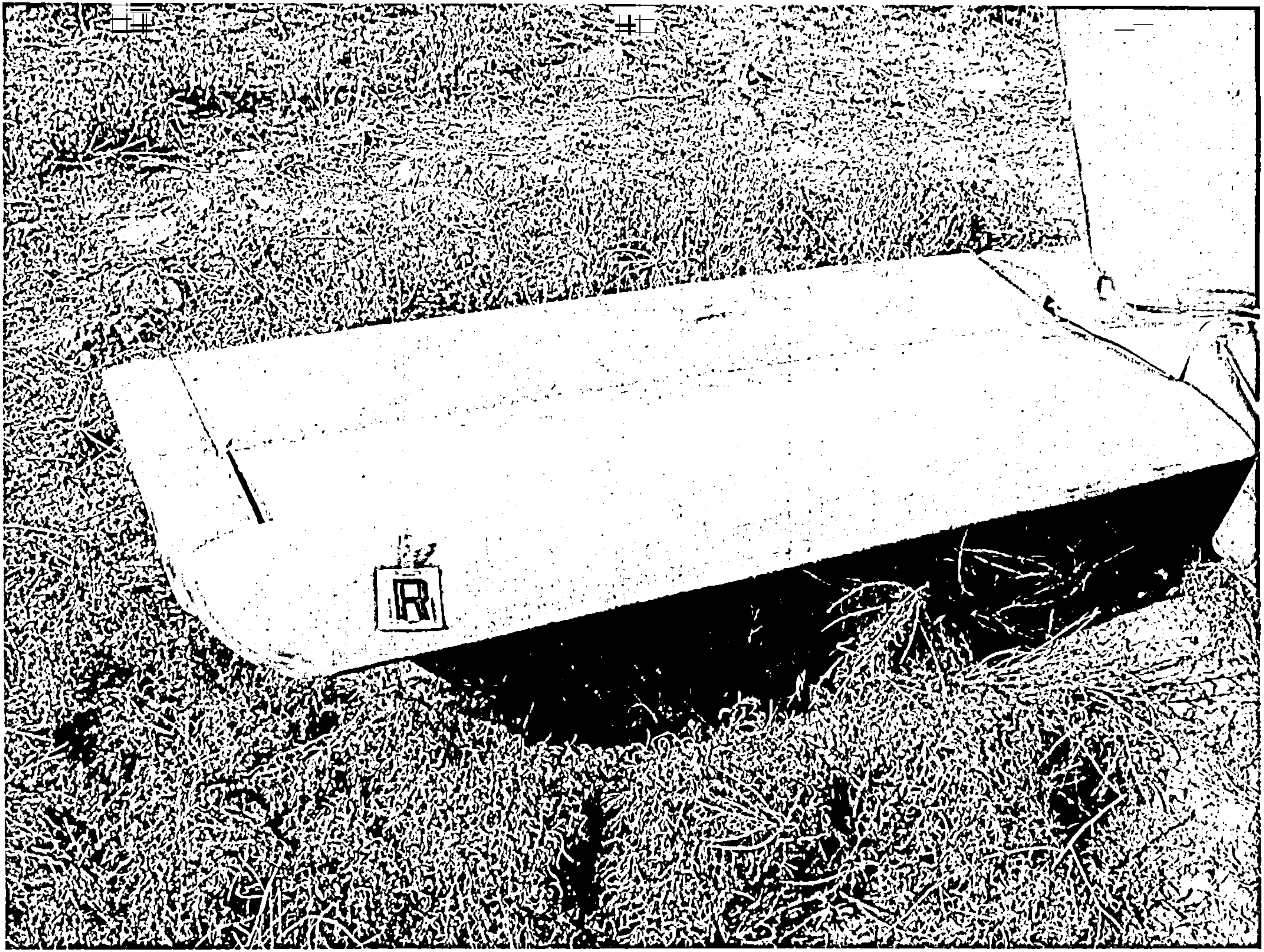


Photo 5 - Empennage right side

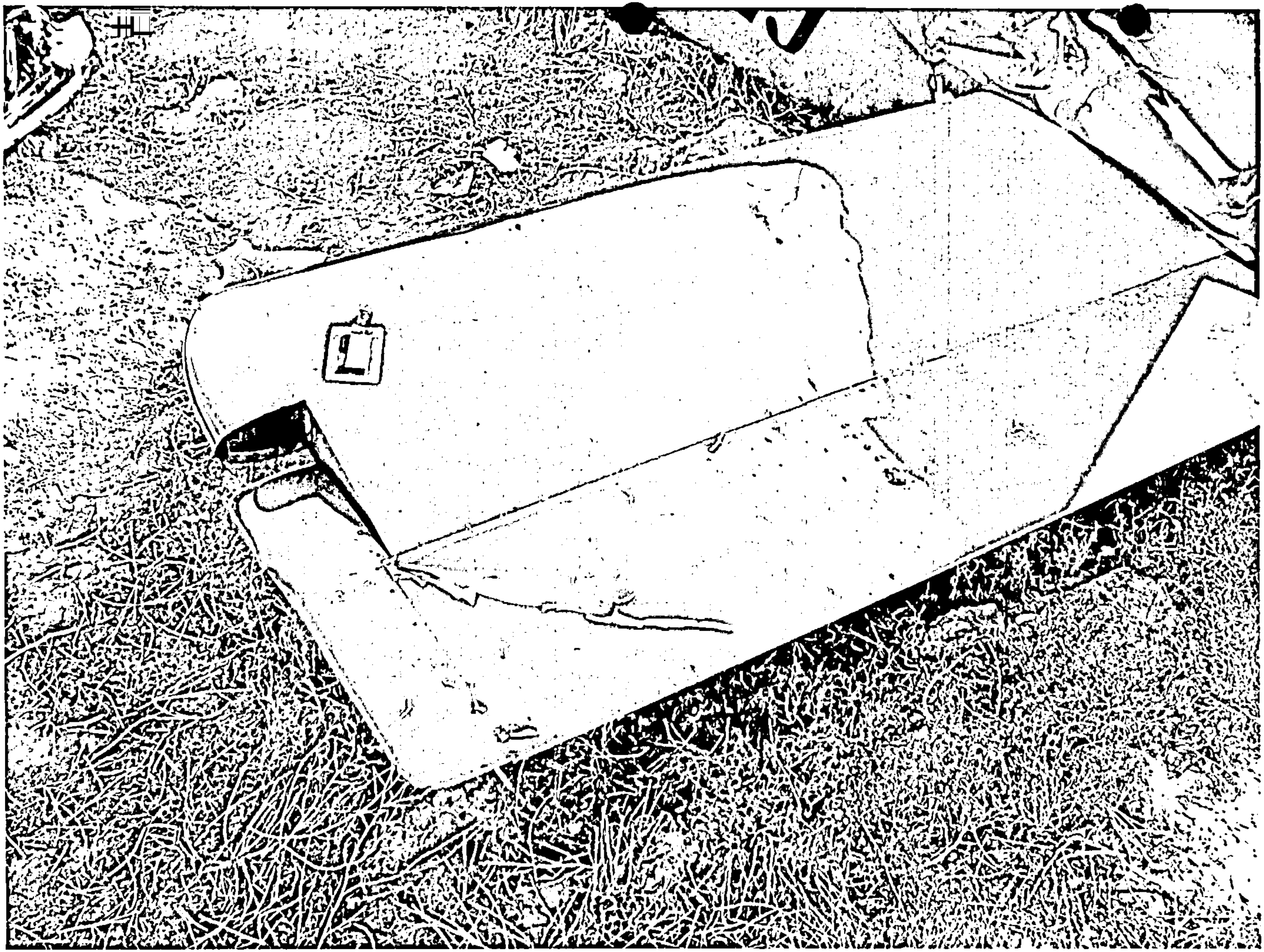


Photo 6 - Empennage left side

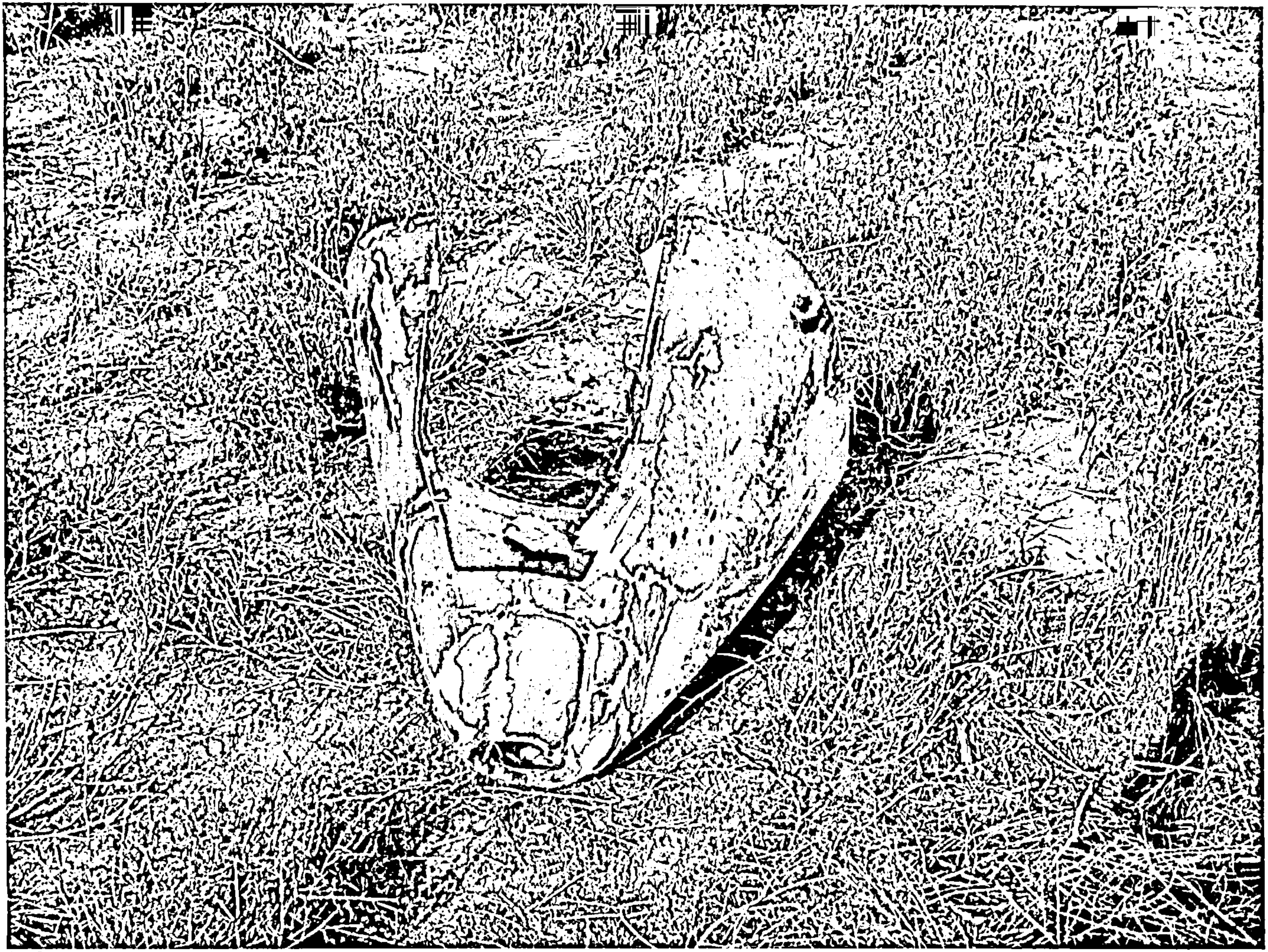


Photo 7 - Nose cone bottom

Photo 8 - Nose cone top

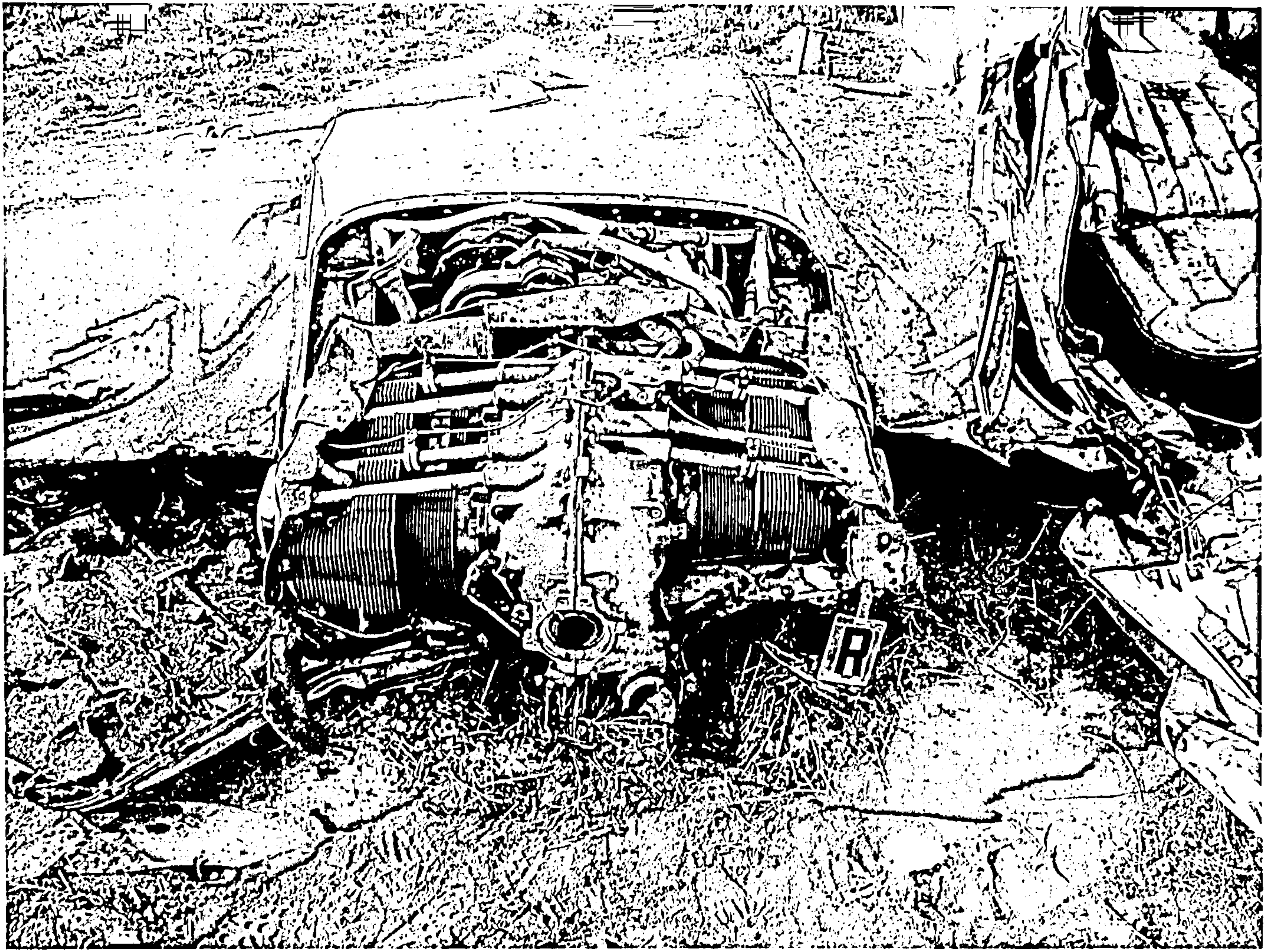


Photo 9 - Right engine

Photo 10 - Left engine & prop

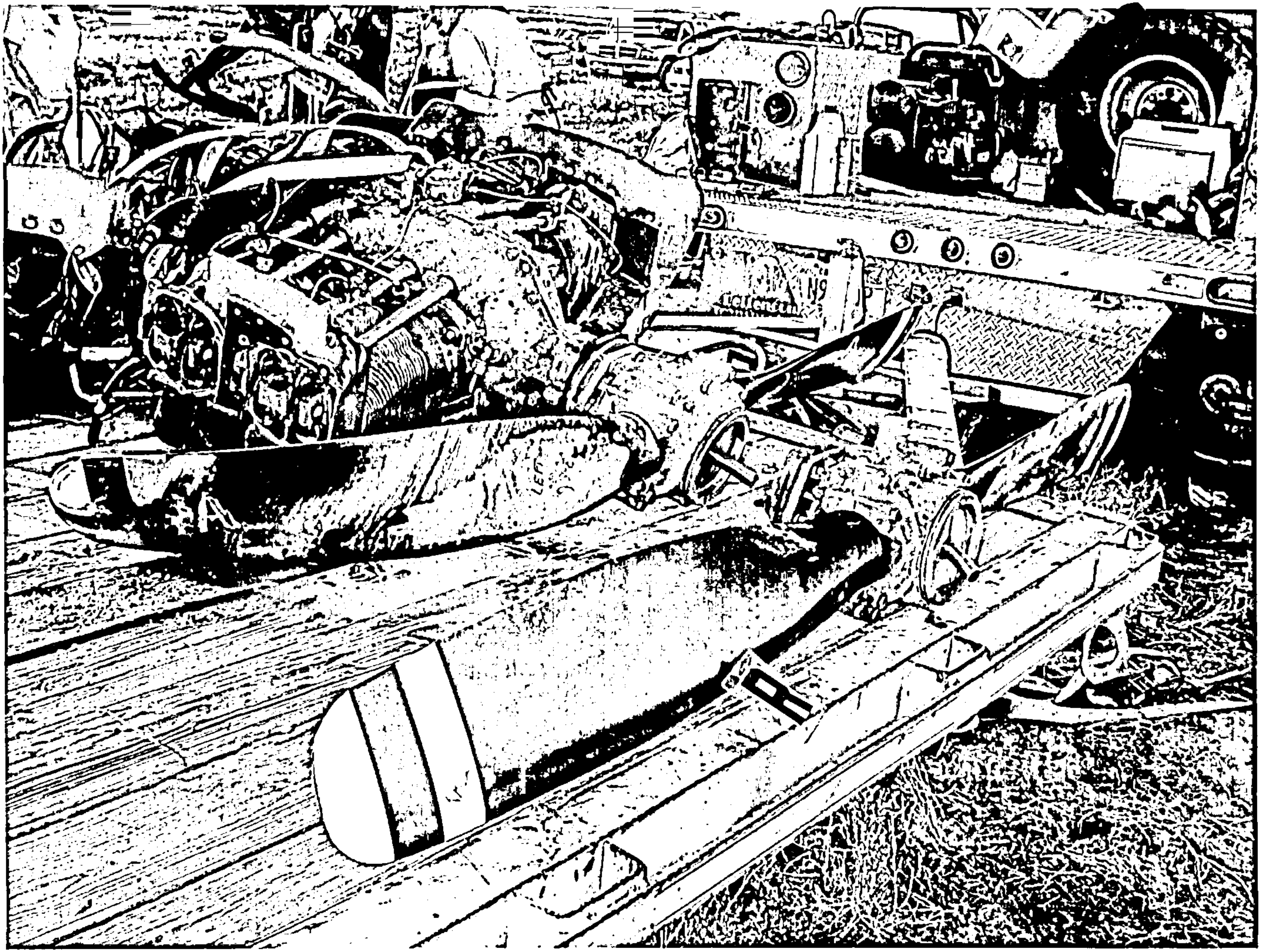


Photo 11 - Left & right props

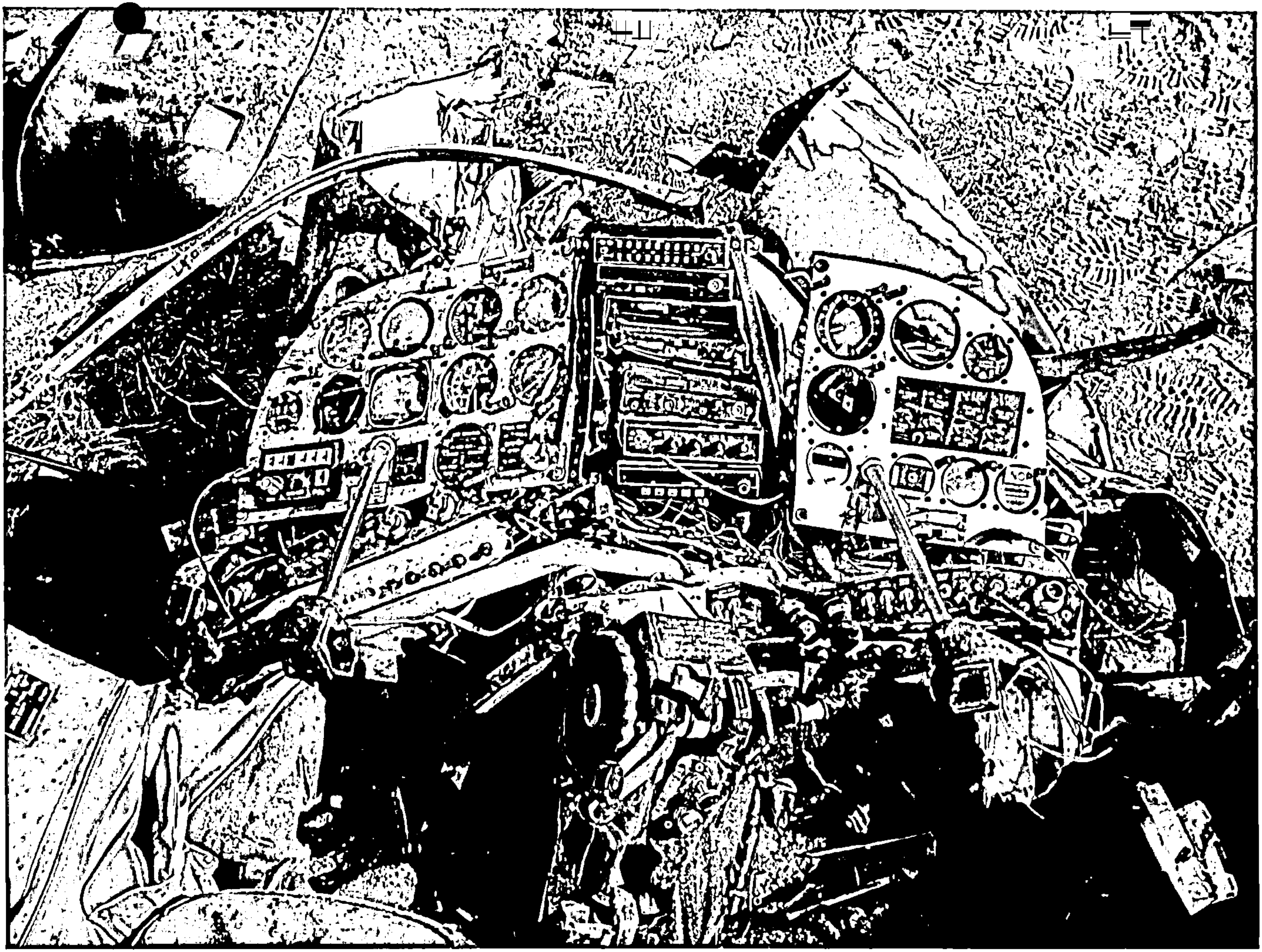


Photo 12 - Cockpit

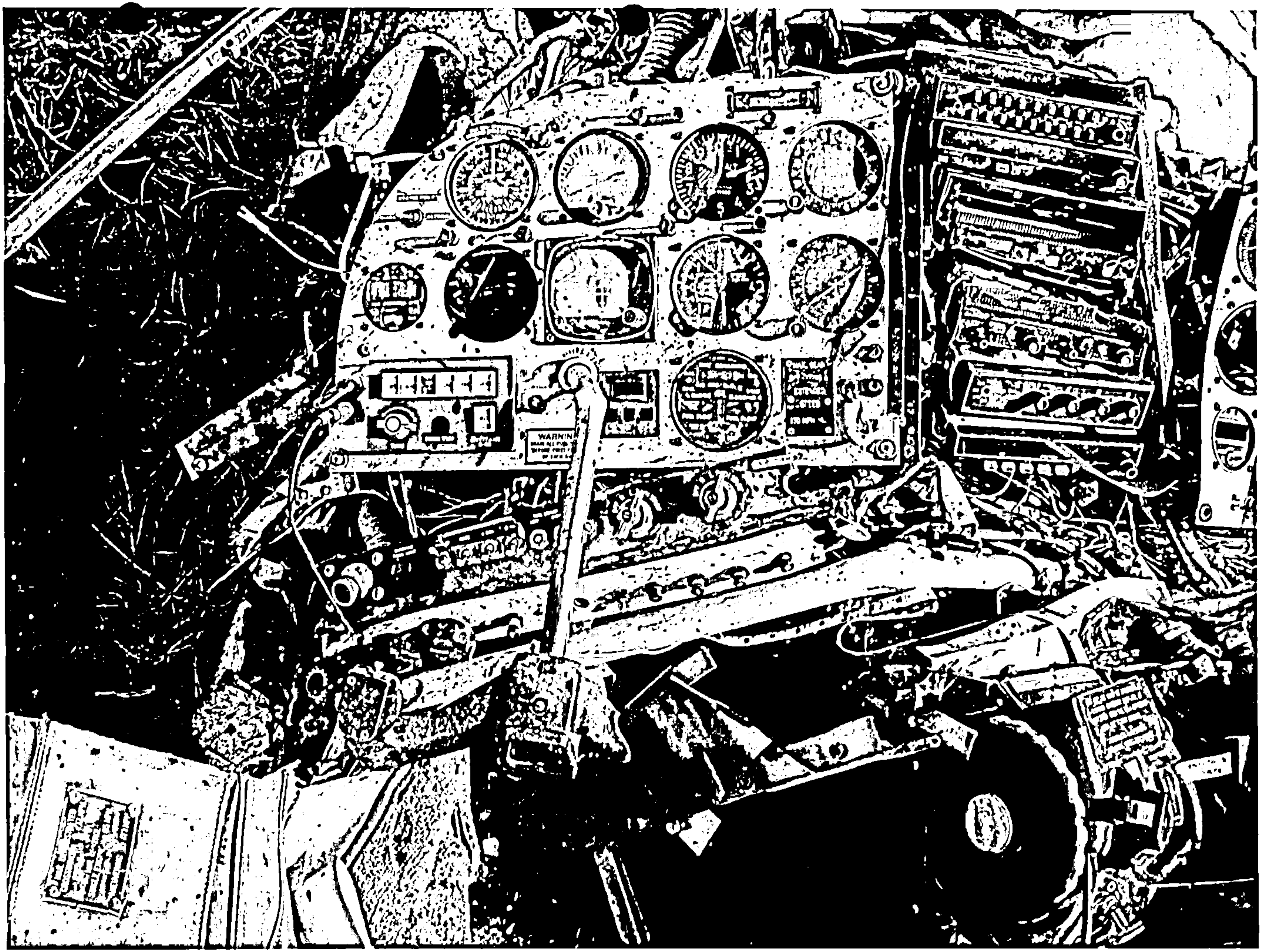


Photo 13 - Cockpit left side

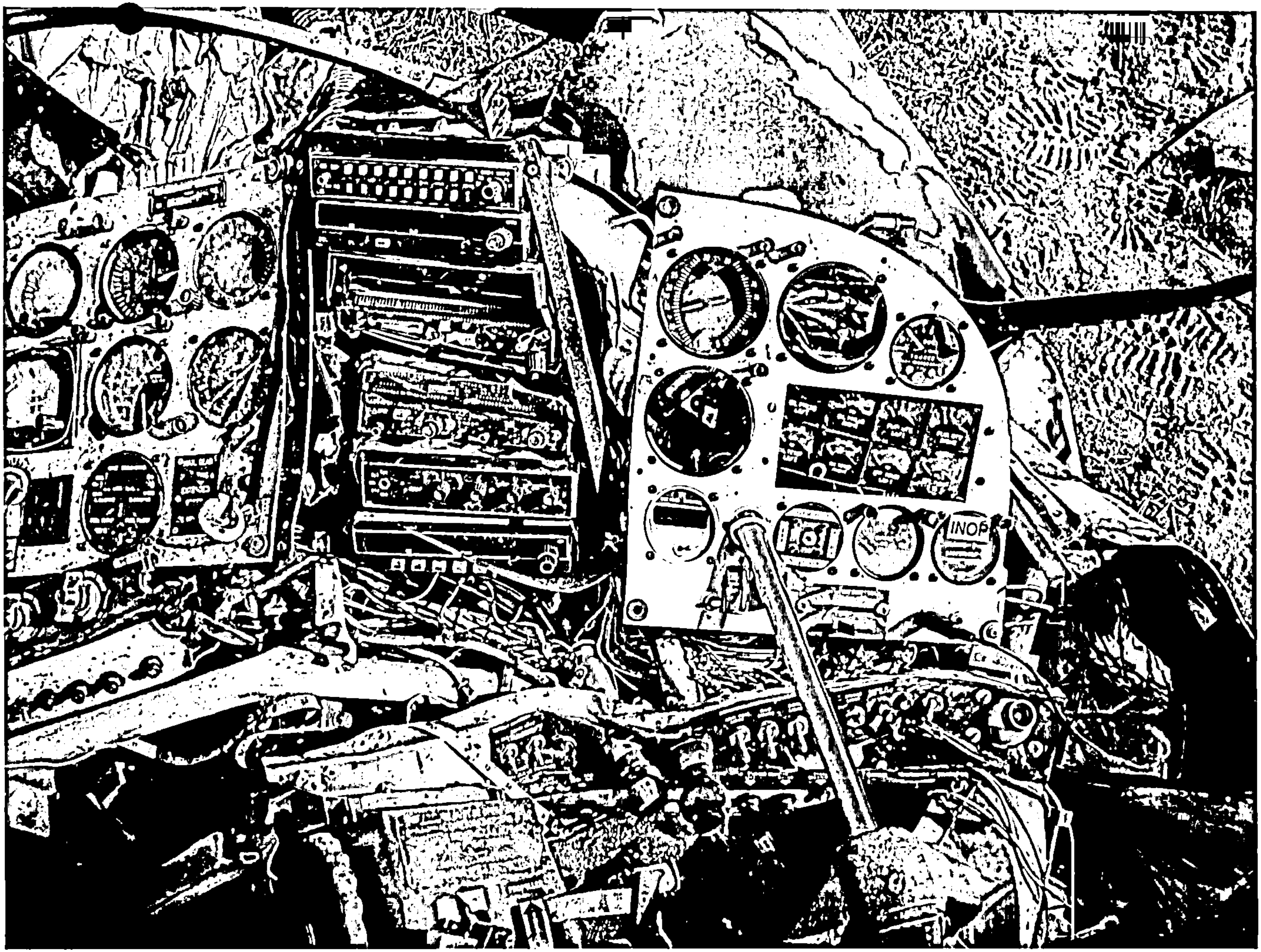


Photo 14 - Cockpit right side

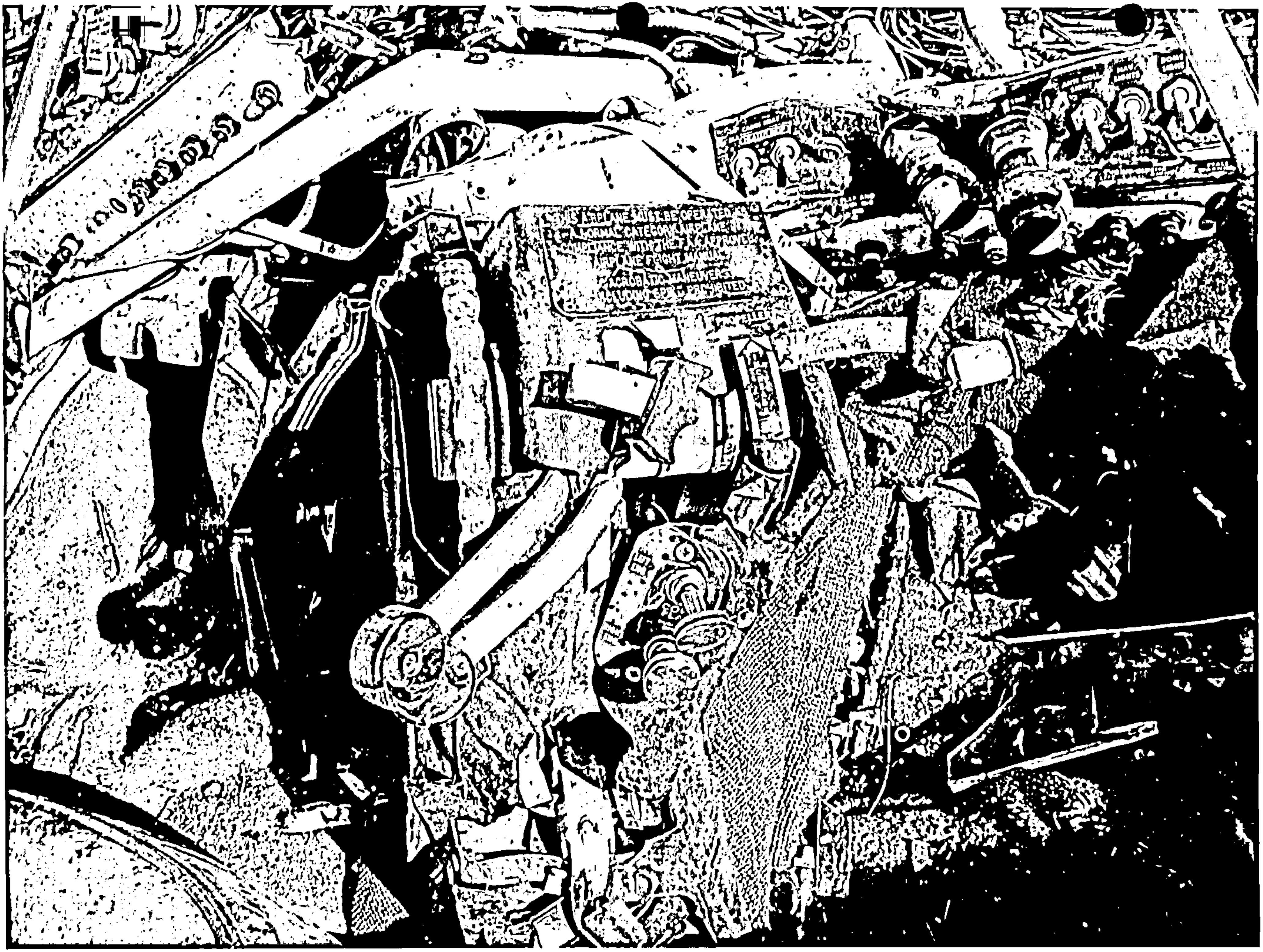


Photo 15 - Throttle quadrant

Analysis of Radar Data
Derringer D-1
N-8602J

By
Sean C. Roberts
National Test Pilot School
Mojave, CA

For
N.T.S.B.

19th August 2004

Table of Contents

Executive Summary

An analysis was performed on the radar data obtained from Joshua Surveillance Radar for the Derringer D-1 aircraft that was lost on December 4th 2003 while performing a familiarization mission for a test pilot candidate attending the National Test Pilot School (NTPS). The pilot in command was an NTPS flight test instructor. The Derringer aircraft performance and flying qualities were used in conjunction with the flight test card to correlate the radar data and the flight test sequence. Correlation was within an elapsed time accuracy of less than one minute and a distance accuracy of 1 to 2 nautical miles. Individual test points are identified for each element of the flight up to the departure from controlled flight which resulted in a spin. The flight path data in the spin was estimated from the radar position and altitude data and using the spin characteristics of a typical Part 23 aircraft. The Derringer D-1 entered a spin in the power approach (PA) configuration at approximately 6,000 ft indicated altitude and impacted the ground after approximately seven turns in a flat spin. A sketch of the estimated aircraft flight path is shown in Radar Map No. 3.

Analysis of the Radar Data Supplied by Joshua Radar for the Derringer D-1, N-8602J

by Seán C. Roberts, Director NTPS

I. Introduction

This analysis was requested by the NTSB accident board since the author was familiar with the Derringer D-1 aircraft, had flown numerous similar missions in the aircraft with students and also knew how the test pilot instructor on board the aircraft typically conducted a training flight. The flight under investigation was a familiarization flight for the student test pilot and his first flight in the aircraft. The mission card for the flight is attached in Fig. 1 and shows that the flight consisted of level flight performance, a stall series, a V_{mca} demonstration series and a single engine performance segment showing the effect of the landing gear and the flaps on simulated single engine climb performance. The aircraft was airworthy and was within the weight and balance limits as show in Fig 2.

Knowing the instructor test pilot, it has been assumed that the test sequence was followed with the instructor pilot (IP) demonstrating the flight test technique (FTT) and the student test pilot (STP) performing the (FTT). The exception to the above demonstration/performance sequence would be the climb and level flight stabilized data points that the (STP) should be able to do without a demonstration. The times estimated to perform each task are from the operational experience of the author in performing the same mission.

Flight Path Analysis
Initially performed in January '04 and finalized in August '04

2.1 The take-off time of the Derringer was 0832 local time as recorded by the Mojave Control Tower. The runway used was 26.

2.2 The estimated time interval (ΔT) to take-off, retract the landing gear and accelerate to climb speed of 115 mph (100.0 KTS) is one (1) minute.

2.3 <u>CLIMB</u>

The climb rate at 115 MPH at 2500 RPM and 25 ins of manifold pressure (MP) is approximately 800 FT/min.

<u>ESTIMATED DATA</u>

The (ΔT) from 3000 to 6000 ft $= \frac{3000}{800} = 3.75$ MINS

The distance in the climb (ΔS) $= V_{TRUE} = \frac{V_i}{\sqrt{\sigma}}(\Delta T) = 7.1$ NM

(Assuming a standard day and an average altitude of 4500 ft.)

Time of day (TOD) at the top of the climb estimated at 0837 HRS.

(1637 HRS Zulu)

<u>RADAR DATA</u>

The radar true airspeed was approximately 108 KTS.

The radar distance (ΔS) was 6.75 nautical miles (NM)

The estimated and the radar data are reasonably close, therefore it is reasonable to say that the top of the climb (6,000 ft) occurred at point No. 2 on map No. 1 at 0837 HRS.

2.4 CRUISE DATA

It is assumed that it takes 1.5 minutes to stabilize the aircraft at each speed and 0.5 mins to record the data i.e. 2.0 minutes for each data point.

(a) V_i = 140 MPH at 6000 ft,	V_T = 134 KTS,	ΔT = 2.0 MIN	ΔS = 4.5 NM
(b) V_i = 120 MPH at 6000 ft,	V_T = 116 KTS,	ΔT = 2.0 MIN	ΔS = 3.9 NM
(c) V_i = 100 MPH at 6000 ft,	V_T = 99 KTS,	ΔT = 2.0 MIN	ΔS = 3.3 NM
(d) V_i = 90 MPH at 6000 ft,	V_T = 90 KTS,	ΔT = 2.0 MIN	ΔS = 3.0 NM
(e) V_i = 85 MPH at 6000 ft,	V_T = 85.9 KTS,	ΔT = 2.0 MIN	ΔS = 2.9 NM
	Totals	10 MIN	17.6 NM

The local time at completion of the cruise data is estimated at 0847 and is shown as point (3E) on the radar plot map No. 1.

2.5 STALLS

The radar plot shows the D-1 Aircraft is level at radar point 1 at 5700 ft or at the estimated point (3E) at 6,000 ft H_i. At point (3E) the aircraft starts a turn to the right at 85-90 KTS (Radar 88 KTS and 5,700 ft) to a heading of 030°.

The estimated time of the turn is one (1) minute.

The estimated time at point (4E) is 0848 hrs local.

The indicated airspeed (V_i) of 95 MPH as per the flight card equates to 82.6 KT V_i and 88 KTS true airspeed. (The radar speed is 88 KTS)

2.5 (a) Once headed essentially northward, the first power off stall is performed at point (4E). The stall configuration is landing gear up, flaps retracted with a one (1) KT/sec bleed rate from 1.3 V_{stall}.

Stall speed (V_s) = 74 MPH (64 KTS)

ΔT = 22 Secs

ΔS = 0.5 NM

Also, the aircraft would be descending about 1,000 ft/min.

$$\therefore \text{Height loss/stall} = \frac{1000}{60} \text{ ft} \times 22 = -367 \text{ ft.}$$

2.5 (b) The second clean aircraft, idle power stall, most likely by the student, occurs at point (5E) which shows a right wing drop and recovery.

ΔT = 22 secs

ΔS = 0.5 NM

ΔH = -367 ft.

This puts the aircraft at approximately 5,266 ft. The radar puts the aircraft at 5,200 ft.

Power is added and the aircraft climbs back to 6000 ft H_t (5700 ft radar). Estimated rate of climb (ROC) is 700 ft/min, $\therefore$ ΔH = 734 ft, ΔT = 1.1 min, V_T = 90 KTS, ΔS = 1.7 NM

The top of the climb point (6E) or radar point (4) is 6000 ft H_t (5700 ft and 88 KTS radar data)

Estimated local time at (6E) is 0850 hrs local.

2.5 (c) TURNING STALLS

I. IDLE POWER

V_{inm} 95 MPH, $\dot{V}$ = 1 KT/sec, bank angle $\phi \pm 30$ degrees started at point (6E) with a left turning stall, followed by a right turning stall.

Rate of sink (ROS) = 1000/ft/min

ΔT about 22 secs/stall

ΔH per stall -366 ft.

Climb back up to 6,000 ft H_i @ 700 ft/min gives $\Delta T = 1.1$ min, $\Delta S = 2.0$ NM : Flight Path essentially towards the west the climb is completed by point (7E)

Estimated local time 0851 hrs.

II POWER FOR LEVEL FLIGHT

Turning stalls to the left and to the right, each at 30° bank angle. The power setting is approximately 2500 RPM, 15" MP at 95 MPH at 6,000 ft. There is no altitude lost in power on turning stalls and perhaps a slight gain (Radar shows an altitude of 5,800 ft.)

At a bleed rate ($\dot{V}$) of 3 kts/sec about 9 secs/stall and allowing 10 secs between stalls $\Delta T = 30$ secs. Stalls completed at point 8E, aircraft at 6,000 ft (5,800 ft radar). The aircraft was accelerated to 130 kts true airspeed on a heading of approximately 210° then slowed down at point (9E) to a slow airspeed of about 70 kts (90 mph) most likely to reconfigure the aircraft in the power approach configuration i.e. landing gear down, flaps full. The aircraft speed was then increased and the aircraft turned to a northerly heading. Estimated local time at point (10E) is 0853 (16.53 Zulu).

2.5 (d) LEVEL FLIGHT POWER APPROACH (PA) CONFIGURATION STALLS

V_{trim} 90 MPH, airspeed bleed rate ($\dot{V}$) of one (1) KT/sec.

Point (11E) on Map No. 2 of the radar plot would indicate a stall approach most likely performed by the instructor pilot to define the trim speed of 1.3 V_S prior to the stall.

Point (12E) looks like an instructor pilot demonstrated P.A. idle stall with a 30 degree heading change to the right. The aircraft was then accelerated up to at least 90 MHP and the aircraft most likely handed over to the student to repeat the maneuver. The aircraft was climbed back to 6,000 ft H_i (5700 ft radar altitude) prior to the stall.

Point (13E) most likely is a student P.A. idle stall. The aircraft appears to recover straight ahead then stalled again point (14E) in which the aircraft turned to the right, was recovered, and then stalled again at point (15E). The (15E) point would seem to be where the aircraft departed controlled flight with a spin to the left Map 3 Radar data.

The next radar hit is point (16E) where the radar altitude is 5,200 ft or 5500 ft H_i indicating that by the time point (16E) was reached, the aircraft most likely had completed 1 ¼ turns in the spin.

Point (17E) 4.5 secs later than point (16E) at 4,500 ft radar altitude shows that the aircraft lost 700 ft in 4.5 secs and most likely had turned about 1 ½ to 1 ¾ turns in the spin.

Point (18E) is 4.8 secs later than point (17E) and at 4,000 ft radar altitude which is most likely 1 ½ turns of the spin.

Point (19E) is 4.78 secs later than (18E) and 500 ft lower at 3500 ft most likely 1 ½ turns.

Point (20E) is 4.8 secs later and 600 ft lower at 2900 ft indicating about 1 ½ turns.

The impact point (21E) is within 0.15 NM from last radar hit and probably took another turn in the spin, assuming the crash site elevation is approximately 2600 ft.

The total number of turns in the spin is estimated at 7 to 8 turns from departure to impact with an average altitude loss per turn ranging from 380 ft to 450 ft.

3. Comments

1. The reconstructed flight path determined from the test card is very close to the radar data. The time difference is less than one minute and the distances within one to two nautical miles.

2. The blue line (dotted) on Map 3 is the final flight path as determined by ATC radar data prior to impact. The time between each radar hit is reasonably consistent at 4.8 seconds. To accomplish the suggested radar flight i.e. with the loss of altitude, the aircraft would have to be in a spiral dive with a sink rate of approximately 8,500 ft/min. Such a steep nose down spiral dive would have resulted in severe overspeeding of the landing gear and the wing flips and would have resulted in ground impact of at least 40 degrees nose down pitch attitude which was not the case upon examination of the impact damage to the aircraft. In addition, a spiral dive is an incontrol maneuver, easily recognized by a pilot and easily recoverable with normal pilot actions.

3. A question arising from the analysis is "Why did the student stall the aircraft three (3) times, departing controlled flight on the third stall?" Note, these three stalls occurred within a 20 to 24 second time frame. It should be noted that the clean configuration i.e. landing gear and flap retracted, idle power stalls, ref. (4E) I.P. demo and (5E) student is very benign in that with full aft yoke, the aircraft stalls, recovers by itself, then stalls again in a purposing type motion with little or no wing drop. These benign clean stall characteristics may have convinced the student that holding the yoke full aft would be a reasonable approach, despite the briefing from the instructor pilot and the demonstration by the IP on the first P.A. configuration stall which requires an immediate unloading of the wing by rapid forward motion of the yoke. Most likely the instructor was also on or close to the yoke on the first stall and assisted in the forward yoke

motion resulting in a straight ahead recovery. Once recovered, the IP would have most likely released the controls in which case the student stalled the aircraft again, perhaps inadvertently or deliberately to see the stall again. On the second stall the IP would be slower to respond, since it was unexpected, resulting in a recovery but with 70° heading change to the right. Ref. Point (14E). Perhaps the student did not like the instructor pilot assisting in the recovery and insisted or inadvertently stalled the aircraft the third time ref. point (15E) which resulted in a departure from controlled flight and an ensuing spin. This scenario means that the student did not respond to oral commands by the instructor pilot and perhaps more than likely overpowered the instructor's input to put the aircraft into the third stall which resulted in the spin. The instructor pilot was very meticulous in strictly following the test card which allowed one stall by the student, not three.

In preflight briefings, each student understands that if the aircraft departs controlled flight, the instructor pilot will command "I have it" which means that the student pilot must relinquish the controls, in which case the instructor pilot could have recovered the aircraft. Obviously either due to communication problems (i.e. language skill deficiency) or stubbornness or aggressiveness by the student, he did not relinquish the flight controls and put the aircraft into a stall and spin despite any actions on the part of the instructor. This was the situation when the aircraft impacted the ground i.e. both side of the yoke were broken off on the instructor side and left side of the student's yoke was broken off which means the student and the instructor pilot were wrestling each other for control of the aircraft.

The question is "Would this accident have happened if (a) the instructor pilot was flying the aircraft solo or (b) If the student had followed the instructor pilot's command of "I have it". The answer is no. The instructor pilot had flown this mission with the author who checked him out on the aircraft and performed the same familiarization mission with absolutely no departures from controlled flight. In addition, the instructor pilot and the author had flown identical familiarization missions with many students without incident.

List of Figures

Mission: D-1 DERRINGER FAM			Date:
Lead	Student:	IP:	
A/C:		Tiger:	
Wingman	Student:	IP:	
A/C:		Tiger:	

Brief:	Step:	T.O.:	Land:
Weight:	C.G.	Fuel:	
Freq:	Ops #:	Airspace:	

T/O time 8 32 MISV Time

Δ 8HRS LOCAL TO ZULU TIME

TIME (Local)

	TIME (Local)
STTO (BRIEF MATCHING MPs ON T.O.)	8.32
CLIMB OUT AT 105 MPH THEN 115 MPH	
CRUISE PERFORMANCE (trim shot for 30 sec)	8.37

V_{trim}	$H_{\pm 10'}$	$V_{\pm 1 KT}$	RPM/FF
140			
120			
100			
90			
85			

STALLS	8.47
Level flight, clean confg., idle power, 1 kt/sec, V_{trim} 95 mph	8.48
Turning 30 bank left/right, clean, idle, 1 kt/sec, V_{trim} 95 mph	8.50
Turning 30 bank left/right, PLF, 3-5 kt/sec, V_{trim} 95 mph	8.51
Level flight, PA config., idle, 1 kt/sec, V_{trim} 90 mph	8.53
V_{MCA} DEMO (predicted 85 mph)	
Clean config., one engine idle/one max RPM & full throttle	
Decel to V_{MCA} (wings level/zero SS/5 deg bank)	
SINGLE ENGINE CLIMB DEMO (hold 110 mph)	
PA config., one engine idle, one engine max RPM & full throttle (note VVI), raise flaps (note VVI), gear up (note VVI), 9" MP on idle engine (simulates feather, note VVI), close cowl flap on bad engine (note VVI), zero SS (note VVI), 5 deg bank (note VVI)	
LANDINGS	

FIG. 1

D-1 Derringer Wt & Bal

N8602J
as of 28 Sep 02

Item	Weight (lbs)	Arm (in)	Moment
Empty A/C	2,246	91.2	204,835
Pilot	150	87	13,050
Copilot	140	87	12,180
Main Fuel	360	92	33,120
Fwd Bag	0	26	0
Aft Bag	0	136	0
TOTAL	2,896	90.9	263,185
		21.8%	mac

Fuel: 88 gal max, @ 6 lbs/gal

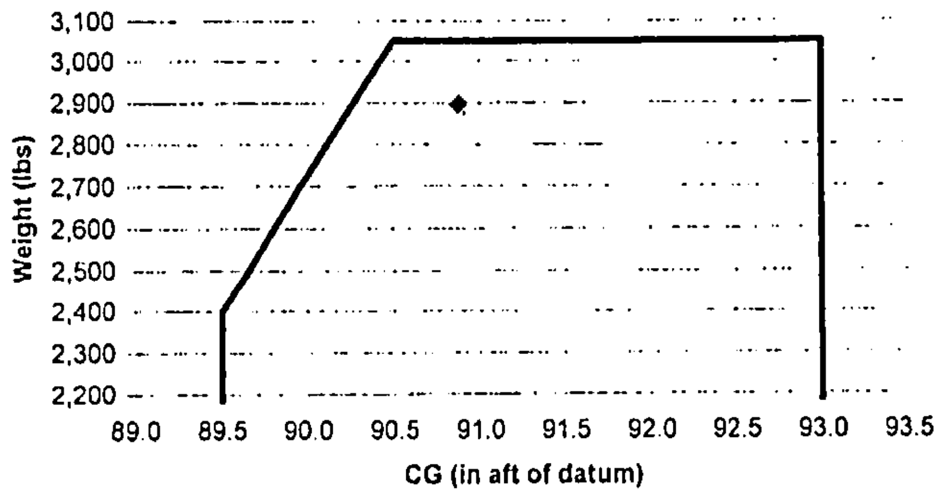
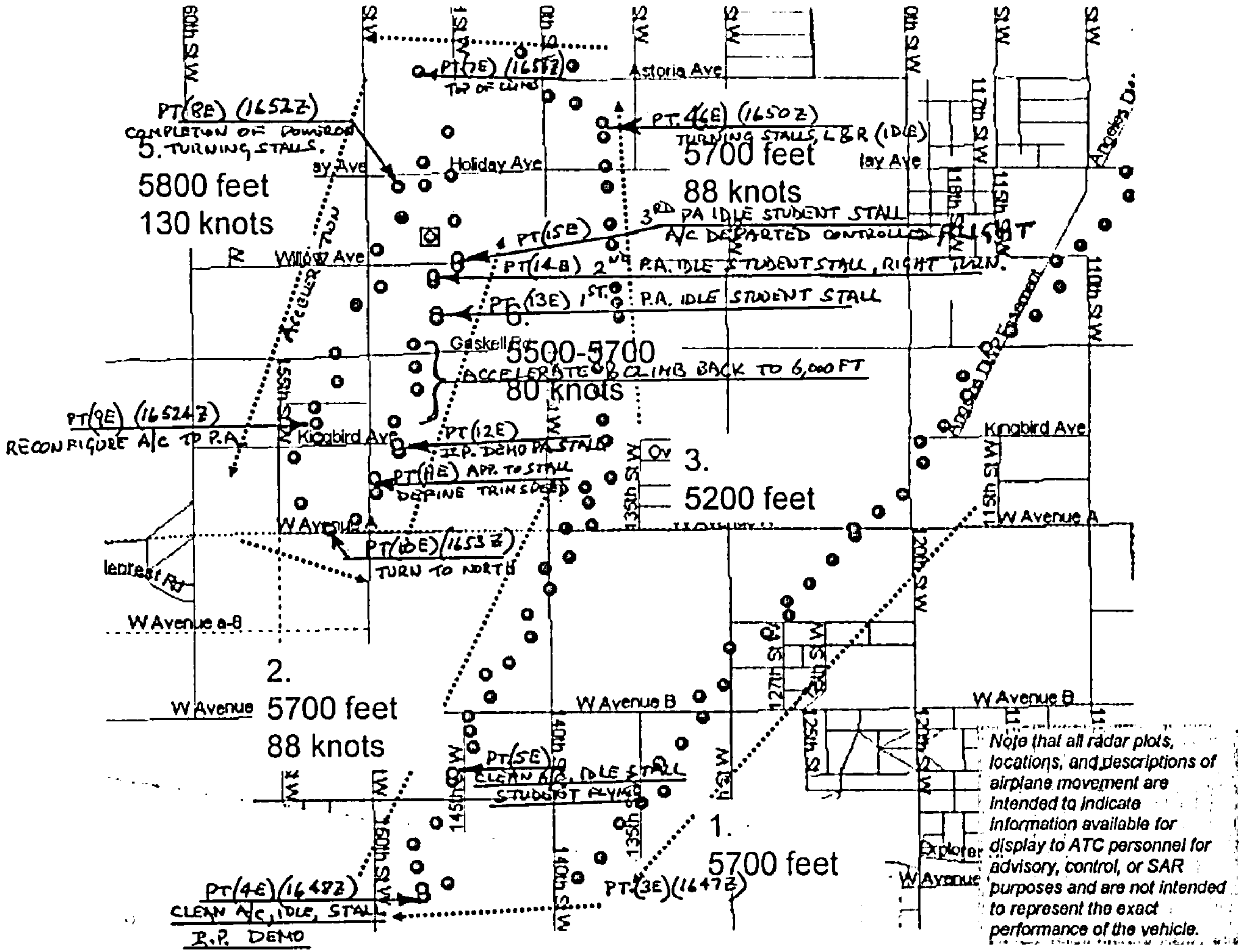
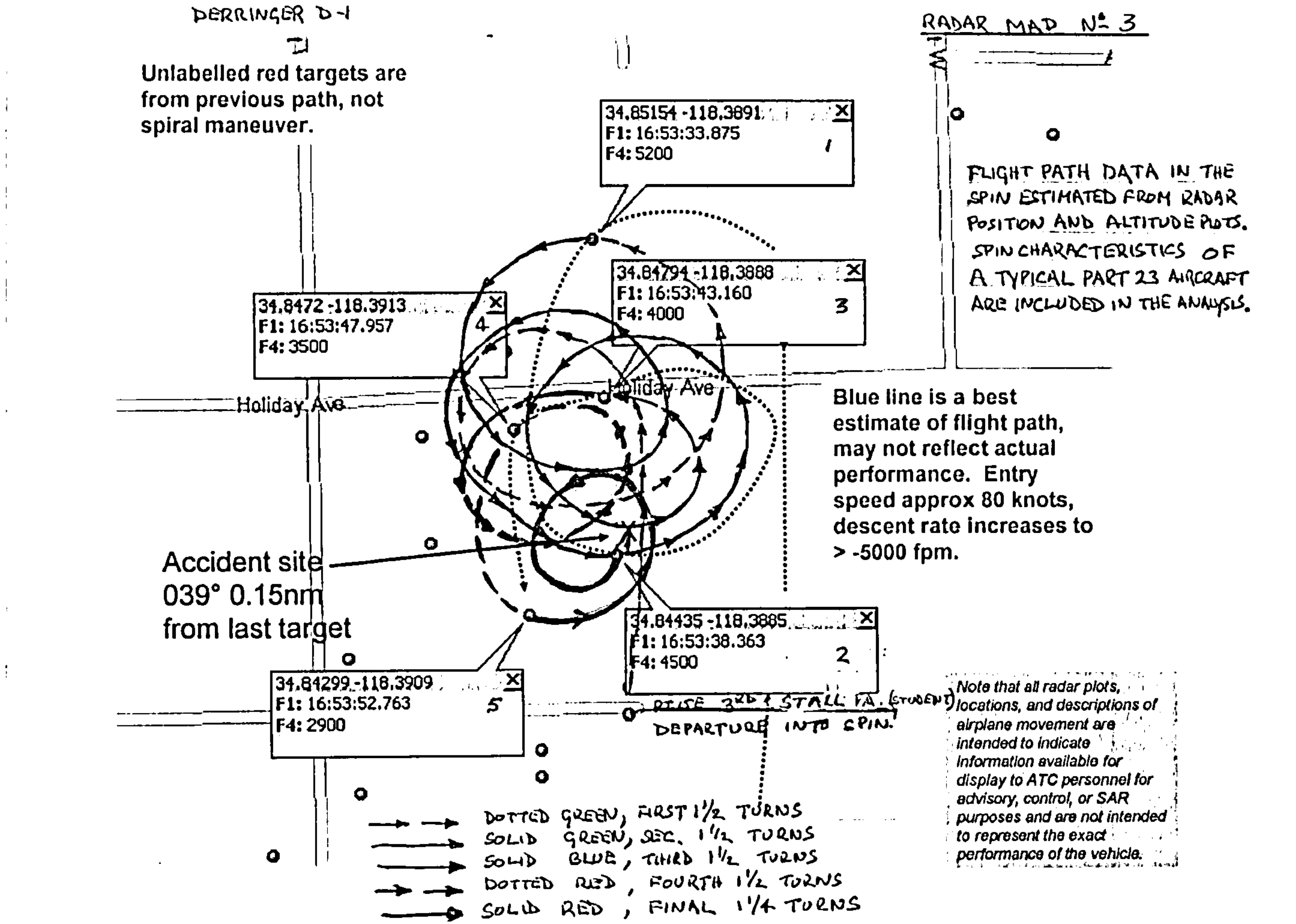


FIG 2

DERRINGER D-1

RADAR PLOT MAP No 1

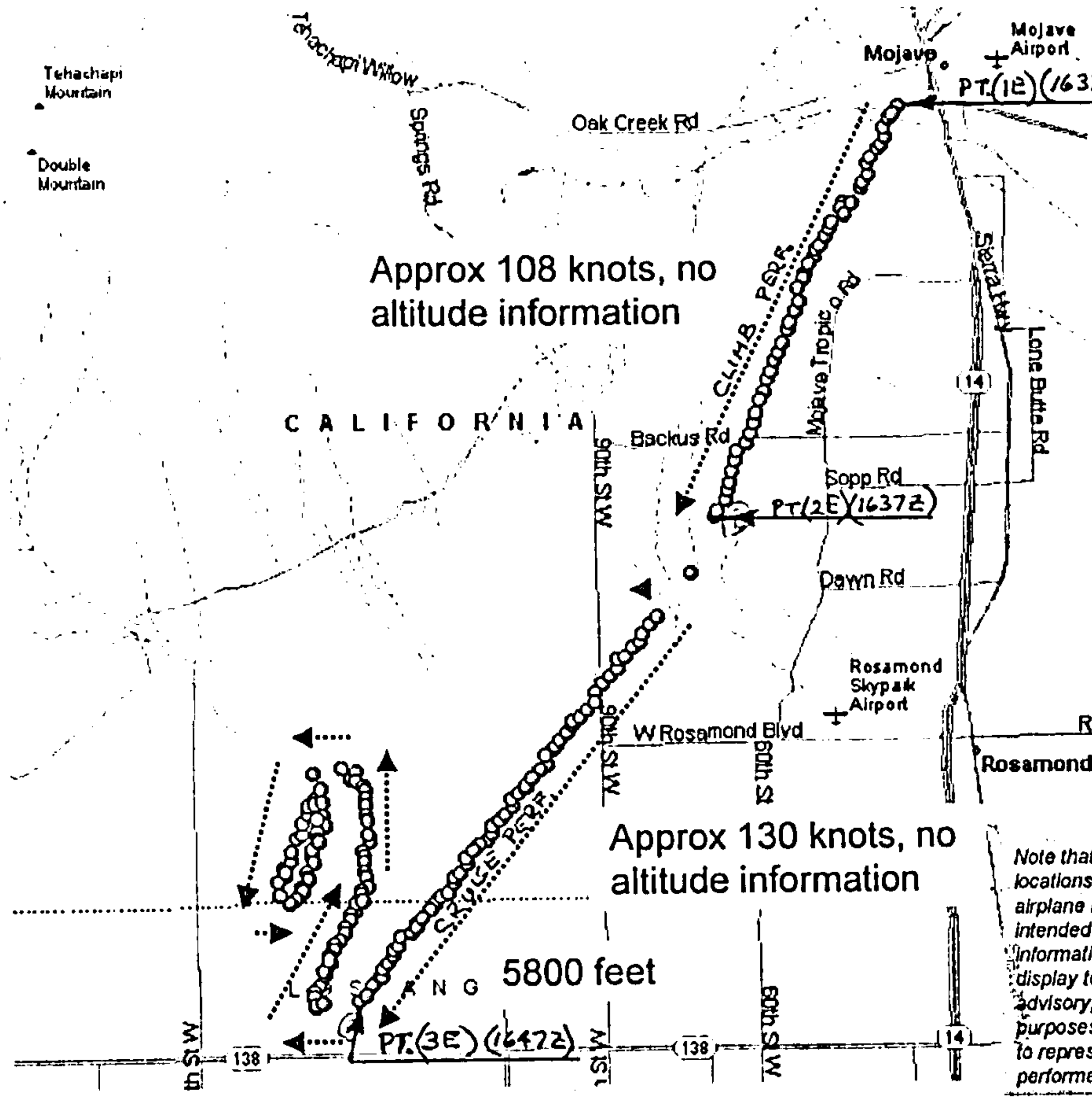




DERRINGER D-1
RADAR MAP No. 3
Unlabelled red targets are from previous path, not spiral maneuver.
34.85154 -118.3891
F1: 16:53:33.875
F4: 5200
1
FLIGHT PATH DATA IN THE SPIN ESTIMATED FROM RADAR POSITION AND ALTITUDE PLOTS. SPIN CHARACTERISTICS OF A TYPICAL PART 23 AIRCRAFT ARE INCLUDED IN THE ANALYSIS.
34.84794 -118.3888
F1: 16:53:43.160
F4: 4000
3
34.8472 -118.3913
F1: 16:53:47.957
F4: 3500
4
Holiday Ave
Holiday Ave
Blue line is a best estimate of flight path, may not reflect actual performance. Entry speed approx 80 knots, descent rate increases to > -5000 fpm.
Accident site 039° 0.15nm from last target
34.84435 -118.3885
F1: 16:53:38.363
F4: 4500
2
34.84299 -118.3909
F1: 16:53:52.763
F4: 2900
5
RISE 3RD STALL FA. (STUDENT)
DEPARTURE INTO SPIN.
Note that all radar plots, locations, and descriptions of airplane movement are intended to indicate information available for display to ATC personnel for advisory, control, or SAR purposes and are not intended to represent the exact performance of the vehicle.
DOTTED GREEN, FIRST 1½ TURNS
SOLID GREEN, SEC. 1½ TURNS
SOLID BLUE, THIRD 1½ TURNS
DOTTED RED, FOURTH 1½ TURNS
SOLID RED, FINAL 1¼ TURNS

DERRINGER D-1

RADAR PLOT 14 ~~Mar~~ Nov 01



Note that all radar plots, locations, and descriptions of airplane movement are intended to indicate information available for display to ATC personnel for advisory, control, or SAR purposes and are not intended to represent the exact performance of the vehicle.

Wing D-1 Derrin

Speeds:	MPH
Flaps	72-135
Norm Ops.	80-200
Smooth Air	200-252
Blue Line	110
Red Line	85/252
Downwind	130
Base	120
Final Flaps 40	100
Final Flaps Up	120
Vs0	72
Vmc	85
Vs1	80
Vr	90
Vfe	135
Vlo (U/D)	170
Vle	170
Va/Vp	170
Vx	85
Vxse	100
Vy	115
Vysc	110
Vno / Vc	200
Vne	252

Weight & Balanc	
Empty	[illegible]
ZFW	2800 lbs
Max TO	3050 lbs
Max Land	2900 lbs
CG limit	90.5-93.0 in
Pilot	87.0 in
Passenger	87.0 in
Cargo	118.0 in
Max Cargo	250 lbs
Fuel	92 in

ENGINE:	Lycoming IO	
	Lycoming IO	
	160 HP at 270	
MP (in HG):	15-29.6	Normal Ops
	30	Max
RPM:	2000-2700	Normal Ops
	2700	Max
Oil	8 Quarts	SAE No.20/No.50
Press (psi):	25	Min
	25-60	Caution
	60-85	Norm Ops
	85-100	Caution
	100	Max
Oil Temp (deg F)	60-120	Min
	120-245	Norm Ops
	245	Max
CHT (deg F):	200-500	Norm Ops
	500	Max
Suct (in HG):	4.95-5.2	Norm Ops
Accel (g):	-1.52 to 3.8 (Flaps UP)	
	0.0 to 2.0 (Flaps DWN)	
FUEL:	68 USG (60 USG Usable)	
	AVGAS 100/130 (Green)	
FUEL Press (psi):	0.5	Min
	0.5-8.0	Norm Ops
	8.0	Max
Miscellaneous		
Max Crosswind:		17 kts

D – 1 DERRINGER

3/5/2003

NORMAL PROCEDURES

PREFLIGHT INSPECTION (COCKPIT & EXTERIOR)

1. Canopy – Open
2. Fuel Shutoff Valves – On/On
3. Landing Gear Lever – Down
4. Battery Switch – On
5. Flaps – Down
6. Exterior Lighting – On and Check
7. Battery Switch – Off
8. Left Wing Flap – Visually Check
9. Left Fuel Cap – Remove & Visually Check Fuel
10. Left Fuel Sumps – Drain
11. Left main Gear/Tire – Visually Inspect
12. Left Engine – Check Oil, Cowl, Prop, Etc.
13. Nose Gear/Tire – Visually Check
14. Right Engine – Check Oil, Cowl, Prop, Etc.
15. Right Main Gear/Tire – Visually Check
16. Right Fuel Sumps – Drain
17. Right Fuel Cap – Remove & Visually Check Fuel
18. Right Wing Flap - Visually Check
19. Right Empennage – Check
20. Horizontal/Vertical Tail Surfaces – Check
21. Left Empennage – Check

BEFORE STARTING ENGINES

1. Exterior Inspection – Complete
2. Seat belt and shoulder harness – Fastened
3. Emergency Gear Lowering Handle - Stowed
4. Radios and electrical equipment – Off
5. Circuit Breakers – In
6. Landing Gear Handle - Down
7. Throttles – Idle
8. Propellers - Full Forward
9. Cowl Flaps – Open
10. Mixtures – Idle Cutoff
11. Fuel Selectors – On
12. Canopy – As Desired

STARTING ENGINES

1. Battery Switch – On
2. Radio Master Switch – On/ Check Intercom

Cold Start

3. Mixtures – In
4. Left Boost Pump – On until fuel flow stabilizes at approx. 2.5 GPH
5. Throttle – 1/4 Inch Forward
6. Start Switch – Engage
7. Throttle – 1000 RPM
8. Left Generator – On
9. Engine Instruments - Check
10. Repeat for right engine
11. Radios – On
12. Rotating Beacon – On
13. Transponder - Stby

Hot Start

3. Left Throttle – 1 Inch Forward
4. Start switch – Engage
5. Mixture – Idle cutoff until engine starts, then full rich
6. Left Throttle – 1000 RPM
7. Left Generator – On
8. Engine Instruments – Check

Repeat for Right Engine

9. Radios – On
10. Rotating Beacon – On
11. Transponder - Stby

TAXIING

1. Canopy – Locked in "Taxi" position or closed
2. Brakes – Check
3. Nosewheel Steering – Check
4. Turn & Slip Indicator and Compasses – Check for movement

BEFORE TAKEOFF

1. Flight Controls - Check
2. Right Engine – 2000 RPM (**DO NOT RUNUP ENGINE UNTIL OIL TEMPERATURE IS IN THE 77°C)**
   a. Prop – Retard Until Approx. 200 RPM Drop **(DO NOT PLACE IN FEATHER)**
   b. Magnetos – Check (150 RPM Max drop)
1. Repeat For Left Engine
2. Radio Master - On
3. Battery – On
4. Generators – On
5. Boost Pumps – On
6. Propellers – Full Forward
7. Lights – On As Required
8. Engine Instruments – Check
9. Mixtures - Rich
10. Flaps – Full Down Then Full Up
11. Trim - Set For Takeoff
12. Transponder – On/Alt
13. Canopy – Closed and Locked
14. Canopy Seal Switch – On (Aft)

TAKEOFF

1. Lineup – Check Heading Indicators, HSI, and Caution/Warning Lights
2. Throttles – Smoothly Advance to Full
3. Rotate – 90 MPH/78 KTS
4. Liftoff – Approximately 100 MPH/87 KTS
5. Gear – Up when positive rate of climb and landing cannot be made
6. Accelerate to "Blue Line" (110 MPH/95 KTS)
7. Throttles – 25 inches
8. Propellers – 2500 RPM

V_Y = 115 MPH/100 KTS **V_X = 105 MPH/91 KTS**

CRUISE

1. Boost Pumps – Off (Above 2000 ft AGL)
2. Manifold Pressure, Prop RPM, Mixture – As Desired
3. Cowl Flaps – Closed

BEFORE LANDING

1. Mixtures – Rich
2. Props – High RPM
3. Boost Pumps – On
4. Landing Gear – Down
5. Wing Flaps – As Desired

Downwind – 130 MPH/115 KTS
Base - 120 MPH/105 KTS
Approach - 120 MPH/105 KTS Flaps Up
100 MPH/87 KTS Flaps Down

AFTER LANDING

1. Landing/Taxi Lights – As Required
2. Wing Flaps – Up
3. Trim – Set For Takeoff
4. Cowl Flaps – Open
5. Boost Pumps – Off
6. Transponder – Off

SHUTDOWN

1. Parking Brake – As Required
2. Electrical Equipment – Off
3. Props – Full Forward
4. Mixtures – Idle Cutoff
5. Magneto Switches – Off
6. Generators – Off
7. Battery – Off
8. Radio Master – Off
9. Canopy Seal Switch – Off
10. Canopy - Open

LIMITATIONS

ENGINE:

OIL TEMP: MAX 245° F/118° C
NORMAL 120 – 245° F/49° – 118° C
CAUTION 60 – 120° F/16° – 49° C

OIL PRESSURE: MAX 100 PSI
MIN 25 PSI
NORMAL 60 – 85 PSI
CAUTION 25 – 60 PSI
85 – 100 PSI

CYLINDER HEAD TEMP:
MAX 500° F
NORMAL 200 – 500° F

TACHOMETER: MAX 2700 RPM
NORMAL 2000 – 2700 RPM

VACUUM:

NORMAL 4.95 –5.20 IN. HG.

AIRSPEED:

V_{NE} = 252 MPH 219 KTS	V_{NO} = 200 MPH 174 KTS	V_A = 170 MPH 148 KTS
V_{FE} = 135 MPH 117 KTS	V_{LE} = 170 MPH 148 KTS	
V_{MCA} = 85 MPH 74 KTS	V_{S1} = 80 MPH 70 KTS	V_{SO} = 72 MPH 63 KTS

LOAD FACTORS:

CLEAN +3.8 TO –1.5 G'S

LANDING CONFIG +2.0 TO 0 G'S

EMERGENCY PROCEDURES

ENGINE FAILURE TROUBLESHOOTING

1. Maintain Aircraft Control
2. Throttles – Full Forward
3. Mixtures – Full Rich
4. Fuel Boost Pumps – On
5. Fuel Pressure – Check Slight Positive
6. Fuel Shut Off Valves – Check On (Observe Fuel Flow Reading)
7. Trim Aircraft
8. Cowl Flaps – Open
9. Fuel Quantity - Check
10. Magnetos – Check On
11. Oil Pressure and Temp – Check in the Green
12. If Engine is Restartable – See AIRSTART PROCEDURE
13. If Engine is Not Restartable – See SINGLE ENGINE OPERATIONS

SINGLE ENGINE OPERATIONS

A. OPERATING ENGINE

1. Throttle – Full Forward
2. Maintain – Airspeed and Altitude (85 MPH/74 KTS
Redline Min, V_{YSE}=110 MPH/96 KTS, V_{XSE}=100 MPH/87 KTS)
3. Bank – 2 Degrees into Good Engine

B. INOPERATIVE ENGINE

1. Prop – Feathered
2. Throttle – Closed
3. Mixture – Idle Cut Off
4. Ignition Switch – Off
5. Fuel Boost Pump – Off
6. Fuel Shut Off Valve – Off
7. Generator Switch – Off
8. Cowl Flap –Closed

SINGLE ENGINE LANDING PROCEDURE

1. Maintain – Min Controllable Airspeed (85 MPH/74 KTS Redline Min)
2. Do not Lower Gear and Flaps Until Landing is Assured

AIRSTART PROCEDURE

1. Fuel Shut Off Valve – Open
2. Generator Switch – On
3. Airspeed – 130 MPH
4. Prop – Full Forward
5. Throttle – Idle
6. Mixture – Idle Cut Off
7. Ignition/Starter – Engage Until 700 RPM & Windmills
8. Mixture – Slowly Enrich by Turning Vernier Knob to
   Prevent Over Rich Mixture
9. Engine Running – Surge to 2700 RPM & Change In Yaw
10. Throttle & Prop – Idle to warm Engine
11. Cylinder Head Temp and EGT – Check for Rise
12. Cowl Flap – Open

ENGINE FAILURE DURING TAKEOFF, BEFORE ROTATION

1. Abort
2. Throttles – Close
3. Brakes – As Required

ENGINE FAILURE DURING TAKEOFF, AFTER ROTATION

1. Mixtures – Full rich
2. Props – Full Forward
3. Throttles – Full Forward
4. Landing Gear – Up
5. Inoperative Engine – Determine
6. Airspeed – 100 MPH/87 KTS to Clear Obstacles
7. Airspeed – 110 MPH/96 KTS After Obstacles Cleared
8. Inoperative Engine- Feather
9. Inoperative Engine – Secure (Use <u>SECURE ENGINE OPERATIONS/</u>**B. INOPERATIVE ENGINE** Checklist)

ENGINE FIRE, INFLIGHT

1. Throttle Good Engine – Full Forward to Maintain Airspeed & Altitude
   BAD ENGINE
2. Throttle – Closed
3. Fuel Shut Off Valve – Off
4. Prop – Feather
5. Mixture – Idle Cut Off
6. Ignition Switch – Off
7. Fuel Boost Pump Switch – Off
8. Generator Switch – Off
9. Cowl Flap – Closed
10. Land – ASAP

ELECTRICAL POWER MALFUNCTION, INFLIGHT

1. Radio Master Switch – Off
2. Battery Switch – Check On
3. Generator Switches – Off
4. Electrical Systems – Off
5. Either Generator – On
6. AMP Meter Selector Switch – Select Operating Generator
7. Generator AMP Output – Check Normal
8. If Load is Good & No Sign of Malfunction, Opposite Generator – On
9. AMP Meter – Select Opposite Generator
10. Generator AMP Output – Check Normal
11. If Either Generator Bad – Turn Off
12. AMP Meter – Select Battery
13. Battery AMP Output – Check
14. If Load is Bad – Battery Off
    TO BRING SYSTEMS BACK ON LINE
15. All Electrical Switches – Insure Off
16. Master/Radio Master Switches – On
17. Selected Systems – On, One At a Time
18. Electrical Systems Load – Min Practical

PROP OVERSPEED

1. Throttles – Retard
2. Oil Pressure – Check
3. RPM – Set
4. Airspeed – Reduce
5. Throttles – As Required

SPIN

1. Throttles – Back
2. Spin Direction – Determine (Turn Needle)
3. Rudder – Opposite Spin Direction
4. Yoke – Forward As Required
5. Ailerons – Neutral
6. Recover With Smooth Control Inputs

EMERGENCY DESCENT

1. Throttles – Closed
2. Props – Full Forward
3. Mixtures – Rich
4. Gear – Down at 170 MPH/148 KTS
5. Pitch – As Required to Hold 170 MPH/148 KTS

NO FLAP LANDING

1. Same as Normal Landing Except Stall Speed is 80 MPH/69 KTS & Final Approach Speed is 120 MPH/104 KTS

THE WING AIRCRAFT

MODEL D-1

PART I

FAA APPROVED FLIGHT MANUAL DATA

PART II

WEIGHT AND BALANCE DATA

PART I

FAA APPROVED AIRPLANE FLIGHT MANUAL

WING AIRCRAFT MODEL D-1

THIS AIRPLANE MUST BE OPERATED IN ACCORDANCE WITH THE LIMITATIONS HEREIN PRESCRIBED.

THIS DOCUMENT MUST BE KEPT IN THE AIRPLANE AT ALL TIMES.

SERIAL NO. 009

REGISTRATION NO. N 8602 J

[redacted]

CHIEF
Aircraft Engineering Division
Western Region
Federal Aviation Administration
Department of Transportation

Date of Approval 12 Aug 69

REVISIONS

REVISON DATE	APPROVED BY: FAA : DATE	PAGES AFFECTED	REMARKS
1-22-71	[redacted] Acting Chief, Aircraft Engineering Division, FAA	Pg. 1,2,3,4,5,5.1, 10 of Part I and Pg. 8,9,10, of Part II.	Revised vacuum setting, placards, and equipment section. Misc. corrections.
7-25-79	[redacted] CHIEF, FLIGHT TEST BRANCH FAA WESTERN REGION	Pg. 3 & 5 & 6 & 7 of Part I and Pg. 4 of Part II	Removed max. zero fuel wt. placard.

TABLE OF CONTENTS

PART I

AIRPLANE FLIGHT MANUAL

SECTION 1: LIMITATIONS

The following limitations must be observed in the operation of this airplane:

Engine or Engine	Two Lycoming Model IO-320-CIA Two Lycoming Model IO-320-BIC	
Engine Limits	For All Operations: 2700 RPM - 160 HP - Full Throttle	
Fuel	100/130 Octane minimum grade aviation gasoline	
Propeller	Two (2) Hartzell Model HC-C2YL-2RB/8459-18 Full feathering, constant speed. Pitch settings, High 78° Low 13.5° at Propeller Station 30"	

Power Instruments

Oil Temperature		
Maximum	245° F	(Red Radial)
Normal	120° - 245° F.	(Green Arc)
Caution	60° - 120° F.	(Yellow Arc)
Oil Pressure		
Maximum	100 PSI	(Red Radial)
Minimum	25 PSI	(Red Radial)
Normal	60 - 85 PSI	(Green Arc)
Caution	25 - 60 PSI	
and	85 - 100 PSI	(Yellow Arc)
Cylinder Head Temperature		
Maximum	500° F.	(Red Radial)
Normal	200° - 500° F.	(Green Arc)
Tachometer		
Maximum RPM	2700	(Red Radial)
Normal RPM	2000 - 2700	(Green Arc)

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Model D-1

VACUUM SYSTEM OPERATION

Normal operation, indicator should read 4.95 to 5.2 in. hg. In event of a failure, a day-glo red indicator button pops out to signal failure and identify failing source.

The vacuum pumps supply power to the instruments simultaneously. Check valves automatically select the power source in case single engine operation is required.

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AIRSPEED LIMITS	MPH CAS	MPH IAS	
Never exceed (V_{ne})	252	252	Red Radial
Max. structural cruising (V_{no})	200	200	
Max. maneuvering (V_p)	170	170	
Max. flap down (V_{fe})	135	135	
Max. gear extension (V_{le})	170	170	
Max. gear operating (V_{lo})	170	170	
Min. control - single engine (V_{mc})	85	85	Red Radial
Stall - clean (V_{sl})	79	80	
Stall - gear and flaps down (V_{so})	72	72	
Best rate of climb - single engine (V_{yse})	110	110	Blue Radial
Best angle of climb - single engine (V_{xse})	100	100	

ARCS			
Yellow Arc	200 MPH, CAS (V_{no})	to	252 MPH, CAS (V_{ne})
Green Arc	80 MPH, CAS (V_{sl})	to	200 MPH, CAS (V_{no})
White Arc	72 MPH, CAS (V_{so})	to	135 MPH, CAS (V_{fe})

FLIGHT LOAD FACTORS			
Maximum positive	3.8	g.	clean
	2.0	g.	flaps down
Maximum negative	1.52	g.	clean
	.00	g.	flaps down

MANUEVERS

Acrobatic manuevers, including spins are prohibited.

MAXIMUM WEIGHT

It is the responsibility of the airplane owner and the pilot to assure that the airplane is properly loaded.

Maximum take-off weight	3050	pounds
Maximum landing weight	2900	pounds
Maximum zero fuel weight	2800	pounds

See Weight and Balance Section for proper loading instructions.

C. G. RANGE - Datum is front of nose cone Station 0.00

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C. G. RANGE (cont'd.)

Weight Pounds	Fwd. Limit In. Aft of Datum	Aft Limit In. Aft of Datum
2100	89.5	93.0
2400	89.5	93.0
3050	90.5	93.0

Straight line variation between points given.

PLACARDS

On the instrument panel in full view of the pilot.
" This airplane must be operated as a normal category airplane in compliance with the FAA Approved Airplane Flight Manual. Acrobatic maneuvers including spins prohibited. "

On the baggage compartment side wall.
" Maximum baggage 250 lbs. For additional loading instructions see Weight and Balance data. "

On right cockpit floor - near manual gear handle.
" To extend gear manually:
1. Gear handle in down position.
2. Pull landing gear motor circuit breakers (2)
3. Extend emergency handle beneath right seat and crank counter clockwise, looking forward, until Green Light is on. "

On top canopy next to canopy handle.
" Do not open canopy in flight. "

On instrument panel close to airspeed indicator.
" Max. gear operating and extended speed 170 MPH (IAS) . "

On instrument panel close to airpseed indicator.
" Max. demonstrated crosswind 17 MPH.
Min. control - single engine 85 MPH.
Maneuvering 170 MPH. "

On instrument panel next to heater switches.
" Red overheat light on, turn off heater switches. "

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PLACARDS (cont'd.)

On the instrument panel in full view of the pilot.

"This airplane is approved for VFR day and night operation when equipped per Section 7 of Part II of Operators Manual RDI-16. Flight into known icing conditions is prohibited."

On the instrument panel next to alternate static air switch.

"Static Press."

"Normal" "Alternate"

On canopy side window.

"Airspeed, Altimeter and Vertical Speed Indicators unreliable when using alternate static source with side window open."

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ALTERNATE STATIC AIR SOURCE

Corrections to be applied when using the alternate static source.

GEAR AND FLAPS UP.

Airspeed MPH,IAS	80	100	120	140	160	180	200
Airspeed Correction(MPH)	0	-1	-3	-4	-6	-8	-9
Altitude Correction (Feet)	0	-15	-35	-60	-90	-130	-180

NOTE: Airspeed and altitude corrections are neglibible with gear and flaps down.

NOTE: The vertical velocity indicator is unreliable for approximately 5 to 10 seconds after making any change in the static source selector switch position.

NOTE: The airspeed, altimeter, and vertical velocity indicators are unreliable when using the alternate static source with the side window open.

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Date: 1-22-71
Model D-1

SECTION 2: NORMAL OPERATING PROCEDURES

Only procedures considered unique to this airplane are prescribed in this section. Conventional procedures, although not prescribed, should nevertheless be followed.

EXTERNAL POWER RECEPTACLE (if installed)

Use only for starting engines.

1. Turn master switch "OFF."
2. Engage external power plug to receptacle, located on bottom of fuselage aft of wing.
3. After engines start, remove external plug.
4. Turn master switch "ON".

TO CHECK ALTERNATORS PRIOR TO TAKE-OFF.

1. Left engine check.
   - A. Turn right generator switch "OFF." (located on instrument panel)
   - B. Turn selector switch to "LEFT GEN." Alternator, if operating, will show charge on ammeter.
2. Right engine check
   - A. Turn left generator switch "OFF." (located on instrument panel)
   - B. Turn selector switch to "RIGHT GEN." Alternator, if operating, will show charge on ammeter.

NOTE:

- GENERATOR SWITCHES ARE TO BE ON AT ALL TIMES EXCEPT TO CHECK GENERATOR OPERATION, OR IN THE EVENT OF MALFUNCTION. (see Emergency Procedures)

BEFORE TAKE-OFF

- A. Fuel on
- B. Fuel pumps on (aux.)
- C. Mixtures rich
- D. Cycle props at 1900 RPM
- E. Cowl flaps open
- F. Engine gauges normal
- G. Trim set for take-off
- H. Flaps set (0^{o})
- I. Seat belts fastened.

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BEFORE TAKE-OFF (cont'd.)

J. Seat locked
K. Canopy locked
L. Controls free
M. Propellers set (high RPM)
N. During take-off apply power smoothly

CRUISE

A. Fuel pumps off
B. Manifold pressure, prop rpm, fuel mixture as desired.
C. Cowl flaps closed

LANDING

A. Mixtures rich
B. Props set (high rpm)
C. Fuel pumps on (aux.)
D. Landing gear down and locked
E. Flaps as desired

CIRCUIT BREAKERS

Circuit breakers are provided for the protection of the electrical system and are located beneath the instrument panel

STALL AND GEAR WARNING HORNS

Stall warning and gear extension warning horns are inoperative with the master switch "OFF."

GEAR EXTENSION - MANUAL

A. Gear handle in "DOWN" position.
B. Pull out L.C. motor circuit breakers. (2)
C. Extend handle under front of right seat and crank counter clockwise looking forward until Green Light is "ON".

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SECTION 3: EMERGENCY OPERATING PROCEDURES

SINGLE ENGINE.

1. Operating engine: throttle open to maintain altitude and airspeed.
   Minimum controllable single engine speed - 85 (IAS) MPH.
2. Inoperative engine:
   - A. Prop control "FEATHERED"
   - B. Throttle "CLOSED"
   - C. Mixture in "IDLE CUT-OFF"
   - D. Ignition switch "OFF"
   - E. Fuel pump (aux.) "OFF"
   - F. Fuel selector valve "OFF"
   - G. Alternator switch "OFF:
   - H. Cowl flap - closed

UNFEATHERING PROCEDURE.

1. Inoperative engine:
   - A. Turn fuel valve "ON"
   - B. Prop control in high rpm (retard upon start)
   - C. Mixture rich
   - D. Ignition "ON"
   - E. Rotate propeller with starter
   - F. Advance throttle after oil temp. is in normal range.
   - G. Re-synchronize engines

ENGINE FAILURE DURING TAKE-OFF - Speed below 85 MPH, IAS
(with sufficient runway remaining for stopping

1. Throttles - close immediately
2. Brakes - as required

ENGINE FAILURE AFTER TAKE-OFF - Speed above 85 MPH, IAS
(without sufficient runway remaining for stopping

1. Mixtures - FULL RICH
2. Propellers - FULL FORWARD
3. Throttles - FULL FORWARD
4. Landing gear - UP
5. Inoperative engine - DETERMINE
   (idle engine same side as idle foot)
6. Inoperative engine - FEATHER
7. Climb to clear obstacle - 100 MPH IAS
8. Accelerate to 110 MPH, IAS after obstacle is cleared
9. Inoperative engine - SECURE as above.

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ENGINE FIRE PROCEDURE AND CHECK LIST

1. Operating engine: throttle open to maintain altitude and airspeed.
   Minimum controllable single engine speed - 85 MPH (IAS)
2. Engine with fire:
   A. Throttle "CLOSED"
   B. Fuel selector valve "OFF"
   C. Prop control "FEATHERED"
   D. Mixture in "IDLE CUT-OFF"
   E. Ignition switch "OFF"
   F. Fuel pump (aux) "OFF"
   G. Alternator switch "OFF"
   H. Cowl flap - closed
3. Land as soon as possible.

SINGLE ENGINE LANDING PROCEDURE.

1. Operating engine: throttle open to maintain altitude and airspeed.
   Minimum controllable single engine speed - 85 MPH (IAS)
2. Same procedure as for two engine landing except do not lower flaps or gear until landing is assured.

NO FLAP LANDING PROCEDURE

1. Same as normal landing with flaps down except stall speed with gear down and flaps up is 80 MPH (IAS).

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ELECTRIC TRIM MALFUNCTION

In case of electric trim malfunction or runaway in either the rudder or elevator axis, turn off the appropriate trim safety switch. Adjustment of cowl flaps and/or power may be used to attain minimum elevator force for prolonged flight. Up to 5° of bank may be used to attain minimum rudder force.

IN-FLIGHT ELECTRICAL POWER MALFUNCTION

In the event that a electrical power failure is experienced or a potential electrical failure suspected for any reason, the MASTER SWITCH should be "TURNED OFF". This will cut off total electrical power and naturally all electrical equipment operation.

In order to restore electrical power and isolate the malfunctioning power source, the following procedure is recommended:

1. Turning the master switch "OFF", the battery switch and two alternator switches are turned "OFF".
2. If time permits, it is next recommended that most electrical systems be turned "OFF", also, and brought back "ON LINE" after the power systems are again in operation.
3. Return one alternator to "ON", making sure that the ammeter selector switch is selected properly for this alternator.

CHECK: If the alternator-ammeter indicates normal power OUTPUT.

NOTE: Due to the starting characteristics of the alternators when the battery is off, they may not " Start " generating if the "On-Line" equipment load is high. For this reason, electrical equipment may have to be temporarily turned off until the load is low enough to permit starting without battery power. (This is approximately 10 Amps.)

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IN-FLIGHT ELECTRICAL POWER MALFUNCTION. (Cont'd.)

4. If the first alternator indicates power output, then next turn "ON" the opposite alternator and note its' power output at the proper ammeter selector.
5. With both or either alternators supplying power, the battery can be brought on-line by turning the battery switch "ON". A malfunctioning battery may be recognized by a high charge rate or highly fluctuating ammeter indications. In this event, turn the battery switch "OFF" and continue with alternator power only. Once started the alternators will supply approximately 60 amps. each.
6. If the procedures disclose that either alternator system appears to be inoperative or malfunctioning, turn "OFF" that alternator switch. Each alternator generating system is a completely independent power source controlled by its' respective "ON-OFF" switch. It is also recommended that the electrical systems loads be carefully managed so as to not exceed the alternator generating capacity in the event only one system is operating.

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SECTION 4: PERFORMANCE

1. VARIATION OF RATE OF CLIMB WITH PRESSURE ALTITUDE AND OUTSIDE AIR TEMPERATURE.

Two Engine, Gross Wt. 3050 lb., Full Power, Clean						
Pressure Altitude (Feet)	Best Angle IAS, MPH	Best Rate IAS, MPH	TEMPERATURE			
			40°F.	60°F.	80°F.	100°F.
Sea Level	84	122	1750	1700	1640	1585
2000	85	120	1555	1505	1450	1400
4000	86	117	1360	1310	1260	1205
6000	87	115	1180	1130	1080	1030

One Engine, Gross Wt. 3050 lb., Full Power, Clean						
Pressure Altitude (Feet)	Best Angle IAS, MPH	Best Rate IAS, MPH	TEMPERATURE			
			40°F.	60°F.	80°F.	100°F.
Sea Level	101	113	450	417	383	350
2000	102	111	347	313	280	245
4000	103	109	238	205	172	138
6000	104	107	135	102	68	35

Two Engine, Gross Wt. 3050 lb., Full Power, Balked Landing						
Pressure Altitude (Feet)	Best Angle IAS, MPH	Best Rate IAS, MPH	TEMPERATURE			
			40°F.	60°F.	80°F.	100°F.
Sea Level	80	87	1027	973	917	862
2000	80	86	860	807	755	702
4000	80	85	687	635	580	528
6000	80	84	523	472	420	367

2. DEMONSTRATED ALTITUDE LOSS DURING STALL RECOVERY IS 160 FT.

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3. STALL SPEED CHART.

STALL SPEED, MPH (IAS) 3050 LBS. GROSS WEIGHT					
Configuration, Power Off	ANGLE OF BANK				
	0°	15°	30°	45°	60°
Flaps Up	80	81	86	95	113
Flaps Down	72	73	77	86	102

4. AIRSPEED CORRECTION TABLE.

FLAPS 0°		* FLAPS 40°	
IAS,MPH	CAS,MPH	IAS,MPH	CAS,MPH
80	79	80	79
90	90	90	90
100	100	100	100
120	120	110	110
140	140	120	121
160	160	130	131
180	180	140	141
200	200		
220	220		
240	240		
260	260		

* Maximum Flap Speed 135 MPH (40°)

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PART II

WEIGHT & BALANCE DATA

NOTE: This is not a part of the FAA approved portion of this Report.

It is the operator's responsibility to determine that the aircraft is loaded in accordance with the Weight and Balance limitations noted.

WING AIRCRAFT COMPANY

REPORT NO. PD1-1C
ISSUE DATE 5-30-80
REVISION DATE NOTED

REVISIONS (PART II)

REVISION DATE	APPROVED BY	PAGES AFFECTED	REMARKS
5-30-80	[redacted]	PG. 8, 9, 10 & 11	UPDATE SECTION 7: EQUIP. LIST.
11-24-80		PG. 9 & 10	REVISED
9-28-81		PG. 11	REV. EQUIP. LIST

8-2241

SECTION 1: WEIGHING INSTRUCTIONS

A. Place the aircraft on scales, one for each landing gear. Scales should be placed on a flat and level terrain.

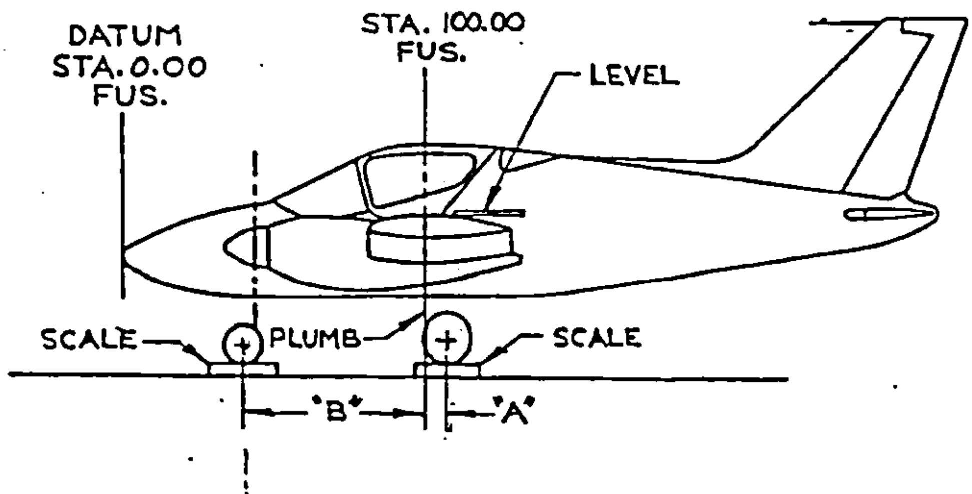
B. Block the main gear struts with 7 in. blocks. Level the aircraft by blocking the nose gear as required. Partially withdraw two machine screws located at Fuselage Sta. 104.75 and Sta. 117.80 at WL 44.680 on the left hand side of the fuselage, these screws are leveling points. Aircraft is longitudinally level when a level placed on the heads of these screws indicates level.

To check lateral level on the airplane, if necessary, place a level across the baggage floor.

C Determine the center line location of the main gear axles by pulling a string between the two axis and with the use of a plumb held from the Fuselage ref. point (a small hole in the bottom fuselage skin located on the center line of the aircraft and Sta. 100.00 Fus. forward face of the main spar). Record measurement "A".

D By measuring parallel to the center line of the fuselage measure the distance between the plumb held from the fuselage reference point and the left hand center of the nose gear axle, and to the right hand center of the nose gear axle, averaging the two measurements. Record as "B".

E. Take the weight reading on each scale and record them below.



WESTERN AIR RADIO

2825 EARHART APRON, TORRANCE, CA 90505 (213) 534-0455

WEIGHT & BALANCE REVISION

N 8602J

Serial # 009

Model # Wing D-1

Date May 3, 1982

AIRCRAFT BEFORE CHANGE:	Weight	Arm	Moment
	2117.80	91.75	194253.70
REMOVE THE FOLLOWING:			
Turn Cord.	2.44	65.4	159.57
ADD THE FOLLOWING:			
B5C Flight Control System	24.7	96.9	2393.43
			196487.56

EMPTY WEIGHT 2140.06

NEW E.W.C.G. 91.81

MAX. GROSS WEIGHT 3050.00

USEFUL LOAD 909.94

BY [redacted]

WESTERN AIR RADIO
2825 Earhart Apron
Torrance, Calif. 90505
FAA Repair Station
#4814

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

MAJOR REPAIR AND ALTERATION
(Airframe, Powerplant, Propeller, or Appliance)

Form Approved
Budget Bureau No. 04-R060.1

FOR FAA USE ONLY
OFFICE IDENTIFICATION

INSTRUCTIONS: Print or type all entries. See FAR 43.9, FAR 43 Appendix B, and AC 43.9-1 (or subsequent revision thereof) for instructions and disposition of this form.

1. AIRCRAFT	MAKE: Wing	MODEL: D-1
	SERIAL NO.: 009	NATIONALITY AND REGISTRATION MARK: N8602J
2. OWNER	NAME (As shown on registration certificate): Coast Aircraft Sales	ADDRESS (As shown on registration certificate): 8620 Gibbs Drive San Diego, CA 92123

3. FOR FAA USE ONLY

4. UNIT IDENTIFICATION / 5. TYPE

UNIT	MAKE	MODEL	SERIAL NO.	REPAIR	ALTERATION
AIRFRAME	(As described in item 1 above)				X
POWERPLANT					
PROPELLER					
APPLIANCE	TYPE MANUFACTURER				

6. CONFORMITY STATEMENT

A. AGENCY'S NAME AND ADDRESS	B. KIND OF AGENCY	C. CERTIFICATE NO.
Western Air Radio 2825 Earhart Apron Torrance, CA CA 90505	[ ] U.S. CERTIFICATED MECHANIC [ ] FOREIGN CERTIFICATED MECHANIC [X] CERTIFICATED REPAIR STATION [ ] MANUFACTURER	4814 Class I, II, Limited Ratings

D. I certify that the repair and/or alteration made to the unit(s) identified in item 4 above and described on the reverse or attachments hereto have been made in accordance with the requirements of Part 43 of the U.S. Federal Aviation Regulations and that the information furnished herein is true and correct to the best of my knowledge.

DATE	S[redacted]
May 3, 1982	

7. APPROVAL [redacted]

Pursuant to the authority given persons specified below, the unit identified in item 4 was inspected in the manner prescribed by the Administrator of the Federal Aviation Administration and is [X] APPROVED [ ] REJECTED

BY				
[ ] FAA FLT. STANDARDS INSPECTOR	[ ] MANUFACTURER	[ ] INSPECTION AUTHORIZATION	OTHER (Specify)
[ ] FAA DESIGNEE	[X] REPAIR STATION	[ ] CANADIAN DEPARTMENT OF TRANSPORT INSPECTOR OF AIRCRAFT	

DATE OF APPROVAL OR REJECTION	CERTIFICATE OR DESIGNATION NO.	SI[redacted]
May 3, 1982	4814	

FAA Form 337 (7-67) ☆ U.S. Government Printing Office [redacted] (8320)

NOTICE

Veight and balance or operating limitation changes shall be entered in the appropriate aircraft record. An alteration must be compatible with all previous alterations to assure continued conformity with the applicable airworthiness requirements.

8. DESCRIPTION OF WORK ACCOMPLISHED *(If more space is required, attach additional sheets. Identify with aircraft nationality and registration mark and date work completed.)*

1. Installed Brittain Model B-5C Autopilot System according to Brittain Installation Instructions 402-012-731, Rev. A, Dated 6/24/81 and Master Drawing list 403-012-736, dated 7/3/81; or later FAA approved revision.
2. Autopilot installed per STC #SA4553SW, dated Nov. 23, 1981.
3. Electrical laad evaluation of equipment installed performed.
4. Magnetic compass checked and calibrated.

----------------------Nothing Follows----------------------

☐ ADDITIONAL SHEETS ARE ATTACHED

Gibbs SERVICE CENTER, Inc.

3717 JOHN J. MONTGOMERY DR.
SAN DIEGO, CALIFORNIA 92123
PHONE 714-277-3311

F.A.A. REPAIR STATION #463-13

WEIGHT & BALANCE DATA

A/C Type Wing D-1 S/N 009 Reg. No. N86025 Date 4/13/82
Weight and balance computed after the installation of the following Avionics equipment

	WEIGHT	ARM	MOMENT
Prev. weight & balance	2070.00	91.86	190164.00
KING EQUIP.			
KR-21	.80	69.00	55.20
KMA 24H-53	1.70	66.00	112.20
KY 197	3.20	66.00	211.20
KNS 80	6.00	66.00	396.00
KCS 55A (KI 525A)	3.90	66.00	257.60
KY 165	5.10	66.00	336.60
KI 202	1.30	69.00	89.70
KR 87	3.10	66.00	204.60
KT 76	3.70	66.00	244.20
Com Antenna	.40	109.00	43.60
ADF Antenna	2.80	150.00	420.00
DME Antenna	.20	75.00	15.00
Transponder Antenna	.20	95.00	19.00
KG 102A	4.80	167.00	801.60
KMT 112A	.30	206.00	61.80
KA 51A	.30	72.00	21.60
Wire	10.00	80.00	800.00
	2117.80	91.75	194253.70

5-3-82 [redacted]

New Empty Weight.. ...2117.80 Lbs.

New Empty Weight C. G. .... REV [redacted] 91.75 In.

New Useful Load..2.20 Lbs.

WESTERN AIR RADIO
FAA REPAIR STATION #4824
CLASS 1 & 2 & 3 LIM
2815 EARHART APRON
TORRANCE, CAL. 90505

[redacted]

N8602J AS WEIGHTED 1-7-82 WITH NO FUEL AND 4 GALS. OIL

A = 6.6 B = 58.0 (Average)

Scale	Reading	- Tare	= Actual Weight
Nose Gear "N"	489	0	489
Left Main "LM"	821	0	821
Right Main "RM"	790	0	790

AIRCRAFT TOTAL AS WEIGHTED "W" 2100 lbs.

$$C.G. = 100 + \frac{(LM + RM)A - (N)B}{W} = STA.\ 91.56\ FUS.$$

LICENSED EMPTY WEIGHT AND C. G.

Item	Weight (Lbs)	C. G. Arm (In.)	Moment (Lbs.-In.)
Aircraft as Weighed	2100	91.56	192,276
REMOVE ~~Undrainable~~ Oil	- 30	70.41	- 2112
Unusable Fuel	0	0	0
Total Licensed Empty Weight	2070	91.86	190,164

Allowable Useful Load = 3050 lbs. - Licensed Empty Weight = 980 LBS.

Superceded 4-14-82
Gibbs Service Center [redacted] [redacted]

8-2841

SECTION 2: MOMENT ARMS

Pilot and Passenger	.... Sta.	87.00
Oil (7.5 Lbs. per Gal.)	.... Sta.	70.41
Fuel (6 Lbs. per Gal.)	.... Sta.	92.00
Baggage (250 Lbs. Max.)	.... Sta.	118.00

SECTION 3: SAMPLE PROBLEM

It is the responsibility of the aircraft owner and the pilot to be sure that the aircraft is properly loaded. The following example shows how to check the loading of your aircraft.

(EXAMPLE ONLY)

Item	Weight Pounds	Moment Thousands of Pounds - Inches	
Licensed Empty Wt. (Includes Oil)	2100	190,050	FROM PG. 2
Pilot	170	14,790	FROM PG. 5 29,550
Passenger	170	14,790	
Baggage	80	8,960	FROM PG. 5
Total Zero Fuel Weight	2520	228,590	
Fuel *	270 (45 gal)	24,840	FROM PG. 5
Total Weight and Moment	2790	253,430	

$$\frac{\text{Total Moment}}{\text{Total Weight}} = \text{C. G.}$$

$$\frac{253,430}{2790} = 90.84 \quad \text{(EXAMPLE ONLY)}$$

If the airplane has been altered, refer to the latest approved repair and alteration form (FAA-337) for this information.

* Unusable fuel is included in licensed empty weight.

TOTAL WEIGHT MUST NOT EXCEED 3050 LBS.

NOTE: The C. G. Position Sta. 90.84 falls withis the C. G. envelope on P. 7 therefore is satisfactory. An alternate check can be made on P. 6 Table by noting that at approx. 2790 lbs. that the 253,430 Moment is between the Fwd. Limit and Aft Limit Moments listed.

SECTION 4: LOADING CHART

TABLE I

FUEL			Pilot and Passenger Total		Baggage Compartment (See Note)			
Gal.	Lbs.	Moment	Lbs.	Moment	Wt. Lbs.	Sta. 112.0 Moment (Fwd. Area)	Sta.124.14 Moment (Center Area)	Sta.136.0 Moment (Aft Area)
5	30	2,760	100	8,700	20	2,240	2,483	2,720
10	60	5,520	120	10,440	40	4,480	4,966	5,440
15	90	8,280	140	12,180	60	6,720	7.448	8,160
20	120	11,040	160	13,920	80	8,960	9,931	10,880
25	150	13,800	180	15,660	100	11,200	12,414	13,600
30	180	16,560	200	17,400	120	13,440	14,897	16,320
35	210	19,320	220	19,140	140	15,680	17,380	19,040
40	240	22,080	240	20,880	160	17,920	19,862	21,760
*45	270	24,840	260	22,620	180	20,160	22,345	24,480
50	300	27,600	280	24,360	200	22,400	24,828	27,200
55	330	30,360	300	26,100	220	24,640	27,311	29,920
60	360	33,120	320	27,840	240	26,880	29,794	32,640
65	390	35,880	340*	29,580	250	28,000	31,035	34,000
70	420	38,640	360	31,320				
75	450	41,400	380	33,060				
80	480	44,160	400	34,800				
85	510	46,920						
88	528	48,576						

* Sample Problem

Note: BAGGAGE LOADING

Fwd. Area defined as baggage CG at Fus. Sta. 112.0
Center Area defined as baggage CG at Fus. Sta. 124.14
Aft. Area defined as baggage CG at Fus. Sta. 136.0

Wing AIRCRAFT COMPANY

REPORT NO. RD1-16
ISSUE DATE 8-12-69
REVISION DATE

SECTION 5: CENTER OF GRAVITY MOMENT ENVELOPE

TABLE II

FLIGHT WT. LBS.	LIMITS	
	MOST FWD. MOMENT	MOST AFT MOMENT
2100	187,950	195,300
2150	192,420	199,950
2200	196,900	204,600
2250	201,370	209,250
2300	205,850	213,900
2350	210,320	218,550
2400	214,800	223,200
2450	219,458	227,850
2500	224,125	232,500
2550	228,786	237,150
2600	233,480	241,800
2650	238,169	246,450
2700	242,865	251,100
2750	247,568	255,750
* 2800	252,280	260,400
2850	257,004	265,050
2900	261,754	269,700
2950	266,494	274,350
3000	271,260	279,000
3050	276,025	283,650

* SAMPLE PROBLEM from P.4

2790 lbs. Moment = 253,430 which falls between the permissable most Fwd. Limit and Most Aft Limit Moments tabulated.

AIRCRAFT COMPANY

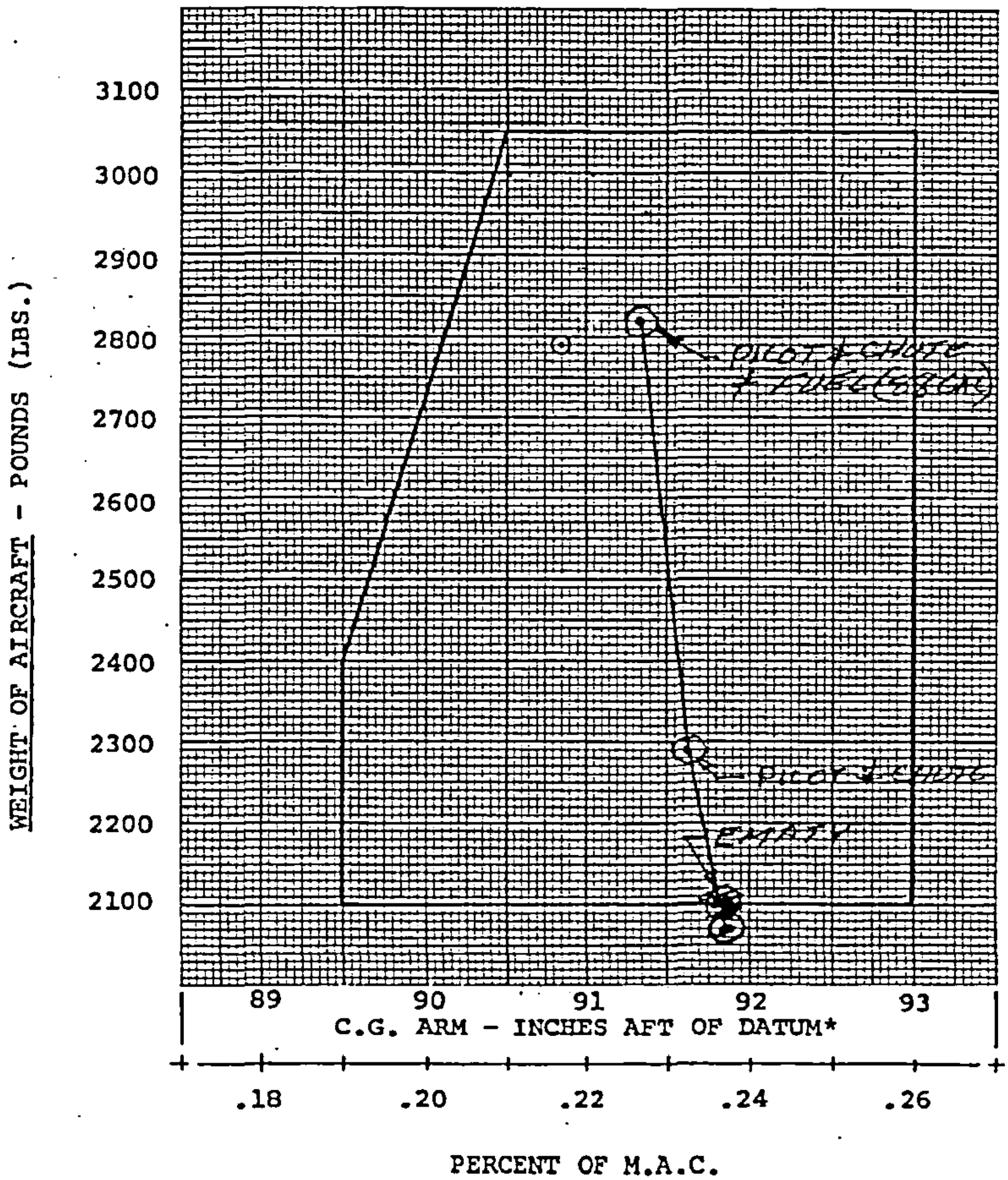
REPORT NO.
ISSUE DATE
REVISION DATE

N8602J SER. NO. 9

AIRPLANE WEIGHT & BALANCE RECORD

ITEM	WT	STA	MOMENT	DATE	REMARKS
A/C EMPTY	2100	91.56	192,276		
PILOT & CHUTE	190	87.00	16,530		
	2290	91.18	208,806		
FUEL (88 GALS)	528	92.00	48576		
	2818	91.33	257382		

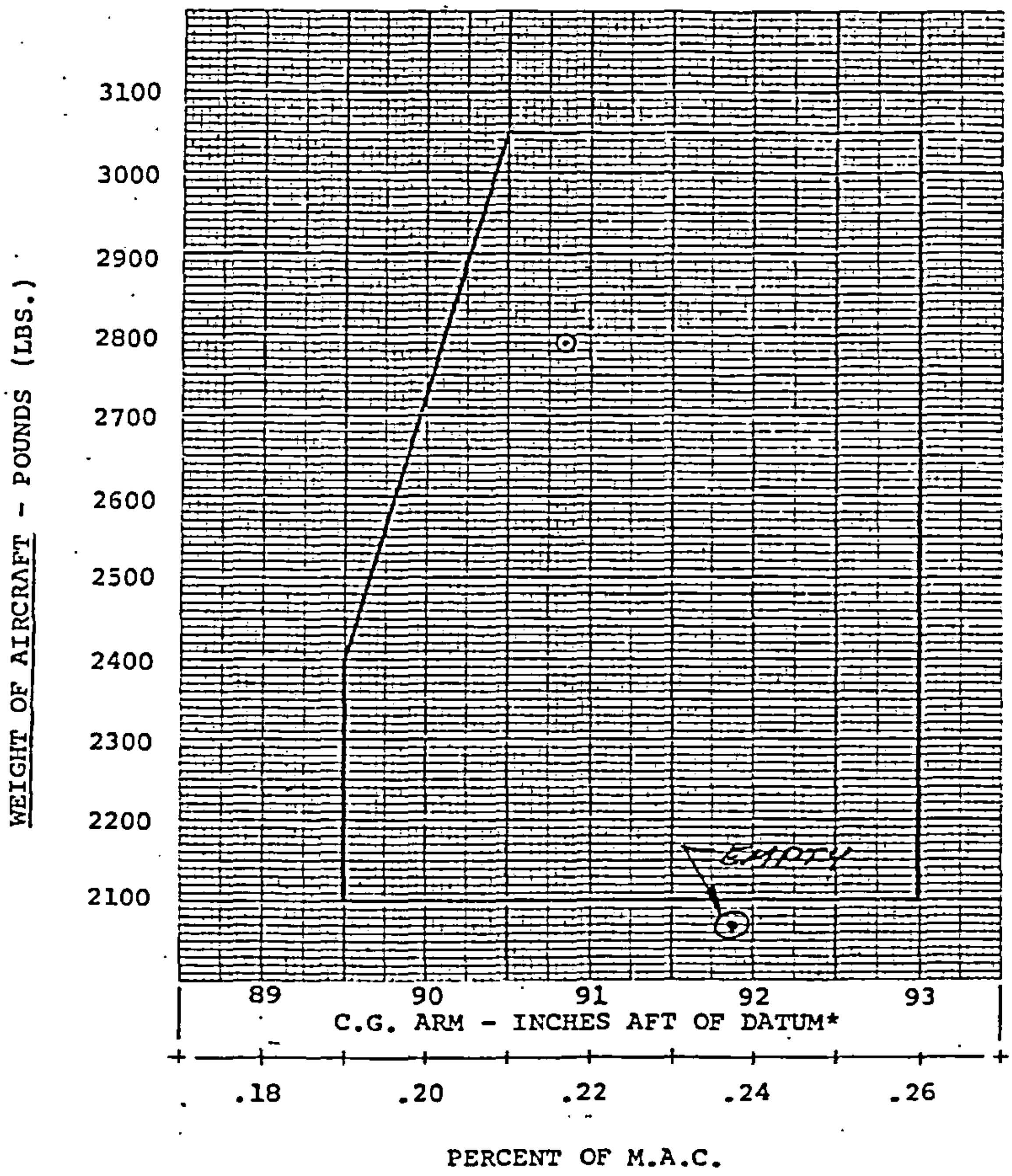
SECTION 6: CENTER OF GRAVITY LIMITS GRAPH



* DATUM = STA. 0.00 FUS.

⊙ SAMPLE PROBLEM

SECTION 6: CENTER OF GRAVITY LIMITS GRAPH



* DATUM = STA. 0.00 FUS.

⊙ SAMPLE PROBLEM

SECTION 7: EQUIPMENT LIST

AIRCRAFT SERIAL NO. ____________________
FAA REGISTRATION NO. ____________________

The following equipment, marked ( ) was installed when the Certificate of Airworthiness, dated ______________ was issued on this aircraft. Equipment removed from this aircraft after the above date should be marked (R) and equipment added should be marked (A).

I. BASIC REQUIRED EQUIPMENT (VFR DAY ONLY)

ITEM NO.	ITEM	WAC DWG NO.	ITEM PART NO. USED	WT. (LB.)	ARM (IN.)
1. ( )	Engines	400010	______	588.0	64.4
2. ( )	Propellers	400010	______	96.0	45.7
3. ( )	Governors	400010	______	12.0	74.6
4. ( )	Spinners	400120	______	8.8	43.6
5. ( )	Filters-Air Ind.	400012	______	2.0	77.5
6. ( )	Oil Radiators	000009 400010	______	3.8	55.0
7. ( )	Fuel Pumps (Boost)	100034 700048	______	6.0	104.2
8. ( )	[illegible] (Eng. Driven)	[illegible]	______	[illegible]	[illegible]
9. ( )	Exhaust Sys.	400180 400181	______	14.2	69.4
10. ( )	Main Wheels	500008	______		
11. ( )	Main Brake Assy.	500008	______	22.0	109.0
12. ( )	Main Tires	500008	______		
13. ( )	Nose Wheel	500001	______	10.0	15.0
14. ( )	Nose Tire	500001	______		
15. ( )	Seat (Pilots)	800002	______	11.7	87.0
16. ( )	Belt (Pilots)	000009	______	0.9	88.0
17. ( )	Alternators	400010	______	26.0	56.0
18. ( )	Starters	400010	______	17.0	60.0
19. ( )	Voltage Reg.	400010	______	1.3	87.5
20. ( )	Battery	700048	______	27.0	151.0
21. ( )	Relay (Over-voltage)	400010	______	0.5	50.5
22. ( )	Airspeed Ind.	900006	______	1.0	67.0
23. ( )	Altimeter	900007	______	1.3	67.0
24. ( )	Compass, Mag.	800037	______	0.8	78.0
25. ( )	Tachometer	700048	______	1.4	67.0

ITEM NO.	ITEM	WAC DWG. NO.	ITEM PART NO. USED	WT. (LB.)	ARM (IN.)
26. ( )	Eng. Cluster Fuel Qty. Oil Press. Oil Temp. Cyl. Hd. Temp.	900005		2.6	67.0
27. ( )	Stall Warning	100242		1.5	81.0
28. ( )	Pitot Tube, Heat	700135		1.2	241.8
29. ( )	Fuel Flow Ind.	900001		1.0	67.0
30. ( )	Flap Pos. Ind.	900002		0.1	69.0
31. ( )	Stab. Pos. Ind.	900003		0.1	75.0
32. ( )	L G Warn. Light	700124		0.06	69.0
33. ( )	Seat, Passenger	800002		11.7	87.0
34. ( )	Belt, Passenger	000009		0.9	88.0
35. ( )	Belt, Cargo	000009		2.0	124.0
36. ( )					
37. ( )					
38. ( )	Manif. Press. Ga.	900008		1.0	67.0
39. ( )	Ammeter	900009		0.4	68.0
40. ( )	O. A. Temp. Ind.	700048		0.6	64.0
41. ( )	Cabin Heater	200050		21.0	37.0
42. ( )	Rudder Pos. Ind.	900012		0.1	75.0

II. REQUIRED EQUIPMENT (VFR NIGHT)

ITEM NO.	ITEM	WAC DWG. NO.	ITEM PART NO. USED	WT. (LB.)	ARM (IN.)
200. ( )	Anti-Collision Lt.	700048		0.25	252.0
201. ( )	Aft. Pos. Lt.	700048		0.12	269.0
202. ( )	Wing Tip Pos. Lt.	700048		0.3	85.0
203. ( )	Landing Light	700048		1.5	4.0
204. ( )	O.H. Inst./Map Lt.	700048		0.3	86.0
205. ( )	Cabin Dome Lt.	700048		0.1	120.0

III. OPTIONAL EQUIPMENT

ITEM NO.	ITEM	WAC DWG. NO.	ITEM PART NO. USED	WT. (LB.)	ARM (IN.)
300. ( )	Prop. Unfeather Accumulator	400045		8.0	95.0
301. ( )	Dual Brake Cont.	600009		1.2	54.7
302. ( )	Hr. Meter-Air SW.	700048		0.6	62.0
303. ( )	Ext. Pwr. Recp.	700048		0.8	150.0
304. ( )	Autopilot	STC #SA 1688WE		26.7	105.7
305. ( )	E.G.T. Instl.	700086		1.0	70.0
306. ( )	Belt, Pilot & Pass.	000009		1.0	88.0
307. ( )	Directional Gyro	700059		2.63	65.4
308. ( )	Artif. Horiz.	700059		1.9	66.3
309. ( )	Rate of Climb	700059		0.75	67.0
310. ( )	Turn Coord.	700059		2.44	65.4
311. ( )	Vacuum Sys.	700021		14.72	77.6
312. ( )	Alt. Static Air Source	700064		0.12	68.5
313. ( )	Propeller Synchrophaser	700097		3.50	93.4
314. ( )	Int. & Sound Proof	800000		36.0	100.0
315. ( )	Paint	000128		21.0	110.0

IV. OPTIONAL COMMUNICATION/NAVIGATION EQUIPMENT

ITEM NO.	ITEM	WAC DWG. NO.	COLLINS PART NO.	WT. (LB.)	ARM (IN.)
400. ( )	Comm Radio	700080	(2) VHF-251	7.6	63.0
401. ( )	Nav Radio	700080	(2) VIR-351	6.2	63.5
402. ( )	Nav Ind	700080	IND-350 A	1.0	66.4
403. ( )	Glide Slope Rcvr.	700080	GLS-350	2.0	47.3
404. ( )	Audio Marker Rcvr.	700080	AMR-350	1.8	66.6
405. ( )	Area Nav Cmptr	700080	ANS-351	3.8	64.3
406. ( )	DME XMTR/RCVR	700080	TCR-451	5.3	171.8
407. ( )	DME IND	700080	IND-451	0.9	66.6
408. ( )	DME Ant.	700080	ANT-451	0.2	102.8
409. ( )	ADF Rcvr.	700080	RCR-650A	3.0	64.1
410. ( )	ADF Ind	700080	IND-650A	0.75	67.3
411. ( )	ADF Ant.	700080	ANT-650A	2.25	144.3
412. ( )	Transponder	700080	TDR-950	2.0	65.8
413. ( )	Slaving Access	700080	328A-3G	3.5	156.8
414. ( )	Course Ind.	700080	331A-3F	3.4	65.8
415. ( )	Dir. Gyro	700080	332E-4	4.5	145.7
416. ( )	Flux Det	700080	323A-2G	2.7	106.5
417. ( )	Radio Alt. XMTR/RCVR	700080	ALT-50A	5.6	158.6
418. ( )	Radio Alt. Ind.	700080	DRI-55	0.7	66.0
419. ( )	Radio Alt. Ant XMTR & Rcvr.	700080	(2) ANT-50	2.0	113.2
420. ( )	Marker Beacon Ant.	700080	EMB-10-84	1.0	19.8
421. ( )	Glide Slope Ant.	700080	RGS-10-48	0.13	19.9
422. ( )	Comm. Ant. Coupler	700080	TCR-20-01	1.0	51.0
423. ( )	Nav Ant Coupler	700080	DRC-20-11	0.25	51.0
424. ( )	Comm Ant	700080	SSB-1	2.0	149.4
425. ( )	Pwr. Booster	700080	RB-125	1.5	44.4
426. ( )	Emer. Loc. XMTR.	700080	ELT-10	3.5	162.4
427. ( )	Nav Ant	700080	CI-159 C	0.35	252.0
428. ( )	Compensator	700080	323A-3G-1	.25	106.5

4

Brittain Industries, Inc.
5023 E. Admiral Place
Tulsa, OK. 74115

Manual No. 407-012-736

FAA APPROVED

AIRPLANE FLIGHT MANUAL SUPPLEMENT

FOR

BRITTAIN MODEL BI-826 B5C

WHEN INSTALLED IN AIRCRAFT MODELS LISTED ON

MASTER ELIGIBILITY LIST 426-010-736

R/N 8602J

S/N 009

Wing D-1
MAKE AND MODEL AIRPLANE

The information in this document is FAA approved material, which together with the appropriate basic FAA approved Flight Manual and/or placarding is applicable and must be carried in the aircraft when it is modified by the installation of Brittain BI-826, B5C Flight Control System in accordance with STC SA4553SW and in conjunction with Brittain model BI-702, B5 Flight Control System.

The information in this document supercedes the basic manual only where covered in the items contained in this manual. For limitations and procedures not contained in this supplement, consult the basic manual.

I. LIMITATIONS

A. No Change.

II. OPERATIONAL PROCEDURES

A. To Fly a Preselected Heading.

1. Rotate heading bug on directional gyro or H.S.I. to desired heading.

2. Select "HDG" mode on controller.

NOTE: When the autopilot master is "ON" and the mode selector switch is "OFF", the autopilot provides stability augmentation.

Dated: 11/23/81

F.A.A. Approved:

III. EMERGENCY

A. In the event of an electrical failure, the autopilot reverts to basic stabilization.

B. In the event of a pneumatic failure as indicated on the gyro pressure gauge, the autopilot becomes inoperative.

IV. PERFORMANCE

A. No change.

FAA APPROVED: [redacted]

for Don P. Watson, Chief
Engineering & Manufacturing Branch
Federal Aviation Administration
Southwest Region
Ft. Worth, TX. 76101

Department of Transportation—Federal Aviation Administration

Supplemental Type Certificate

Number SA4553SW

This certificate, issued to Brittain Industries, Inc.
5023 East Admiral Place
Tulsa, OK 74115

certifies that the change in the type design for the following product with the limitations and conditions therefor as specified hereon meets the airworthiness requirements of Part 3 of the Civil Air Regulations.

Original Product—Type Certificate Number: See Limitations and Conditions
Make: See Limitations and Conditions
Model: See Limitations and Conditions

Description of Type Design Change: Installation of Brittain Model NAV Flite IV Model BI-825 System according to Brittain Installation Instructions 402-010-736 Revision A dated 6/24/81 and Master Drawing List 403-010-736 dated 7/3/81; Installation of Brittain Model B5C Model BI-826 System according to Brittain Installation Instructions 402-012-736, Revision A, dated 6/24/81 and Master Drawing List 403-012-736 dated 7/3/81; or later FAA approved revision.

Limitations and Conditions:
1. For applicable Type Certificate Number, Aircraft, and Model see Master Airplane Eligibility List 426-010-736 Revision A dated 7/2/81, or later FAA approved revision.
2. FAA Approved Airplane Flight Manual Supplement dated November 23, 1981, is required for Brittain B5C Model BI-826; or FAA Approved Airplane Flight Manual Supplement dated November 23, 1981, is required for Brittain NAV Flite IV Model BI-825.
3. Compatibility of this modification with other previously approved modifications must be determined by the installer.

This certificate and the supporting data which is the basis for approval shall remain in effect until surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: July 3, 1981

Date reissued:

Date of issuance: November 23, 1981

Date amended:

By direction of the Administrator

[redacted]
(Signature)

Don P. Watson
Acting Chief, Aircraft Certification Division
(Title)

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

This certificate may be transferred in accordance with FAR 21.47.

FAA Form 8110-2 (10-68)

BRITTAIN INDUSTRIES, INC.
P. O. Box 51370
Tulsa, OK. 74151

Manual No. 407-026-504

FAA APPROVED

AIRPLANE FLIGHT MANUAL SUPPLEMENT

FOR

WING AIRCRAFT MODEL D-1

S/N 009

R/N 8602J

This supplement must be attached to the F.A.A. Approved Airplane Flight Manual dated August 12, 1969, when a Brittain Model B5 Flight Control System is installed in accordance with STC SA4315SW.

The information contained herein supplements or supersedes the basic manual only in those areas listed herein. For limitations, procedures, and performance information not contained in this supplement, consult the basic airplane flight manual.

I. LIMITATIONS

A. Autopilot master shall be "OFF" for take-off and landing.

B. Autopilot shall not be operated at speeds above Vno (green Arc).

C. Single engine approaches prohibited.

D. Coupled approaches shall be conducted using only the VOR-LOC receiver-indicator combination demonstrated to perform satisfactorily in accordance with FAA Approved Brittain Ground and Flight Check Procedures Manual No. 3952. VOR-LOC receiver-indicator combinations not so demonstrated shall be placarded "DO NOT USE THIS RADIO FOR COUPLED APPROACHES".

II. OPERATING PROCEDURES

A. Normal

1. Make certain aircraft is properly trimmed before engaging autopilot.

2. To engage autopilot, pull autopilot master "ON" and rotate mode selection switch to desired mode.

NOTE: When the autopilot master is "ON" and mode selector is "OFF", the autopilot provides stability augmentation.

3. Turns may be made by selecting the manual (MAN) mode and rotating the "TURN" knob left or right.

4. Command aircraft pitch attitude with manual elevator trim tab. Power variations will establish climb or descent.

5. To maintain a desired altitude, adjust the aircraft elevator trim system until the pitch trim indicator is in neutral position and the aircraft is in level flight. Engage the altitude hold.

6. Pitch trim indicator provides a visual reference of the elevator trim status. When the indicator bar is above center, the aircraft has a nose up trim and vice-versa.

7. To Fly A Magnetic Heading

   A. Rotate the heading azimuth to desired magnetic heading and place function knob in heading (HDG) mode.

8. To Fly A VOR Course

   A. Rotate omni bearing selector (OBS) and autopilot heading azimuth to desired course.

   B. Select capture (CAP) mode. Aircraft will turn to intercept the VOR course. Maximum capture angle is 60 degrees.

   C. As VOR needle approaches center position, select track (TRK) mode.

NOTE: (1) VOR-LOC left/right needle indication may be interrupted or lost during transmission with some NAV-COMM systems. In this case, the autopilot will steer the aircraft towards the heading selected on the autopilot heading azimuth.

(2) When the mode selector is in the track (TRK) position, VOR needle deflection greater than half scale will cause the autopilot to revert to magnetic heading information for about one minute.

BRITTAIN INDUSTRIES, INC.
P. O. Box 51370
Tulsa, OK. 74151

Manual No. 407-026-504

9. To Fly A VOR Approach

A. Rotate omni bearing selector (OBS) and autopilot heading azimuth to approach course.

B. Select capture (CAP) mode. Aircraft will turn to intercept the VOR course. When aircraft heading is within 60° of the selected course, select localizer (LOC) mode. Aircraft will complete the interception and track the selected course.

C. If the VOR approach requires a course change over the station, select the final approach course on the omni bearing selector (OBS) and the autopilot heading azimuth as soon as positive station crossing has been made.

10. To Fly A Localizer Approach

A. Rotate autopilot heading azimuth to inbound localizer course.

B. Select localizer (LOC) mode after aircraft heading is within 60° of localizer course. Aircraft will turn to intercept the localizer.

B. Emergency

1. In the event of a malfunction, disengage the autopilot by pushing the autopilot master "OFF". The autopilot can be overpowered at any time without damage to the aircraft or components.

2. Maximum altitude loss during a nose down hardover is 120 ft.

3. In the event of a partial or complete vacuum failure, (indicated by a drop of vacuum pressure as shown on the aircraft vacuum gauge) disengage autopilot until system can be inspected and repaired as necessary.

III. PERFORMANCE INFORMATION

1. No change.

APPROVED: [redacted]
for
Engineering & Manufacturing Branch
Federal Aviation Administration
Southwest Region, Ft. Worth, TX. 76101

Dated: April 1, 1981

United States of America

Department of Transportation—Federal Aviation Administration

Supplemental Type Certificate

Number SA4315SW

This certificate, issued to Brittain Industries, Inc.
P. O. Box 51370
Tulsa, OK 74151

certifies that the change in the type design for the following product with the limitations and conditions therefor as specified hereon meets the airworthiness requirements of Part 3 of the Civil Air Regulations.

Original Product—Type Certificate Number: A9WE

Make: Wing Aircraft

Model: D-1

Description of Type Design Change: Installation of Brittain Model B5 Flight Control System in accordance with Installation Instructions 402-026-504, Revision A, dated 1/19/81 and Master Drawing List 403-026-504, Revision A, dated 3/30/81, or later FAA approved revision.

Limitations and Conditions:

FAA Approved Airplane Flight Manual Supplement dated April 1, 1981, is required.

Compatibility of this modification with other previously approved modifications must be determined by the installer.

This certificate and the supporting data which is the basis for approval shall remain in effect until surrendered, suspended, revoked, or a termination date is otherwise established by the Administrator of the Federal Aviation Administration.

Date of application: January 22, 1981

Date reissued:

Date of issuance: April 1, 1981

Date amended:

By direction of the Administrator

[redacted]

(Signature)

Don P. Watson
Chief, Engineering and Manufacturing Branch

(Title)

Any alteration of this certificate is punishable by a fine of not exceeding $1,000, or imprisonment not exceeding 3 years, or both.

This certificate may be transferred in accordance with FAR 21.47.

FAA Form 8110-2 (10-68)

NATIONAL TEST PILOT SCHOOL

GENERAL BRIEFING GUIDE

a. Roll Call

b. Time Hack

c. Brief Description of the Primary Mission

d. Mission Times:

(1) Station
(2) Start
(3) Takeoff
(4) Range

e. Flight Lineup:

(1) Aircraft Commander
(2) Call Sign
(3) Aircraft Assignment
(4) Flight Position

f. Radio Frequencies:

(1) Start
(2) Taxi
(3) Takeoff
(4) Mission Frequencies
    (a) Primary
    (b) Backups
(5) Landing
(6) After Landing

g. Aircraft

(1) Weight
(2) Center of Gravity
(3) Stores/Cargo/Fuel Load
(4) Limits/Specific Aircraft Differences
(5) Takeoff and Landing

h. Weather

i Aircraft and Armament Preflight

j. Taxi and Arming

k. Takeoff

(1) Runway
(2) Lineup
(3) Checks
(4) Signals
(5) Interval
(6) Departures
    (a) Routes
    (b) Terrain Features
    (c) Ranges

l. After Takeoff

(1) Checks
(2) Join Up

m. IFF Procedures

n. Joker, Bingo and Divert Fuel

o. Recovery and Landing:

(1) Type of Patterns
(2) Checks

p. After Landing

(1) Taxi
(2) Parking

q. Emergency Procedures:

(1) Radio Failure
(2) Hydraulic, Electrical, Fuel, Oxygen, Engine (HEFOE)
(3) Takeoff Emergency Airspeeds
(4) Jettison Areas
(5) Bailout/Ejection
(6) Ground Egress

r. Special Subjects:

(1) Lost Wingman
(2) Survival and Life Support Systems
(3) Exchange of Aircraft Control and Configuration Changes
(4) Crew Coordination/Duties
(5) Enroute Terrain Features
(6) Midair Avoidance (see attached generic THA)

s. Alternate Mission (If Any)

t. Specific Mission Briefing (See SPECIFIC MISSION BRIEFING GUIDE)

u. Passenger/Non-Qualified Crew Member Briefing (See PASSENGER / NON-QUALIFIED AIRCREW BRIEFING GUIDE)

v. Local Area Briefing for Non-NTPS Crewmembers

Mission: D-1 DERRINGER FAM			Date:
Lead	Student:	IP:	
A/C:		Tiger:	
Wingman	Student:	IP:	
A/C:		Tiger:	

Brief:	Step:	T.O.:	Land:
Weight:	C.G.	Fuel:	
Freq:	Ops #:	Airspace:	

STTO (BRIEF MATCHING MPs ON T.O.)

CLIMB OUT AT 105 MPH THEN 115 MPH

CRUISE PERFORMANCE (trim shot for 30 sec)

V_{Trim}	$H_{I\pm10'}$	$V_{I\pm1\,KT}$	RPM/FF
140			
120			
100			
90			
85			

STALLS

- Level flight, clean confg., idle power, 1 kt/sec, V_{trim} 95 mph
- Turning 30 bank left/right, clean, idle, 1 kt/sec, V_{trim} 95 mph
- Turning 30 bank left/right, PLF, 3-5 kt/sec, V_{trim} 95 mph
- Level flight, PA config., idle, 1 kt/sec, V_{trim} 90 mph

V_{MCA} DEMO (predicted 85 mph)

- Clean config., one engine idle/one max RPM & full throttle
- Decel to V_{MCA} (wings level/zero SS/5 deg bank)

SINGLE ENGINE CLIMB DEMO (hold 110 mph)

PA config., one engine idle, one engine max RPM & full throttle (note VVI), raise flaps (note VVI), gear up (note VVI), 9" MP on idle engine (simulates feather, note VVI), close cowl flap on bad engine (note VVI), zero SS (note VVI), 5 deg bank (note VVI)

LANDINGS

Mission:	Date:

D-1 DERRINGER FAM

Lead | Student: | IP:
A/C: | | Tiger:
Wingman | Student: | IP:
A/C: | | Tiger:

Brief: | Step: | T.O.: | Land:
Weight: | C.G. | Fuel:
Freq: | Ops #: | Airspace:

STTO (BRIEF MATCHING MPs ON T.O.)

CLIMB OUT AT 105 MPH THEN 115 MPH

CRUISE PERFORMANCE (trim shot for 30 sec)

V_{trim}	$H_{\pm 10'}$	$V_{\pm 1\,KT}$	RPM/FF
140			
120			
100			
90			
85			

STALLS

Level flight, clean confg., idle power, 1 kt/sec, V_{trim} 95 mph

Turning 30 bank left/right, clean, idle, 1 kt/sec, V_{trim} 95 mph

Turning 30 bank left/right, PLF, 3-5 kt/sec, V_{trim} 95 mph

Level flight, PA config., idle, 1 kt/sec, V_{trim} 90 mph

V_{MCA} DEMO (predicted 85 mph)

Clean config., one engine idle/one max RPM & full throttle

Decel to V_{MCA} (wings level/zero SS/5 deg bank)

SINGLE ENGINE CLIMB DEMO (hold 110 mph)

PA config., one engine idle, one engine max RPM & full throttle (note VVI), raise flaps (note VVI), gear up (note VVI), 9" MP on idle engine (simulates feather, note VVI), close cowl flap on bad engine (note VVI), zero SS (note VVI), 5 deg bank (note VVI)

LANDINGS

Student Enrollment Form
* Required Fields

Student Information:

Name (Last) *	(First) *	(Middle Initial)	Email Address *
KIM	CHEONGON		[redacted]

Organization / Company Address
Gyoungnam, Sacheonshi, Sacheoneup, Suseogri [redacted] Republic of Korea

Rank Title	Crew Position	SSN/ID	Passport Number
Major	Pilot		[redacted]

Drivers License Number	Work Phone	Birth Date and Location
		[redacted]

Permanent Address	Country
Gyoungnam, Sacheonshi, Sacheoneup [redacted]	Republic of Korea

Course Attending *	Specify for Other
Professional Course Fixed Wing	

Course Date

Academic Background:

High School	Date Graduated	Location	
Taean High School	2/28/1988	Republic of Korea	
College / University	**Date Graduated**	**Location**	**Major**
Air Force Academy	2/28/1992	Republic of Korea	Aeronautics
Graduate School	**Date Graduated**	**Location**	**Major**
Advanced Degree	**Date Graduated**	**Location**	**Major**

Flying Background:

Fixed Wing Rating (Select)	Type	Year Rated	Hours
Military	Single Engine	12.5	1,500
Rotary Wing Rating (Select)	**Type**	**Year Rated**	**Hours**
Select Here.....	Select Here.....		
Instrument Rating		**Year Rated**	**Hours**

License Number	Country Issued
	Republic of Korea

Aircraft Qualifications:

Fixed Wing Type Aircraft and Hours

1.)	T-41 : 23 Hours	2.)	T-37 : 122Hours
3.)	F-5E/F : 420 Hours	4.)	F-16C/D(Block 32) : 230 Hours
5.)	KF-16C/D(Block 52) : 750 Hours	6.)	
7.)		8.)	

Rotary Wing Type Aircraft and Hours

1.)		2.)	
3.)		4.)	
5.)		6.)	
7.)		8.)	

Total Flight Time

Total First Pilot Flight Time

Current Position / Job Description / Field of Expertise

Now I am working for 52nd Test&Evaluation Group in Korea,My major job is a chaser for T-50;Golden Eagle.
I have flown a chase for T-50 since first flight;august 2002.

Future Position / Job Description / Field of Expertise

After graduation of NTPS, I am going to involve for T 50 developing test and weapon test.

For Professional course applicants only. Please use the space below to indicate your housing requirements i, e., single, married with spouse, spouse and children. If applicable, please list number of children, gender and age.

Submit Reset

Student Information Sheet

MAJOR

Name: CHEONGAN KIM

Passport #: [redacted]

Social Security #: ______

Drivers License #: ______

Local Address while attending school:

[redacted] Lancaster

CA. 93534

Phone/Fax: [redacted]

Spouse's Name: Jeongsim Koo

Children:

Name	Age
Donghyun Kim	5
Sihyun Kim	3

Company Name or Military Branch & Address:

Gyeung-Nam, Sacheon-Shi, Sacheon-Eup

[redacted]

Republic of Korea

Phone/Fax: [redacted]

Country: KOREA

Clearance: ______
(Top secret, secret, confidential)

Rank: Major
(civilian, major, capt.,etc.)

Crew position: Pilot
(pilot, eng., nav., etc.)

Permanent Home Address:

Gyeung-Nam, Sacheon-Shi, Sacheon-Eup

[redacted]

Republic of Korea

Phone/Fax [redacted]

Emergency contact:

Name: Jeongsim, Koo

Phone: [redacted]

Administrative use:

Assigned key #: 5-3

Class #: 04A Badge SF060

NTPS Biography

[redacted]

Ron Bradley
Test Pilot Instructor
Director of Flight Operations
Flying Safety Officer

Academic Qualifications:

Civilian

MS in Systems Management, University of Southern California
MS in Astronautics, Purdue University
BS in Engineering, US Air Force Academy

Military

Graduate of US Air Force Test Pilot School
Squadron Officer School
Air Command and Staff College
Armed Forces Staff College
Air War College
National Security Management

Professional:

Associate Fellow, Society of Experimental Test Pilots

Flight Qualifications:

Type of Aircraft / Hours [Flown over 150 different aircraft]
Total Time (6000 hrs) [5170 pilot/830 navigator]
F-4 (3300 hrs) [2700 pilot/600 Weapon System Operator]
E-8A/C [modified B-707] (400 hrs)
F-16 (350 hrs)
T-38 (175 hrs)
F-15 (150 hrs)
A-7 (25 hrs)
MB-326 Impala (200 hrs) [current]
SK-35 Draken (25 hrs) [current]
F-4 Combat AC/WSO (433/486 hrs)
Instructor Pilot F-4/F-16/Other (1600/75/50 hrs)
Airline Transport Pilot B-707/B-720/B-737 Type Ratings

Experience:

Over 20 years experience as a test pilot at Air Force Flight Test Center, Electronics Systems Center, and Civilian Flight Test Center. Experience includes all aspects of aircraft flight test, weapons test and systems test. Flight test experience in over 30 different types of military and civilian aircraft. Extensive flight test experience with the F-4, F-15, F-16, and E-8A/C weapon systems.

Test Program Experience:

F-4 new weapons release computer for Federal Republic of Germany

Introduction of F-110 engine and increased area horizontal tail to F-16
Full scale development of E-8A/C aircraft / weapon system
Laser ring gyro replacement for F-4

National Test Pilot School
P.O. Box 658
Mojave, CA 93502-0658 USA

Phone: **661-824-2977**
Fax: **661-824-2943**
Email: **rbradley@ntps.edu**

2002 DATE	AIRCRAFT MAKE & MODEL	AIRCRAFT IDENT	ROUTE OF FLIGHT FROM	TO	DURATION OF FLIGHT	AIRCRAFT CATEGORY & CLASS AIRPLANE SEL	MULTI-ENGINE	INSTRUMENT ACTUAL	SIMULATED	INSTRUMENT APPROACHES	SIMULATOR OR FTD	L D
21NOV	D-1	8602J	MHV	MHV	0.4		0.4					1
22NOV	C-150	8531	MHV	MHV	1.0	1.0						1
22NOV	B-76	6632R	MHV	HII	1.5		1.5					
24NOV	B-76	6632R	HII	MHV	1.7		1.7					1
25NOV	B-717										4.0	
27NOV	C-150	8531	MHV	MHV	1.2	1.2						1
27NOV	C-150	8531	MHV	MHV	1.2	1.2						1
27NOV	B-76	6632R	MHV	HII	1.9		1.9					1
1DEC	B-76	6632R	HII	MHV	1.7		1.7					1
3DEC	DH-1B	4KV	MHV	MHV	0.9	0.9						1
THIS RECORD IS CERTIFIED TRUE AND CORRECT [redacted]			PAGE TOTALS		11.5	4.3	7.2				4.0	
			PREVIOUS TOTALS		1454.0	1164.9	288.1				145.0	135
			NEW TOTALS		1465.5	1169.2	295.3				149.0	136

1 of 29

2003 DATE	AIRCRAFT MAKE & MODEL	AIRCRAFT IDENT	ROUTE OF FLIGHT FROM	TO	DURATION OF FLIGHT	AIRCRAFT CATEGORY & CLASS AIRPLANE SEL	MULTI ENGINE	INSTRUMENT ACTUAL	SIMULATED	INSTRUMENT APPROACHES	SIMULATOR OR FTD
21NOV	B-76	6632R	IWA	MHV	3.2		3.2				
27NOV	C-47TP	5341P	MHV	MHV	2.6		2.6				
2DEC	B-33	606V	MHV	MHV	1.0	1.0					
2DEC	C-150	8531	MHV	MHV	1.0						
3DEC	B-76	6632R	MHV	MHV	1.2		1.2				
THIS RECORD IS CERTIFIED TRUE AND CORRECT			PAGE TOTALS								
			PREVIOUS TOTALS		1701.6	1321.0	380.6				171.0
PILOT'S SIGNATURE			NEW TOTALS								

LANDINGS DAY	NIGHT	GROUND TRNG REC'D	FLIGHT TRNG REC'D	CROSS COUNTRY	NIGHT	SOLO	PILOT IN COMMAND	REMARKS
							3.2	XC FINAL PROJ
1				3.2			2.6	SYS EVAL #1
1							1.0	FAM 04A
1							1.0	FAM 04A
							1.2	FAM 04A
1								
159	41		34.2	126.4	29.6		1665.9	

29 of 29

[...]OFICIENCY CHECK – FAR §61.57(d)

_____ HAS SATISFACTORILY [...] INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

_ CFI _____

_____ EXP. _____

[...]OFICIENCY CHECK – FAR §61.57(d)

_____ HAS SATISFACTORILY [...] INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

_ CFI _____

_____ EXP. _____

[...]OFICIENCY CHECK – FAR §61.57(d)

_____ HAS SATISFACTORILY [...] INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

_ CFI _____

_____ EXP. _____

INSTRUMENT PROFICIENCY CHECK – FAR §61.57(d)

MR./MS. _____ HAS SATISFACTORILY COMPLETED AN INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

INSTRUMENT PROFICIENCY CHECK – FAR §61.57(d)

MR./MS. _____ HAS SATISFACTORILY COMPLETED AN INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

INSTRUMENT PROFICIENCY CHECK – FAR §61.57(d)

MR./MS. _____ HAS SATISFACTORILY COMPLETED AN INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

INSTRUMENT PROFICIENCY CHECK – FAR §61.57(d)

MR./MS. _____ HAS SATISFACTORILY COMPLETED AN INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

INSTRUMENT PROFICIENCY CHECK – FAR §61.57(d)

MR./MS. _____ HAS SATISFACTORILY COMPLETED AN INSTRUMENT PROFICIENCY CHECK ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

FLIGHT REVIEW – FAR §61.56

MR./MS. Ron Beasley HAS SATISFACTORILY COMPLETED A FLIGHT REVIEW ON TI[redacted]

DATE 1-27-03 CFI [redacted]

CFI N[redacted] EXP. 12/04

FLIGHT REVIEW – FAR §61.56

MR./MS. _____ HAS SATISFACTORILY COMPLETED A FLIGHT REVIEW ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

FLIGHT REVIEW – FAR §61.56

MR./MS. _____ HAS SATISFACTORILY COMPLETED A FLIGHT REVIEW ON THIS DATE.

DATE _____ CFI _____

CFI NO. _____ EXP. _____

FLIGHT REVIEW – FAR §61.56

MR./MS. _____ HAS SATISFACTORI[...] COMPLETED A FLIGHT REVIEW ON THIS DATE.

DATE _____ CFI _____

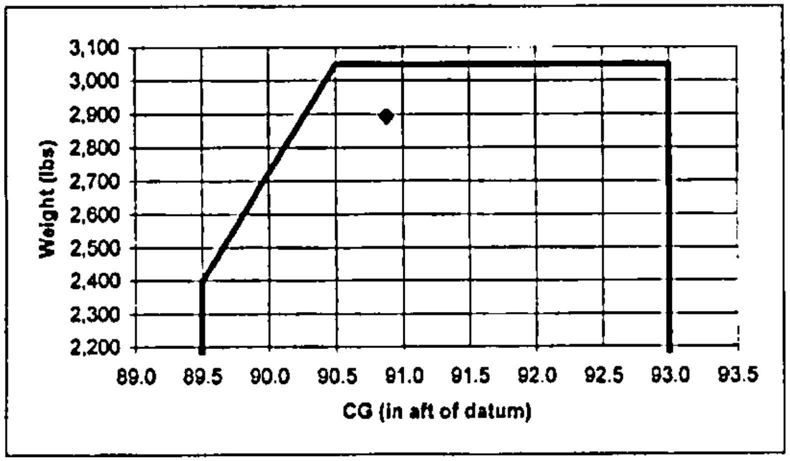
CFI NO. _____ EXP. _____

D-1 Derringer Wt & Bal

N8602J
as of 28 Sep 02

Item	Weight (lbs)	Arm (in)	Moment
Empty A/C	2,246	91.2	204,835
Pilot	150	87	13,050
Copilot	140	87	12,180
Main Fuel	360	92	33,120
Fwd Bag	0	26	0
Aft Bag	0	136	0
TOTAL	2,896	90.9	263,185
		21.8%	mac

Fuel: 88 gal max, @ 6 lbs/gal



NTPS FLYING RECORD

THURSDAY 4 DECEMBER 2003

BRIEF TIME	ACFT FLIGHT START	PILOT NAME	CALLSIGN TRK #	CREW	ACFT TYPE TAIL #	MISSION	OPS NUMBER	EST FLT DUR	TAKEOFF TIME	FLIGHT TIME	OTHER TIME	STUDENT LANDING	IP LANDING	INITIALS	REMARKS
0730	0815	MIKE	11	SOLO	[illegible]	TCP		[illegible]	0905	~~0.3~~	0.3		1	[illegible]	MX
0730	0815	GREG	9	CHRISTIAN P	B-33/[illegible]	FAM		1.0	0829	0.9		3		G	PRETPS 111003
0730	0815	ED	17	[illegible] P	[illegible]	FAM		1.0	0830	1.0		3		[illegible]	PRETPS 111003
0730	0815	[illegible]	10	KIM P	[illegible]	FAM		1.0							PRETPS 111003
0900	0945	RYAN	12	[illegible] P	[illegible]	[illegible]		1.0	1000	1.0		1	2	R	PRETPS 111003
0900	0945	JOHN	10	[illegible] P	[illegible]	[illegible]		1.0	1035	1.0		3	1	[illegible]	PRETPS 111003
0930	1015	GREG	9	KRISTINA P	[illegible]	FAM		1.0	1021	1.0		4		G	PRETPS 111003
0930	1015	DAN	10	AN P	[illegible]	FAM		1.0							PRETPS 111003
1000	[illegible]	MIKE	11	CHRISTIAN P	[illegible]	FAM		1.0	CX	DUE	WX [illegible]				PRETPS 111003
	1145	Russ	12	[illegible]	B-33/[illegible]			2.0	1145	[illegible]	1.2		1	R	
	1230	Mike	15	DWC/Tom B. [illegible]	UH-1N/[illegible]			2.0	1203		1.2		3	[illegible]	

NOTE: BOLD REQUIRES GRADESHEET

NATIONAL TEST PILOT SCHOOL

COURSE SIGN IN SHEET

COURSE TITLE: Pre- TPS

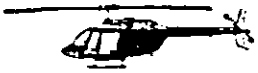
COURSE DATES: November 10-December 19, 2003

CLASSROOM # 1 2 3 4 5 6

NAME (Print as you want it on your certificate)	Emergency Contact & Number	ORGANIZATION	WEIGHT	Pilot/Crew position	work phone
CHRISTIAN LOLORUP (RW)	[redacted]	ROAF 160	160	PILOT	+4599624920
SURASAK SESAWECH		RTAF 140	140	PILOT.	6624601703
Cheongon Kim		ROKAF 150	~~150~~ 150	PILOT	
Taebeom Jin		ROKAF 190	190	PILOT	
Iljong Ku		ROKAF 178	178	FTE	[illegible]
KRITSANA PIUMSRI Krits		RTAF 167	150\167	PILOT	
Ciccotti Luigi		ITAF 185	185	TECHICION	[illegible]
GRASSO, GABRIELE		ITAF 165	165	TECNICION	

NAME: CHEONGON KIM

PROFESSIONAL COURSE FLYING TIME RECORD



CHEONGON KIM TEST PILOT FW
PROFESSIONAL COURSE JAN 2004 - DEC 2004

DATE	INSTRUCTOR	ACFT	MISSION	GRADE	SORTIE TIME	TOTAL TIME
17Nov03	[illegible]	UH-1N/1212TP *	GPS/NAV EVAL	N/A	1.7	1.7
18Nov03	Mike	UH-1N/1212TP	Flir Demo	N/A	0.8	2.5
2Dec03	Greg	[illegible]/2SAJ	FAM	N/A	1.0	3.5
2Dec03	Ron	C-152/18531	FAM	N/A	1.0	4.5
3Dec03	Ron	B-76/6632R	Fam	N/A	1.2	5.7
3Dec03	Cuz	B-33/606V **	Fam	N/A	0.9	6.6
		*	[illegible]			
		**	[illegible]			
			[illegible]			

1

11/6/2003

1

Embassy of the Republic of Korea
2450 Massachusetts Avenue, Northwest
Washington, D.C. 20008

Facsimile Transmittal

To: Mr. Kristi Dunks NTSB, SW Regional Office	Tel No: 310-380-5658 Fax No: 310-380-5666
From: Col. Kim, Hyungchul Air Attache	Tel No: 202-939-5693 Fax No: 202-483-1843
Date: Apr. 15, 2004	Page(Including cover): 2

SUBJECT: Major Kim's Cetificate of Flight Experience

Dear Mr. Kristi Dunks,

As I mentioned in the Email, I fax you Major Kim's flight record cetified by the Korea Air Force.
Please find the attachment, and if you have any question or concerns, please let me know.

Attachment: Certificate of Flight Experience

Sincerely,

[redacted]

Colonel HyungChul Kim, Air Attache
Embassy of the Republic of Korea

o : 04-111

CERTIFICATE OF FLIGHT EXPERIENCE

ame : Kim Cheon Gon Service : 52nd Test & Evaluation Group
ate of Birth(SSN / Passport No) : [redacted]

Type of A/C	Landing	Pilot in Commander	Co-Pilot	Duty: Instructor Pilot	Duty: Student Pilot	Flight Engineer	Total Time	Day: Local	Day: Cross	Night: Local	Night: Cross	Night: Simulate	Instrument: Actual	Instrument: Simulate	Others	Date of Flight
F16C/D	335	158:19	0:00	71:26	0:00	0:00	[redacted]	34:15	137:03	3:33	14:14	0:00	40:40	0:00	0:00	2002082
F5E/F	625	416:57	0:00	0:00	0:00	0:00		62:02	248:12	6:18	25:15	0:00	75:10	0:00	0:00	1996022
KF16C/D	625	535:10	0:00	198:35	0:00	0:00		99:00	396:02	27:19	109:19	0:00	102:05	0:00	0:00	2003100
CN235M	0	1:18	0:00	0:00	0:00	0:00		0:15	1:03	0:00	0:00	0:00	0:00	0:00	0:00	200303
HH60P	1	2:08	0:00	0:00	0:00	0:00		0:25	1:43	0:00	0:00	0:00	0:00	0.00	0:00	200303
KTX1	1	0:00	0:00	1:11	0:00	0:00		0:10	0:41	0:00	0:00	0:00	0:20	0:00	0:00	2003030
T37C	182	122:20	0:00	0:00	0:00	0:00		20:29	81:56	0:42	2:48	0:00	16:25	0:00	0:00	1992040
T41B	50	0:00	0:00	0:00	23:21	0:00		4:40	18:41	0:00	0:00	0:00	0:00	0:00	0:00	
T50	1	0:59	0:00	0:00	0:00	0:00		0:11	0:48	0:00	0:00	0:00	0:00	0:00	0:00	200309
F16SIM	0	0:00	0:00	0:00	0:00	0:00		0:00	0:00	0:00	0:00	0:00	0:00	66:45	0:00	200109
Total	1820	1237:11	0:00	271:12	23:21	0:00		221:27	886:03	37:52	151:36	0:00	234:40	66:45	0:00	

This certifies Flight experience of the person mentioned above according to article 79, Korea Aviation Enforcement Regulations.

Date: 08 January 2004 Agency : H.Q. ROKAF Telephone : 02-506-3561 **Chief of Staff ROKAF**

Ref: NTSB ID LAX04FA057 Wing Derringer D-1 N8602J

To: Kristy Dunks @ NTSB

From: Dan Chandler, Work Phone 661 824 4136 Cell [redacted]

This is an opinion to support the theory of how the 3" section of the elevator aft control tube became missing as a result of the accident on 04 December 2003. Reference attached photos.

The following parts will be discussed and there involvement in the theory.

Follower assembly P/N 300225-27
Elevator control tube (forward) P/N 300020-5
Elevator control tube (Aft) P/N 300020-7

Photo #1 shows the elevator control at its most aft position with the top of the follower assembly positioned forward. The forward end of p/n 300020-5 was found attached to its normal point at the lower end of elevator vertical control tube (not shown). The aft end of p/n 300020-7 was found attached to its normal point at the elevator control bellcrank. With the two control tubes fixed at both ends and at the follower assembly, this places a point of the forward section of p/n 300020-7clevis (missing) hard against a section of the follower assembly P/N 300225-27 (see photo #2 clevis/follower contact area). The remaining section of the aft control tube showed evidence of a shearing action from the inside caused by the downward rotation of the clevis. I believe with the elevator in the position described above, the force of the impact with the ground was what broke the clevis from the aft tube and the section from the follower assembly (see photo # 2 and 3).

Note: The position indicator (L) in photo #2 is incorrect. It should show the position as viewed from the Right side.

Attachments: Photo 1,2,3.

Dan Chandler
661 824 4136

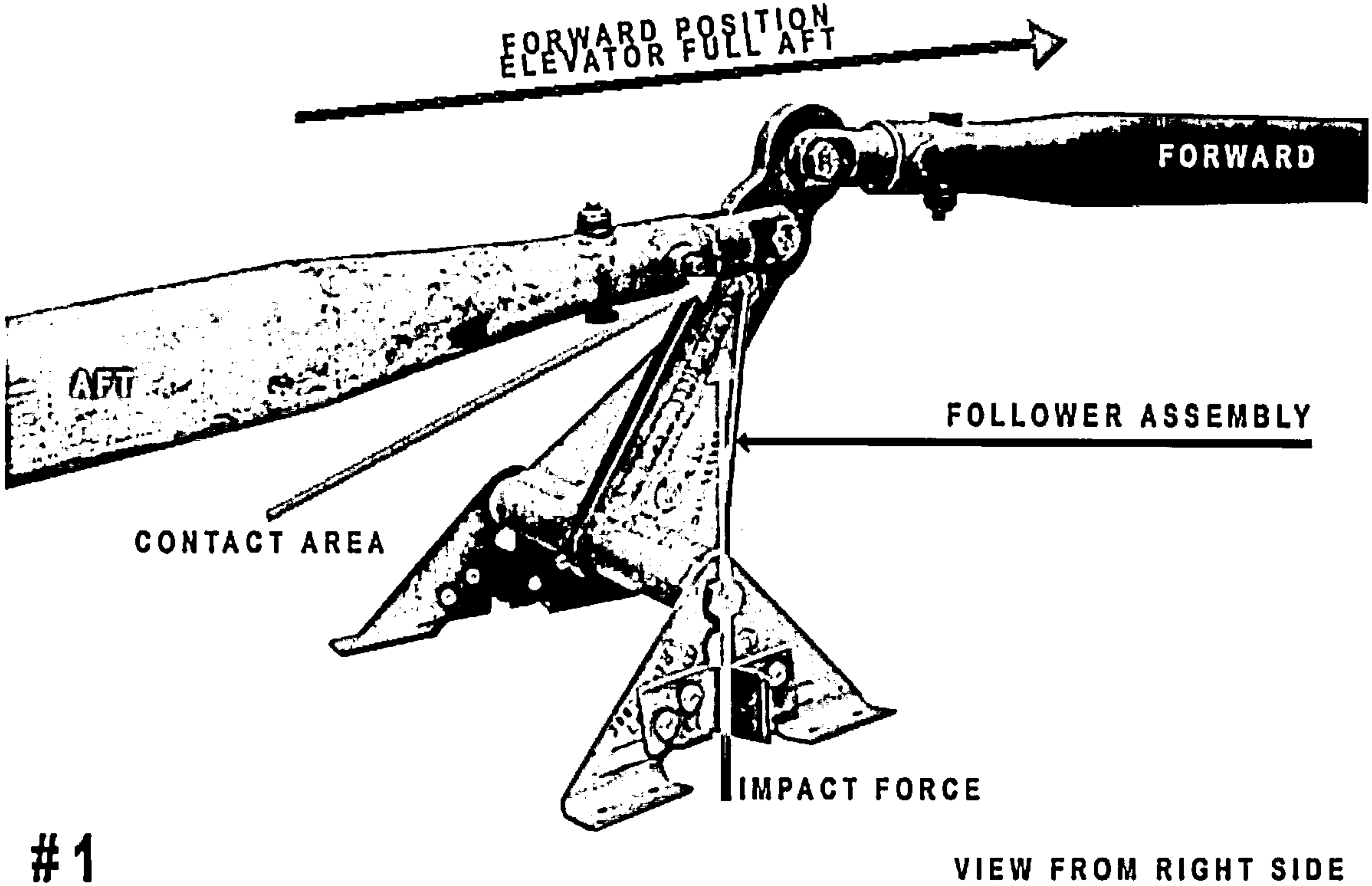


Photo 1. Elevator Control (1)

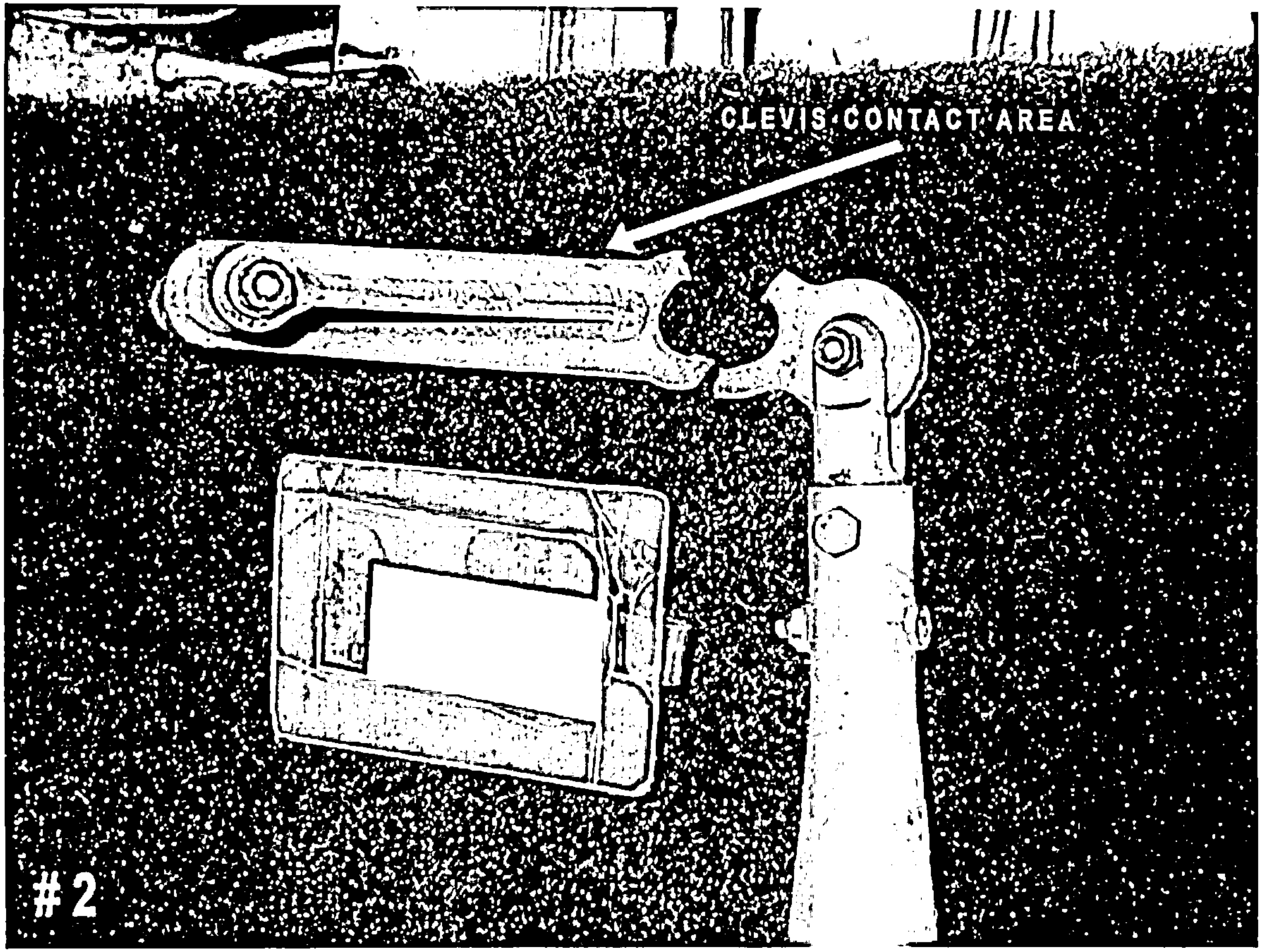


Photo 2. Elevator Control (2)

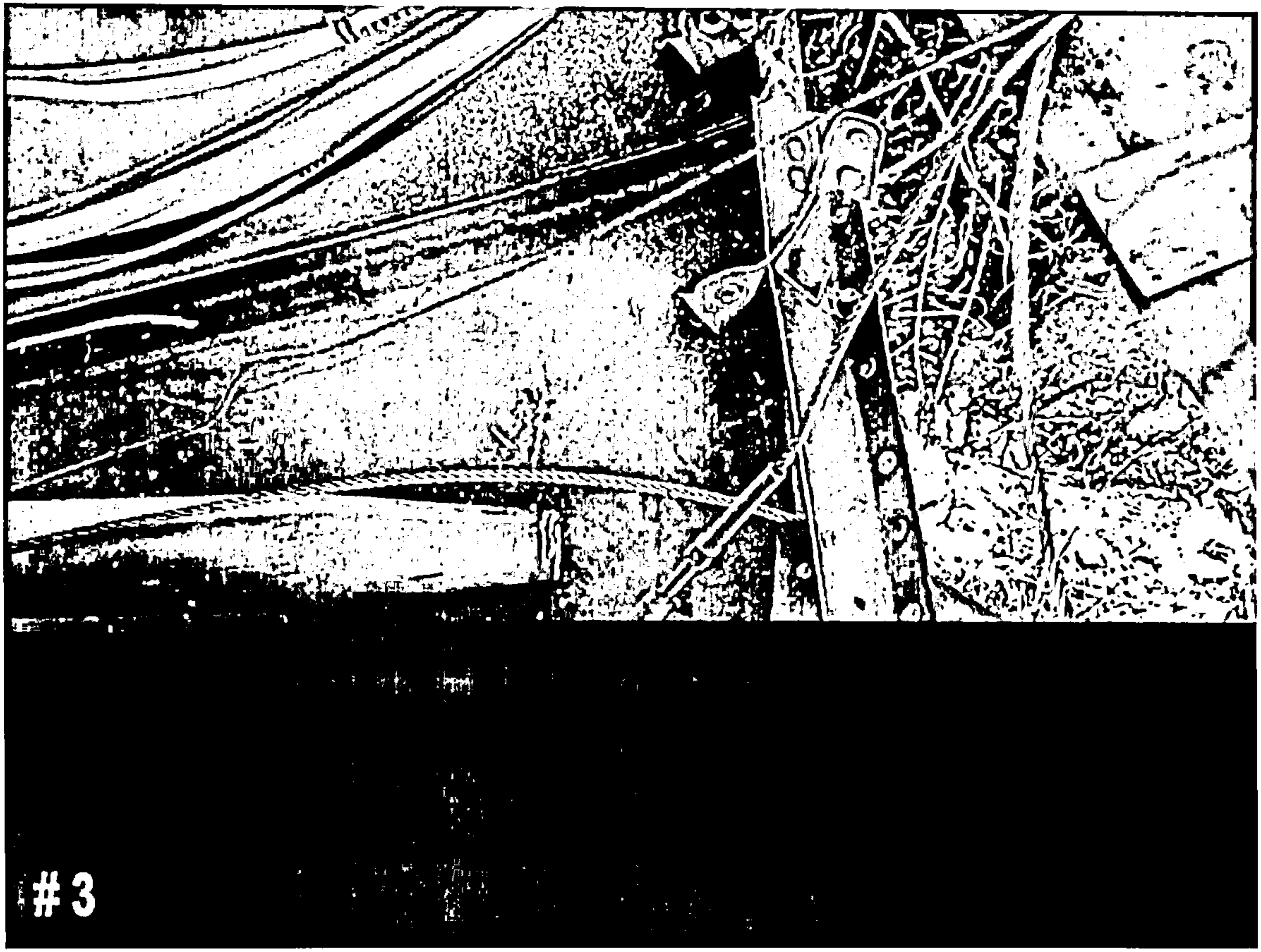


Photo 3. Elevator Control (3)

16:37:21.421	35.04586806	-118.1862802	1200
16:37:26.216	35.04379323	-118.1882097	1200
16:37:30.696	35.04240195	-118.189483	1200
:37:35.501	35.03995188	-118.191686	1200
:37:40.296	35.03697693	-118.1911711	1200
16:37:44.776	35.0352184	-118.1926969	1200
16:37:49.576	35.03380469	-118.1939057	1200
16:37:54.377	35.03095916	-118.1962911	1200
16:37:58.856	35.02952744	-118.1974677	1200
16:38:03.652	35.02658502	-118.1967975	1200
16:38:08.459	35.02407143	-118.198792	1200
16:38:13.255	35.02262725	-118.1999168	1200
16:38:17.735	35.01495415	-118.2056427	1200
16:38:22.539	35.01826113	-118.2032258	1200
16:38:27.018	35.01675444	-118.2072981	1200
16:38:31.816	35.01823589	-118.2062174	1200
16:38:36.623	35.01302727	-118.2099511	1200
16:38:41.409	35.01152713	-118.2109926	1200
16:38:45.898	35.00926715	-118.2125337	1200
16:38:50.697	35.00623594	-118.2145488	1200
16:38:55.502	35.00509403	-118.2152926	1200
16:38:59.980	35.00318466	-118.2165181	1200
16:39:04.778	35.00088332	-118.2179649	1200
16:39:09.256	34.99818475	-118.21962	1200
16:39:14.054	34.99663622	-118.2205498	1200
16:39:18.859	34.99391513	-118.2221489	1200
16:39:23.340	34.99030679	-118.2214033	1200
16:39:28.143	34.98757855	-118.2229193	1200
16:39:32.939	34.98405146	-118.2248155	1200
16:39:37.417	34.98208279	-118.2258432	1200
:39:42.222	34.9785231	-118.2276462	1200
39:47.018	34.97574054	-118.229007	1200
16:39:51.497	34.97334607	-118.2301442	1200
16:39:56.303	34.9705418	-118.2314368	1200
16:40:01.089	34.9681292	-118.2325153	1200
16:40:05.577	34.96449529	-118.2340821	1200
16:40:10.376	34.96206297	-118.2350925	1200
16:40:15.178	34.95840044	-118.2365566	1200
16:40:19.657	34.9559497	-118.2374983	1200
16:40:24.453	34.95267117	-118.2387109	1200
16:40:29.248	34.94979264	-118.2397316	1200
16:40:33.747	34.94787041	-118.243027	1200
16:40:38.534	34.94495413	-118.2439843	1200
16:40:43.339	34.94161114	-118.2450314	1200
16:40:47.817	34.93825786	-118.2460283	1200
16:40:52.613	34.93657752	-118.2465079	1200
16:40:57.411	34.93363123	-118.2473168	1200
16:41:01.887	34.93067703	-118.2506824	1200
16:41:06.695	34.92854717	-118.2512087	1200
16:41:34.855	34.91239809	-118.2596603	1200
16:42:03.016	34.9004545	-118.2715504	1200
16:42:07.494	34.89791326	-118.2743701	1200
16:42:12.302	34.89533166	-118.2771628	1200
16:42:17.089	34.89303621	-118.2773569	1200
16:42:21.893	34.89178491	-118.2799982	1200
16:42:26.372	34.88911631	-118.2827249	1200
16:42:31.171	34.8882852	-118.2853186	1200
42:35.974	34.88546924	-118.2854692	1200
16:42:40.452	34.88366026	-118.2880903	1200
16:42:45.259	34.88134927	-118.2907133	1200
16:42:50.054	34.87852652	-118.2933248	1200

TIME (UTC)	LAT	LONG	MODE 3A	MODE C	GROUNDSPEED
16:37:21.421	35.04586806	-118.1862802	1200	UNK	
16:37:26.216	35.04379323	-118.1882097	1200	UNK	
16:37:30.696	35.04240195	-118.189483	1200	UNK	
16:37:35.501	35.03995188	-118.191686	1200	UNK	112
16:37:40.296	35.03697693	-118.1911711	1200	UNK	112
16:37:44.776	35.0352184	-118.1926969	1200	UNK	112
16:37:49.576	35.03380469	-118.1939057	1200	UNK	112
16:37:54.377	35.03095916	-118.1962911	1200	UNK	112
16:37:58.856	35.02952744	-118.1974677	1200	UNK	116
16:38:03.652	35.02658502	-118.1967975	1200	UNK	116
16:38:08.459	35.02407143	-118.198792	1200	UNK	116
16:38:13.255	35.02262725	-118.1999168	1200	UNK	116
16:38:17.735	35.01495415	-118.2056427	1200	UNK	116
16:38:22.539	35.01826113	-118.2032258	1200	UNK	112
16:38:27.018	35.01675444	-118.2072981	1200	UNK	112
16:38:31.816	35.01823589	-118.2062174	1200	UNK	112
16:38:36.623	35.01302727	-118.2099511	1200	UNK	112
16:38:41.409	35.01152713	-118.2109926	1200	UNK	112
16:38:45.898	35.00926715	-118.2125337	1200	UNK	112
16:38:50.697	35.00623594	-118.2145488	1200	UNK	112
16:38:55.502	35.00509403	-118.2152926	1200	UNK	120
16:38:59.980	35.00318466	-118.2165181	1200	UNK	120
16:39:04.778	35.00088332	-118.2179649	1200	UNK	120
16:39:09.256	34.99818475	-118.21962	1200	UNK	120
16:39:14.054	34.99663622	-118.2205498	1200	UNK	120
16:39:18.859	34.99391513	-118.2221489	1200	UNK	120
16:39:23.340	34.99030679	-118.2214033	1200	UNK	120
16:39:28.143	34.98757855	-118.2229193	1200	UNK	140
16:39:32.939	34.98405146	-118.2248155	1200	UNK	140
16:39:37.417	34.98208279	-118.2258432	1200	UNK	140
16:39:42.222	34.9785231	-118.2276462	1200	UNK	140
16:39:47.018	34.97574054	-118.229007	1200	UNK	140
16:39:51.497	34.97334607	-118.2301442	1200	UNK	140
16:39:56.303	34.9705418	-118.2314368	1200	UNK	140
16:40:01.089	34.9681292	-118.2325153	1200	UNK	140
16:40:05.577	34.96449529	-118.2340821	1200	UNK	140
16:40:10.376	34.96206297	-118.2350925	1200	UNK	140
16:40:15.178	34.95840044	-118.2365566	1200	UNK	140
16:40:19.657	34.9559497	-118.2374983	1200	UNK	140
16:40:24.453	34.95267117	-118.2387109	1200	UNK	140
16:40:29.248	34.94979264	-118.2397316	1200	UNK	140
16:40:33.747	34.94787041	-118.243027	1200	UNK	134
16:40:38.534	34.94495413	-118.2439843	1200	UNK	134
16:40:43.339	34.94161114	-118.2450314	1200	UNK	134
16:40:47.817	34.93825786	-118.2460283	1200	UNK	134
16:40:52.613	34.93657752	-118.2465079	1200	UNK	134
16:40:57.411	34.93363123	-118.2473168	1200	UNK	134
16:41:01.887	34.93067703	-118.2506824	1200	UNK	134
16:41:06.695	34.92854717	-118.2512087	1200	UNK	134
GAP IN RADAR RETURNS					
16:41:34.855	34.91239809	-118.2596603	1200	UNK	134

MAG COURSE	VERT SPEED
	UNK
	UNK
	UNK
193	UNK
193	UNK
193	UNK
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THESE RECORDS MAY BE RELEASABLE UNDER THE FOIA REQUEST 15 DAYS AFTER SIGNATURE DATE UNLESS WE HEAR OTHERWISE FROM FAA NTSB COUNSEL

U.S. Department of Transportation
Federal Aviation Administration

Mike Monroney Aeronautical Center

P.O. Box 25082
Oklahoma City, Oklahoma 73125

Tuesday, January 20, 2004

National Transportation Safety Board
1515 W. 190th St., Suite 555
Gardena, CA 90248

ACCIDENT # 0353	INDIVIDUAL#: 001	NAME: BRADLEY, RONALD G.	MODE: AVIATION
DATE OF ACCIDENT	12/04/2003	DATE RECEIVED 12/09/2003	PUTREFACTION: Yes
	N # 8602J	NTSB # LAX04FA057	CAMI REF # 200300353001

LOCATION OF ACCIDENT ROSAMOND, CA

SPECIMENS Bile, Blood, Brain, Gastric, Heart, Kidney, Liver, Lung, Muscle, Spleen

FINAL FORENSIC TOXICOLOGY FATAL ACCIDENT REPORT

CARBON MONOXIDE: The carboxyhemoglobin (COHb) saturation is determined by spectrophotometry with a 10% cut off. Where possible, positive COHb values are confirmed by GC/TCD.

>> NO CARBON MONOXIDE detected in Blood

CYANIDE: The presence of cyanide is screened by Conway Diffusion. Positive cyanides are quantitated using spectrophotometry. The limit of quantitation of cyanide is 0.25 ug/mL. Normal blood cyanide concentrations are less than 0.15 ug/mL, while lethal concentrations are greater than 3ug/mL.

>> NO CYANIDE detected in Blood

VOLATILES: The volatile concentrations are determined by headspace gas chromatography at a cut off of 10 mg/dL. Where possible, positive ethanol values are confirmed by Radiative Energy Attenuation.

>> 10 (mg/dL, mg/hg) ETHANOL detected in Blood
>> 33 (mg/dL, mg/hg) ACETALDEHYDE detected in Blood
>> NO ETHANOL detected in Muscle
>> NO ETHANOL detected in Brain

-Notes:
-The ethanol found in this case is from postmortem ethanol formation and not from the ingestion of ethanol.

DRUGS: Immunoassay and chromatography are used to screen for legal and illegal drugs which include: amphetamine (0.010), opiates (0.010), marihuana (0.001), cocaine (0.020), phencyclidine (0.002), benzodiazepines (0.030), barbiturates (0.060), antidepressants (0.100), antihistamines (0.020), meprobamate (0.100), methaqualone (0.100), and nicotine (0.050). The values in () are the threshold values in ug/mL used to report positive results. Values below this concentration are normally reported as not detected. GC/Mass Spec, HPLC/Mass Spec, or GC/FTIR, is used to confirm most positive results.

>> NO DRUGS LISTED ABOVE DETECTED in Blood

Dennis Canfield, PhD.
Manager, Bioaeronautical Sciences Research Laboratory

Dennis V. Canfield Date: 2004.01.23 12:51:20 -06'00'

THESE RECORDS MAY BE RELEASABLE UNDER THE FOIA REQUEST 15 DAYS AFTER SIGNATURE DATE UNLESS WE HEAR OTHERWISE FROM FAA NTSB COUNSEL

U.S. Department of Transportation
Federal Aviation Administration

Mike Monroney Aeronautical Center

P O Box 25082
Oklahoma City, Oklahoma 73125

Friday, January 02, 2004

National Transportation Safety Board
1515 W. 190th St., Suite 555
Gardena, CA 90248

ACCIDENT # 0353 INDIVIDUAL#: 002 NAME: KIM, CHEON GON MODE: AVIATION

DATE OF ACCIDENT 12/04/2003 DATE RECEIVED 12/09/2003 PUTREFACTION: No

N # 8602J NTSB # LAX04FA057 CAMI REF # 200300353002

LOCATION OF ACCIDENT ROSAMOND, CA

SPECIMENS Bile, Blood, Brain, Gastric, Heart, Kidney, Liver, Lung, Muscle, Spleen

FINAL FORENSIC TOXICOLOGY FATAL ACCIDENT REPORT

CARBON MONOXIDE: The carboxyhemoglobin (COHb) saturation is determined by spectrophotometry with a 10% cut off. Where possible, positive COHb values are confirmed by GC/TCD.

>> NO CARBON MONOXIDE detected in Blood

CYANIDE: The presence of cyanide is screened by Conway Diffusion. Positive cyanides are quantitated using spectrophotometry. The limit of quantitation of cyanide is 0.25 ug/mL. Normal blood cyanide concentrations are less than 0.15 ug/mL, while lethal concentrations are greater than 3ug/mL.

>> NO CYANIDE detected in Blood

VOLATILES: The volatile concentrations are determined by headspace gas chromatography at a cut off of 10 mg/dL. Where possible, positive ethanol values are confirmed by Radiative Energy Attenuation.

>> NO ETHANOL detected in Blood

DRUGS: Immunoassay and chromatography are used to screen for legal and illegal drugs which include: amphetamine (0.010), opiates (0.010), marihuana (0.001), cocaine (0.020), phencyclidine (0.002), benzodiazepines (0.030), barbiturates (0.060), antidepressants (0.100), antihistamines (0.020), meprobamate (0.100), methaqualone (0.100), and nicotine (0.050). The values in () are the threshold values in ug/mL used to report positive results. Values below this concentration are normally reported as not detected. GC/Mass Spec, HPLC/Mass Spec, or GC/FTIR, is used to confirm most positive results.

>> NO DRUGS LISTED ABOVE DETECTED in Blood

Dennis V. Canfield

Date: 2004.01.23 13:23:45 -06'00'

Dennis Canfield, PhD
Manager, Bioaeronautical Sciences Research Laboratory

VOLK

KERN REGIONAL CRIMINALISTICS LABORATORY
REPORT OF ANALYSIS - CORONER'S REQUEST

CASE #: C-2461-03	CASE DATE: 12/4/2003	COLLECTION DATE: 12/5/2003	LAB #: CT03-00595-01
SUBJECT'S NAME: Ronald Gay Bradley		CRIME LAB / RECEIVED DATE: 12/9/2003	
REFERENCE LAB:		REFERENCE LAB #:	

[X] Alcohol [X] Drug Screen [ ] Carboxyhemoglobin [ ] Volatiles

[ ] Individual Drug

[ ] Other(s)

TEST	*SAMPLE TYPE B	U	V	O	LABORATORY RESULTS	ANALYST(S)	DATE OF ANALYSIS
DRUGS OF ABUSE:	X				Negative	MCF	12/16/2003
Methamphetamine							
Amphetamine							
Barbiturates							
Benzodiazepines							
Cocaine							
Opiates							
Codeine							
Morphine							
Acetylmorphine							
PCP							
Marijuana							
Alcohol	X				Negative	MCF	12/17/2003
CO							
Volatiles							
Other							

NOTES:

*Sample Type
B=Blood U=Urine
V=Vitreous O=Other

REVIEWED BY: [redacted] DATE: December 26, 2003

1-2-04

VOUL

KE..N REGIONAL CRIMINALISTICS LABORA.ORY
REPORT OF ANALYSIS - CORONER'S REQUEST

CASE #: C-2462-03	CASE DATE 12/4/2003	COLLECTION DATE: 12/5/2003	LAB #: CT03-00596-01
SUBJECT'S NAME: Cheongon Kim		CRIME LAB / RECEIVED DATE: 12/9/2003	
REFERENCE LAB:		REFERENCE LAB #.	

[X] Alcohol [X] Drug Screen [ ] Carboxyhemoglobin [ ] Volatiles

[ ] Individual Drug

[ ] Other(s)

TEST	*SAMPLE TYPE B	U	V	O	LABORATORY RESULTS	ANALYST(S)	DATE OF ANALYSIS
DRUGS OF ABUSE:	X				Negative	MCF	12/16/2003
Methamphetamine							
Amphetamine							
Barbiturates							
Benzodiazepines							
Cocaine							
Opiates							
Codeine							
Morphine							
Acetylmorphine							
PCP							
Marijuana							
Alcohol	X				Negative	MCF	12/17/2003
CO							
Volatiles							
Other							

NOTES:

*Sample Type
B=Blood U=Urine
V=Vitreous O=Other

REVIEWED BY: [redacted] DATE: December 26, 2003

[redacted]

1-2-04

STATEMENT OF PARTY REPRESENTATIVES TO NTSB INVESTIGATION

Aircraft Identification

Registration Number 8602J
Make and Model Wing D-1
Location Lancaster, PA
Date 12-4-03

The undersigned hereby acknowledge that they are participating in the above-referenced aircraft accident or incident investigation (including any component tests and teardowns or simulator testing) on behalf of the party indicated adjacent to their name, for the purpose of providing technical assistance to the National Transportation Safety Board.

The undersigned further acknowledge that they have read the attached copy of 49 C.F.R. Part 831 and have familiarized themselves with 49 C.F.R. § 831.11, which governs participation in NTSB investigations and agree to abide by the provisions of that regulation.

It is understood that a party representative to an investigation may not occupy a legal position or be a person who also represents claimants or insurers. The placement of a signature hereon constitutes a representation that participation in this investigation is not on behalf of either claimants or insurers and that, while any information obtained may ultimately be used in litigation, participation is not for the purposes of preparing for litigation.

By placing their signatures hereon, all participants agree that they will neither assert, nor permit to be asserted on their behalf, any privilege in litigation, with respect to information or documents obtained during the course of and as a result of participation in the NTSB investigation as described above. It is understood, however, that this form is not intended to prevent the undersigned from participating in litigation arising out of the accident referred to above or to require disclosure of the undersigned's communications with counsel.

SIGNATURE	NAME (Print)	PARTY	DATE
[redacted]	ROBERT D. SHADDLE	FRI	5 Dec 03
	John Butler	Lycoming	5 Dec 03

(Continued on reverse side)

PART 831 – ACCIDENT/INCIDENT INVESTIGATION PROCEDURES

Sec.

Authority: Independent Safety Board Act of 1974, as amended (49 U.S.C. 1101 et seq.); Federal Aviation Act of 1958, as amended (49 U.S.C. 40101 et seq.).

§ 831.1 Applicability of part.

Unless otherwise specifically ordered by the National Transportation Safety Board (Board), the provisions of this part shall govern all accident or incident investigations, conducted under the authority of title VII of the Federal Aviation Act of 1958, as amended, and the Independent Safety Board Act of 1974. Rules applicable to accident hearings and reports are set forth in Part 845.

§ 831.2 Responsibility of Board.

(a) *Aviation*. (1) The Board is responsible for the organization, conduct, and control of all accident and incident investigations (see Sec. 830.2 of this chapter) within the United States, its territories and possessions, where the accident or incident involves any civil aircraft or certain public aircraft (as specified in Sec. 830.5 of this chapter), including an investigation involving civil or public aircraft (as specified in Sec. 830.5) on the one hand, and an Armed Forces or intelligence agency aircraft on the other hand. It is also responsible for investigating accidents/incidents that occur outside the United States, and which involve civil aircraft and/or certain public aircraft, when the accident/incident is not in the territory of another country (i.e., in international waters).

(2) Certain aviation investigations may be conducted by the Federal Aviation Administration (FAA), pursuant to a "Request to the Secretary of the Department of Transportation to Investigate Certain Aircraft Accidents," effective February 10, 1977 (the text of the request is contained in the appendix to part 800 of this chapter), but the Board determines the probable cause of such accidents or incidents.[1] Under no circumstances are aviation investigations where the portion of the investigation is so delegated to the FAA by the Board considered to be joint investigations in the sense of sharing responsibility. These investigations remain NTSB investigations.

(3) The Board is the agency charged with fulfilling the obligations of the United States under Annex 13 to the Chicago Convention on International Civil Aviation (Eighth Edition, July 1994), and does so consistent with State Department requirements and in coordination with that department. Annex 13 contains specific requirements for the notification, investigation, and reporting of certain incidents and accidents involving international civil aviation. In the case of an accident or incident in a foreign state involving civil aircraft of U.S. registry or manufacture, where the foreign state is a signatory to Annex 13 to the Chicago Convention of the International Civil Aviation Organization, the state of occurrence is responsible for the investigation. If the accident or incident occurs in a foreign state not bound by the provisions of Annex 13 to the Chicago Convention, or if the accident or incident involves a public aircraft (Annex 13 applies only to civil aircraft), the conduct of the investigation shall be in consonance with any agreement entered into between the United States and the foreign state.

(b) *Surface*. The Board is responsible for the investigation of: railroad accidents in which there is a fatality, substantial property damage, or which involve a passenger train (see part 840 of this chapter); major marine casualties and marine accidents involving a public and non-public vessel or involving Coast Guard functions (see part 850 of this chapter[2]); highway accidents, including railroad grade-crossing accidents, the investigation of which is selected in cooperation with the States; and pipeline accidents in which there is a fatality, significant injury to the environment, or substantial property damage.

(c) *Other Accidents/Incidents*. The Board is also responsible for the investigation of an accident/incident that occurs in connection with the transportation of people or property which, in the judgment of the Board, is catastrophic, involves problems of a recurring character, or would otherwise carry out the policy of the Independent Safety Board Act of 1974. This authority includes, but is not limited to, marine and boating accidents and incidents not covered by part 850 of this chapter, and accidents/incidents selected by the Board involving transportation and/or release of hazardous materials.

§ 831.3 Authority of Directors.

The Director, Office of Aviation Safety, or the Director, Office of Surface Transportation Safety, subject to the provisions of Sec. 831.2 and part 800 of this chapter, may order an investigation into any accident or incident.

§ 831.4 Nature of Investigation.

Accident and incident investigations are conducted by the Board to determine the facts, conditions, and circumstances relating to an accident or incident and the probable cause(s) thereof. These results are then used to ascertain measures that would best tend to prevent similar accidents or incidents in the future. The investigation includes the field investigation (on-scene at the accident, testing, teardown, etc.), report preparation, and, where ordered, a public hearing. The investigation results in Board conclusions issued in the form of a report or "brief" of the incident or accident. Accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties. They are not subject to the provisions of the Administrative Procedure Act (5 U.S.C. 504 et seq.), and are not conducted for the purpose of determining the rights or liabilities of any person.

§ 831.5 Priority of Board Investigations.

Any investigation of an accident or incident conducted by the Safety Board directly or pursuant to the appendix to part 800 of this chapter (except major marine investigations conducted under 49 U.S.C. 1131(a)(1)(E)) has priority over all other investigations of such accident or incident conducted by other Federal agencies. The Safety Board shall provide for the appropriate participation by other Federal agencies in any such investigation, except that such agencies may not participate in the Safety Board's determination of the probable cause of the accident or incident. Nothing in this section impairs the authority of other Federal agencies to conduct investigations of an accident or incident under applicable provisions of law or to obtain information directly from parties involved in, and witnesses to, the transportation accident or incident, provided they do so without interfering with the Safety Board's investigation. The Safety Board and other Federal agencies shall assure that appropriate information obtained or developed in the course of their investigations is exchanged in a timely manner.

§ 831.6 Request to withhold information.

(a) *Trade Secrets Act (18 U.S.C. 1905), Exemption 4 of the Freedom of Information Act (5 U.S.C. 552) (FOIA), and The Independent Safety Board Act of 1974, as amended.*

(1) General. The Trade Secrets Act provides criminal penalties for unauthorized government disclosure of trade secrets and other specified confidential commercial information. The Freedom of Information Act authorizes withholding of such information; however, the Independent Safety Board Act, at 49 U.S.C. 1114(b), provides that the Board may, under certain circumstances, disclose information related to trade secrets.

(2) Procedures. Information submitted to the Board that the submitter believes qualifies as a trade secret or confidential commercial information subject either to the Trade Secrets Act or FOIA Exemption 4 shall be so identified by the submitter on each and every page of such document. The Board shall give the submitter of any information so identified, or information the Board has substantial reason to believe qualifies as a trade secret or confidential commercial information subject either to the Trade Secrets Act or FOIA Exemption 4, the opportunity to comment on any contemplated disclosure, pursuant to 49 U.S.C. 1114(b). In all instances where the Board determines to disclose pursuant to 49 U.S.C. 1114(b) and/or 5 U.S.C. 552, at least 10 days' notice will be provided the submitter. Notice may not be provided the submitter when disclosure is required by a law other than FOIA if the information is not identified by the submitter as qualifying for withholding, as is required by this subsection, unless the Board has substantial reason to believe that disclosure would result in competitive harm.

(3) Voluntarily-provided Safety Information. It is the policy of the Safety Board that commercial, safety-related information provided to it voluntarily and not in the context of particular accident/incident investigations will not be disclosed. Reference to such information for the purposes of safety recommendations will be undertaken with consideration for the confidential nature of the underlying database(s).

(b) *Other*. Any person may make written objection to the public disclosure of any other information contained in any report or document filed, or otherwise obtained by the Board, stating the grounds for such objection. The Board, on its own initiative or if such objection is made, may order such information withheld from public disclosure when, in its judgment, the information may be withheld under the provisions of an

[1] The authority of a representative of the FAA during such investigations is the same as that of a Board investigator under this part.

[2] Part 850 also governs the conduct of certain investigations in which the Board and the Coast Guard participate jointly.

exemption to the Freedom of Information Act (5 U.S.C. 552, see part 801 of this chapter), and its release is found not to be in the public interest.

§ 831.7 Right to representation.

Any person interviewed by an authorized representative of the Board during the investigation, regardless of the form of the interview (sworn, unsworn, transcribed, not transcribed, etc.), has the right to be accompanied, represented, or advised by an attorney or non-attorney representative.

§ 831.8 Investigator-in-charge.

The designated investigator-in-charge (IIC) organizes, conducts, controls, and manages the field phase of the investigation, regardless of whether a Board Member is also on-scene at the accident or incident site. (The role of the Board member at the scene of an accident investigation is as the official spokesperson for the Safety Board.) The IIC has the responsibility and authority to supervise and coordinate all resources and activities of all personnel, both Board and non-Board, involved in the on-site investigation. The IIC continues to have considerable organizational and management responsibilities throughout later phases of the investigation, up to and including Board consideration and adoption of a report or brief of probable cause(s).

§ 831.9 Authority of Board representatives.

(a) *General.* Any employee of the Board, upon presenting appropriate credentials, is authorized to enter any property where an accident/incident subject to the Board's jurisdiction has occurred, or wreckage from any such accident/incident is located, and do all things considered necessary for proper investigation. Further, upon demand of an authorized representative of the Board and presentation of credentials, any Government agency, or person having possession or control of any transportation vehicle or component thereof, any facility, equipment, process or controls relevant to the investigation, or any pertinent records or memoranda, including all files, hospital records, and correspondence then or thereafter existing, and kept or required to be kept, shall forthwith permit inspection, photographing, or copying thereof by such authorized representative for the purpose of investigating an accident or incident, or preparing a study, or related to any special investigation pertaining to safety or the prevention of accidents. The Safety Board may issue a subpoena, enforceable in Federal district court, to obtain testimony or other evidence. Authorized representatives of the Board may question any person having knowledge relevant to an accident/incident, study, or special investigation. Authorized representatives of the Board also have exclusive authority, on behalf of the Board, to decide the way in which any testing will be conducted, including decisions on the person that will conduct the test, the type of test that will be conducted, and any individual who will witness the test.

(b) *Aviation.* Any employee of the Board upon presenting appropriate credentials is authorized to examine and test to the extent necessary any civil aircraft, aircraft engine, propeller, appliance, or property aboard an aircraft involved in an accident in air commerce.

(c) *Surface.* (1) Any employee of the Board, upon presenting appropriate credentials, is authorized to test or examine any vehicle, vessel, rolling stock, track, pipeline component, or any part of such item when such examination or testing is determined to be required for purposes of such investigation.

(2) Any examination or testing shall be conducted in such a manner so as not to interfere with or obstruct unnecessarily the transportation services provided by the owner or operator of such vehicle, vessel, rolling stock, track, or pipeline component, and shall be conducted in such a manner so as to preserve, to the maximum extent feasible, any evidence relating to the transportation accident, consistent with the needs of the investigation and with the cooperation of such owner or operator.

§ 831.10 Autopsies.

The Board is authorized to obtain with or without reimbursement, a copy of the report of autopsy performed by State or local officials on any person who dies as a result of having been involved in a transportation accident within the jurisdiction of the Board. The investigator-in-charge, on behalf of the Board, may order an autopsy or seek other tests of such persons as may be necessary to the investigation, provided that to the extent consistent with the needs of the accident investigation, provisions of local law protecting religious beliefs with respect to autopsies shall be observed.

§ 831.11 Parties to the investigation.

(a) *All investigations, regardless of mode.* (1) The investigator-in-charge designates parties to participate in the investigation. Parties shall be limited to those persons, government agencies, companies, and associations whose employees, functions, activities, or products were involved in the accident or incident and who can provide suitable qualified technical personnel actively to assist in the investigation. Other than the FAA in aviation cases, no other entity is afforded the right to participate in Board investigations.

(2) Participants in the investigation (i.e., party representatives, party coordinators, and/or the larger party organization) shall be responsive to the direction of Board representatives and may lose party status if they do not comply with their assigned duties, activity proscriptions or instructions, or if they conduct themselves in a manner prejudicial to the investigation.

(3) No party to the investigation shall be represented in any aspect of the NTSB investigation by any person who also represents claimants or insurers. No party representative may occupy a legal position (see Sec. 845.13 of this chapter). Failure to comply with these provisions may result in sanctions, including loss of status as a party.

(4) Title 49, United States Code Sec. 1132 provides for the appropriate participation of the FAA in Board investigations, and Sec. 1131(a)(2) provides for such participation by other departments, agencies, or instrumentalities. The FAA and those other entities that meet the requirements of paragraph (a)(1) of this section will be parties to the investigation with the same rights and privileges and subject to the same limitations as other parties, provided however that representatives of the FAA need not sign the "*Statement of Party Representatives to NTSB Investigation*" (see paragraph (b) of this section).

(b) *Aviation investigations.* In addition to compliance with the provisions of paragraph (a) of this section, and to assist in ensuring complete understanding of the requirements and limitations of party status, all party representatives in aviation investigations shall sign "*Statement of Party Representatives to NTSB Investigation*" immediately upon attaining party representative status. Failure timely to sign that statement may result in sanctions, including loss of status as a party.

§ 831.12 Access to and release of wreckage, records, mail, and cargo.

(a) Only the Board's accident investigation personnel, and persons authorized by the investigator-in-charge to participate in any particular investigation, examination or testing shall be permitted access to wreckage, records, mail, or cargo in the Board's custody.

(b) Wreckage, records, mail, and cargo in the Board's custody shall be released by an authorized representative of the Board when it is determined that the Board has no further need of such wreckage, mail, cargo, or records. When such material is released, Form 6120.15, "*Release of Wreckage,*" will be completed, acknowledging receipt.

§ 831.13 Flow and dissemination of accident or incident information.

(a) Release of information during the field investigation, particularly at the accident scene, shall be limited to factual developments, and shall be made only through the Board Member present at the accident scene, the representative of the Board's Office of Public Affairs, or the investigator-in-charge.

(b) All information concerning the accident or incident obtained by any person or organization participating in the investigation shall be passed to the IIC through appropriate channels before being provided to any individual outside the investigation. Parties to the investigation may relay to their respective organizations information necessary for purposes of prevention or remedial action. However, no information concerning the accident or incident may be released to any person not a party representative to the investigation (including non-party representative employees of the party organization) before initial release by the Safety Board without prior consultation and approval of the IIC.

§ 831.14 Proposed findings.

(a) *General.* Any person, government agency, company, or association whose employees, functions, activities, or products were involved in an accident or incident under investigation may submit to the Board written proposed findings to be drawn from the evidence produced during the course of the investigation, a proposed probable cause, and/or proposed safety recommendations designed to prevent future accidents.

(b) *Timing of submissions.* To be considered, these submissions must be received before the matter is calendared for consideration at a Board meeting. All written submissions are expected to have been presented to staff in advance of the formal scheduling of the meeting. This procedure ensures orderly and thorough consideration of all views.

(c) *Exception.* This limitation does not apply to safety enforcement cases handled by the Board pursuant to part 821 of this chapter. Separate *ex parte* rules, at part 821, subpart J, apply to those proceedings.

Issued in Washington, DC this 21st day of January, 1997

Jim Hall,
Chairman

[FR Doc. 97-1810 Filed 1-24-97; 8:45 am]
BILLING CODE 7533-01-M

NATIONAL TRANSPORTATION SAFETY BOARD RELEASE OF AIRCRAFT WRECKAGE	ACCIDENT IDENTIFICATION NUMBER LAX04FA057

PART I—RELEASE OF AIRCRAFT WRECKAGE

REGISTERED OWNER (name and address)	REGISTRATION NUMBER—N
DAC Holdings, Inc. 802 N. West St. Wilmington, DE 19801	8602J MAKE Wing

MODEL	DATE OF ACCIDENT	LOCATION
D-1	12/04/03	Rosamond, CA

The National Transportation Safety Board has ☒ has not ☐ completed its investigation of the aircraft wreckage described above. All wreckage except that listed on the reverse side is hereby released to the registered owner, or owner's representative, for appropriate disposition. (If no parts are retained, insert NONE.)

SIGNATURE OF NTSB REPRESENTATIVE	TITLE	DATE
[redacted]	AIR SAFETY INVESTIGATOR	03/04/04

(This section may be signed by a person, not the owner or owner's representative, who has knowledge of the disposition of the aircraft wreckage and its parts. Such signature does not place a responsibility for disposition of the wreckage upon that person.)

I HEREBY ACKNOWLEDGE:

☒ Receipt of the above described aircraft wreckage.

☒ Removal of the parts, if any, listed on the reverse side of this form.

SIG[redacted]	TITLE	DATE
W.G. Bertles	Insurance Representative for owner	3/6/04

REMARKS:

The airplane wreckage is released from its storage location at Aircraft Recovery Service, Littlerock, California.

NTSB FORM 6120.15 (Rev. Jan-87)

NATIONAL TRANSPORTATION SAFETY BOARD
RECEIPT OF PARTS

ACCIDENT/INCIDENT IDENTIFICATION NUMBER: LAX04FA057

PART II - RELEASE OF PARTS

REGISTRATION NUMBER	MAKE	MODEL
N8602J	Wing	D-1

DATE OF ACCIDENT/INCIDENT	LOCATION
12/04/03	Roszmond, CA

The National Transportation Safety Board has retained, for further examination, those parts, pieces, or components listed below. When the examination is complete, they will be returned to:

OWNER OR OWNER'S REPRESENTATIVE - National Test Pilot School

ADDRESS DAC Holdings, Inc.
802 N West St.
Wilmington, DE 19801

(hand delivered to Jerry Prince, Aircraft Recovery Service, Inc., on June 1, 2005)

PARTS, PIECES, OR COMPONENTS RETAINED:

20-inch long section of right rudder cable (aft portion)
21-inch end of right rudder cable (forward portion)
2, 3-foot long aft portions of elevator control tube assembly from aft of rear cabin to aft empennage

SIGNATURE OF NTSB REPRESENTATIVE	TITLE	DATE
[redacted]	Air Safety Investigator	5/31/2005

The registered owner or owner's representative will acknowledge receipt of the materials by signing this form in the spaces designated below.

SIGNATURE OF OWNER OR OWNER'S REPRESENTATIVE	TITLE	DATE
[redacted]	ARS	6/1/05

09/?/2004

12/20/2004

F/A-22

Cutting the F/A-22 acquisition number that drastically could have huge near-term implications for F/A-22 production lines at Lockheed Martin and Boeing. The latter builds one-third of the aircraft's structure. The Air Force has already awarded contracts for 83 of the stealth fighters. If production were capped at near 100, it would force the companies to start shuttering lines soon after 2006.

It would also undermine efforts to reduce the price of the fighter, since suppliers would no longer be able to amortize efficiency improvements over the rest of the program. The Air Force says the cost of an F/A-22 is about $130 million, although that doesn't account for the billions spent on its development.

The repercussions on the V-22 could be nearly as severe. Officials are bracing for a near-term reduction of eight tiltrotors in the 2006-11 budget period. The aircraft, although they haven't been cut outright, are moved beyond the defense planning period.

The near-term impact would be to

F/A-22 Takes a Fall

Test aircraft crashes soon after takeoff; search for the cause is in high gear

DAVID A. FULGHUM and ROBERT WALL/WASHINGTON

Early analysis of the recent Lockheed Martin F/A-22 crash at Nellis AFB, Nev., is, for the most part, producing theories of what did *not* cause the accident.

But Air Force officials fear—that with Congress looking to cut programs in order to finance more ground troops—it is almost certain the mishap will further delay production, and ultimately jeopardize the stealth fighter's future.

THE TEST DID NOT involve flying with a heavy ferry-load of fuel, shifting the aircraft's center of gravity or taking off with insufficient speed.

"It was a routine flight with no unusual configuration of external fuel tanks or weapon stores," says a senior Air Force official. "The problem appeared on takeoff after liftoff. The pilot's only input to the flight controls was [upward] pitch. There was no engine problem. There was a pitch command and all of a sudden the nose went down. The pilot had about 1.5 sec. to react, so he ejected."

There were areas of immediate interest. One early inquiry involved determining if there was an aircraft taking off on a parallel runway that could have produced a wake or vortices that affected the F/A-22.

In September, an F/A-22 was stressed to 10-11g, past its operational limit of 9g, when flying through the wake of an F-16 while carrying external fuel tanks. The overstressing was blamed on a glitch in the digital flight control software that produced a violent pitch reaction. Gain in the pitch controls was set too high in the earlier accident. Its response was calibrated for low-altitude operations instead of high-altitude flight where it was maneuvering at the time of the incident, according to Air Force officials.

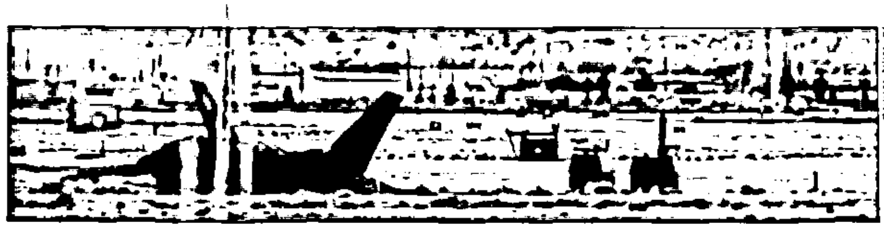
"The high-rate command was supposed to have been ironed out," the senior Air Force official said. "That problem was fixed, but the software could still have some squirrels in it." The aircraft involved in the incident has re-

mained grounded and USAF officials are still uncertain whether it will ever fly again.

An Air Force official notes: "Now that we understand the sensitivity to turbulence with external fuel tanks, we have identified modifications to our flight control software to preclude this from happening again." The adjustments have been tried out in a laboratory and are being incorporated in the aircraft for flight testing.

THE FAULT LEADING to the crash also is unlikely to have been associated with the assembly process. The aircraft is one of a small number of production representative test vehicles built starting in 1999. These aircraft were assembled between the development phase and before the Air Force was given the green light to commence low-rate production. The mishap aircraft had about 150 hr. on it and was delivered to Nellis in 2002.

The Air Force suspended flights of all F/A-22s soon after the Dec. 20 crash. The service has seven F/A-22s remaining at Nellis, with eight at Edwards AFB, Calif., and 13 at the training unit at Tyndall AFB, Fla.



AP/WIDE WORLD

The Dec. 20 crash of a Lockheed Martin F/A-22 at Nellis AFB, Nev., was the second Class A incident for the stealth fighter in 2004.

The still-unnamed pilot was conducting a training mission and was unharmed. This test pilot and Weapons School graduate has about 60 hr. in the F/A-22, making him one of the more experienced pilots in the aircraft, says Maj. Gen. Stephen Goldfein, commander of the Air Warfare Center at Nellis.

The Air Force has convened its two standard post-accident review boards. Brig. Gen. Kurt Cichowski, commander of the 49th Fighter Wing at Holloman AFB, N.M., will lead the safety board. The accident board will be headed by the Air Combat Command's Col. Ted Kresge.

The only other crash of the design was a YF-22, early in the program, as the result of pitch control problems. Over-sensitive controls produced violent altitude oscillations that ended in a wheels-up landing from which the pilot walked.

Lockheed Martin was hoping to complete assessment of the aircraft's critical military requirements and obtain permission to ramp up to full-rate production of 32 aircraft per year.

In late March, Pentagon officials are slated to review the program's progress. However, the hiatus in flight ops may delay that event. USAF officials had hoped to declare the first F/A-22 operational unit ready in December, although acquisition officials have hinted that the milestone may slip into 2006.

01/13/2005

Impact Assessment

Pilatus PC-21 crash and grounding may force delays in production plans

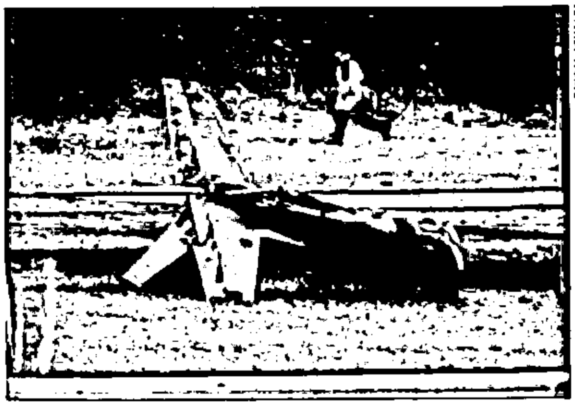
ROBERT WALL/PARIS

Swiss authorities are trying to achieve a balance in investigating the first crash of a Pilatus PC-21 trainer in order to minimize negative focus on the company while giving due attention to safety concerns.

The crash of the newer of two PC-21 prototypes near Pilatus' airfield at Buochs, Switzerland, killed Andy Ramseier, the company's chief test pilot, and injured one pedestrian. Swiss authorities immediately grounded the other aircraft, which was also flying at that time. The accident occurred at about 4:20 p.m. local time, Jan. 13, when the trainer touched the ground and went out of control over a nearby dam, where the pedestrian was struck.

An accident investigator notes the remaining aircraft was first grounded so officials could inspect it. But Switzerland's federal civil aviation authority has continued the grounding status pending accident investigators' initial findings. The aircraft that crashed had just joined the flight test in June 2004, two years after the first prototype flight.

The PC-21 is critical to Pilatus' future, although the company continues to offer the PC-9M and PC-7 Mk. 2 trainers, and PC-12 single-engine turboprop general aviation aircraft that have long been the backbone of its order book. With the PC-21, it decided to forgo further trainer upgrades and instead gamble on an entirely new design. The aircraft is powered by a Pratt & Whitney PT6A-68B 1,600-shp. turboprop engine, has a Martin Baker MK 16L ejection seat, and a glass cockpit compatible with night-vision goggles.



One of two Pilatus PC-21 trainer prototypes broke apart during a Jan. 13 crash.

The company late last year received type certification for the PC-21, and was gearing up to start series production, even though it has yet to land a customer. The two prototypes had amassed more than 750 flight hr.

Pilatus officials so far have refused to address the accident, or its impact on the PC-21 program and the company's long-term health. It has spent more than $150 million on the program.

An accident investigator says authorities are aware that the PC-21 program is crucial to the company, and will consider that as they pursue their analysis. The investigation could take months to complete, but authorities may issue a preliminary finding-of-facts much earlier, the official notes, which could return the aircraft to flying status. The final decision on return to flight rests with the civil aviation authority.

LAST WEEK, investigators were still assessing what data they could harvest from the crashed aircraft. The PC-21 was carrying neither voice nor flight data recorders. However, with the help of component suppliers, investigators are hoping to yield valuable clues from computer memory that may have survived the crash.

Pilatus was recovering from a sharp drop in aircraft sales and earnings in 2002, and the crash could cause a significant setback. PC-12 sales grew in 2003, with 61 deliveries, and in 2004, with about 70. Projections for 2005 are that PC-12 sales will grow further, although the weak dollar has had a negative earnings impact.

PC-21 Plan

ROBERT WALL/WASHINGTON

Pilatus plans to upgrade its remaining PC-21 prototype and add the first production aircraft to the test program to offset the loss of one of the trainers in a crash last month.

A week after the second of two PC-21 prototypes (HB-HZB) crashed during flight operations at the Buochs, Switzerland, airfield near Stans, Swiss safety authorities lifted the grounding they had placed on the remaining prototype (HB-HZA). Authorities for the civil aviation agency say their preliminary examinations don't suggest any technical problems with the aircraft, so the grounding could be lifted.

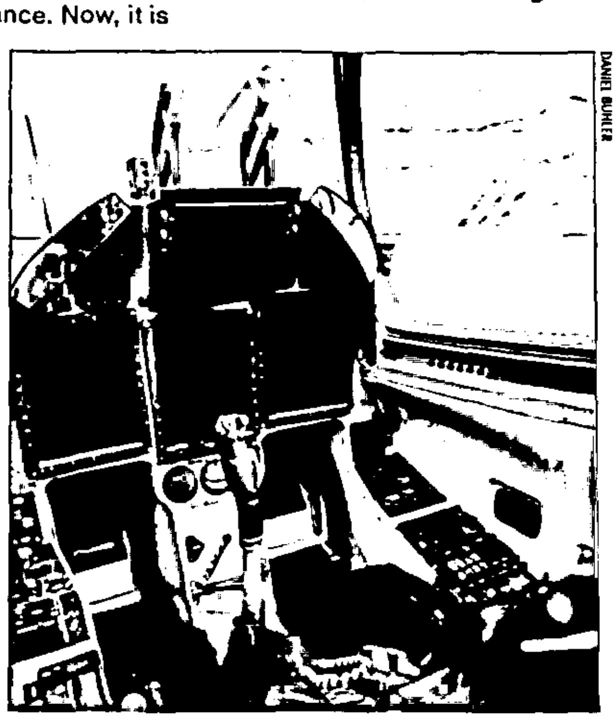
The mishap aircraft was conducting flight show preparations with the other prototype on Jan. 13. The pilot, who died in the crash, flew a 360-deg. turn and shortly after, the right wing struck the ground, causing the aircraft to catch fire and break apart, the Swiss federal department of environment, transport, energy and communications said late last month. The pilots flew the same routine previously performed during a flight display in Payerne, Switzerland, in September 2004. The accident investigation is expected to last several more months.

Even though the PC-21 has been cleared to resume flight operations, Pilatus doesn't expect that to happen immediately. The remaining prototype had served mainly to assess the trainer's aerodynamic performance. Now, it is being upgraded to take on the roles of the destroyed airplane, primarily full avionic testing. Pilatus says in a statement that HB-HZA should be ready to fly in about two months.

Pilatus is accelerating the production of the first series production PC-21 but will make it part of the test program. "It will then be used to help secure the type's IFR and autopilot certification," Pilatus says. At this point, the company isn't planning any design modifications to the aircraft.

Other series production aircraft will start becoming available in December 2005, says Pilatus President and CEO Oscar J. Schwenk. Moreover, he insists that even though the program has lost some time due to the accident, its future isn't in jeopardy.

Pilatus has yet to secure its first PC-21 customer, although discussions with several potential clients are underway. The leading candidate may be the Swiss air force.



DANIEL BUHLER

The PC-21 prototype that crashed last month served to validate the full-avionics functionality. The remaining PC-21 will now receive all aspects of that system, which includes glass cockpit and head-up display.

Flying High

Companies predict another stellar year despite looming budget ax

JOSEPH C. ANSELMO/WASHINGTON

Aerospace executives are forecasting another robust business cycle in 2005, despite a Bush administration proposal to cut at least $30 billion from the Pentagon's six-year spending plan.

Defense titan Lockheed Martin Corp., which would be hit hard if proposed cuts to the F/A-22 and C-130J aircraft programs become reality, increased its sales and earnings forecast for 2005 last week as it reported a 20% hike in net income during 2004 to $1.3 billion. Net sales rose 12% to $35.5 billion, fueled by strong growth in the company's information technology and aeronautics businesses.

Lockheed Martin's fourth-quarter net earnings rose 8% from a year earlier to $372 million, while sales were up 11% to $10 billion. General Dynamics also rolled out robust financial results and says it expects earnings to grow another 11-13% this year. The company's net income for 2004 grew 22% to $1.2 billion. Revenue rose 17% to $19.2 billion, bolstered by strong sales in its information technology unit.

WHILE A MASSIVE FEDERAL budget deficit and the costly war in Iraq are putting pressure on the Pentagon, company Chairman and CEO Nicholas D. Chabraja anticipates robust U.S. defense spending will be maintained in the near term. "What we hear is investment accounts in the 2006 budget are expected to be up over the 2005 level by a modest but significant amount," says Chabraja.

For the fourth quarter, General Dynamics reported a net income of $336 million, a 21% rise from the same period a year earlier. Quarterly revenue rose 11% to $5.2 billion.

To be sure, the White House's proposed budget cuts have made investors nervous, leading to a modest decline in defense stocks as Wall Street waits for more details. President Bush's fiscal 2006 defense budget request is expected to be unveiled on Feb. 7.

Thomas W. Rabaut, president and CEO of combat vehicle and weapons contractor United Defense Industries, says Air Force and Navy programs could be cut to help the Army pay for war-related costs but believes it's too early to assess the impact on his company. UDI's fourth-quarter net income rose 8% to $31 million on revenue of $596 million, a 14% increase. For the year, the company's net income rose 18% to $166 million, while revenue grew 12% to $2 billion.

Jan 31, 2005

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Büro für Flugunfalluntersuchungen BFU
Bureau d’enquête sur les accidents d’aviation BEAA
Ufficio d’inchiesta sugli infortuni aeronautici UIIA
Uffizi d'investigaziun per accidents d'aviatica UIAA
Aircraft accident investigation bureau AAIB

Final Report No. 1909

by the Aircraft Accident

Investigation Bureau

concerning the accident

of the aircraft Pilatus PC-21, HB-HZB, Prototype P02

on 13 January 2005

on Buochs aerodrome, municipality of Buochs NW

approx. 12 km SSE of Lucerne

Bundeshaus Nord, CH-3003 Berne

GENERAL INFORMATION REGARDING THIS REPORT

This report contains the conclusions of the AAIB concerning the circumstances and causes of the investigated accident/serious incident.

In accordance with the Convention on International Civil Aviation (ICAO Annexe 13), the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, are indicated in local time (LT) for Switzerland, corresponding at the time of the accident to Central European Time (CET). The relationship between LT, CET and universal time coordinated (UTC) is as follows: LT = CET = UTC + 1 h.

The masculine form is used in this report regardless of gender for reasons of data protection

Contents

Final Report

Owner	Pilatus Flugzeugwerke AG, 6371 Stans
Operator	Pilatus Flugzeugwerke AG, 6371 Stans
Aircraft type	Pilatus PC-21 prototype
Country of manufacture	Switzerland
Registration	HB-HZB
Location	Buochs aerodrome
Date and time	13 January 2005, 16:39

General

Synopsis

On Thursday, 13 January 2005, a training flight was carried out which was intended to serve as preparation for a planned display of the two Pilatus PC-21 prototypes abroad. An aerobatics programme was to be practised during this flight.

In order to facilitate understanding, since two aircraft of the same type were involved in this flight, in the following report serial number P01 is used for aircraft HB-HZA and serial number P02 for aircraft HB-HZB.

The two Pilatus PC-21 aircraft took off in formation, in an easterly direction, from runway 07 L at Buochs at about 16:33. During take-off, the matt black aircraft P01 was flying in front as leader and the silver P02 followed as "wing man". After take-off, both aircraft climbed to approximately 5000 ft QFE (height above aerodrome). They then performed a steep dive and a low pass over the runway in a westerly direction, at low altitude and high speed. There followed a tight 180-degree turn over Stans. The formation then again performed a low pass over runway 07L. After an inclined 360-degree turn to the right, with a maximum height of 2200 ft QFE, the formation split over the centre line of the runway at a height of approximately 400 ft QFE. Aircraft P01 performed a loop over the runway centre line, and at the same time aircraft P02 flew a tight 360-degree turn at low altitude to the right. Towards the end of the 360-degree turn, aircraft P02 went into a shallow dive. A little later, its right wing clipped the ground. In the high-speed crash the aircraft was destroyed and a fire broke out. The pilot suffered fatal injuries. A passer-by was seriously injured in connection with the accident.

Investigation

The accident occurred on 13 January 2005 at 16:39. The notification was received at the Aircraft Accident Investigation Bureau (AAIB) at 16:55. The investigation was opened in co-operation with the Nidwalden cantonal police at the site of the accident on the same day at 18:00.

1 Factual information

1.1 History of flight

1.1.1 Pre-flight history

The Pilatus PC-21 aircraft had been developed by Pilatus Flugzeugwerke AG in Stans as a training aircraft for prospective military jet pilots. Two aircraft were built as prototypes and used for trials and for carrying out test flights and certification flights. The type certificate was issued in December 2004 for the Pilatus PC-21. However, the two aircraft with the serial numbers P01 and P02 were still prototypes and did not fully conform to the type certificate.

In addition to flight testing, these two aircraft were also used in displays for potential customers. In this context, participation at events abroad was planned, where the same aerobatics programme which had been presented by the same pilots at the Air 04 air show in Payerne in September 2004 was to be flown.

The departure of the two aircraft abroad was scheduled for Friday 14 January 2005. In preparation for the displays a further joint training exercise was to take place on Thursday 13 January 2005. A maintenance check and cleaning of the aircraft were scheduled beforehand.

This maintenance on both aircraft was carried out in the morning. Since, in addition to the check, various deficiencies had to be rectified, there was a delay. The pilot of aircraft P02 made use of the time for a discussion with his colleagues in connection with the management duties he had to perform in his department.

The customary briefing on the status of the aircraft and configuration by a member of the "Flighttest (EA)" department was not possible until after 15:30. At this time, both pilots were busy briefing the flight. Both had a copy of the planned programme in front of them. Whilst the pilot of P01 was studying the sequence, the pilot of P02 was informed of the work which had been performed on his aircraft.

During the briefing, it was decided that P01 would start as leader and a minimum height above ground of 500 ft was decided. Runway 07L/25R served as the centre line of the display and the road which crossed the aerodrome served as the '*centre*' (the centre of the display space). For the combined aerobatic figure looping and horizontal circle they convened, that P01 would fly along the axis of the runway and P02 remain south of the runway edge.

Once the briefing had ended, the pilots stated that they were satisfied with the status of the aircraft and were waiting to take over the aircraft.

At 16:15, the pilot of P02 again called the member of department EA in order to ascertain the availability of his aircraft, as the pilot of aircraft P01 was already on board. He was informed that the workshop was in the process of making the aircraft available. Around 16:25, the pilot climbed on board the aircraft in the hangar. Shortly after this, the maintenance was completed and P02 was rolled out of the hangar.

1.1.2 History of flight

After the formation had received clearance from the Buochs air traffic controller, both aircraft taxied to the holding point for runway 07L. The two Pilatus PC-21 aircraft took off in formation, in an easterly direction, from runway 07L at Buochs at about 16:33. During take-off, the matt black aircraft P01 was flying in front as "leader" and the silver P02 followed as "wing man". After take-off, both aircraft climbed to approximately 5000 ft QFE (height above aerodrome). They then performed a steep descent and a low pass over runway in a westerly direction, at low altitude and at high speed. There followed a tight 180 degree turn over Stans. The formation then again performed a low pass over runway 07L. After an inclined 360 degree turn to the right, with a maximum height of 2200 ft QFE, the formation split over the centre line of the runway at a height of approximately 430 ft QFE.

The separation took place 6 minutes and 12 seconds after releasing the brakes for take-off and the corresponding command was given by the pilot of aircraft P01 with the words "looping, looping now". When his aircraft passed the top of the loop after 14 seconds, the pilot confirmed that he had established visual contact with the other aircraft with the word "contact".

Three seconds later, when aircraft P02 had flown approximately 210° of its 360 degree turn, its pilot also confirmed that he had the aircraft in the loop in sight with the word "visual".

After a further ten seconds he asked the pilot of aircraft P01 to continue flying his figure with the words "keep going". His position was markedly behind that of aircraft P01.

Two seconds later, the pilot of P02 commented on the beginning of the next planned figure, a tight 180 degree turns, with the words "turn right".

After another eight seconds, the pilot of aircraft P01 asked "where are you?", as he was expecting aircraft P02 to catch up with him but did not have the latter in sight.

One second later, the ground observer of the exercise informed him "we have an accident".

According to eye-witness statements, aircraft P02 went into a shallow dive towards the end of the 360 degree turn. A little later, its right wing clipped the ground. In the high-speed crash, the aircraft was destroyed and a fire broke out. The pilot suffered fatal injuries.

A passer-by was seriously injured.

Aircraft P01 was able to land on Buochs aerodrome undamaged.

1.2 Injuries to persons

	Crew	Passengers	Third parties
Fatally injured	1	---	---
Seriously injured	---	---	1
Slightly injured or uninjured	---	---	

1.3 Damage to aircraft

The aircraft was destroyed.

1.4 Other damage

As a result of the shallow impact of the aircraft on the frozen ground between the two runways there was only slight damage to the terrain in this area. However, there was slight contamination of the soil due to leaking fuel.

The aircraft's impact on the protective embankment of the Engelberger Aa river caused damage to the embankment and the surrounding vegetation. The fuel which leaked out was largely consumed by the fire.

In addition, there was slight contamination of the Engelberger Aa river. This contamination was combated by the competent military services.

1.5 Personnel information

1.5.1 Pilot P02

Person	Swiss citizen, born 1965
Licences	Air Transport Pilot's Licence, issued by the Federal Office for Civil Aviation on 29.11.2004 Commercial Pilot's Licence, helicopter CPL(H)
Ratings	RTI (VFR/IFR); NIT (A); IFR (A); CRI (A); ACR (A)
Registered aircraft classes	SE Piston; Pilatus SET
Registered aircraft types	PC12; PC9/PC7MkII
Medical fitness certificate	Class 1 VDL (must wear spectacles)
Last medical examination	13 August 2004
Other permissions	Special permission A for performing aerobatics below the legal minimum height above ground issued by the Federal Office for Civil Aviation on 02.08.2004

Flown hours	Total aircraft:	8480 hours
	During the last 90 days:	85 hours
	PC-21:	411 hours
	PC-21 during the last 90 days:	48 hours
Number of flights on PC-21	374 during the last 90 days:	45

1.5.1.1 Experience

The pilot concluded his flight training in civil aviation.

Before joining Pilatus Flugzeugwerke AG, he had flown twin-jet business jets and commercial turboprop aircraft.

The FOCA issued him an aerobatics rating in 1991. In 2001, the pilot had attended a course for test pilots of several weeks' duration at the National Test Pilot School (NTPS) in the USA. According to the available documentation, no training in aerobatics or formation flying was provided at this school. All further training in aerobatics took place within the company.

On 16.11.2000, the pilot was authorised after an internal check to perform aerobatics down to a minimum height of 500 ft; the training took place on a PC-9. The first flight training on a PC-21 in formation flying and low flying took place on 26.08.2004. Up to the end of the year, a further 8 training units were flown under the supervision of a works pilot.

During the two weeks before the accident, he had carried out several aerobatic flights.

The aerobatics programme which was flown on the day of the accident had already been practised earlier by the two pilots on Buochs aerodrome.

1.5.1.2 Other duties

In addition to his activity as a works pilot with Pilatus Flugzeugwerke AG, the pilot involved in the accident of aircraft P02 had been designated Chief Test Pilot and Manager Flight Operations in 2002. In addition to his activity as test pilot and works pilot, he was therefore also responsible for the management of this entire unit. This also involved a large amount of organisational work.

In addition to the test flights and certification flights, he carried out many works flights for the production of the Pilatus PC-12 aircraft. Moreover, the forthcoming trips had to be organised and as many as possible of the foreseeable tasks had to be dealt with before his absence.

1.5.2 Pilot P01

Person	Swiss and British citizen, born 1942
Licence	Commercial Pilot's Licence CPL (A), issued by the Federal Office for Civil Aviation on 05.07.2004
Ratings	RTI (VFR/IFR); NIT (A); IFR (A); ACR (A)
Registered aircraft classes	Pilatus SET
Registered aircraft types	PC12; PC9/PC7MkII
Medical fitness certificate	Class 1
Last medical examination	25 October 2004
Other permissions	Special permission A for performing aerobatics below the legal minimum height above ground issued by the Federal Office for Civil Aviation on 02.08.2004
Flown hours	Total aircraft: 9152 hours
	During the last 90 days: 44 hours
	PC-21: 354 hours
	PC-21 during the last 90 days: 37 hours
Number of flights on PC-21	301 during the last 90 days: 35

1.5.2.1 Experience

The pilot was trained in aerobatics and formation flying within the framework of the military regulations and worked as a jet pilot for a foreign air force.

The FOCA issued him with a civil rating for aerobatics in 1982.

During his activity as a works pilot and test pilot for Pilatus, he transferred his specialist knowledge of aerobatics and trained pilots in this discipline.

1.5.3 Passer-by

Swiss citizen, born 1977

A footpath is situated on the embankment on the north side of the Engelberger Aa. A passer-by was walking with his dog on this path towards Stans. When the wreckage impacted the embankment, the fuel ignited. The resulting heat and flame front engulfed the passer-by. He was thrown into the Engelberger Aa by the pressure wave and was seriously injured in the process.

1.6 Aircraft information

The two aircraft had been used as prototypes in the certification process and did not completely correspond to the type certificate which had been issued since then. The aerodynamic configuration of both aircraft was identical.

1.6.1 General

Manufacturer	Pilatus Flugzeugwerke AG
Type	PC-21 prototype
Characteristics	Turboprop aircraft, low-wing, full metal construction with pressurised cabin and ejector seat
Seating positions	Tandem arrangement with raised rear seat; minimum crew: one pilot in the front seat
Year of construction / serial number	2004 / P02
Airworthiness certificate	Provisional airworthiness certificate, issued by the Federal Office for Civil Aviation on 02.06.04/No. 1 valid till 31.05.05. Valid for flights within the framework of the approved flight testing programme. Validity in non-commercial transport. Special category Experimental (prototype).
Certification	VFR day
Operating hours	161:17 hours
Mass and centre of gravity	The applicable masses are specified in the AFM as follows: Basic empty mass: 2340 kg Maximum ramp mass: 3120 kg Maximum take off mass: 3100 kg Maximum landing mass: 3100 kg Maximum zero fuel mass: 2750 kg Maximum mass in bag. compartm.: 25 kg The take-off mass of the aircraft was 2822 kg. The mass and centre of gravity were within the permitted limits.
Maintenance	On 12.01.2005, at 161:17 operating hours, an early 100 hour inspection was carried out. WO No. 819742.
Fuel	462 litres JET A1 fuel on board according to the load sheet. In view of the degree of destruction and because of the fire, no fuel was available for an investigation.
Flight time remaining	Approximately one hour for the flight at low altitude and high power.

1.6.2 Engine

1.6.2.1 General

Manufacturer	Pratt and Whitney Canada
Type	PT6A-68B
Serial number	S/N 1712
Construction	Free turbine turboprop
Year of construction	2003
- Operating time since manufacture	269:37 h
- Flying cycles since manufacture	336 cycles

1.6.2.2 Power management system (PMS)

The PMS regulates the maximum engine power as a function of speed (power scheduling). During the initial take-off roll, reduced engine power only is available (805 kW or 1080 SHP); this is then increased progressively as speed increases (above 200 kt to 1193 kW or 1600 SHP).

As a result, among other things the behaviour of the aircraft on take-off and acceleration is intended to resemble that of a jet aircraft.

1.6.3 Propeller

Manufacturer	Hartzell
Type	HC-E5A-2/E9193B,K
Construction	5-bladed, variable pitch, feathering, constant speed composite propeller

1.6.4 Cockpit equipment

1.6.4.1 General

The PC-21 aircraft has a modern two-man glass cockpit in a tandem arrangement. The equipment consists of IFR equipment with FMS according to civil criteria and a military mission computer with the corresponding displays.

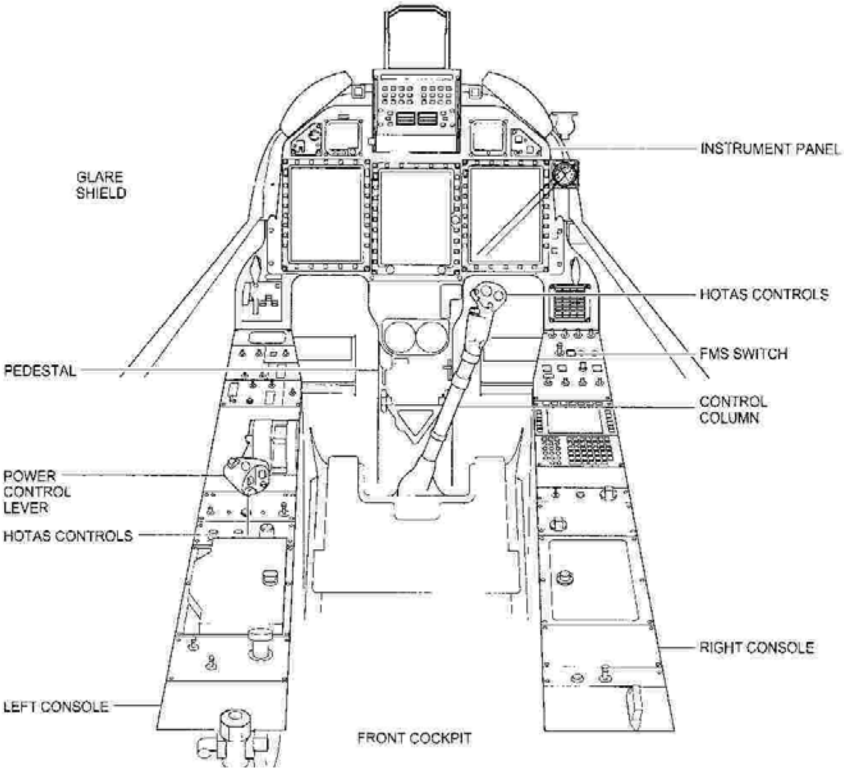
View of the PC-21 P02 tandem cockpit

1.6.4.2 Cockpit layout, front seat

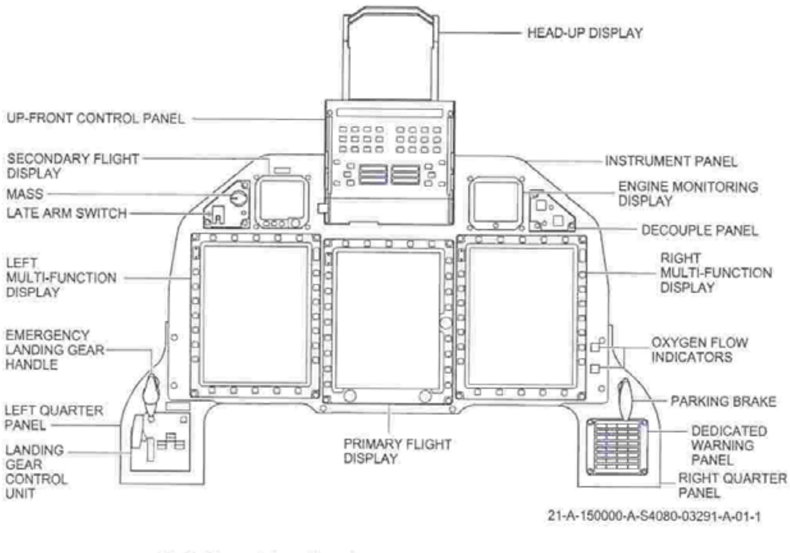
The controls and displays at the front are located in a main instrument panel, a glare shield panel, on the left and on the right a side console and a pedestal. Control is exercised via so-called HOTAS (Hands On Throttle And Stick) controls on the power control lever (PCL) and on the control column.

The main elements of the instrumentation are:

- head-up display (HUD)
- up front control panel (UFCP)
- engine monitor display
- primary flight display (PFD)
- 2 multi function displays (MFD)
- AMLCD standby instruments



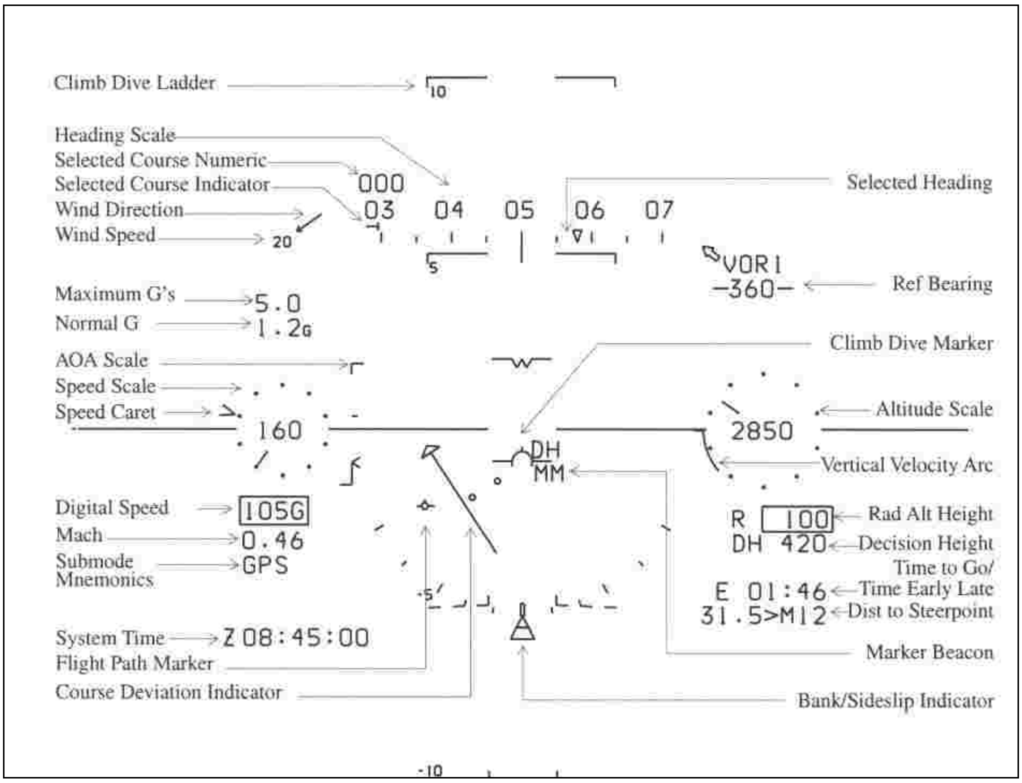
Layout of the front workstation



Layout of the instrument panel

1.6.4.3 Head-up display (HUD)

The cockpit was equipped at the front with a head-up display. The most important flight data were projected in the pilot's primary field of view, so that they were visible to the pilot at all times.



Sample of the head-up display information visible in the field of view

1.6.4.4 Altimeter

The PC-21 is equipped with two different altimeter systems:

- a barometric altimeter system
- a radio altimeter system

1.6.4.4.1 Barometric altimeter system consisting of the following components

- pitot static system
- primary air data computer ADC
- secondary air data unit ADU

The pitot static system (*Prandtl*) supplies the necessary parameters, i.e. static and total pressure, to the primary air data computer (ADC). This supplies the altitude data to the following devices:

- altimeter displays
- PFD
- FMS
- HUD signal generator -HSG

The ADC converts the pressure signals into engineering units and makes the information available on the ARINC Bus.

The secondary air data unit (ADU) is a dumb box, which merely converts the pressure signals into raw digital signals. These signals are only converted into so-called engineering units in the secondary flight display (SFD) for display purposes.

Altimetry errors

Measurement errors occur in all aeronautical barometric altimetry systems. Among other things, these depend on airspeed, altitude and aircraft configuration. This error is particularly great at high airspeeds.

The ADC processor could be fitted with a static source error correction (SSEC) chip, in order to correct the measurement errors found during the licensing flights.

P02, the aircraft involved in the accident, was equipped with an SSEC chip. At approximately 300 kt at aerodrome altitude, the corrected measurement error was 30 ft +/- 15 ft.

Aircraft P01 was not equipped with an SSEC chip.

In the case of aircraft P01 without an SSEC chip, the altimetry error at approximately 300 kt at aerodrome altitude was 120 ft +/- 15 ft, i.e. the displayed value was approximately 120 ft lower than the actual altitude.

1.6.4.4.2 Radio altimeter system consisting of the following components

- radar altimeter transceiver
- transmit antenna
- receive antenna

The radar altimeter transceiver (TXCVR) sends a signal to the ground via the transmit antenna. The signal reflected from the ground is received by the receive antenna and forwarded by it to the TXCVR. The receiver calculates the altitude and transfers the data via the ARINC 429 Bus to the open system mission computer, the HSG and the front and rear PDF.

If the aircraft flies below the set decision height (DH), a signal is transmitted from the front PFD to the audio management unit AMU.

1.6.4.4.3 Utilisation of the displayed barometric altitude in the P01 HUD

From the HUD camera video recording it was possible to establish the barometric altitude displays on the HUD during the entire flight of P01. The altitude data were based on the QFE setting before the flight and indicated the height above Buochs aerodrome.

For all the P01 altitude information entered in the report, the values taken were those which had been displayed on the HUD, i.e. no account was taken of the SSEC.

1.6.5 System description, flight control

1.6.5.1 Primary control

The aircraft was controlled by three independent systems.

- By aileron and spoiler around the longitudinal axis (roll control)
- By elevator around the transverse axis (pitch control)
- by rudder around the vertical axis (yaw control)

Elevators and rudder were linked by cables and rods.

The ailerons were linked by rods. Deflection of the two ailerons was supported hydraulically by a servo-actuator.

To increase the speed of rotation about the longitudinal axis, two hydraulically actuated spoilers, left and right, were mounted on the top of the wing close to the two ailerons. They were lifted, starting at an aileron deflection of 4° up and achieved their full extension at an aileron deflection of 14°.

All the above controls were provided with electric trimming.

The aircraft was equipped with dual controls.

1.6.5.2 Secondary control

The secondary control system consisted of flaps and an airbrake, which were operated hydraulically.

1.6.6 Ejector seat

1.6.6.1 General

Two Martin Baker (MB) Type A Mk CH16C ejector seats were installed in aircraft P02. This type was a lightweight seat for turboprop military training aircraft. Up to the time of the accident flight, four such seats out of a planned first series of 12 seats had been built.

1.6.6.2 Operating limits

The Type A Mk CH16C ejector seat was specified as a so-called 0/0 seat, meaning that successful ejection was guaranteed at a speed of 0 kt and a height of 0 ft above ground.

The minimum height above ground for a safe ejection close to the ground depended on the following parameters:

- speed of the aircraft
- bank angle
- rate of descent
- attitude

The required minimum heights for successful ejection close to the ground were laid down for the individual flight conditions in a total of 21 tables.

More details on these operating limits are provided in section 1.15 with regard to the flight involved in the accident.

1.6.7 Pressurised cabin and equipment for the anti-g suit

The PC-21 was the first model in the range of Pilatus trainers to be equipped with a pressurised cabin. Pressure generation and regulation were handled by a so-called cabin conditioning system, which also supplied the pressurisation of the anti-g system. It was mandatory to wear an anti-g suit on every flight and to connect it to the system.

During the flight involved in the accident, the pilot was equipped with an anti-g suit. The damage to the connecting hose of the anti-g suit indicated that the latter was connected to the system.

There were no indications, and in particular no statements by the pilot, that the anti-g suit was not functioning.

1.6.8 Finish of the aircraft P01 and P02

Aircraft P01 was painted matt black (Akzo Aerodex Finish matt 00744 black).

Aircraft P02, the one involved in the accident, was painted silver-grey (Akzo ECL-G-850 Mica Silver non-metallic System plus ECL-G-2 Clearcoat).

1.6.9 Maintenance of the aircraft

The aircraft were maintained by the Experimental Shop (AX), a specialised unit of Pilatus Flugzeugwerke AG.

Periodic checks carried out on aircraft P02:

Date		Airframe hours (time since new)
12.01.2005	100 + 50 + 25 hour check	161.17 hours
03.12.2004	25 + 50 hour check	143.48 hours
05.10.2004	25 hour check	115.57 hours
13.09.2004	100 + 50 + 25 hour check	92.31 hours
27.08.2004	25 hour check	73.10 hours
07.08.2004	25 + 50 hour check	50.31 hours
09.07.2004	25 hour check	25.33 hours

In addition to the periodic checks, deficiencies were rectified on an ongoing basis and modifications and tests arranged by the Flight Test Department were implemented. Proper documentation was maintained for all this work.

No airworthiness directives were published, so none were applicable.

The investigation revealed that the ejector seats had been removed and refitted to gain access to various components. No specific record was kept of these removals and refittings.

1.7 Meteorological information

1.7.1 General weather situation

A weakened cold front had crossed Switzerland in the course of the day in a north-westerly upper air current. A high-pressure area centred over France was increasingly affecting the weather in Switzerland.

1.7.2 Weather at the time and location of the accident

The following information on the weather at the time and location of the accident is based on a spatial and chronological interpolation of the observations of different weather stations. This interpolation was done by MeteoSchweiz.

Cloud	3-4/8 at 6000 ft AMSL
Visibility	about 10 km
Wind	Variable at 1 – 3 kt
Temperature/dew point	05 °C / 02 °C
Atmospheric pressure	QFE 977 hPa; QNH 1030 hPa
Dangers	None detectable

1.7.3 Weather according to witness statements

A witness described the weather as very good, with visibility in excess of 20 km. Broken cloud cover of about 4/8 was located at 6000 to 7000 ft AMSL in the vicinity of the Buochserhorn. At this time of day, the clouds appeared very bright in comparison with the terrain as a result of the low position of the sun.

1.7.4 Position of the sun and lighting in relation to Buochs aerodrome

1.7.4.1 Astronomical data for 13.1.2005 (local time)

Sunrise	08:09
Sundown	17:02
End of civil twilight	17:36
Moonrise	10:26
Moonset	20:57
Moon phase	0.15 (waxing)

Remarks:

The time for civil twilight differs from that published in the AIP (17:40) because the last one refers to Bern.

Also sunrise and sundown may not be compared with those from the AIP, because different definitions are used.

1.7.4.2 Position of the sun

At the time of the accident, the sun was low on the south-west horizon. The azimuth was 235° and the elevation was 2.6°.

The diameter of the sun was 32.5 arc minutes (approximately 0.5 degrees).

1.7.4.3 Shadow on the terrain

The shadow cast onto the ground was calculated by the Swiss Federal Office for Topography for a 2.6 degree elevation of the sun. It must be borne in mind that at such a low angle of incidence any inaccuracies in the elevation model (DHM25) are magnified accordingly.

The model shows large parts of the landscape in shadow, including the entire southern part of the aerodrome with the runway. Bürgenstock and the south-west side of the Rigi were still in sunlight. Please refer to appendix 3.

1.7.4.4 Clouds

At 2.6 degrees elevation of the sun, even light clouds have a major effect. Video recordings made by the camera of the accompanying aircraft show the clouds and the aerodrome completely in shadow.

1.8 Aids to navigation

Not involved.

1.9 Communication

The formation was in radio contact with the Buochs air traffic controller (Buochs TWR). This radio communication took place on the aerodrome frequency of 119.625 MHz and was handled by the pilot of aircraft P01.

The pilot of P01 requested taxi clearance after the engines had been started and received it During his taxi, hw informed the air traffic controller about the planned programm. After line-up on runway 07L, the air traffic controller issued the take-off clearance.

When the formation was ready to begin their training, they reported overhead Gersau at 5000 ft. The air traffic controller authorized it as follows:

"…aerobatics aooroved, wind calm"

There was no further radio contact between the air traffic controller and the formation.

Communication between the two aircraft P01 and P02 took place on the company frequency. The ground observer also communicated with the pilots on this frequency.

Find bellow the transcription of the radio communications from the beginning of the loop up to the time of the accident.

Time in minutes and seconds since:					
Switching on the main switch	Releasing brakes during take-off	order "looping, looping now"	Text	by	Position of the aircraft
21:09	06:12	0:00	*looping, looping now*	P01 pilot	
21:14	06:17	0:05	*nice*	Observer	
21:23	06:26	0:14	*contact*	P01 pilot	Top of the loop
21:26	06:29	0:17	*visual*	P02 pilot	after approximately 210° of the 360° turn
21:36	06:39	0:27	*keep going*	P02 pilot	
21:38	06:41	0:29	*turn right*	P02 pilot	
21:46	06:49	0:37	*where are you*	P01 pilot	
21:47	06:50	0:38	*we have an accident*	Observer	

1.10 Aerodrome information

Buochs aerodrome, ICAO code LSZC, was an aerodrome for combined military and civil use. The airport reference point (ARP) was N 46°58 28′ and E 008°23 49 (WGS 84) or 672 910/202 990 (Swiss Grid) 2 km to the west of Buochs. The reference elevation was 1473 ft or 449 m AMSL.

The hard runway 07L/25R was 2000 m long and 40 m wide. Its magnetic orientation was 064° or 244° respectively, with a variation of 0°39'E.

The so-called "emergency runway"07R/25L run parallel 300 m to the south; it was 1500 m long and 40 m wide. This was also a hard runway.

The aerodrome could be used as well during its hours of operation, when it had an aerodrome traffic control unit as outside these times. Prior permission is required at all times (PPR: prior permission required).

The aerodrome was used by the Pilatus Flugzeugwerke AG company as a company aerodrome. The aerodrome could be reached from the factory area via a taxiway. This crossed a public road. The taxiway/road crossing was provided with a radio-operated signalling system.

During military flying operations, a Class D control zone was active from the ground up to flight level 130.

1.11 Flight recorders

1.11.1 General

1.11.1.1 Installation regulations for flight data recorders in Switzerland

The installation of a flight data recorder was not prescribed for this aircraft.

1.11.1.2 Flight recorders in the PC-21

A mission data recorder system and a flight test instrumentation system were normally installed in the two aircraft, P01 and P02.

However, all the flight test instrumentation equipment had been removed from both aircraft for the display abroad.

1.11.1.3 Brief description of the mission data recorder

The mission data recorder is based on a computer with a Windows XP operating system and has the following functions:

- Recording data from the open systems mission computer, plus 2 video channels and 2 audio channels on the removable memory module, a solid-state NTSF formatted disk.
- During flight preparation, data for the flight can be saved to the removable memory module (brick) on the ground via a PC; in flight, these data are then accessed by the open system mission computer. Conversely, flight data is recorded using the open system mission computer and analysed subsequently on the ground.
- The data processed by the open system mission computer are transferred via an Ethernet link to the mission data recorder. Video and audio signals are fed via separate inputs.

- The Windows XP operating system and application software were stored in the permanent memory module on the PCMCIA flash storage card.

1.11.1.4 Brief description of the flight test instrumentation

A flight test instrumentation system was installed in the luggage space behind the cockpit as additional equipment for carrying out the certification flights. This consisted of data capture, telemetry, recording and sensors.

256 different signals could be conditioned and recorded. The majority of the signals originated from strain gauges which were fitted to many relevant points in the aircraft. In addition, system data were also recorded.

The data were transferred via the built-in radiotelemetry system to the ground station and simultaneously to a solid-state data recorder with a capacity of 3.26 gigabytes. Consequently, the data was backed up in the aircraft in the event of an interruption in the telemetry.

The telemetry system operated in the VHF range. The 4 antennae on the aircraft, arranged uniformly on the circumference of the fuselage, were fed from a 15 watt FM transmitter.

1.11.1.5 Mission data recorder in P02, the aircraft involved in the accident

The mission data recorder was installed in the aircraft. Since no removable memory module was installed, no recordings could be made. Hence no flight parameters were available to the investigation for analysis.

In view of the minor damage to the mission data recorder and other electronic devices in the cockpit area, it can be assumed that any recorded flight parameters would have been readable.

1.11.1.6 Mission data recorder in P01, the sister aircraft

The mission data recorder was installed in the aircraft. A removable memory module was fitted and in operation. According to information from Pilatuswerke AG the data feed via Ethernet was not working. Consequently no flight parameters were recorded in the removable memory module. However, the removable memory module had recorded the video signal from the on-board camera and the audio signal from the audio management unit, as these two signals had a separate input. It was possible to analyse the video and audio recordings.

1.11.2 Analysis of the P01 video recordings

1.11.2.1 Introduction

Aircraft P01 and P02 were equipped with a permanently installed camera positioned in front of the HUD. The camera recorded a forward view of the area in front of the aircraft. The symbols of the HUD were electronically superimposed onto the video signal. The mission data recorder was able to record this signal.

No removable memory module was installed in P02, the aircraft involved in the accident, so no recording was available. However, it was possible to analyse the video data from the sister aircraft P01 which enabled reconstruction of the loop by P01 prior to the accident.

For the analysis, the data were divided into two sub-areas:

- Data which was based only on the HUD displays and which were therefore independent of the video signal provided by the camera.
- Data which additionally included the area visible on video, the analysis of which was therefore dependent on the characteristics of the camera and its installation. Here greater deviations than normal had to be taken into account as a result of the tolerances of the camera alignment and the superimposition of the HUD symbols.

In order to evaluate the accuracy of the video data used, these were first compared with an earlier flight by P02, during which the flight data has been recorded. The comparison showed that this method provides sufficiently accurate results. It should be noted that the video recordings provided 30 datasets per second, whereas the mission data recorder provided only one dataset per second.

1.11.2.2 Camera installation

Since the aircraft was equipped with an HUD for the pilot in the front cockpit seat only, a representation on a video monitor was provided for the pilot in the rear cockpit seat. This showed a video image of the forward view, with the HUD information superimposed on it.

The digital video camera was fitted with a lens with a focal length of 16 mm. The camera was fitted in front of and slightly below the HUD with a longitudinal inclination of minus 3° in relation to the longitudinal axis of the aircraft.

Since various uncertainties existed with regard to the recorded field of view, this was determined during the investigation through a test. The horizontal field of view was 21.8° and the vertical field of view was 15.5°.

1.11.2.3 Camera adjustment

For the HUD and video displays to be aligned with the longitudinal axis of the aircraft, they had to be adjusted. This took place in two stages:

1. The HUD symbols were adjusted according to the longitudinal axis of the aircraft.
2. The camera image was centred on the longitudinal axis of the aircraft and the HUD display.

Some time after the accident, the HUD symbol generator, in which the adjustments were also stored, had to be swapped out on aircraft P01. After that the HUD symbols and video were re-set.

By means of the above-mentioned test and the available video data, the adjustment at the time of the accident could be reconstructed with reasonable accuracy. The optical axis was inclined approximately 3° downward in relation to the longitudinal axis of the aircraft (which corresponded to the mechanical installation) and offset approximately 1.8° to the right. These values were in accordance with the observations of the video from take-off and approach.

1.11.2.4 Results of the HUD data analysis

General: Only the HUD symbols on the video were used for the HUD data analysis, i.e. without reference to the terrain. This meant that the data were correct within the accuracy of the system and the read-out.

Pitch: in the first quarter of the loop the pitch rate was constant. Thereafter, it exhibited certain variations and a reduction towards the end of the loop.

Bank angle: the roll angle in the loop was around zero up to the last quarter, when the bank angle was 10°-28° to the right.

Heading: the heading increased in the first quarter of the loop from approximately 64° (runway direction) to approximately 70°. In the last quarter of the loop, the heading changed continuously from 56° to 86° and was therefore never stable.

In inverted flight, the heading could not be clearly determined, because only the gradations were recorded on the video, not the values. For the first quarter of the loop, the runway markers served as a reference, and for the last quarter the passing zero marker on the HUD symbols was used.

Barometric altitude (BAROALT): the altimeter was set to QFE and therefore showed the height above the aerodrome. The loop was started at 390 ft QFE and ended at 180 ft QFE; the height loss was therefore about 210 ft.

The top of the loop was at about 3680 ft QFE.

Radio altitude (RADALT): the radio altitude at the start of the loop was about 100 ft higher than the barometric altitude. At the end of the loop it was about 150 ft (this can be explained at least in part by the longitudinal inclination of the runway).

This discrepancy can hardly have been caused by the inertia of the BAROALT, because in this case the barometric altitude would be greater than the radio altitude.

A comparison with earlier data from P02 showed the same effect.

An analysis of data from different flights showed, that the discrepancy was attributable to the different aircraft configuration (gear and flaps retracted).

Normal acceleration:

Normal acceleration (N_z) could not be clearly determined for somewhat less than the first half of the loop. In the second half, the load twice briefly increased from 4 g to 5 g. Minimum acceleration at the top of the loop was +0.4 g.

1.11.2.5 Snapshots

With reference to the flight a data set for five specific moments had been recorded as follows:

At the moment of the radio communication: *"looping, looping now"*, the following data was extracted from the HUD of P01:

- Video time: 00:21:09
- Altitude: 430 ft Baro Alt
- Height: 741 ft Rad Alt
- IAS: 309 kt
- Heading: 062°

- N_z: 3.3 g
- Pitch: -5.8°
- Angle of Bank (AOB): 50° right

About one second later, when pitch and roll were zero, the data showed the following values:

- Video time: 00:21:10
- Altitude: 390 ft Baro Alt
- Height: 487 ft Rad Alt
- IAS: 308 kt
- Heading: 065°
- N_z: 3.6 g
- Pitch: 0°
- AOB: 0°

At the moment, when the aircraft P01 passed the planed minimum altitude of 500 ft and the communication "keep going" was heard, the following data was extracted from the HUD:

- Video time: 00:21:36
- Altitude: 500 ft Baro Alt
- Height: 689 ft Rad Alt
- IAS: 300 kt
- Heading: 070°
- N_z: 3.0 g
- Pitch: -20°
- AOB: 20° right

At the moment of the radio communication: "*turn right*", the following data was extracted from the HUD of P01:

- Video time: 00:21:38
- Altitude: 270 ft Baro Alt
- Height: 430 ft Rad Alt
- IAS: 307 kt
- Heading: 077°
- N_z: 3.1 g
- Pitch: -10°
- AOB: 25° right

When the aircraft P01 reached his lowest height, the following data was extracted from the HUD:

- Video time: 00:21:39
- Altitude: 180 ft Baro Alt
- Height: 331 ft Rad Alt
- IAS: 308 kt
- N_z: 3.1 g
- Pitch: 0°
- AOB: 23° right

1.11.2.6 Flight path and development of a 3D- model

The flight path of P01 was reconstructed from various reference points visible in the video. As a base were used:

- Calculations from the video recordings of aircraft P01
- Orthophotos from the airfield and his environment
- Digital height model (DHM 25)
- 2D- plan of the airfield
- Data from the survey of the accident site

The flight path of P02 was reconstructed mathematically und verified based on data from earlier flights as well as statements from pilots and witnesses. The timing was adapted to the loop flown by P01. As starting point, the position as wingman in the formation was used and as end point the point of impact.

Both flight path were drawn tri dimensionally and fitted in the terrain model. The reconstructed flight path of P01 was the correlated with the video image best possible (see appendix 5).

The loop was started with some degree of certainty at the middle of the runway and slightly to the right of the runway centre line.

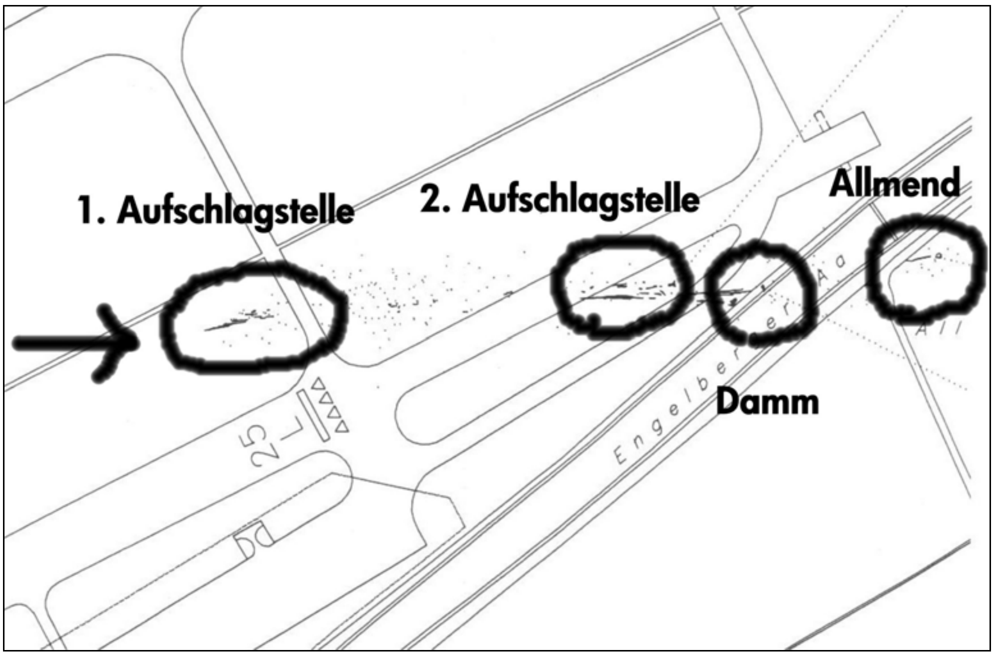
Approximately six seconds before the end of the loop the aircraft travelled over the runway centre line to the right. The distance in relation to the runway centre line increased to approximately 140 metres at the end of the loop.

The loop was completed approximately 600 m to 1000 m after the middle of the runway.

1.12 Wreckage and impact information

1.12.1 The site of the accident

Most of the site of the accident was located on Buochs aerodrome and extended from the area north of the threshold of runway 25L over the Engelberger Aa river as far as "*Buochser Allmend*". See also appendix 1. The area of damage was approximately 520 m long and 110 m wide.



1st point of impact 2nd point of impact Embankment "Allmend"

1.12.2 The impact

Immediately prior to the impact, the aircraft was flying at a bank angle to the right of approximately 30°-40° in a shallow dive. The aircraft touched the frozen, flat terrain of the aerodrome with the tip of its right wing. See the detailed simulation in appendix 4.

After rolling level, the aircraft slid across a taxiway and was catapulted into the air again. The cockpit canopy began to rupture during this phase. The distance to the second point of impact was approximately 160 m. During this flight phase, parts of the wing and fuselage separated. The tail was torn off during the second impact on the terrain of the aerodrome, between runway 25L and the Engelberger Aa embankment. The remainder of the aircraft slid along the ground and after about 75 m it hit the slope of the embankment side-on, with the front of the fuselage section pointing south. During this impact, the aircraft broke up into several sections which were scattered in different directions. In the process an intense fire broke out.

The wing separated from the fuselage and came to rest on the embankment. The pilot and the forward ejector seat, was found on the south-east bank of the Engelberger Aa river. The engine was thrown into the Engelberger Aa. The fuselage with the cockpit and the rear cockpit ejector seat were thrown approximately 150 m beyond the river onto "*Buochser Allmend*".

The distance from the initial contact point on the ground to the final position of the fuselage was 440 m.

Coordinates (Swiss Grid):

First point of impact	673 570 / 203 150
Second point of impact	673 740 / 203 160
Embankment point of impact	673 870 / 203 150
Common point of impact	674 010 / 203 170

Sheet No. 1171 Beckenried, National map of Switzerland 1:25 000

1.12.3 First findings relating to the parts of the wreckage

See also appendix 1 and 2.

1.12.3.1 First point of impact

The parts first detached from the wreckage were the tip of the right wing and the right aileron.

The badly shattered and detached propeller blades were lying in the environs of the point of impact.

Part of the engine oil cooler lay at the point at which the fuselage first impacted.

1.12.3.2 Area between the first and second point of impact

This area was covered with parts of the wreckage of the aircraft, which had broken up in the air. The most notable parts were:

- parts of the right aileron
- parts of the airbrake
- parts of the flap system

- parts of the leading edges of the left and right wings
- Plexiglas parts of the cockpit canopy
- pilot's helmet and the two separated visors

1.12.3.3 Second point of impact

The rear section of the fuselage which had separated from the aircraft lay at the end of the second point of impact. The rudder and the two elevators together with the corresponding trim tabs were secured to the rear section of the fuselage, with minimal traces of impact. From the parts found it was not possible to draw any conclusions concerning the rudder/elevator settings and trim before the impact.

1.12.3.4 Embankment point of impact

The very distinct point of impact on the western slope of the embankment of the Engelberger Aa river, the traces of fire found here and the main parts of the wreckage lying further to the east, such as the engine, wing and fuselage, allow the conclusion that final destruction of the aircraft with separation of the fuselage, engine and wing took place at this point. The degree of destruction of the main parts of the wreckage permits the conclusion that the aircraft impacted the slope of the embankment side-on, with the front part of the fuselage pointing to the south.

During this impact the two ejector seats were also thrown out of the cockpit.

The central section of the wing with the main gear, severely damaged, lay on the embankment of the Engelberger Aa river.

1.12.3.5 The Engelberger Aa

The front ejection seat lay on the south bank of the Engelberger Aa river and was badly damaged. The release handle had been torn out of its bracket. The pilot had been separated from the ejector seat belts and lay not far from the ejector seat. Part of the parachute had been pulled out of its pack.

The engine was also on the south bank in the Engelberger Aa.

1.12.3.6 The common

The fuselage and the rear ejector seat lay 175 m to the east of the embankment point of impact.

1.12.4 Identification and survey

The debris field was surveyed in detail. The parts of the wreckage were identified and logged accordingly. In addition to the photographic record, a new system was applied to survey the site of the accident. Further information on this can be found in section 1.19.

1.12.5 Examination of the parts of the wreckage

The wreck was examined after it had been recovered. In particular, the flight controls and the engine were subjected to comprehensive examination. Among other things, the following points were established:

1.12.5.1 Flight controls

It was possible to identify the wing and rudder surfaces, the control elements and the components of the landing flap system. A visual inspection of the control columns, rudder pedals, guide pulleys, control cables, turnbuckles and the components of the flap system produced no indication of any malfunction of the controls and flaps.

During the visual inspection of the wreck, no fractures which indicated pre-existing damage such as fatigue, corrosion or thermal effects could be found.

The parts examined in the laboratory were manufactured from materials which were typical and appropriate for aircraft applications. The microfractographic and macroscopic fracture analyses produced no indications that these parts were defective before the crash. They were all fractures which had been caused by the crash. In particular, no technical material defects could be found and there were no signs of primary damage due to fatigue, corrosion or thermal effects.

A comprehensive investigation was carried out to determine the satisfactory operation of the flight controls and the position of the controls and flaps prior to the crash.

The results of the investigation indicate that the flight controls were functioning without limitations at the time of the crash.

- It was not possible to clearly establish the position of the rudder or elevators.
- It was not possible to clearly establish the position of the ailerons. The parts of the right aileron found in the wreckage at the first point of impact, however, permit the conclusion that the right aileron was deflected downwards, indicating a rotary movement around the aircraft's longitudinal axis to the left.
- The examination of the spoiler system showed that with a high degree of probability the spoiler was extended about one third to the left. This indicates that at the time of impact the aircraft was in a rotary movement to the left.
- The rudder trim tab was extended approximately 1.5° to the right.
- The elevator trim tab was extended upwards by approximately 6°, corresponding to a nose down trim. This setting corresponds to the expected position for horizontal flight at speeds in excess of 300 kt.
- The aileron trim tab was in the area of the neutral position.

Examination of the spoiler system produced the following results:

The piston rod of the left spoiler actuator was partially extended; this corresponded to a spoiler setting of approximately 14° extended (the max. deflection of the spoiler is 40°). This position of the piston rod was confirmed by an x-ray examination. In the course of the forensic investigation, a small notch was found on the inside of the housing section of the control valve. This notch was very probably caused by the control fork of the control valve on initial impact. The position of this notch corresponded to the "left spoiler fully extended" setting. This valve control position was reached at an aileron deflection to the left at an aileron setting of about 14° degrees up (full deflection 17.5°). The piston rod of the right spoiler was found in the "retracted" position.

The examination of the ailerons produced the following results:

Parts of the right aileron were found, extensively destroyed, near the first point of impact. The left aileron was found as a complete component with severe damage behind the embankment point of impact.

The examination of the flap system produced the following result:

The flaps actuator was in flaps up position.

1.12.5.2 Examination of engine PT6A-68 S/N 1712

The engine was examined in detail. The following is a summary of the corresponding investigation report:

The engine exhibited severe impact damage.

The following assemblies were examined more closely because of the axial contact of the rotating parts with the adjacent components:

- 1^{st} stage power turbine vane ring
- 1^{st} stage power turbine
- 2^{nd} stage power turbine vane ring
- 2^{nd} stage power turbine

Radial traces of grinding caused by the deformation of the housing on impact were also found on these parts.

The reduction gearbox propeller shaft coupling had a torque fracture which had occurred as a result of the high load on impact.

No indications were found of pre-existing defects which might have affected normal operation of the engine.

1.13 Medical and pathological information

1.13.1 History and medical findings

According to information from the family doctor as well as from the FOCA medical examiner, the pilot was healthy and in particular free from any cardiac complaints; this was confirmed respectively by the regular examinations and the normal ECG findings. There are no indications in the available medical documents of any medication being taken.

The pilot was known since years to have a refraction defect. He was therefore required to wear lenses or spectacles (VDL). This refraction defect was treated twice by laser therapy on the left eye .With these values, the pilot would not have been fit to fly before the intervention. Fitness to fly could also not been achieved after the intervention. No documents are present concerning a medical examination by an eye specialist as part of the periodic examinations with regard to fitness to fly up to 2004.

The VDL note – must wear spectacles or contact lenses – was present in the medical fitness certificate dated 13.08.2004. The medical examiner made this entry based on the report of the eye surgeon, who had carried out the interventions. At the time of this examination, the pilot did not indicate his eye operation on the corresponding form. According to information from the operating eye specialist, the pilot was no longer advised to wear a vision aid for the left eye after the examination on 17.12.2004. A corrective lens for the right eye was still necessary and was worn regularly.

A copy of the eye specialist's examination report on the FOCA form "*Augenärztlicher Untersuchungsbericht*" completed by the operating eye specialist on 26.03.2004, was found in the medical examiner's records. The operation was not mentioned in this form, nor is the note regarding the need to wear an aid to vision in the right eye present. The eye specialist was neither a FOCA technical expert nor a medical examiner (AME).

1.13.2 Forensic findings

The pilot's corpse underwent a forensic examination.

The pilot died immediately after the accident as a result of the destruction of multiple organs. Survival was impossible, given the numerous injuries and destruction of organs.

The condition of the vital inner organs, despite serious damage, was sufficiently good to allow reliable examination and analysis.

A myocardial bridge 2.5 cm long and 0.7 cm thick was found in the heart above the left coronary artery, just after the outlet from the aorta. On the vessel itself, on the segment under the bridging, there was a considerable intimal plaque formation, though this did not constrict the lumen.

In the supply area of the left coronary artery, no signs of any acute or chronic circulatory disorder were found during examination under the microscope.

Sight defects cannot be determined post mortem, even under detailed examination. The right contact lens, which was probably being worn, could not be found.

All toxicological investigations for alcohol, drugs and medications were negative, i.e. no traces were found.

1.14 Fire

An intense fire broke out on impact with the embankment. Most of the fuel was combusted during this fire. There were no indications of a fire occurring before impact.

1.15 Survival aspects

The impact was not survivable due to the high forces and the resulting injuries.

It was investigated whether rescue should have been possible and survivable by using the ejector seat immediately before the impact.

The Martin Baker A Mk CH16C ejection seat is specified as a so-called 0/0 seat. This means that successful ejection is guaranteed at a speed of 0 kt and a height of 0 ft above ground. For flight conditions which deviate from horizontal flight and 0° bank attitudes, the required minimum height for successful ejection can be determined from corresponding tables which are published in the AFM.

For the aircraft involved in the accident, the following attitude values applied for calculation of the required minimum height using the tables:

- Bank angle 30° - 40° right
- Pitch 0° to -3°
- Speed approx. 300 kt

According to table 21-A-150095-A-S4080-03481-A-01-1 of the AFM PC-21 Draft, the required minimum height for successful ejection was between 0 and 20 feet above ground.

Successful ejection would thus have been just possible immediately before impact. The decision to use the ejector seat to eject would have been required 0.5 to 0.7 seconds before this.

1.16 Tests and research

1.16.1 Analysis of the examinations of non-volatile memories

In the course of collecting evidence, the various items of equipment installed in the cockpit were examined to determine whether installed non-volatile memory (NOVRAM) might have contained information on the last known position, speed and attitude, etc. Although many devices did possess such memories, generally only information on the condition of the unit (health information) is stored.

It was possible to subject the two devices below to analysis, in the course of which certain data which were sought proved to be serviceable:

- the open system mission computer
- the primary flight display (PFD)

1.16.1.1 Analysis of the open system mission computer

The open system mission computer was examined with regard to the content of the NOVRAM. This was intact and could be analysed. In addition to information on the state of the unit, the following information in particular was of significance:

Last recorded position	N46:58,52; E008:24,34	
Last recorded heading	098,5°	
Selected transponder code	3584	
Selected frequencies	COM 1:	1XX.X25 MHz
	COM 2:	119.625 MHz
	NAV 1:	110.350 MHz
	NAV 2:	110.350 MHz
G-forces	Accident flight:	10.900 g
	Previous flight:	3.390 g

It should be noted that the exact time of the last data recording could not be established with certainty, since recording ceased at some point during the destruction of the aircraft.

1.16.1.2 Analysis of the primary flight display (PFD)

The two PFDs from the front and rear cockpit were examined with regard to the NOVRAM content. This was intact in both units and could be analysed.

The recorded data of the NOVRAM correspond to a snapshot of the status 50 seconds after a cold start. Afterwards, only infringements of the pre-set limits for acceleration N_z and speed were registered.

In addition to information on the state of the unit, the following information was retrieved, which show the condition 50 seconds after switching the master switch on. It probably represents the settings used during the preceding flight with two crewmebers on board.

Set configuration	MAP mode; range at 40 NM
Set navigation source	VOR 1
Altimeter setting	1030 mbar
Set decision height (DH)	300 ft

Analysis of the two PFDs produced identical values.

The preset limits of +8g and -4g as well as 329 kt have not been exxeded during the accident flight.

1.16.2 Verification flights

Verification flights were necessary in order to be able to clarify issues regarding flight mechanics, visibility and workload.

For this purpose, a flight test schedule was drawn up. These two flights were carried out over Buochs on 2 November 2005.

The available resources were a PC-21 (P01) and a black PC-9. The light conditions were comparable with those at the time of the accident.

1.16.2.1 Schedule

First flight:

- Horizontal turns up to an accelerated stall at altitudes of 7000, 6000 and 5000 ft AMSL
- Turns with constant acceleration of approximately 3.5 g at altitudes of 4600, 4000, 3000 and 2000 ft AMSL
- Measurement of the roll rate (45° AOB and 60° AOB)
- Loop with an initial altitude of 5000, 4000 and 3000 ft AMSL

Second flight:

- Assessment of the visibility of a black PC-9, by analogy with the black PC-21
- Assessment of the manoeuvre flown at the time of the accident.
- Several repetitions with a gradual reduction of the minimum height to 500 ft

1.16.2.2 Results of the verification flights

Accelerated stall:

In the speed ranges included in the assessment, the manoeuvres flown at altitudes of 5000-7000 ft AMSL exhibited stable flow conditions with no indications of an accelerated stall. For an initial speed of 310 kt at maximum engine power, speed diminished under constant acceleration between 3.5 and 4.5g, so the stall occurred between 206 kt and 200 kt. The stall behaviour exhibited characteristics typical of the PC-21, with an abrupt stall without prior aerodynamic warning and with a rapid roll to the left. The greatest variations in speed that it was possible to fly in the 360-degree turn, with variations in the geometry and speed, fluctuated between 310 and 250 kt. It was not possible to come close to the range which would be critical for stalling. On the basis of this analysis, an accelerated stall (high-speed stall) can be excluded, with a very high degree of probability, as a possible cause of the accident.

Visibility:

In what follows, the visibility of an aircraft which is painted black is assessed under the same environmental conditions from the viewpoint of the aircraft involved in the accident.

In the first half of the 360-degree turn, the black aircraft was not visible when looping the loop, as the first part of the loop was flown in the rear segment of the aircraft executing the 360-degree turn.

In the segment of the 360-degree turn between 180° and 270° the pilot had to establish visual contact with the aircraft in the loop; otherwise the remaining time was not sufficient to estimate correctly the remaining part of the 360-degree turn with regard to the runway centre line and the converging vectors, and to plan the flight path appropriately.

The manoeuvre was flown several times. In the process it was apparent that the black aircraft in the descending segment of the loop never entered the dark background of the Bürgenstock for the pilot on the horizontal 360-degree turn up to the end of the manoeuvre but remained highly visible in the bright sky above the Bürgenstock. Even though the black aircraft was positioned during the last 20 degrees of the loop against the background of the Bürgenstock, the visibility of the black aircraft was not problematical in this phase either, because of the relatively small separation (100 – 400 m).

Summary results:

- In the repetitions of the manoeuvres, no abnormal or restricting behaviour of the PC-21 aircraft type could be detected.
- The visibility of the black aircraft in the second part of the loop was very good.
- Despite the onset of dusk, the light conditions were non-critical.

1.16.3 Investigations of the ejector seat

1.16.3.1 Technical description

A Martin Baker Type Mk CH16C-1 lightweight ejector seat was fitted in the front cockpit of the PC-21 HB-HZB.

Ejection would have been triggered by pulling on the release handle at the front of the seat, between the pilot's legs. This would have resulted in ignition of several launching cartridges and a rocket motor. The sequences of these ignitions and the ignition of the pilot/seat separation cartridge would have been controlled by gas pressure.

In order to guarantee safe ejection of both pilots in the case of a two-man crew, on initialisation of one of the two seats, ejection of the front seat would be delayed. This control system also operated via gas pressure. In the case of a one-man crew, only the front seat would eject, without a delay.

Prior to launch of the ejector seat, the canopy would have been blasted away by means of detonating cord. Since these detonating cords had not yet been fitted to the two prototypes, a canopy of lesser strength was used, through which direct penetration would have been possible without detonation.

1.16.3.2 Situation at the accident site

Front ejector seat:

The front ejector seat was found badly damaged on the east bank of the Engelberger Aa. The parts of the wreckage were 70 metres away from the point of impact on the embankment. The release handle had been torn from its fixing. The stabilising parachute of the ejector seat was deployed. The lines of the pilot rescue parachute were deployed and connected to the pilot harness. The ends of the lines were badly scorched. The chute canopy was missing. The parachute container was in the Engelberger Aa and exhibited major fire damage.

The pilot was found approximately 5 metres from the ejector seat on the east bank of the Engelberger Aa.

Rear ejector seat:

The rear ejector seat was found slightly damaged on "*Buochser Allmend*", approximately 120 metres east of the embankment point of impact, without any visible signs of ignition.

1.16.3.3 Technical investigation of the front ejector seat

1.16.3.3.1 Release handle

The release handle had been torn from its fixing. The mechanism fixed to the release handle had ignited the two cartridges for initialisation of ejection.

The forensic examinations of the release handle produced no indications that the release handle had been pulled by the pilot.

Tests at the manufacturer's premises had shown that in the event of a major vertical impact with 25 g or over, the release handle can separate independently from the interlock and the initialisation cartridges are ignited as a result.

1.16.3.3.2 Ignited cartridges

Of the 17 cartridges installed in the seat, 10 have been fired. The rocket motor was found in the riverbed of the Engelberger Aa and had not ignited.

1.16.3.3.3 Mode selector

The mode selector in the rear cockpit was set to the "solo" position, which means that only the front seat will eject when his release handle is pulled.

1.16.3.3.4 Shoulder belt retraction mechanism

The shoulder belt retraction cartridge mechanism had fired. The lines to retract the shoulder belt were coiled inside the mechanism apart from the last 10 cm. The heavy contamination of the belts and take-up rollers inside the mechanism, caused by grass and soil, indicate that the shoulder belt retraction mechanism cartridge had fired only at the second point of impact.

1.16.3.3.5 Pilot/seat separation

The investigation showed that the cartridges of the pilot/seat separation system were fired on impact with the embankment.

1.16.3.4 Conclusions

Although the front ejector seat release handle was pulled out of its fixing, the pilot was no longer belted to the seat and the cartridge of the shoulder belt retraction mechanism had fired, it can be assumed with a high degree of probability that the ejector seat was not triggered by the pilot.

1.16.4 Investigations on the helmet and visor

During the accident flight, the pilot was wearing an ALPHA 703 type helmet, a product of Helmet Integrated Systems Ltd. It was equipped with two visors, one clear and one dark, as glare protection. In addition, the oxygen mask was fixed to the helmet. The helmet was found in the area between the first and second point of impact. The two visors were found in the vicinity.

The helmet was examined with regard to the position of the two visors at the time of the accident:

According to AFM 02 operating limitations, after arming the ejector seat one of the two helmet visors must be lowered and locked in this position. On the basis of indentations and deformations on the helmet and visors, and from the position of the visor mechanism, it was possible to establish that at the time of impact the position of the transparent visor was approximately 8 cm further down than the dark visor.

The dark visor (glare protection) was in the area of the upper locking position at this time. From this it can be concluded that the transparent visor had been used.

1.17 Organisational and management information

1.17.1 Pilatus Flugzeugwerke – flight operations

Pilatus flight operations were part of the "Research and Development (E)" unit. They were handled by two departments reporting to this unit: the "Flight Test (EA)" department and the "Flight Operations (EF)" department. The "Experimental Shop (AX)" department was responsible for preparing the aircraft.

1.17.1.1 The Flight Test department

The "Flight Test" department was responsible for all test flight activities within Pilatus Flugzeugwerke AG. It drew up the necessary test flight programmes and supervised the flights and the recording of all data. After the flights, it was responsible for preparing and forwarding the captured data.

Before test flights were made, a so-called "Flight Safety Form" (FSF) was produced. This document contained all information on any modifications made and on the operating limits to be complied with. It had to be signed by all departments concerned before the flight was made. This procedure was part of the "design organisation approval (DOA)".

A detailed order, the "flight test order (FTO)", was drawn up for a test flight which was to be carried out. Actual implementation then took place after a detailed briefing by the pilots of the "Flight Operations" department.

1.17.1.2 The Flight Operations department

The "Flight Operations" department carried out all types of works flights within Pilatus Flugzeugwerke. These included verification flights with newly-built aircraft, display flights on behalf of the Marketing department, training flights for works pilots, ferry flights for delivery and test flights on behalf of the "Flight Test" department.

Certain flights served to test newly developed systems and to furnish data for licensing purposes. The performance of these test flights was completely under the control of the "Flight Test" department, whilst the other flights came under the responsibility of the "Flight Operations" department, even if aircraft might not yet have gained type approval.

No entry in the licence was possible for flights by prototypes, as the corresponding type approval did not yet exist. The regulations governing such flights were laid down in the DOA and had been approved by the FOCA.

1.17.2 Pilatus Flugzeugwerke – maintenance of the PC-21 prototypes

Pilatus had its own dedicated workshop, the so-called Experimental Shop (AX). This shop was attached to the production operation and approved by the FOCA within the framework of the production organization exposition under JAR-21. After construction, AX also took over maintenance of these aircraft.

The maintenance regulations for the test flight operation were defined by Pilatus in a technical memo, countersigned by the FOCA as part of the first flight approval and were valid for the two aircraft P01 and P02. The regulations were based predominantly on values acquired from experience of earlier aircraft certifications, taking into account special requirements of new systems, which had never yet been used on a Pilatus aircraft.

1.17.3 Federal Office for Civil Aviation – approval procedure

The Federal Office for Civil Aviation (FOCA), *Sektion Sicherheit, Flugtechnik, Entwicklung und Herstellung STEH* (safety division aircraft, design and manufacturing) was responsible for the civil type approval of the quasi-military trainer PC-21. Pilatus's application for a Swiss type approval was lodged with the FOCA on 4 February 1999.

For reasons of continuity with the Pilatus product line (PC-7 and PC-9 series), the following regulations were applied as a basis for certification:

- US Federal Aviation Regulations Part 23 (FAR-23) Acrobatic Category, including supplements 23-1 to 23-54, valid on 13 December 2000.
- Decree on the airworthiness of aircraft VLL, 748.215.1 (Verordnung über die Lufttüchtigkeit von Luftfahrzeugen – VLL), dated 18 September 1995.
- Decree on emissions from aircraft VEL, 748.215.3 (Verordnung über die Emissionen von Luftfahrzeugen – VEL), dated 10 January 1996.
- ICAO Annex 16, Chapter 10.

A project team which covered all the component sections of the aircraft was assembled under the leadership of the FOCA's project certification manager (PCM).

Pilatus had to produce a master certification programme for the FOCA. This master certification programme, approved by the FOCA, had to show that all the applicable regulations were fulfilled.

In a continuous process during the construction of the aircraft and the test flight period, documentary evidence for type approval was compiled and handed over to the FOCA for checking. The FOCA then decided whether the documentary evidence was complete and conclusive or whether additional clarification and examination were necessary.

Swiss type approval certificate No. F 56-35 was issued on 23 December 2004 by the Federal Office for Civil Aviation for "VFR day". The process for subsequent certification such as for VFR night, IFR and aerobatics was continued.

1.18 Additional information

1.18.1 Formation flights and displays – general considerations

1.18.1.1 Prevention of collisions – the legal basis

The Decree relating to traffic rules for aircraft regulates among others the prevention of collisions in so far as the following points must be complied with regard to separations:

- An aircraft must not be brought so close to another than the risk of collision arises.
- For flights in formation, including take-off and landing, the commanders must reach agreement beforehand.

1.18.1.2 FOCA flying event conditions

In the flying event conditions, the FOCA regulates the conditions and stipulations which must be complied with for public flying events which are subject to authorisation. This document entered into force on 1 May 2003 and since then has been used as a basis for the organisation of flying events, especially major events such as Air04 in Payerne.

There follow a number of key excerpts from this document:

Qualification:

- Only licensed pilots (CPL or at least FI) shall take part in public flying events, in their category. They must be in possession of a corresponding JAA Display Authorisation from their national authority, a special FOCA A authorisation or another display authorisation recognised by the FOCA.
- Aerobatic pilots must be in possession of a valid personal special authorisation A to fly lower than the minimum height.
- Pilots may take part in formation flying only if they have been trained in this and provide evidence of adequate training.

Permitted flying manoeuvres as a function of aircraft categories:

The information below applies to Category II which is relevant to the PC-21 aircraft (propeller or turboprop aircraft with a maximum take-off mass from 1000 kg to 4000 kg).

Cat II	Manoeuvre	Solo	Formation
v_{max}	-	-	-
H_{min}	Normal flying, horizontal, straight	30 m AGL (100 ft AGL) $v_{min} \geq 1.3 * v_s$	30 m AGL (100 ft AGL) $v_{min} \geq 1.3 * v_s$
H_{min}	Aerobatics and evolutions including interception	50 m AGL (150 ft AGL)	50 m AGL (150 ft AGL)
H_{min}	Outside the display centre line	150 m AGL (500 ft AGL) $v_{min} \geq 1.3 * v_s$	150 m AGL (500 ft AGL) $v_{min} \geq 1.3 * v_s$

1.18.1.3 Difficulties specific to formation flying

Systematic training is not provided for formation flying outside the air force. For air force pilots, this type of flying is, of course, part of their everyday activity and corresponding training is provided.

Formation flying places special demands on crews and is accompanied by specific risks. Estimation of relative speeds, distances and vectors in general, as well as awareness of one's own attitude, are central themes and demand intensive training. Essentially, the formation leader has to plan the flying manoeuvre in such a way that a high degree of flight safety is guaranteed. The patrol pilot follows the formation leader. In displays, it is often the case that very small separations between aircraft and heights above ground are chosen.

Visibility conditions have a great effect on the performance of formation flights. For example, the structure of the aircraft may greatly impede outside visibility. In addition, the position of the sun, the weather conditions, the terrain and the colour of other aircraft may affect perception and the ability to estimate.

During the approach phase, attention of the pilot in the approaching aircraft is largely devoted to the other aircraft.

1.18.1.4 The Swiss Air Force PC-7 team training programme

In view of the similarity of the aircraft used and the figures flown, the training of the pilots in the PC-7 team was examined for purposes of comparison.

For several years the Swiss Air Force has had a formation of nine Pilatus PC-7 turboprop aircraft which had participated in many national and international air displays. The pilots in the PC-7 team were recruited from the corps of active jet pilots in the Swiss Air Force.

The PC-7 team had a training programme, defined in writing, which described how new team members were trained. The first two flights took place with two aircraft. Training in close formation flying simpler aerobatic figures at moderate altitudes was provided. The third flight took place with three aircraft at medium and low altitudes. The candidate then completed an introductory flight in low-level aerobatics. A former soloist was used as the flying instructor. If necessary, the flights were repeated.

As part of the one-week PC-7 team training course, the new member was integrated into the overall formation of nine aircraft. In all, 12 to 13 flights were made during this period. The altitudes were progressively reduced to the desired display altitude.

The training of the soloists followed a special programme and consisted of about three flights.

The level of training of the team was continuously assessed during the season by its leader and his commander and if necessary extra training was arranged in addition to the displays.

As a rule, a standard briefing, conducted by the leader, took 15-20 minutes. The commander monitored the flights of the PC-7 team from the ground. His observations and the video recordings formed the basis for the debriefings.

1.18.2 Formation and display flights by the Pilatus company

The Pilatus company organised display flights on the occasion of air fairs and customer events. The special feature of these flights was to highlight the advantages of the respective aircraft, i.e. in particular their performance and manoeuvrability. The flying programme was therefore drawn up accordingly.

1.18.2.1 Display flights with the PC-21

A new display programme was required for the PC-21 aircraft as the latest product from the Pilatus company. A corresponding flying programme was defined in summer 2004 within the flight operation framework. This envisaged using two PC-21 aircraft in formation. The two crews involved in the accident were assigned as pilots. The aim was a first-time display by this formation on the occasion of Air 04 in Payerne in September 2004.

This programme was flown for the first time with both aircraft on 26 August 2004. Five formation-training flights were made at Buochs aerodrome from 26 August to 2 September 2004.

Three flights were made at Air 04 in Payerne from 3 to 5 September 2004.

The flight resulting in the accident was the first training flight by the PC-21 formation after Air 04 in Payerne. In the two weeks prior to the accident, the pilot of P02 trained fairly often solo in low-level aerobatics over Buochs aerodrome.

1.18.3 g - forces

For the level turn, an acceleration of 3-4 g can be assumed. One g corresponds to a mean gravitational acceleration of 9.81 m/s^2. As the acceleration increases, circulation in the head/brain area becomes increasingly worse. The field of vision becomes restricted; there may be a transitory loss of consciousness up to the total loss of consciousness.

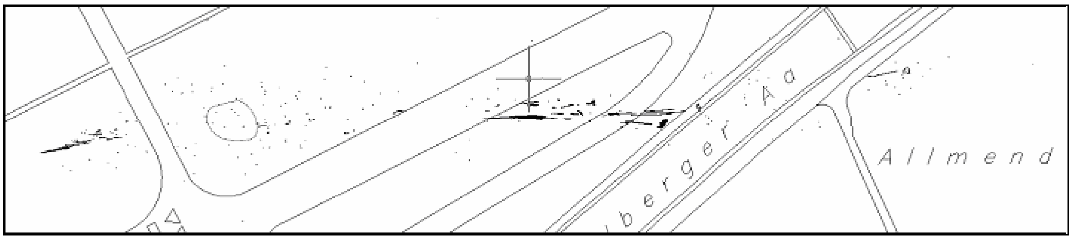
1.18.3.1 g - induced loss of conscious (g-loc)

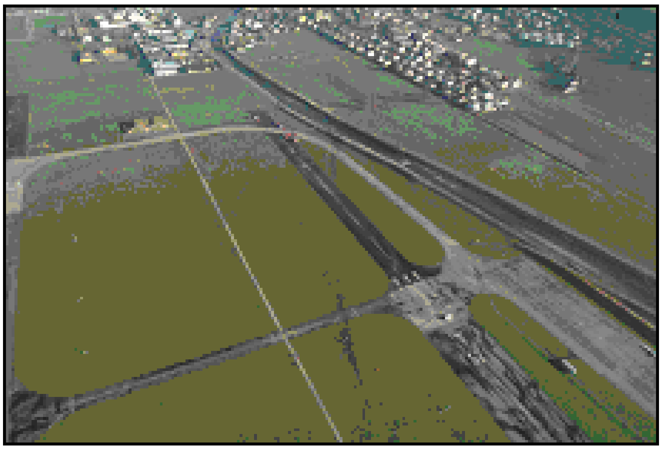
A g- loc corresponds to a complete loss of consciousness in the event of a high, long-term g-force. In very abrupt manoeuvres the rise in g-force may be so fast and strong that loss of consciousness may occur suddenly and without a warning sign. The phenomenon may also occur when an existing high g-force is increased with a high gradient.

1.19 Useful or effective investigation techniques

1.19.1 Survey of the site of the accident using a laser scanner and photogrammetry

The debris field of the Pilatus PC-21 involved in the accident extended from Buochs aerodrome (the point of impact) over the Engelberger Aa (the final position of the pilot involved in the accident) as far as Buochs common (the cockpit). The distance from the first trace of impact to the final measured piece of wreckage was approximately 520 m, with a lateral extent of approximately 110 m.



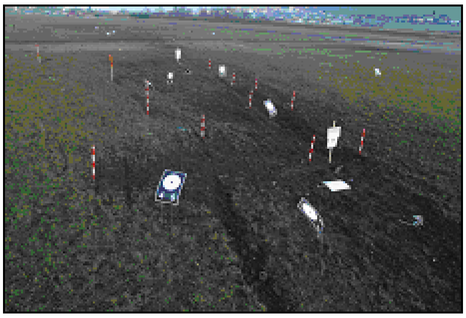


The damage area was surveyed using the following measurement methods:

Photogrammetry was used to survey the traces of impact, skid marks, the aft section of the aircraft, the part of the wing and the cockpit.

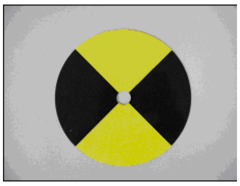
A calibrated survey camera with a resolution of 6.17 million pixels was used to take the survey photographs.

Tachymetry was used to determine the position of the identified parts of the corpse, the technical components and the particular scattered parts of the air-craft. In addition, link points were recorded for photogrammetry, tachymetry and scanning.

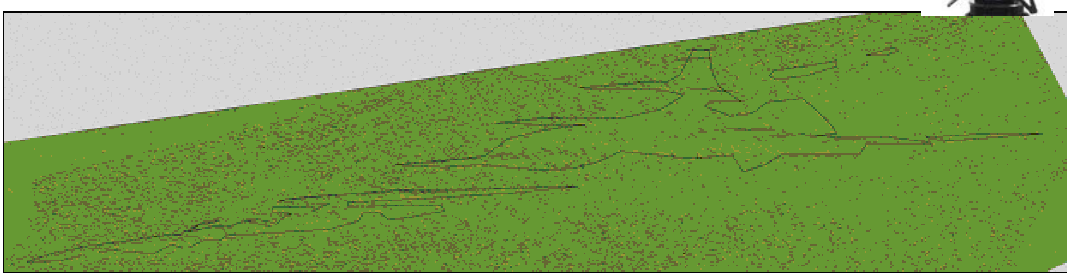


The tachymeter has a range of 10 000 m, with an accuracy of <5 mm, measured on standard prisms. The tachymeter operates in the temperature range from –20 °C to +50 °C.

GPS was used to determine the geographical reference points and the parts which were at a great distance which were pinpointed in the Swiss national system of coordinates for purposes of global orientation. A DGPS with a 12-channel receiver code/phase was used. The recorded points were defined using a specific technical code list. The data accuracy, corrected by post-processing, is about 30 cm.



The primary trace of the impact was recorded in three dimensions with a high resolution **3D laser scanner**. The points measured by the scanner were polygonised and converted into a 3D surface, in which the smallest gouges caused by the impact are precisely recognisable.



The 3D laser scanner is able to scan 360° x 270°, at an accuracy of 6 mm over 50 m.

The data collected at the site from all the instruments employed, was analysed using the appropriate software and assembled into a whole. The Pilatus company provided us with a 3D model, together with plans of the PC-21. The 3D model was additionally completed with the 4 racks which were substantially responsible for registering the traces of the impact.

It was possible to exactly determine the impact sequence of the PC-21 using the model and the traces of the impact, provided with special features (rack lines). Please refer to appendix 4.

2 Analysis

2.1 Technical aspects

The results of the investigation of the parts of the wreckage, the various components of the aircraft controls and the engine produced no indications of any pre-existing technical faults which might have caused the accident.

The marks on the propeller and engine, and the extent of the destruction of the airframe bear witness to a high-speed impact of the aircraft. The damage found can all be explained by the accident sequence.

2.1.1 Position of the ailerons at the time of impact:

Examination of the aircraft control system with regard to the final position of the controls produced the following results:

2.1.1.1 Left spoiler

The nick which was found inside the housing component of the control valve was very probably caused at the time of the initial impact. The position of the control valve's control fork, which matched the nick found in the housing component, just corresponded to a "left spoiler fully extended" control position. This control position was reached at an aileron deflection to the left at an aileron setting of about 14° degrees up (full deflection 17.5°).

2.1.1.2 Ailerons

From the extent of the destruction of the two ailerons and the positions in which they were found after the accident, it can be concluded that on initial impact the right aileron was lowered.

2.1.1.3 Conclusions

The results of the investigation and analysis thereof allow the conclusion that at the time of the initial impact the pilot was on the point of aligning the aircraft after its previous right turn.

It was not possible to establish whether the alignment after the turn took place sharply and as a reaction to perceiving the terrain or as an adaptation to the flight path of the aircraft flying ahead.

2.2 Human and operational aspects

2.2.1 Medical aspects

On the basis of the information from the family doctor and the FOCA medical examiner, the pilot was in excellent health.

2.2.1.1 Vision

According to the applicable national and international regulations (JAR-FCL3), the pilot, with the refraction defect existing before the operation (astigmatism and curvature of the cornea), would have been fit to fly neither before nor after the corrective cornea operation.

At the time of the pilot's initial examination, an eye specialist's examination with accurate refraction measurement was not yet required. Aperently, such an examination did not take place within the framework of the periodic medical fitness examinations either. The pilot should have reported the operations without delay to his competent medical examiner (AME). Such notification did not take place. The AME would have been dependent on such notification in order to be able to decide on subsequent action, as the consequences of such types of laser operation can only be determined during examination by a change in visual acuity. It was not possible to establish why the pilot did not notify the FOCA medical examiner of his two operations.

The possible consequences of such an operation are:

- visual acuity which changes in the course of the day
- increased sensitivity to glare
- decrease in contrast sensitivity

After a corrective corneal operation, it would have been customary according to FOCA practice for the pilot to be designated unfit to fly for at least four weeks.

After this period, fitness to fly could have been reinstated exceptionally subject to the following criteria:

- pre-operative refraction defect within the limits applicable to visual aids
- stable conditions after the operation, i.e. no fluctuations in visual acuity during the day
- no sensitivity to glare
- normal contrast sensitivity
- an application by a FOCA eye specialist to the AMS, decision by the AMS

In the case of the pilot of P02, a refraction defect which would have meant he was unfit to fly – even after a corrective cornea operation – existed prior to 18.12.03.

The result of the operations was documented only incompletely and was not confirmed by a FOCA technical eye specialist. It is not possible to make any statement about the visual capability of the P02 pilot at the time of the accident, particularly with regard to any increased sensitivity to glare or decreased contrast sensitivity.

2.2.1.2 g - forces

Reduced cerebral circulation, which could cause a restriction in the field of vision as a result of a high g-force loading, can never be proved by an autopsy. In order to cause a loss of visual capability, a force of at least 5 to 6 g (1 g = mean gravitational acceleration of 9.81 m/s^2) is needed. A g- force of 6 g and more may cause loss of consciousness. If an anti-g system is used, the g-tolerance is increased.

There were no indications that the anti-g system had not functioned.

In the present case, the average g-force of approximately 3.5 g was not very high.

g-tolerance can be improved, among other things, by intensive training under g forces. In the two weeks before the accident, the pilot of P02 had performed low-level aerobatics quite often.

2.2.1.3 Forensic aspects

The myocardial bridge mentioned in section 1.13.2 above the left coronary artery is a congenital variety; a variation from the norm which is relevant to ischemia under special conditions (obstruction to circulation) which may cause coronary symptoms (heart pains).

Circulatory defects due to such a myocardial bridge as a direct cause of death must be considered as extremely rare. More common, however, are chest pains caused by exertion (pains in the heart), with a normal ECG, which are associated with a myocardial bridge. It is difficult or even impossible to make a clinical diagnosis of such a myocardial bridge, particularly given the absence of pain, a very good general condition and a normal ECG. Appropriate clarification (intracoronary ultrasound, coronarography when subjected to exertion, etc.) is therefore sought only in the event of subjective discomfort or when ECG changes are determined objectively.

Since the pilot had no indications of any kind, subjective or objective, of a heart circulation defect, no such examinations were carried out and the myocardial bridge was accordingly not diagnosed.

In the pilot’s heart, a relatively long segment of a coronary artery ran under a myocardial bridge. It is therefore in principle possible that the artery was compromised under the myocardial bridge as a result of exertion during the aerobatics, the g-forces and the production of stress hormones. This might, likewise temporarily, have led to reduced circulation to the myocardium with acute chest pains (heart pains) and hence to a very brief diversion of concentration, which might have affected or even prevented the correct control of the aircraft. The forensic report considers such a circulation defect, caused by the myocardial bridge, to be possible. However, this cannot be verified by the investigations.

2.2.1.4 Conclusions

The recorded control inputs to exit from the right turn and the clear readability of the last radio communication make any adverse effects due to the above-mentioned medical influences improbable.

2.2.2 Instruction and training

Instruction in aerobatics, followed by instruction in formation flying, is required in the military sphere for flights in formation. In the civil sphere, however, this is not regulated.

The general aviation experience of the pilot of P02 was considerable. In addition, he had completed training in aerobatics, but this had not included any specific training for flying in formation.

In the framework of continuing training courses, consideration was indeed given to the special requirements for testing aircraft. This training did not include any modules on aerobatics or formation flying.

The pilot of P01 was trained in aerobatics and formation flying during his activity in a foreign air force during long years.

Pilatus Flugzeugwerke AG trained its pilots for their activity as display and demonstration pilots.

The planned flight programme was shown at AIR 04 after a corresponding training phase. After AIR 04, no further training flights in formation took place.

When training was resumed, it began with a minimum height of 500 ft QFE and a lateral separation of half the width of the runway. Given such a long interruption in training, an increase in the minimum height and lateral separation would have been appropriate.

The training status must be described as inadequate for carrying out such complex flying manoeuvres in formation.

Apart from the fact that the training was scheduled only one day before the envisaged departure, an additional aggravating factor is that the flight was delayed repeatedly as a result of incomplete maintenance work. This is an indication of a certain pressure.

2.2.3 Multiple responsibilities

Since the pilot of the aircraft involved in the accident had to perform other tasks within the company in addition to his activity as a works pilot, he was unable to concentrate exclusively on carrying out his flights.

As a result of his duel role as chief test pilot and manager flight operations, he bore a heavy professional responsibility. This had increased even further in recent times as a result of his impending departure abroad. However, his quickness of mind and his ability to maintain on overview of his area of responsibility meant that his work colleagues had been persuaded that he would cope with this temporary stress.

2.2.4 Analysis of the manoeuvres flown, visibility and workload

2.2.4.1 Horizontal 360-degree turn and joining manoeuvre, P02

Because of the terrain, the first part of the 360-degree turn up to approximately the end of the first 180° or so was flown in a gentle climb (200 – 300 ft) at a constant acceleration of 3.5 - 4.0 g. Between 180° and 270° of the circular trajectory, the turn was continued, presumably with a glance upward to the culmination point of P01’s loop. As soon as visual contact had been made with the aircraft high above in the aft position (loop), the pilot’s own flight path had to be managed in such a way that the two flight paths would close, with the necessary safety separation. In this context, extrapolation of the vector of the descending and very quickly accelerating aircraft was very demanding and difficult.

In order to estimate the distance from the 360-degree turn to an aircraft which was rapidly accelerating vertically, the circling pilot had to incorporate in his estimates as an additional reference the right edge of runway 07L, as his lateral safety separation line. This demanded a rapidly repeated glance back and forth between the descending P01 aircraft and his references on the terrain.

A lateral safety separation of 100 m was agreed for the verification flights. The manoeuvres which were being flown ended with a lateral separation of 100 - 200 m, corresponding to a deviation of 100 m. If one assumes that during the flight involved in the accident half the runway width, i.e. about 20 m, had been agreed as the lateral separation, the controlled convergence of the two flight paths has been described as an almost impossible task by the pilot carring out the verification flights.

If, because of the slight delay of aircraft P02 in relation to P01, the pilot had tried to shorten his flight path by pulling in more, this would have led to an increase in the g-force. However, a resulting transitory loss of consciousness can be excluded, as if this had occurred it would have resulted in a relaxation of the muscles, with a reduction in his ability to control the aircraft. As a result, the aircraft would have flown in a tangent out of its envisaged orbital path. However, the initial point indicated, that P02 followed the flight path of P01.

2.2.4.2 Visibility of P01 in the joining manoeuvre

In view of the good visibility established in the verification flights and the radio sequence with the instructions by the pilot in P02, it has to be assumed that visual contact existed from P02 to P01.

Flying in a 360-degree turn with a bank angle of approximately 70 – 75° it was extremely difficult to join up with an aircraft which was levelling out of a dive and accelerating. It is possible that in the final phase of the loop, aircraft P01 and the runway might have disappeared for the pilot of P02 behind the edge of his cockpit, the wing and the fuselage.

In order to maintain visual contact with aircraft P01 during the closing manoeuvre, the pilot of P02 had to assume a position which was to the right of and lower than P01. It must be assumed that P02 wished to maintain constant visual contact with P01 and was therefore in the position described.

The infringement of the agreed minimum altitude by aircraft P01 was detectable only with difficulty by the joining pilot in this phase. Furthermore, in this phase the manoeuvre also did not allow a glance away from the other aircraft to the altimeter display on the HUD or PFD. Thus he was also unable to take in the extreme proximity of the ground. To do this, he would have had to glance to the right above the wing.

2.2.4.3 Analysis of attitudes

The "keep going" radio instruction from the pilot of aircraft P02 involved in the accident allows the conclusion that the pilot of P02 felt able to carry out the joining manoeuvre and the subsequent leader switch.

The radio instruction from P02 – "turn right" – came two seconds later. This instruction was clear and without any indications of a transitory loss of consciousness by the pilot. At this time the pilot of P01 was already flying at a bank angle of 20° right. It must be assumed that the pilot of P02 was concentrating solely on the joining manoeuvre and thus on his position relative to the aircraft in front. He was apparently not aware of the effective attitude and direction of movement in space.

2.2.4.4 P01 loop

One second after the "turn right" message from P02, P01 reached the lowest point of the loop at 180 ft QFE and a radio altitude of 330 ft and began to climb again. The speed was IAS 307 at a bank angle of 23° right.

Presumably, at this time the pilot of P01 had no opportunity to perceive the dangerous position of P02, as the latter was very probably concealed by the wing and/or fuselage.

The distinct infringement of the agreed minimum height of 500 ft and the acceleration sequence indicate that the pilot of P01 did not adequately comply with the intended sequence in the last part of the loop manoeuvre. It has to be assumed that he was looking for visual contact with aircraft P02, to the right. This assumption is supported by the fact that the aircraft was banking 10° - 28° to the right in the last quarter of the loop.

The shallow dive of the aircraft involved in the accident towards the end of its 360-degree turn, observed by eye witnesses could have occurred if the pilot of P02 was using aircraft P01, with its descending instead of horizontal flight path, as a reference. The lateral intersection of the runway centre line to the right in the final quarter of the loop by aircraft P01 may possibly have put the pilot of P02 under pressure and made his joining manoeuvre more difficult, as the reference vector was not only descending, but was also unexpectedly converging with him laterally.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects P01

- The aircraft was admitted for transport as a prototype.
- The video recording from the camera installed on board could be analysed and allowed a reconstruction of the loop which was flown.
- All the flight test instrumentation equipment had been removed from the aircraft for the display flight abroad.

3.1.2 Technical aspects P02

- The aircraft was admitted for transport as a prototype.
- The investigation produced no indication that a technical fault on the aircraft or on the engine was present.
- During the repetition of the manoeuvres during the verification flights, no abnormal or limiting behaviour of the aircraft PC-21 was observed.
- The maintenance regulations for the test flight operation were defined by Pilatus in a technical memo and were accepted by the FOCA within the approval for the first flight.
- The results of the investigations of the flight controls indicate that these were functioning without limitations at the time of the initial impact.
- The left roll spoiler actuator was extended at the time of the impact.
- The right roll spoiler actuator was retracted at the time of the impact.
- The activation of the left roll spoiler actuator indicates that at the time of the initial impact the pilot was on the point of levelling the aircraft after its previous right turn.
- On the basis of checks in the two verification flights, an accelerated stall (high-speed stall) can be excluded as a possible cause of the accident with a very high degree of probability.
- The release handle of the front ejector seat was torn from its fixing by the impact forces during the crash. The partial detonation of the ejector seat munitions which was found was not due to the pilot but was a result of the impact with the ground.
- All the flight test instrumentation equipment had been removed from both aircraft for the display flight abroad.

3.1.3 Crew

- The pilots were in possession of the necessary licences, medical fitness certificates and ratings.
- From the medical viewpoint, the pilot involved in the accident would not have been fit to fly because of the refraction defect in his vision.

- The ascertained control inputs to come out of the right turn and the clear comprehensibility of the last radio conversations make it unlikely that the capacity of the pilot of P02 was adversely affected by ill health.
- The pilots were acquainted with the aircraft and the figure to be flown.
- Unlike pilot P01, pilot P02 had not been systematically trained in formation flying.

3.1.4 Course of the flight

- The accident occurred in the very demanding phase of "joining" after looping and the horizontal 360-degree turn.
- The manoeuvre was very demanding for the pilot of P02 in particular, as his full attention was needed to assess the convergence vectors.
- The pilot of P01 flew as leader (of the formation) in the first phase of the aerobatics programme up to the "joining".
- 500 ft above ground was prescribed as the minimum height. Runway 07L/25R served as the centre line of the display and the road which crossed the aerodrome served as the '*centre*' (the centre of the performance space).
- For the combined loop and horizontal 360-degree turn aerobatic figure, it was agreed that P01 would fly on the runway centre line and that P02 would fly south of the edge of the runway.
- Initiation of the loop took place without a stabilisation phase immediately after the figure that had previously been flown.
- The flight parameters of P01 at the start of the loop were: height indicated on the HUD: 390 ft QFE; height corrected for SSEC: 510 ft QFE; heading: 065° i.e. on runway centre line; lateral displacement: slightly to the right of the runway centre line; attitude: 0°
- The flight parameters of P01 at the end of the loop were: height indicated on the HUD: 180 ft QFE; height corrected for SSEC: 300 ft QFE; heading: 084°; lateral displacement: approx. 140 metres to the right of the runway centre line; attitude: 23° right.
- The pilot of P02 very probably aligned his flight path according to that of aircraft P01.
- At the top of the loop, the pilot of P01 confirmed that he could see the other aircraft with the word "*contact*".
- Three seconds later, when aircraft P02 had flown approximately 210 of its 360-degree turn, its pilot also confirmed that he had the aircraft in the loop in sight with the word "*visual*".
- After a further ten seconds the pilot of P02 asked the pilot of aircraft P01 to continue flying his figure with the words "*keep going*". His position was clearly behind that of aircraft P01.
- Two seconds later, the pilot of P02 again commented on the beginning of the next planned figure, a tight 180-degree turn, with the words "turn right".

- The "keep going" radio instruction from the pilot of aircraft P02 permits the conclusion that he felt able to carry out the joining manoeuvre and the subsequent leader switch.
- It must be assumed that there was visual contact from P02 to P01.

3.1.5 General conditions

- There are no indications that environmental influences affected the course of the accident.
- The flight could not take place until early evening because of trouble rectification on the aircrafts.
- This programme was flown for the first time with both aircraft on 26 August 2004. Five formation-training flights were made at Buochs aerodrome and three display flights were made as part of Air04 in the period from 26.08.2004 to 05.09.2004.
- The flight involved in the accident was the first formation training since the display at Air04.

3.2 Causes

The accident is attributable to a collision with the terrain during an aerobatic formation flight, because the pilot of the aircraft involved in the accident was very probably concentrating on the closing manoeuvre with the other aircraft. In the process, he did not pay attention to his height above the terrain.

The following factors may possibly have contributed to the accident:

- The impairment of the vision of the pilot involved in the accident.
- The pressure of time and the multiple tasks imposed on the pilot.
- The difficulty of the manoeuvre which was being flown.
- The low level of training in formation flying.
- Non-compliance with the agreed altitudes and separations.

Appendices

Appendix 1: Overview of the site of the accident

Appendix 2: Final position of different parts of the wreckage

Appendix 3: Model of the position of the sun and shadows cast

Appendix 4: Simulation of the aircraft impact

Appendix 5: Reconstruction of the two flight paths

Berne, 27 July 2006 Aircraft Accident Investigation Bureau

This report has been prepared solely for the purpose of accident/incident prevention. The legal assessment of accident/incident causes and circumstances is no concern of the incident investigation (Art. 24 of the Air Navigation Law).

Overview of site of the accident

Smoke over the dam of the *Engelberger Aa*

Overview in direction east

First traces of right wing impact

First point of impact and second point of impact plus detached tail in rear

Tail and point of impact on the dam; behind the cockpit in the area of Buochs

Point of impact on the dam of the *Engelberger Aa*

Final position of different parts of the wreckage

Final position of the tail

Final position of wing main- spar / fuel tank section

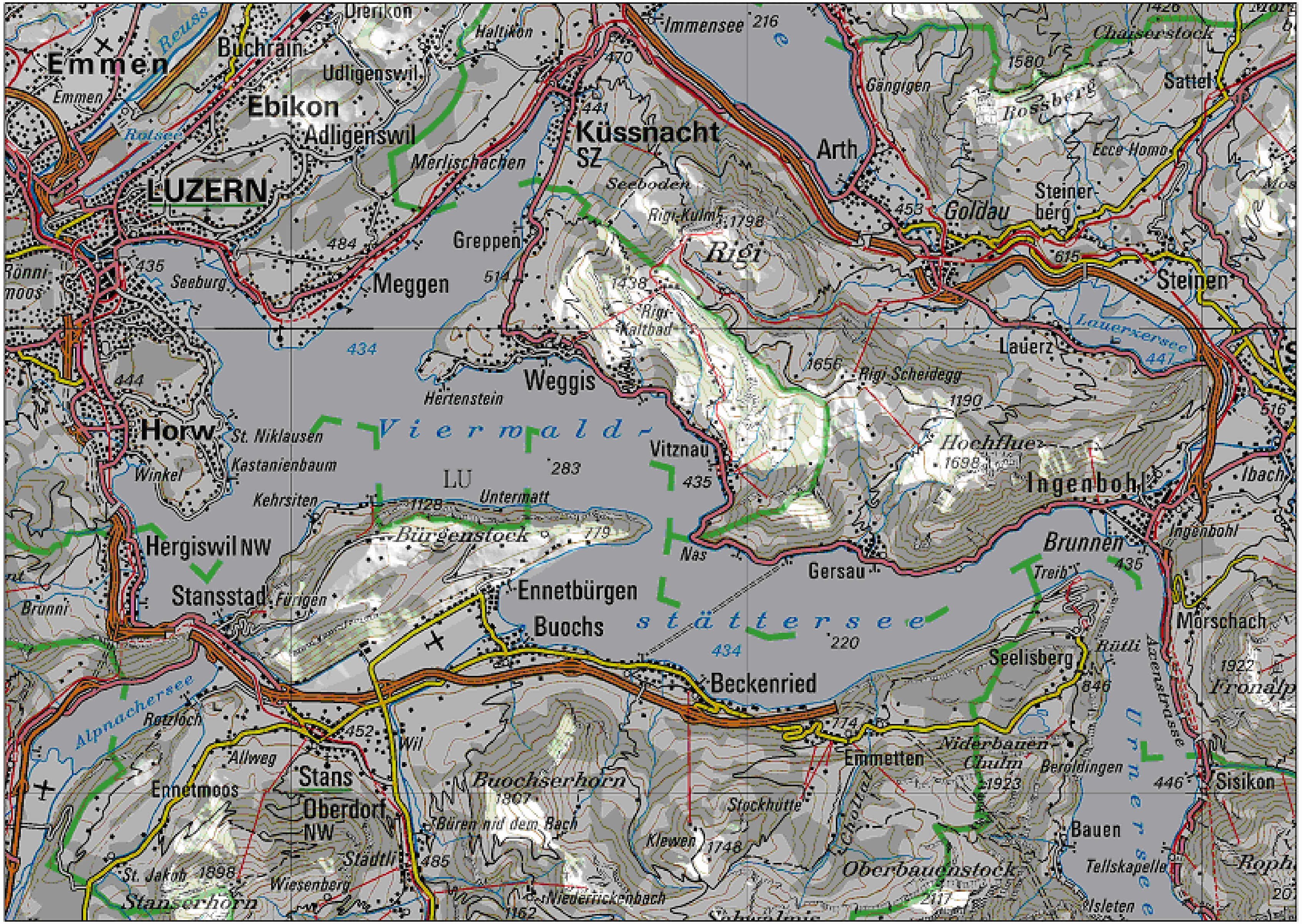

Skin of left wing on the board of the *Engelberger Aa*


Cockpit on the Buochs side of the channel

Engine on the bank of the *Engelberger Aa*

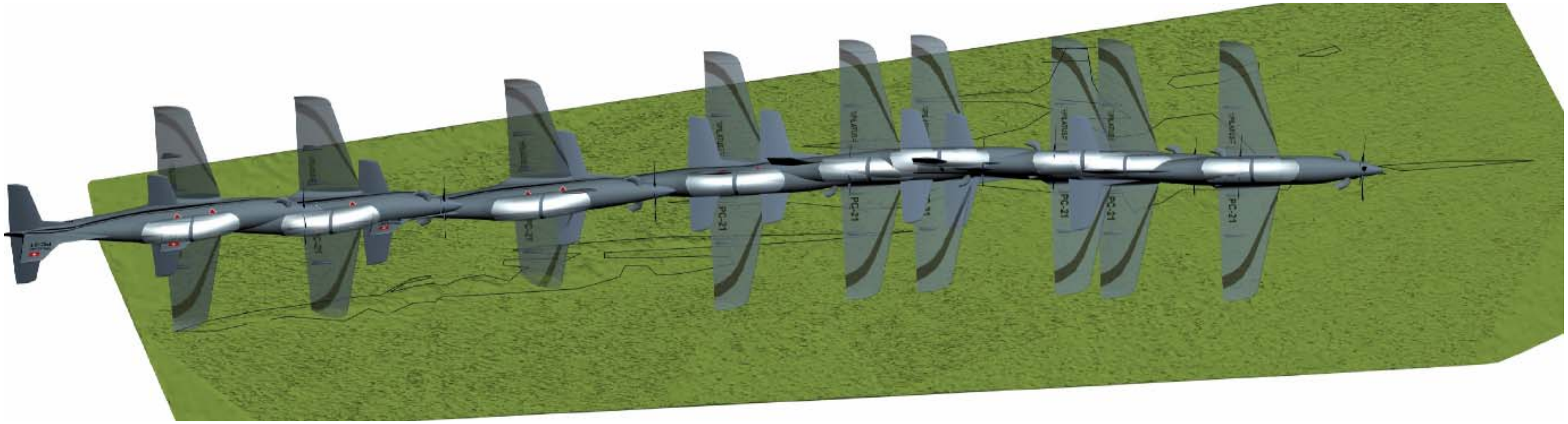
Propeller hub in the *Engelberger Aa*

Model of the position of the sun and shadows cast



Simulation of the aircraft impact

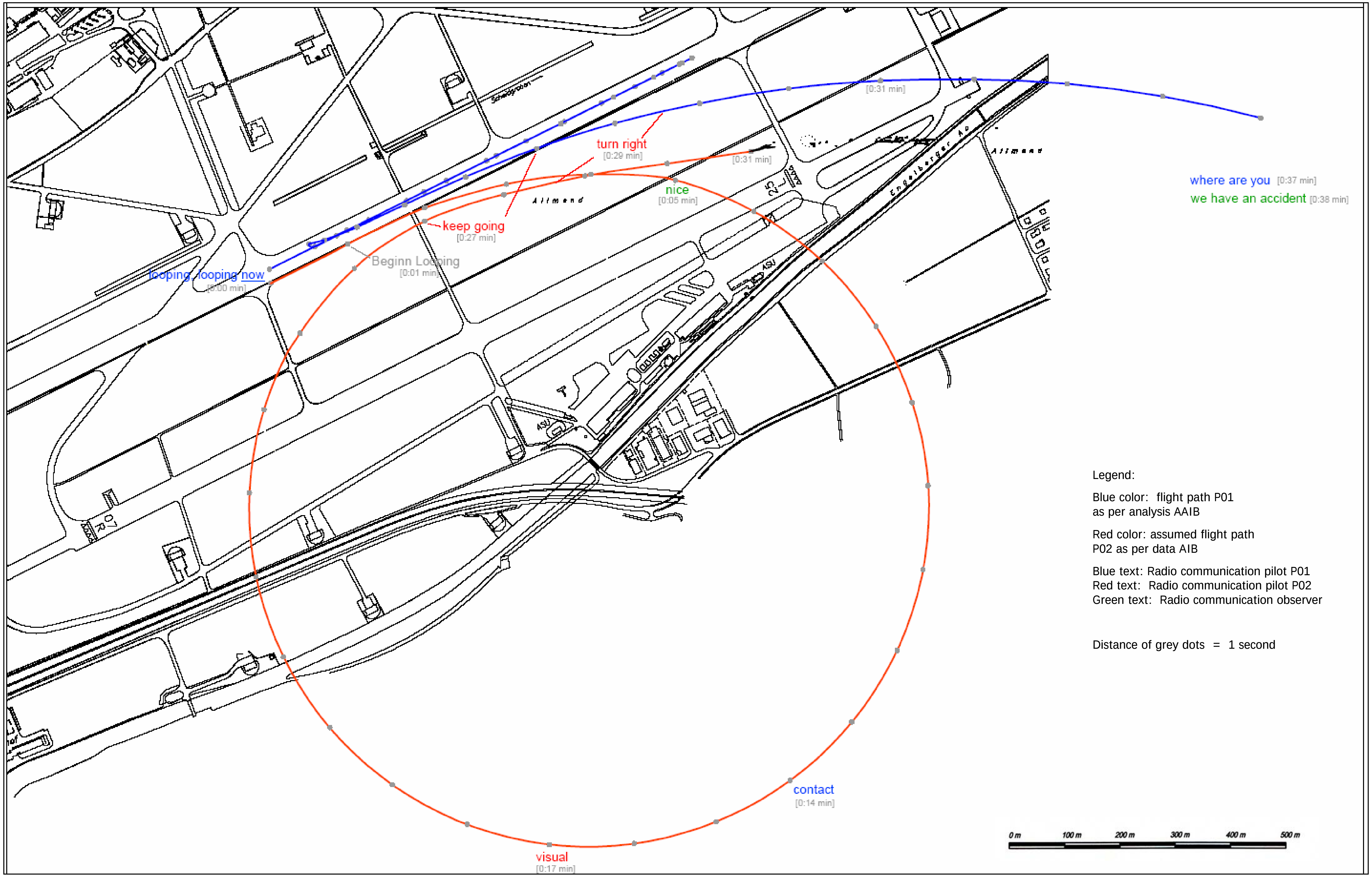
The reproductions below show a plan view and a lateral view of the positions of aircraft P02 from the point of initial impact until leaving the ground anew in the area of the first point of impact.



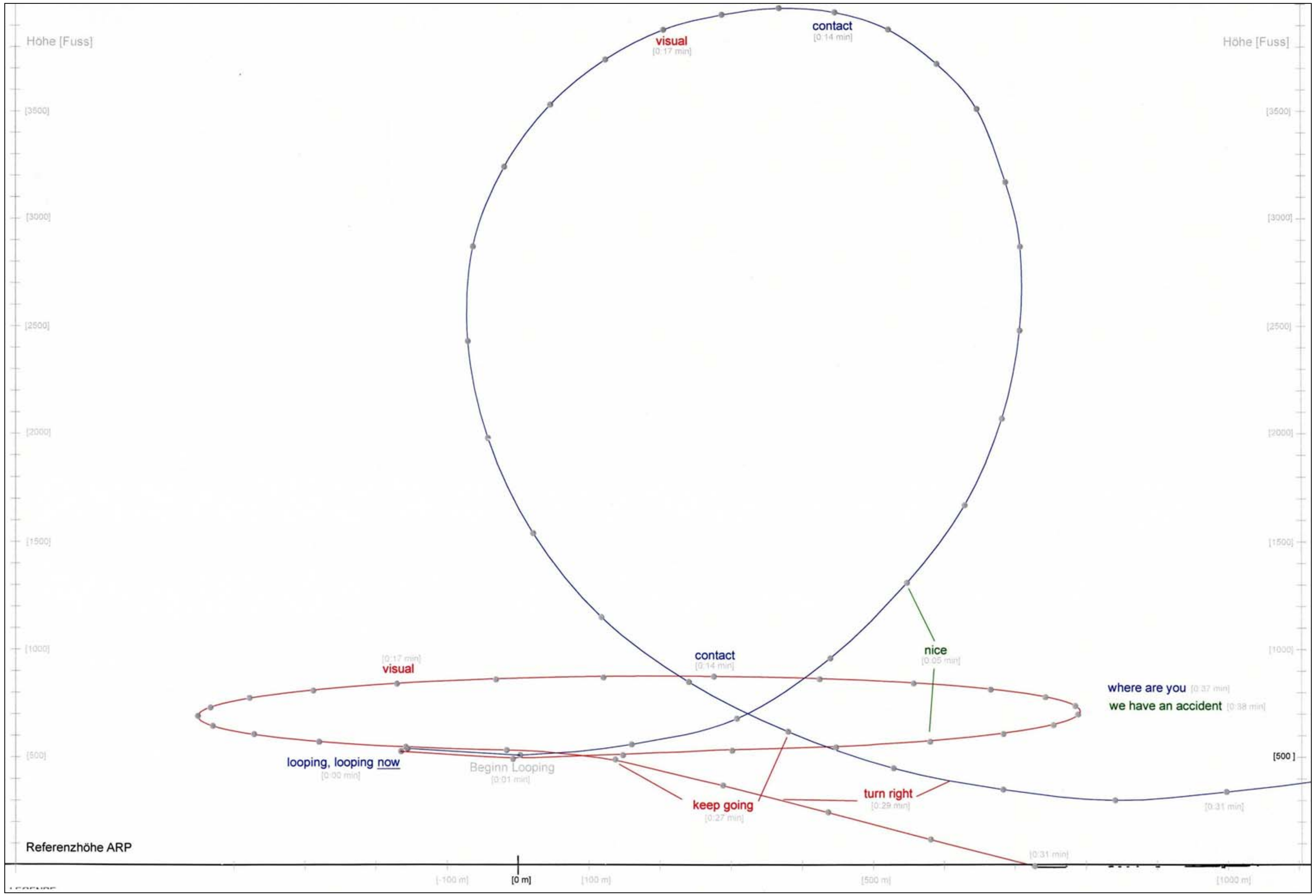
Plan view

Lateral view

Reconstruction of the two flight paths; plan view



Reconstruction of the two flight paths; lateral view



Legend:

Blue color: flight path P01 as per analysis AAIB

Red color: assumed flight path P02 as per data AIB

Blue text: Radio communication pilot P01
Red text: Radio communication pilot P02
Green text: Radio communication observer

In this drawing, the static source error was accounted for (see 1.6.4.4).

Distance of grey dots = 1 second

07/25/2006

A Spectrum 33 very light jet crashed shortly after takeoff on July 25 from Spanish Fork, Utah, killing two test pilots. Glenn Mayben, director of flight operations for Spectrum Aeronautical LLC, and Nathan Forrest, vice director, had just lifted off for a post-maintenance test flight, when the twinjet rolled sharply to the right. At approximately 90 deg. right wing down, the wingtip hit the ground and the aircraft cartwheeled, breaking up. A preliminary NTSB report issued last week notes that, just prior to the accident, an "aileron upper torque tube V-bracket" had been removed and redesigned to provide adequate clearance following changes to a main landing gear strut. NTSB investigators found that, during the part's reinstallation, a "translation linkage" had been "connected in a manner that reversed the roll control." When the pilot or copilot commanded a left roll via the Spectrum 33's sidesticks, ailerons would have been deflected in such a way to produce a right roll and vice versa. The NTSB cautions that this is preliminary information subject to change. The Spectrum 33 had logged 44 hr. since its maiden flight on Jan. 7.

NTSB Identification: SEA06FA146
14 CFR Part 91: General Aviation
Accident occurred Tuesday, July 25, 2006 in Spanish Fork, UT
Aircraft: Spectrum Aeronautical LLC 33, registration: N322LA
Injuries: 2 Fatal.

This is preliminary information, subject to change, and may contain errors. Any errors in this report will be corrected when the final report has been completed.

On July 25, 2006, approximately 1606 mountain daylight time, a Spectrum 33 experimental twin-engine jet airplane, N322LA, collided with terrain following a loss of control during the initial climb after takeoff from runway 30 at Spanish Fork-Springville Airport, Spanish Fork, Utah. The airplane, which was registered to and operated by Spectrum Aeronautical LLC, was destroyed by impact forces. The two commercial pilots aboard received fatal injuries. Visual meteorological conditions prevailed and no flight plan was filed for the 14 CFR Part 91 local maintenance test flight. The flight was originating when the accident occurred.

Witness observations indicate that the airplane entered a right roll almost immediately after takeoff. The roll continued to about 90 degrees right wing down when the right wingtip impacted the ground.

Examination of the accident site revealed that the initial impact point was located about 150 feet right of the runway 30 centerline. A ground scar oriented on a magnetic heading of about 330 degrees extended from the initial impact point to a barbed wire fence about 120 feet away. Various pieces of right wing debris were found along the ground scar. The wreckage path veered about 20 degrees right at the fence and then remained essentially straight to the main wreckage site on about a 350 degree magnetic heading. The main wreckage was located about 750 feet from the initial impact point and included the forward fuselage, aft fuselage and a majority of the wing structure. All major components of the airplane were accounted for in the wreckage path or with the main wreckage. There was no evidence found of any pre-existing failures of the airplane's structure.

Roll control on the airplane was from the pilots' side sticks to the ailerons through a mechanical system of torque tubes and push-pull tubes. The left side stick was primary, and the right side stick was slaved to the left side stick. The roll control motion of the left side stick was linked through a quadrant below the cockpit floor to the lower torque tube. The lower torque tube ran from the quadrant to the aft pressure bulkhead. The translation linkage, the linkages and bell cranks that translated the rotational motion of the lower torque tube to a linear motion of the aileron push-pull tubes, was located on the aft side of the pressure bulkhead in the main landing gear (MLG) gearbox area.

During examination of the wreckage, aileron control continuity could not be established from the cockpit to the aft pressure bulkhead due to fragmentation of the airplane, however, all of the lower torque tube was accounted for. Control continuity was established from the torque tube input on the aft pressure bulkhead to the aileron bellcrank on the right wing and to the torque tube about 50 inches inboard of the aileron bellcrank on the left wing. Examination of the translation linkage on the aft side of the aft pressure bulkhead revealed that it was connected in a manner that reversed the roll control. Specifically, the linkage was connected such that left roll input from the side sticks would have deflected the ailerons to produce right roll of the airplane, and right roll input from the side sticks would have deflected the ailerons to produce left roll of the airplane.

According to information provided by the operator, the airplane had accumulated about 44 hours total flight time since its first flight on January 7, 2006. Prior to the accident flight, the airplane's most recent flight, flight number 46, had taken place on June 30, 2006. During the time between flight 46 and the accident flight, the airplane had been undergoing maintenance. The maintenance included removal of the MLG in order to stiffen the MLG struts. Upon reinstallation of the MLG, it was found that inadequate clearance now existed between the left MLG strut and the aileron upper torque tube V-bracket. The V-bracket was removed and redesigned to allow proper clearance of the MLG. Removal of the V-bracket required disconnection and removal of a portion of the translation linkage.

10/06/2006

A-67

Gear Collapse upon
Ldg of First Flight

African country, two years after the lifting of an arms embargo. However, industry observers say Libya is more likely to start by upgrading its Mirage F1s, as Morocco—another potential Rafale buyer—is doing.

RUSSIA

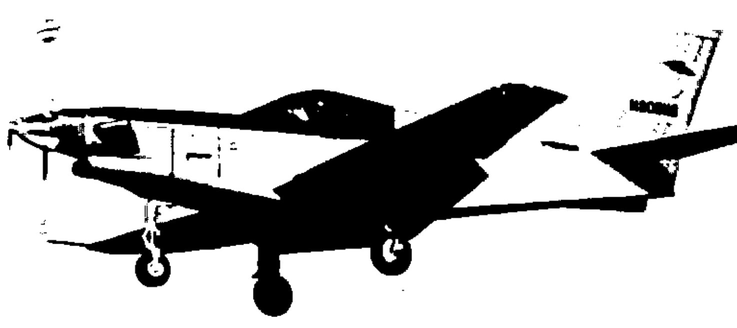
The air force has formally accepted into service an improved version of the Saturn AL-31 engine—the AL-31F-M1—for its Sukhoi Su-27 and Su-30 fighter aircraft. The upgrade offers an 8% increase in maximum power, and is expected to extend engine life.

ASIA-PACIFIC

The first Australian C-17 has moved out of Boeing's paint hangar at Long Beach, Calif., to begin preparations for its first flight later this month. The Australian C-17 is a Block 17 aircraft that includes upgraded combat lighting, formation flying capability and flight-control software.The second C-17 for Australia is set for delivery in 2007 followed by two more in 2008.

Following Australia's clearance last week, France's Thales will acquire a 50% share in ADI, which is owned by Transfield Holdings. The A$170-million ($127.5-million) deal will give Thales full control of the country's leading aerospace and defense contractor. ADI, which generates annual sales of A$700 million and employs 2,500 people, will be combined with subsidiaries that produce underwater systems, air traffic management and training/simulation, to form a new entity, Thales Australia.

China has published a new white paper setting out a space road map for the next five years. One priority of China's second plan will involve developing and operating a high-resolution Earth-observation system, a polar and geostationary weather satellite network and a system of small disaster protection spacecraft—along with associated satellite, launcher and ground production and operating facilities. Launcher development will focus on a new nontoxic low-cost high-performance rocket family capable of lifting 25 metric tons to low Earth orbit and 14 tons to geostationary transfer orbit. Extravehicular activity and rendezvous/docking maneuvers will be the main thrust of manned missions.



A Canton, Ohio, aerospace company is fielding an entry in the competition for a counter-insurgency aircraft. A proof-of-concept for the turboprop-powered A-67 Dragon flew Oct. 6.

Test pilot Dale Mitchell completed a 45-min. test regime after takeoff from Cassville, Mo. Upon landing at Monett Municipal Airport, also in Missouri, the right landing gear failed, causing the aircraft to slide off the runway. The gear and four-blade Hartzell propeller were damaged; a stronger main gear is under consideration.

In development since 2003 by US Aircraft Corp., a subsidiary of US Technology Corp., the Dragon is designed for multimission roles, built with commercial off-the-shelf parts and armored for small arms survivability. Similar in appearance to a straight-wing fighter of World War II vintage—except for side-by-side seating and a tricycle landing gear—the Pratt & Whitney PT6A-67A turboprop engine, rated at 1,200 shp., allows an armament payload exceeding 3,000 lb.

The Dragon is being developed for fighter and attack roles, with capabilities to provide close air support, perform as a patrol and reconnaissance aircraft, and serve as a trainer. Distinctive features are a ballistic parachute recovery system and alternate deployment as an unmanned aerial system.

The aircraft incorporates leading-edge stealth polymer, ceramic and metals technologies and will provide a unique platform for the U.S. and allied countries, a company abstract says. The concept was developed during conversations between US Aircraft President Raymond F. Williams and USAF Brig. Gen. (ret.) Charles Jones, 3rd, a former A-37 Dragonfly wing commander. Jones says the need for a counter-insurgency aircraft is acute in the developing world, where cost and maintenance are major considerations. The price tag: $3.5 million. The Pentagon has reawakened its interest in a counter-insurgency aircraft, and a Rand report notes a continuing need for this special capability (*AW&ST* Aug. 21/28, p. 36).

Restoration specialist Golden Aviation of Monett built the A-67 prototype. Williams provided $5 million for initial funding. In spite of the delay, Williams says he is moving forward with a production facility and fixed-base operation at Akron (Ohio) Fulton Airport. He expects to benefit from a partnership program involving the NASA Glenn Research Center and as many as 10 Ohio universities with similar capabilities.

Corrections: The chronology of milestones for the Airbus A380 program should have noted that the first flight took place Apr. 27, 2005, after having been scheduled originally for late 2004 (*AW&ST* Oct. 9, p. 26).

An article inaccurately described the proposed Falcon 9 rocket that SpaceX is developing to launch its planned Dragon vehicle for NASA's Commercial Orbital Transportation Services (COTS) effort (*AW&ST* Oct. 9, p. 66). The Falcon 9 first stage carries nine engines; its upper stage is a truncated version of the first stage, and both stages are planned to be reusable.

The Rockot light launcher returned to service on July 28. The flight return of Dnepr, provisionally expected by late November, will be the third in four months for Russian boosters, after Rockot and Proton M (*AW&ST* Oct. 2, p. 70).

11/29/2006

7Y181-0-0

The crash of Grob Aerospace's second SPn light jet prototype is likely to set back plans for certification next summer. The all-composite aircraft crashed shortly after takeoff, killing the two pilots. The aircraft joined the flight test program in September.

Crash Consequences

ROBERT WALL/PARIS

German accident investigators are expected to release initial findings on the crash of the Grob Aerospace SPn utility jet prototype in the coming weeks. What's already clear, though, is that the program, already fighting an uphill schedule battle, now faces further delays.

The Nov. 29 crash of the second SPn prototype killed the company's chief test pilot, Gerard Guillaumaud, and has forced Grob to restructure SPn development plans. Design changes loom, company officials acknowledge. What those will be depends on the investigators' findings.

Flight testing has been suspended in the wake of the crash, which occurred shortly after takeoff near the manufacturer's Mattsies-Tussenhausen site. The prototype lost control surfaces during a demonstration flight, leading to the accident. German flight accident investigators say the suspension is not an official grounding, but was a company decision.

The loss of the second prototype is particularly troublesome for the aircraft maker because it featured design changes to alleviate shortcomings on the first aircraft. The flight envelope for those alterations had not been fully explored. It's also the first production-like model because it features the enhanced Honeywell Primus Apex avionics suite.

Grob has had a third prototype in build since October and says that aircraft is still scheduled to join the flight-test program in the second quarter. However, company officials are not saying whether this will allow time for design modifications. The fourth SPn, which is the first production aircraft, will be pulled into the flight-trial phase.

Development of the 8-seat all-composite aircraft has suffered repeated delays. For instance, the mishap aircraft entered the flight-test program nearly three months late. Moreover, Grob once hoped to certify the SPn in early 2007. A weather-induced slowdown in flight testing, along with design changes, forced a delay, setting certification back to the third quarter this year. Now, Grob has again revised its outlook and says it is targeting approval from the European Aviation Safety Agency in the first quarter of 2008—FAA certification would follow in the second quarter.

The delay has financial implications for Grob, which was hoping to deliver the first aircraft next year and 15 within the first year of production. CEO Niall Olver says "ramp-up on subsequent production will now be faster to compensate for this delay." The goal is to reach an annual production output of 40 aircraft by the third year. Olver took over running the company this year when Zurich-based ExecuJet Aviation Group, which he also heads, bought Grob Aerospace.

03/06/2009

THE HINDU

Date:21/07/2009 URL: http://www.thehindu.com/2009/07/21/stories/2009072156231300.htm

Back

National

"Wrong relight drills caused Saras crash"

Ravi Sharma

BANGALORE: The board of inquiry constituted by the Directorate-General of Civil Aviation (DGCA) has completed its investigation into the March 6 crash of the Light Transport Aircraft Saras near Bidadi in Karnataka.

Two pilots and an engineer, all from the Indian Air Force's Aircraft and Systems Testing Establishment, were killed in the crash of the Prototype Two (PT2).

An official of the National Aerospace Laboratories (NAL), designers of the Saras, said the DGCA had promised to make the report available before month-end.

The Hindu has learnt from officials connected with the board of inquiry that the engine relight (engine restart) drills given by the designers and followed by the pilots were wrong.

The two test pilots were for the first time on the Saras, attempting to switch off and relight in midair one of the two Pratt and Whitney (PT6A-67) engines. The test is a mandatory requirement of the flight development programme. The aircraft had reached its designated height of 9,000 feet and the left engine switched off. After one minute, the crew attempted to relight the engine, and this was communicated to the ground crew. But soon after radio communication was lost, the aircraft started losing height and crashed. "Prior to the flight, the pilots were briefed by the designers about the drills to be followed during relight, and they followed it. But the relight drills were incorrect. With each aero engine having its own unique set of procedures to be adhered to during relight (like at what speed, airflow, where the propellers stop, etc), the pilots just followed the designer's briefings. Errors occurred; the aircraft went out of control and crashed," an official explained.

reduction plan ahead of first flight to bring 787 performance back in line with customer expectations."

SPEEA Rejects Strike, Hopes To Resume Boeing Talks. The Puget Sound Business Journal (3/9, McCoy) reported, "Four days after rejecting The Boeing Co.'s contract offer for the second time in under a month, members of its engineers' union in Wichita, Kan., hope to soon return to talks with the company." Although "members of the Society of Professional Engineering Employees in Aerospace voted down Boeing's contract offer," the union "also voted against givin SPEEA leadership the authorization to call a strike." The vote "expressed their displeasure with the contract, but also their willingness to work with the company," said SPEEA Midwest Director Bob Brewer. He adds that "no timetable has been set returning to contract negotiations, but that the two sides are discussing how and when to schedule the next round of talks."

DARPA Funds Search To Develop Production Of JP-8 Algae Fuel.

Biodiesel Magazine (3/10, Schill) reports in its April issue that "algae research will get a big boost from two projects involvin multiple partners that received funding this winter through the US Department of Defense's Defense Advanced Research Projects Agency. DARPA's BioFuels program is exploring energy alternatives and fuel efficiency efforts in a bid to reduce tl military's reliance on traditional fuel through cost-effective alternatives." The projects "aim to develop a scalable process fo cost-effective, large-scale production of algae oil to be processed into a JP-8 jet fuel surrogate."

American Completes First Commercial Flight With Fuel-Saving Winglets.

Air Transport Intelligence (3/9, Ranson) reported, "American Airlines today completed the first flight of a Boeing 767-300ER blended winglets supplied by Aviation Partners Boeing." The airline "says APB estimates each winglet-equipped aircraft sh save up to 500,000 gallons of fuel annually depending on miles flown, which could result in a total savings of 29 million gall annually." The winglets should also provide "a 277,000 metric ton reduction in carbon dioxide emissions and an increase in aircraft range of 360nm" and "the improved take-off performance of the aircraft could generate up to 12,000lbs of additional payload."

NATS Pledges 10% Emissions Reduction By 2020.

Flight International (3/10, Learmount) reports, "UK air navigation service provider NATS has promised to reduce the emissi aircraft it controls by 10% per flight by 2020." A NATS study has "calculated that 26 million tonnes of CO_2 is emitted in UK airspace annually. It says this is its benchmark for the planned reductions, to be achieved through shorter routeings, green airport approaches and departures and enabling optimum en-route flight levels." NATS CEO Paul Barron added, "this is a t target in challenging times, but aviation is making strides to be more sustainable and air traffic control must play its part."

India's Prototype Saras Turboprop Crashes, Kills Three.

Aviation Week (3/9, Warwick) reported, "The second prototype of India's indigenously designed Saras 14-seat twin-turbopr crashed near Bangalore on March 6 during a test flight, killing all three crewmembers." The plane "has been criticized for b overweight, over budget and behind schedule, but according to Indian media its developer, the National Aerospace Labora (NAL), expects the project to continue despite the crash." NAL "is building a production-standard third prototype, targeting a kg. weight reduction, but this is not expected to fly before year-end."

UK Recalls Nimrod Fleet For Safety Modifications.

Flight International (3/9, Hoyle) reported, "The UK Royal Air Force is to restrict operations of its British Aerospace Nimrod M and Nimrod R1 surveillance aircraft fleets for the next several months, following a decision to complete essential safety modifications to the aged types." According to the RAF, "required modifications include replacing engine bay hot air ducts a fuel seals in 15 MR2s...and three R1s." The article notes that "scrutiny of the RAF's Nimrod fleets has been intense since a September 2006 mid-air explosion over southern Afghanistan which destroyed MR2 XV230 and killed 14 service personnel accident was attributed to factors including leaking fuel coming into contact with super-heated bleed air pipes routed from tl type's engines."

Report Finds Flaws In RSA Safety Improvements.

Air Transport Intelligence (3/9, Croft) reported that a Transportation Department investigation "faults the FAA's airports

FINAL INVESTIGATION REPORT ON ACCIDENT TO NATIONAL AEROSPACE LABORATORIES, BANGALORE SARAS PT2 AIRCRAFT VT-XRM AT SESHAGIRIHALLI NEAR BIDADI (KARNATAKA) ON 6TH MARCH 2009

1.	**Aircraft**	**Type & model**	**: Saras Prototype PT 2**
		Nationality	**: Indian**
		Registration	**: VT-XRM**
		Engine	**: P&W,PT6A-67A**

2. Owner & Operator : **National Aerospace Laboratories**
P.B.No:1779, Kodihalli
Bangalore-560017

3. a) Pilot-in command : **Wg Cdr (22917-S),F(P)**
b) co-pilot : **Wg Cdr (23165-H),F(P)**
c) Flight test engineer : **Sqn Ldr (24746-M),AE(M)**

b) Extent of injuries : **Fatal**

4. a) Number of passengers : **Nil**
b) Extent of injuries : **N/A**

5. Place of Accident : **Seshagirihalli , near Bidadi about 37 Km Southwest of HAL airport, Bangalore**
Latitude: N 12° 50' 56"
Longitude: E 077° 23' 46"

6. Date and time of Accident : **6th March 2009, appr 1004 UTC**

(All Timings in this report are in UTC)

SYNOPSIS

Saras Prototype PT2 aircraft VT-XRM manufactured and owned by National Aerospace Laboratories, Bangalore was scheduled for carrying out its test flight no 49. On 06.3.2009 which also include inflight engine shut down and relight procedure at 10000'AMSL . Chief test pilot was on commander seat , test pilot was on co -pilot seat and Flight test engineer was also on board. Aircraft took-off at 0925 UTC and thereafter changed over to radar. There was no events. Aircraft was then cleared to flight level 100, operate up -to 10miles. After completing general handling checks at 9000'AMSL without any events, Single engine simulated approach was carried out on r/w 09. At about 0941 UTC aircraft was cleared for overshoot, wind 090/06 kts. Aircraft made overshoot at 300'AGL. Aircraft was then changed over to radar again. At 0942 UTC Aircraft was cleared to climb FL100 and pr oceed sector Southwest 2 for carrying out engine relight test procedure. After climbing to about 9000'AMSL in sector Southwest aircraft reported 15 miles and FL 90 at about 0948 UTC and reported turning around. But HAL radar as well BIAL radar was showing level 72 for which aircraft replied that it has descended and climbing back to 9000'AMSL. At about 0956 UTC aircraft reported "OPS NORMAL" at 20Nm in sector Southwest 2. **This was the last contact of aircraft with radar but was in contact with FTD telemetry desk of ASTE, Bangalore.** After successful left engine shut down and its securing procedure, at about 1001 **UTC left engine relight procedure was initiated at about 9200'AMSL. During the relighting of left engine, FTD desk also lost contact with aircraft about 37 secs prior to crash. Aircraft crashed at about 1004 UTC.**

There was no response from pilots even after repeated calls made by the Radar controller as well as FTD desk. Radar contact with the aircraft was also completely lost. All possibl e communication means including through en -route traffic to contact the aircraft went in vain. After extensive search efforts, at about 1100 UTC it was finally established that the aircraft crashed at a village called Sehsagirihalli (close to wonderland amusement park) near Bidadi, 37km by road (1km off Mysore road) southwest of HAL airport, Bangalore.

All the three persons on board were charred to death. There was post impact fire. Aircraft was completely destroyed due impact and fire.

1. Factual Information :

1.1 History of the flight

On 06.3.2009 Saras Prototype PT2 aircraft VT-XRM manufactured and owned by National Aerospace Laboratories, Bangalore was scheduled for carrying out its test flight no 49 . Test flight programme includes general a ir tests/handling checks to ascertain the aircraft flying characteristics after the 50 hrs Scheduled servicing, dummy approach in simulated single engine configuration at 5000'AMSL, go around at 300'AGL in a simulated one engine inoperative condition, landing in a simulated one engine inoperative condition and to carry out in-flight engine shut down and relight procedure at 10000'AMSL within 130 -150 kts speed. Tests are to be carried out as per existing SOP and test procedures and limitations and pre flight test briefing meeting. Aircraft was cleared by approved inspectors of NAL after carrying out daily inspection on 6.3.2009 for test flight No:49 and was duly accepted by the Chief test pilot. Preflight briefing was taken by the **Wg Cdr (22917-S), F(P),** chief test pilot was on commander seat , **Wg Cdr (23165-H), F(P)** - test pilot was on co-pilot seat and **Sqn Ldr (24746-M), AE(M)** was on Flight test engineer on board. The test team also accepted flight test schedule of flight No:49. Total duration of the tests was estimated to about 45 minutes.

Engines were started at 0913 UTC at ASTE, dispersal area . All engine parameters were reported normal. After carrying out post start up and pre taxy checks, aircraft taxied out for Runway 09 at HAL airport. As per departure instructions after departure R/W 09 aircraft to climb on R/W heading 5000', turn right set course to southwest -2 and in coordination with approach radar to operate upto 10 miles and level 100. Aircraft was cleared for take -off from R/W 09 with surface wind 090°/06kts. Aircraft took-off at 0925 UTC and changed over to radar at 0926 UTC. There was no event. Aircraft was then cleared to level 100, operating upto 10miles. After completing general handling checks at 9000'AMSL without any events, Aircraft was stabilized with simulated single engine approach to the landing r/w 09. Single engine simulated approach was carried out. At about 0941 UTC aircraft was cleared for overshoot, wind 090/06 kts. Aircraft made overshoot at 300'AGL. Aircraft was t hen changed over to radar again. At 0942 UTC aircraft was cleared to climb level 100 and proceed sector southwest 2. Aircraft right engine was throttled up to match left engine and aircraft climbed out to 9000'AMSL in sector southwest. At about 0948 UTC aircraft reported 15 miles and FL 90 and reported turning around. But HAL radar as well as BIAL radar showing level was 72 for which aircraft replied that it has descended and climbing back to 9000'AMSL. At about 0955 UTC aircraft reported "OPS NORMAL" at 20 Nm in sector southwest 2. **This was the last contact by aircraft with radar.** After 0955 UTC Radar contact with the aircraft was completely lost.

As per ASTE Telemetry, after turned round to point towards HAL airfield aircraft was observed about 20 miles at 9000'AMSL with 140 kts speed. Telemetry link was good at this position Left engine was then shut down and secured following the test procedure at about 10:00:40 UTC. Pilot was in touch with Flight test director on R/T at telemetry desk. After about 47 secs, **left engine relight procedure was initiated at around 9200'AMSL.** Pilot also reported to Telemetry the start of relight of the engine. Telemetry indications also showed the rise in Ng and ITT. At about 100 secs prior to crash airc raft went into sudden dive from 9200' to 7300' for about 13 secs. Meanwhile **During the relighting of left engine, FTD desk also lost RT contact with aircraft about 37 secs prior to crash and telemetry link with the aircraft was also intermittent. At 37 secs prior to crash when Telemetry called aircraft " can you call up. What is going on", aircraft replied "Standby" this was the last contact of Telemetry with aircraft. After that there was no contact from the pilot.**

Just before 7 secs of crash when the telemetry data signal was restored aircraft already lost to the height of 4260'AMSL(1900'AGL) and in continuous loss of height and Ng was about 31%. There was no response from pilots even after repeated calls from FTD desk.. Aircraft was rapidly loosing the height without any control. **Cockpit voice recording clearly showed that on last moments just 10 secs prior to crash ,commander called out " Aircraft has departed" indicating aircraft completely gone out of control. During the last moment of crash telemetry recorded Ng : about 54%(63% as per FDR), Engine oil pressure 88, fuel flow 94%,ITT 647 deg C, indicating engine relight was successful. But by the time aircraft was almost on ground. Aircraft crashed at about 1004 UTC.(10:03:44)**

All possible communication means including through en-route traffic to contact the aircraft went in vain. Search operation by ALH helicopter (A67) ,Chetak(T45) and T55 was effected. At about 1033 UTC police control room reported that an aircraft had crashed near Bid adi. After extensive search efforts, at about 1100 UTC, A67 found out the crash site having bearing 251° and 17Nm from HAL airport. Later it was affirmed that the aircraft crashed at a village called Sehsagirihalli (close to wonderland amusement park) ne ar Bidadi and 37km by road(off Mysore road) Southwest of HAL airport, Bangalore. The crash site was a wide -open residential plot area of uneven hard terrain surrounded by poles and wild plants. It was on a radial of 251° /17 NM from HAL, Bangalore airpo rt having coordinates LAT : N12° 50'56" , LONG: E077° 23'46")

All the three persons on board were charred to death and were on their seats. There was post impact fire. Aircraft fuselage was broken from rear of the main plane and found in an inverted position. The vertical fin leading edge was facing the ground and the respective tail mounted engines by the side of it. The nose portion of the aircraft was facing East direction. Aircraft was completely destroyed due impact and fire.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	**Three**	Nil	Nil
Serious	Nil	Nil	Nil
Minor/none	Nil	Nil	

1.3 Damage to Aircraft

Aircraft was completely destroyed due impact and post impact fire.

1.4 Other Damage

Nil

1.5 Personnel information

The test flight No:49 of Saras PT2 aircraft VT-XRM was operated by flight test team nominated by ASTE, IAF, Bangalore. The flight test team includes two Indian Air Force Test Pilots and a Test Engineer. The details of the crew members of the flight test team are as follows:

i. Wg Cdr (22917-S), F(P) Chief test pilot was the commander of the aircraft,
ii. Wg Cdr (23165-H), F(P), test pilot was Co-Pilot and
iii. Sqn Ldr (24746-N), AE(M) was Flight Test Engineer.

Both the cockpit crew have become test pilots after comp letion of the Experimental Test Pilot's course in May 2006.

a) Wg Cdr (22917-S), F(P),aged 35, is a DGCA approved Chief test pilot for Saras PT2 with effect from 5^{th} Aug' 2008. He is also flight test incharge and responsible for deploying DGCA approved test pilots and flight test engineers to carry out flight tests of Saras PT2 aircraft. He had a total flying experience of 2414:00 hrs with about 310:00 hrs on turbo-props including Saras Aircraft.

b) Wg Cdr (23165-H), F(P),aged 36, is a DGCA approved prototype test pilot for Saras PT2 aircraft with effect from 14.11.2007. He had a total flying experience of 2080:00 hrs with about 315:00 hrs on turbo props including Saras Aircraft.

c) Sqn Ldr (24746-M), AE(M) , aged 33, is a DGCA accepted flight test engi neer and approved by chief test pilot of Saras PT2 team with effect from 1.12.2006.

1.6 Aircraft Information

a) The SARAS PT-2 aircraft is an experimental aircraft under development by M/s National Aerospace Laboratories, Bangalore and is intended for passe nger and cargo transportation on domestic routes. It is designed, manufactured and operated by NAL, Bangalore as Saras Prototype-II aircraft. This aircraft has been duly entered in the register of India with effect from 5.12.2006 and was given the

Registration marking as VT-XRM. The Certificate of Registration issued bears Cert. No. 3460, under category A. The aircraft serial number is SP002 and the year of manufacture is 2006.

b) The aircraft is light transport aircraft configured as a low wing monoplane with T-tail powered by two Pratt & Whitney, Canada ,PT6A-67A Turboprop engine in the pusher configuration. Each engine is fitted with a 5 bladed MT propeller made of Aluminum alloy incorporating a variable pitch, constant speed unit and a propeller over speed governor. The engines are installed on the stub wings on either side of the rear fuselage.

c) The flight compartment is equipped to allow operation of aircraft by a two-man flight crew. The standard design configuration is provided with seating for 14 passengers, seated 2 abreast. Front and rear baggage compartments are provided for the purpose of accommodating the baggage.

d) The fuselage is of semi monocoque construction and is made up of front, center and rear sections. It has all-metal, fully cantilevered dihedral wing.

e) There is a swept back, fully cantilevered vertical stabilizer attached to the top of rear fuselage. A horizontal stabilizer is mounted on top of the vertical stabilizer. Both the stabilizers are removable and are of twin spar construction. Elevators are hinge mounted to the rear spar of the horizontal stabilizer and similarly rudder is mounted to the vertical stabilizer. Balance tab for all the control surfaces with gear ratios are provided.

f) Aircraft is fitted with wing integral tank having fuel capacity of 840 litres on each wing. Fuel used is any of the following: JP1, Jet A, Jet A-1, AVTUR. Oil used is of type II conforming to P&WC SB 14001 or synthetic Oil MIL-L-23699C

g) In a standard design configuration it features a pressurized cabin and is capable of cruising at altitudes upto 30,000 ft. It is designed for all weather operations. SARAS PT2 is designed to meet the airworthiness standards of FAR-25 and operational requirements of FAR-121

h) The aircraft was still under the development stage. Hence the weight schedule was not yet finalized. However the restriction was fixed for the 49th i.e the accident test flight the details of which are given below:

   i. Maximum take off weight of the aircraft: 6400Kg.
   ii. C.G at 30.02% MAC(U/C RETRACTED)
   iii. Fuel status-752 Kg
   iv. Ballast – 99 Kg
   v. Persons on board – Three.
   vi. Max Speed – 200 knots IAS

The aircraft was prepared as per Standard of Preparation SARAS PT-2, Vol 33; Report SOP – 2 dated Nov-2006, Issue B with modifications as indicated in document Ref. vol 33, MOD-SOP-2 Issue A June 2008. There was 793 kg of fuel on the aircraft on clearing the aircraft for 49th test flight on 6.3.2009. Aircraft was also carrying three serviceable parachute unit for emergency purpose.

Aircraft is also maintained by NAL, Bangalore and completed 48 test flights prior to the accident test flight. Aircraft propeller had logged 50:20 hrs on completion of 48th test flight. On 6.3.2009 aircraft was inspected by the airframe, engine, avionics, instruments, electrical system inspectors approved by DGCA as per daily inspection/preflight/engine ground run schedule. Also telemetry serviceability was reported signed by separate person as per DI. Aircraft was certified airworthy for test flight 49 in the form "daily inspection and clearance for Test flight-Saras aircraft" by concerned DGCA approved inspectors. Aircraft was also accepted by the pilots in the form IAFF(T) 700D. **However pilots also signed the "daily inspection and clearance for Test flight". DI inspection record indicating various approved personnel/engineers checked the aircraft prior to departure of 49 th flight was not available.**

The following aircraft documents were checked.

1. 50 Hrs. inspection Schedule
2. SARAS PT2 Systems documents.
3. Taxiing & Development test Flights
4. 25 Hrs. Inspection Schedule
5. Snags (Deficiency / Deviation) lists
6. System integration documents.

No significant findings / observations are noticed except reported high control forces.

Further, the following documents were scrutinized:

1. SARAS PT-2 Compendium of mass properties - No major findings observed
2. Pilot Defect Register (PDR) – Flaps struck at 18°, 10°, 2°, 2° and 4° during flight nos. 18,22,24,25 and 34 respectively. Subsequently, flap was set at 10°. Otherwise no major snags observed
3. Electrical, Battery capacitance records verified and found both Main & auxiliary batteries were periodically Capacity tested and recharged and was valid on the day of accident.

From the aircraft flight test records and post flight pilot reports some of the obse rvations are:

- Rudder Force feel inadequate, rudder response sluggish
- During Asymmetric Torque handling, Rudder Force reported heavy
- Poor Aircraft controllability during approach, flare out & touchdown. Exceedance of ITT & Ng reported high at high Torque settings at high altitude

In general, there are Controllability issues and high control forces exist.

It is also observed from the post flight pilot reports(PFPR) that no PFPR was submitted by ASTE for the flight no 38 and 39. Also for flight 40 to 46 PFPR were not submitted by ASTE as the aircraft was used for flying demonstration in Aero India 2009 show at Bangalore. But no DGCA permission was taken by NAL for the purpose.

1.7 Meteorological Information

As per the existing procedure the met report is obtained on telephone. Accident took place at about 1004 UTC under broad day light conditions. The MET report received on 06.03.2009 at 1000UTC is as follows :

METAR VOBG 061000Z 08008KT 8000 NSC 34/07 Q1012

Weather was fine and is not a contributory factor to the Accident.

1.8 Aids to Navigation

SARAS PT2 aircraft is fitted VHF-NAV, ADF, DME, ATC transponder, weather radar, compasses, altimeters and their appropriate indicators to obtain navigational information.

Navigation factor is not having any bearing in the accident.

1.9 Communications

SARAS PT2 had following communication systems installed:

- 2 VHF radio systems
- 1 HF system
- Passenger address / briefing system
- Audio management system (AMS)
- Cockpit voice recorder
- 2 Radio tuning units (RTU).

The real time performance of the aircraft is communicated to the ground station by a system known as Telemetry. This is an effective tool for online monitoring of prototype test flying wherein test crew could be warned by the Test Director in case of any exceedances in flight parameters or a potential hazardous situation leading to an unsafe flight . Some of the Telemetry /data analysis sheet for the previous test flights (eg., flight test no.40) had been checked and did not revea l any telemetry link problems. However during the face to face to discussions, **the reliability of the telemetry system has been reported poor in general throughout the sortie and the auto tracking system was not available on the day of accident.** All various monitoring groups at telemetry station have expressed the same. Moreover **telemetry radio conversation between FTD desk and the aircraft is not a recorded channel.** However CVR conversation reveals telemetry was intermittent. But FTD is in general in contact with the aircraft till 37 secs prior to the aircraft crash. This also includes starting of engine relighting procedure.

At about 0955 UTC aircraft reported "OPERATIONS NORMAL" at 20Nm in sector southwest 2. This was the last contact by aircraft with the radar. HAL radar did not check the position of the aircraft almost for 10 mins after the last reporting at 0956 UTC. **After that radar tried to call the aircraft only at 1006 UTC. Radar also did**

not contact immediately the Telemetry. Its contact with telemetry was also about 15 minutes after the last contact with aircraft.

However the two way communication between HAL Airport and the aircraft was satisfactory and is not a contributory factor to the accident.

1.10 Aerodrome information

Aircraft had crashed near Bidadi on a radial of 251° /17 NM from HAL, Bangalore airport (coordinates N12°50'56" E077°23'46") and subsequently caught fire resulting into the fatal injuries to the three flight crew and loss of the aircraft. The aircraft crashed at a village called Sehsagirihalli (close to wonderland amusement park) near Bidadi and 37km by road(1 km off Mysore road) southwest of HAL airport, Bangalore. The crash site was a wide open residential plot area of uneven hard terrain surrounded by poles and wild plants. It was on a radial of 251° /17 NM from HAL, Bangalore airport.

1.11 Flight Recorders

SARAS aircraft, VT–XRM is installed with M/s Penny & Giles, UK manufactured a combi version recorder for data and voice recording. It is a combined Solid State Flight Data Recorder and Cockpit Voice Recorder. This is crash and fire protected and is installed in the rear i.e. dorsal fin area. Consequent to accident, the recorder was damaged in post crash fire, the unit was sent to manufacturer's facil ity at UK for retrieval of the data. From the UK facility, the data has been obtained separately for the Voice and Flight data. The details of the extract of the CVR and DFDR recording are as follows:

Cockpit Voice Recorder:

The voice data has been played, in the Flight Recorder laboratory of DGCA HQ, using different support equipments. Transcript has been prepared after complete and combined hearing of all the channels.

CVR data transcript for last 38 minutes along with elapsed time from the crash even t analysed. In addition, 06 more minutes of data has also been added to the transcript to give proper continuity for the events.

In the CVR transcript there has been many occasions where the conversation between crew indicates concern. Such locations have been given in bold letters and have been land marked under remarks column with alphabets A to Z. Detailed analysis was carried out at these sites, to evaluate the circumstances in which the crew remained to make such statements. The findings on these si tes have been given in the subsequent paragraphs of this report.

Flight Data Recorder:

FDR data has been obtained in raw format from M/s P&G, UK. The data has been converted in to engineering units by using NAL, FOQA, a software tool meant specifically for SARAS aircraft. Though the data length is for last 24 hours, only the test flight number 49 has been decoded and examined. Subsequently different sets of graph have been generated with judiciously chosen various combinations of aircraft and flight parameters. These sets of graphs have been generated for different time lengths. These time lengths vary from 15 seconds to 30 minutes. Inferences have been derived from these graphs and it has been given in the subsequent paragraphs.

Synchronization procedure of CVR and FDR Data and Telemetry data:

As this being a combi version recorder, it is believed that both the components of data would have stopped at the same instant during the final and last event of the crash process. Hence the last coordinate of data appearance in both Voice and Flight Data has been taken as the crash point and has been designated with time mark of 00:00 (minute: sec). The data has been subsequently allowed to grow in the reverse direction with negative timing marked in graphs as well as in CVR text. With this, at any time of required reference, both CVR and FDR can be viewed together for any analysis work. This is one of the adopted procedures for combi version recorders.

The subject flight being a test flight, it remained on complete telemetry monitoring. The telemetry data has also been compared with FDR data and also been used to prepare this data analysis report. Particularly there are some essential parameters like engine oil pressure,ITT,fuel flow etc. are only available with telemetry data. The following analysis includes use of data from FDR and data of flight test Instrumentation with cockpit conversation.

FDR data presentation:

FDR data for the entire test flight no 49 has been converted into engineering units. Of the large volume of data, relevant parameters have been chosen and graphs have been made against time. Graphs in the form of six sets, with each set containing six parameters. The time duration for these data graph have been kept for the last two and five minutes. The time axis grows in negative direction with 00:00 designated as crash point. At any time of required reference CVR and FDR data can be read together as they have been converted to a common time scale.

FDR data inferences:

GO-AROUND in simulated one engine inoperative was done at 100 feet AGL. against the test schedule clearance of 300'AGL. Subsequently, with full power on both engines a normal climb was made up to 9000 feet height.

During left engine shutting down:

Before the left engine shutting down the flying remained steady with speed of 140 kts, altitude of 9400 feet and heading remaining at 60 – 70 deg. The engine oil pressure remained at 122 psi for both L&R engines. The PLA of left engine was brought to zero at the time of -04:53. With this the fuel flow reduced to 80 kg/h, Ng reduced to 73%, torque reducing to 3% with no appreciable change in Np. At the time of -04:00, the prop lever was moved to feathered, as indicated by the Np reducing to 15% from 100%. Torque has increased from 0% to 30% and Ng now is steady at 73%. There has been no change in right engine parameters.

At the time of -03:35, the left engine Ng reduced to 60% indicating possible condition lever moving to ground IDLE. Fuel flow (FF) now reduced to 55 kg/h. all the att itude parameters remains unchanged. At the time of -03:24, the FF indicates to zero implying that the condition lever has been selected to CUT OFF. This has resulted in ITT, Engine OIL Pressure, EOP reducing to minimum level. Heading now is seen steady at 70 degree. To balance the asymmetry, the rudder remained at -12 degree, elevator and aileron remained respectively at 5 deg and 3 deg. Side slip was seen to 2 deg with bank angle remaining 10 deg to right.

During the period while left engine remained shut down:

From time -03:20 to -01:56 the left engine (LE) remains shut down, Np remained nearly 5% with prop in feathered stage. ITT remained at 115deg, while the EOP remained 06 psi. The heading remained constant at 65 deg with a steady rudder of 12 deg and pedal force of 20 Kg. The bank angle varied between -6 to 12 degrees.

Left Engine relight:

At the time of -01:44, Np is seen rising through 55% with EOP having remained low at 5 psi. A small rise in Ng could be seen to the level of 7%, which is lower than the minimum 13% required for beginning of relight exercise. FF is seen increasing to 25 - 30 kg/h indicating the condition lever having moved forward from CUT OFF.

Attitude parameters like side slip and bank angle position has started showing changes. Side slip increases up to 28 deg and bank angle changing from 8 deg R to 70 deg L. also the pitch attitude is seen reaching -42 deg.

The rise in prop rpm could be attributed to prop blade pitch having reached FINE from feathered statues. However, with EOP having remained at 5 psi, the blade normally not expected to change the pitch from feathered status. At the time of -01:41, Np is seen to reaching 91% with no change in EOP, pitch angle, roll and side slip kept increasing respectively to -42, 70 and 28 deg. Rudder deflection has changed now from 12 deg R to 4 deg L with pedal force nearly 70 Kg. elevator remained at 8 deg down and aileron wheel deflection to 40 deg. The aircraft speed has reduced from 150 to 130 kt with altitude steady at 9200 feet.

Right engine power reduction:

At the time of -01:40, PLA of R engine was brought down from 26 deg to 0 deg. This has resulted in reduction of torque to 2 % and EOP to 32 psi. This attempt could possibly be explained as an attempt to reduce the thrust asymmetr y and the large side slip faced. During the time of -01:31, both L & R PLAs are seen increasing in steps. In response to this, R torque is seen to increasing and during the same time the course has reduced from 70 deg to 0 deg within a time period of 12 se conds.

Between the times of -01:36 to -01:24, the speed is seen to increase from 125 KTS to 181 KTS with altitude reducing from 9200 feet to 7300 feet. Rate of descend for 12 secs is very high can be attributed to diving of aircraft and speed of aircraft also increasing. The seen ROD, rate of descend is about 10,000 feet per minute, which is very high for this class of aircraft. During this phase, the NpL remained at 100 % and NgL is seen at 12%. Subsequently the aircraft was brought under control with all attitude parameters tending to change towards the normal levels.

During the time of -01:18 the speed has reduced to 160 Kts, altitude at 7200 feet, NpL remained 100%, Ng L at 15 % and the torque L remained 0%. At the time of -00:59 NpL is seen reducing to 80% with Ng L increasing to 22%. Other battery related electrical parameters indicate that the relight process has not been fully successful, or possibly it has been aborted. At the time of -00:28, the aircraft has been observed to be on left turn. The side slip remained at 22 deg with pitch attitude about -15 deg. The speed remained at 130 kt and altitude reducing from 7000 feet to 5200 feet. The R engine torque that has been reduced close to 0, is showing a sharp rise to 85%. Both PLAs were seen to be moving together. All the controls forces have been increasing excessively.

Second relighting attempt:

During time of -00:30, a rise in PLA_ L could be seen with proportional rise in Ng. The raise in Ng, goes up to 60 % with Np having rem ained at the level of 80%. The FF increased to 98 kg/h. Further the ITT – L increasing to 635 deg C and EOP_L increasing to 95 psi together indicates the possible success in relight operation of Left engine. During the period of last 15 seconds there has been large input of pilot controls in all 3 axis resulting in large and proportional variations in aircraft attitude in all axis.

CVR data inferences

Over the 38 minutes of transcript prepared, about 26 different landmarks have been identified, as containing conversations requiring detailed analysis. Such landmarks have been marked with letter A to Z. With reference to the transcript material the following write-ups, details the possible interpretation of the remarks at these identified sites.

(A) Probably referring to the Elevator trim run out (-15 deg, nose down limit reached, as expected at speed ~ 160 KTS).

(B) No comments

(C) No comments

(D) Descending for OEI simulated approach, Torque_L 21%, Torque_R 3%. The crew needs to have some little p ower ON to live engine.

(E) Still Descending for OEI simulated approach (telemetry t=1884s, ALT 3900ft). To maintain the speed of 125 KTS, at level flight, the crew discusses about the need for more power.

(F) CVR Time of - 22:48 (telemetry t=1963.6s, 15:10:45)
Rudder 2 deg, Boom_SS -10 deg, AIL_L -13, Ail_R 8 deg, bank 8 deg left
Torq_L increased from 44% to 64%
Under these conditions, large Left aileron input required to maintain about 10 deg bank to left.(running out of rudder and aileron limit)

(G) CVR Time -22:26, telemetry t= 1986s, 15:11:07

Probably referring to NG_R (E2Ng), which is now close to 102.5%, while the flight test limit is 103% (actual limit is 104% from OEM manual).

(H) CVR Time -21:37, telemetry t=, 2035s, 15:11:56

Here it is symmetric power, controls at normal levels. Discussion seems to pertain to the requirement in general regarding desirability of procedure to bring all trims to neutral before landing.

(I) CVR Time -20:50, 46:33:45, telemetry t=2082s, 15:12:43

Erroneous speed indication on the masked side of speed sensors which is in the wake of Nose Landing gear door when sideslip is > 5 deg. Pilots are probably discussing here the sideslip effect on IAS on two different EFIS.

"Saturation of what?" - Is not understood -. Air show flights being spoken may be referring to NAOA behavior, which used to go to 100% (spurious indication). However, at this instant, in the current flight, NAOA is 30% -40% and no saturation is observed on this.

(J) CVR time -15.47, 46:38:48, telemetry t =2384.6 s, 15:17:46

Seems to be general talk, specific reasons/parameters could not be identified.

(K) CVR Time -15:03

Seems to have descended but not registered in their mind. While communicating to ATC, altitude reported is 9000' in place of 7200 feet. Hence, this reference was to just from P1 to P2.

(L) CVR Time -13:12, 46:41:23
Telemetry t= 2539.6 s, 15:20:21

Torq_L zero, Torq_R 89%, Rud -8 deg (right rudder), Rud tm full +13, side slip 12 deg, wheel 15 deg. The crew may be mea ning the insufficient force here. At this instant the rudder force is 15 kg.

(M) CVR Time -12:56, 46:41:39
Telemetry t= 2555 s, 15:20:37

Rudder is -12 deg (to the right), though Rudder Trim has continued to be full. This comment may be in reference to Rudder trim rather than rudder surface. Pedal force ~ 25 kg

(N) CVR time -12:36, Relative Time 46:41:59
Telemetry t = 2560 s, IST 15:20:39

Sideslip 3-5 deg, speed is 130 Kts. As Torq_L is ~zero, this propeller would be creating negative thrust (disking), so aircraft would appear to encountering more drag, even in clean configuration. Hence, the comment on inability to maintain speed is understandable. Aircraft was descending

(O) Comment is in continuation of that at (N). Reasons at (N) apply here also. Aircraft continued descending and level flight could not be maintained.

(P) CVR Time -11:54, 46:42:41

Comment is in continuation of that at (N). Reasons at (N) apply here also. Subsequently Torq_L increased moderately to remove asymmetric.

(Q) CVR Time -10:56, 46:43:39
Telemetry t = 2675.6 s, IST 15:22:37

Symmetric engine power here. Comment does not seem to relate to parameters at this time. Probably, related to fuel imbalance condition that could have existed.

(R) CVR Time -9:56, 46:44:39

Left Torque is higher (60%) than Torque R, So understandably the ITT_L would be more (750) than ITT_R (710).

He speaks later to explain his doubt expressed at (R). Later, may be it has been realized by crew that, with the left torque remaining higher than right torque, a difference need to exist in ITT also.

(S) CVR Time -07:14, 46:47:21
Telemetry t = 2897.6 s, IST 15:26:19

Torq_L zero, Torq_R 92%, height 9000 feet, bank angle 0 deg, sideslip 6 to 7 deg. 'Zyada' seems to refer to more drag on the aircraft. With undercarriage down we will die with this drag.

Probable, reasons could be :
left engine torque is zero (more disking),
sideslip is ~ 6 deg
which also would add to increase in the windmilling drag.

(T) CVR Time -07:02, 46:47:33

Expresses that landing at 10,000 feet airfield elevation, would be difficult with single engine operation ,with the performance seen by the crew in this flight.

(U) CVR Time -05:50, 46:48:45
Telemetry = 3041.6 s, IST 15:28:43
Torq_L 3.5%, Torq_R 92%, sideslip,6 degrees, bank 15 degrees to left

Bank angle is normally used to relieve the rudder requirement from pilot. Here he has been applying pedal force for quite some time. This bank angle would lead to some extra torque requirement to maintain speed/altitude. Additio nally, sideslip also not being at zero (~ 6 deg), could increase the drag. **So overall, more torque would be needed in this configuration.**

(V) CVR Time -05:33, 46:49:02

This is about high Ng at RH engine at high altitudes, which is a known phenomenon. It was explained probably by the ground here, that this problem would not occur at lower altitudes. **When ground opined "low altitude it is better", P1 expressed the dying situation at low altitude.**

At -05:1, 7 FE expressed desire to go back (*and not carry out subsequent tests*). P2 telling not to go back, we will shut down and later shown to PM, - project manager. Co-pilot also hilariously telling commander "road is there for emergency" and advised FTE for the placing readiness of parachute for emergency, without assessing the risk of the situation, which was also expressed by the commander.

(W) CVR Time -01:47, DFDR: 46:52:48

NP_L 38%, ht,9178 feet ,

FE is asking the pilots in suspicion about the actions taken till now. At this instant Rudder, elevator, sideslip are all steady at the values which were maintained till now. There is no change in HDG, also. Immediately within a second heading started changing rapidly and loosing the height

(X) CVR Time -01:18

Battery discharging voice warning is heard for the first time after left engine shut down, indicating that the battery is in use now and probably starter -motor has been engaged. This is the first instant when NG_L has crossed 13%, after the shut down. Speed now is 120 Kts. At this time telemet ry link also lost

Battery discharging sound was heard for 13 sec. Then it has stopped. At the instant of Battery discharge sound stopping, NG_L was constant at 25%. For further 5 seconds, NG_L remained at 25% and subsequently started reducing. Fuel flow remained on for 36 sec (could possibly lead to wet start and high ITT).

During this time NP_L was 100% and reduced to 85%. This is an un - natural condition for a engine to start, in the presence of high NP_L. The presence of light-up can't be determined as ITT information is not available for some small length of time.

One more and possible reason for unsuccessful re light could be improper fuel-air mixture.(seen from fuel flow rate)

(Y). CVR time -00:55,

Tor-R-0%, wheel- full, IAS-132 Kts, h-6620 feet, Bank-2 degrees,. Pitch- -12 degrees ,. Rudder-9 degrees right.

Concern is developing between the crew about, the intentional reduction of power by P1 on the live engine.

(Z) CVR time -00:22, Height : 5000 feet.

P2 instructing P1 to do the action which ever it is, which has brought the aircraft to some stable attitude when it was done earlier).

Again anguish is expressed by P2 to P1on the action of cutting off of the live engine. Stressing to keep the live engine in LIVE condition only.

In addition to the above mentioned, and identified land mark remarks, the most important is last 3 minutes 20 secs and the correlation of CVR with DFDR and available telemetry data is analyzed below.

(a) CVR Time: -03:22

Securing left engine off after shut down procedure.

(b) CVR time: -03:03 to -01: 50

Preparing for relight procedure

(c) CVR time: -1:47

FE is asking the pilots in suspicion about the actions taken till now. At this instant Rudder, elevator, sideslip are all steady at the values which were maintained till now. There is no change in HDG, also. Immediately within a second heading started changing rapidly and loosing the height

(d) CVR Time : -01:41

Np -L- 90%, Ng- L- 10 %, Side slip- 28 degrees, Rudder moved from

-12 to +4 degrees. Heading 44 degrees, Rudder force - 65 Kg,. Roll -23 degrees and further building, reaching 32 degrees within 2 sec, Pitch -24 degrees, nose down and increases to 40 degrees, Bank going up t o 70 degrees. Both pitch rate and roll rate remained at high level.

It is hypothesized here that the flare up of NP_L was possibly due to blade pitch angle reducing below Primary blade angle(PBA).

With disc effect in full force in left propeller, the up wash wind force raising out of the disc, could have caused HT and aileron of the left side, to, induce, an upward force and consequent nose down attitude. As the right side not having similar upward force, a case of asymmetric tail vertical load could have caused the seen roll also.

(e) CVR Time -01:41 to -01:31

speed increased from 140 to 158
Aircraft loosing height from 9200'to 8200'.

Ng_L: 10%, Np_L reaching 99%, Engine oil pressure down to 4.6, fuel flow increased to 38 but still torque is zero on left side, ITT : 102 .

at the same time on right side: Ng down to 73 from 101, Np maintaining 101, oil pressure 119, fuel flow gone down to 72 from 261, torque to zero . this indicates right side engine was brought down

(f) CVR time—01:27,

Altitude: 7311 ft , Bank angle recovers to 8 degrees, pitch recovers to – 9 degrees, side slip recovers to + 2 degrees .

These conditions imply that the **aircraft is momentarily returning to normal attitude. (pilots laughing)**

The possible reasons behind this seen recovery could be:

1. Reduced disc effect due to side slip reduced airflow, over the disc.
2. Pilot added control inputs to correct body attitude.
   But altitude loss continued.

From time -1:41 to -1: 22 aircraft lost height from 9223' to7266' i.e. almost 2000' in 20secs.

At -1:22, CVR revealed the hurried voice of FE telling the pilots to start the engine quickly.

From -1:09 to 0:57 telemetry link was not there.

(g) CVR Time—01:02,

Speed losing to 116 KTS, Altitude to 7280 feet, pitch –9 degrees, bank 0 degree, Live engine Torque was coming up to 16% which was reduced to zero earlier.

Large drop in speed seen, and hence is the comment. P2 is demanding from P1 the same action (which ever recovered the aircraft from bad attitude felt few seconds before).

(h) CVR Time - 00: 55,

PLA-right brought down from 16 to Zero again. Right Torque -0%,right fuel flow reduced to 70, Speed 132 KTS, Bank 2 degrees, pitch – 12 degrees, Rudder – 9 degrees, ht– 6620 feet , engine oil pressure-left increased to 56 and subsequently started reducing to 38, ITT still 68 deg, Fuel flow remained 36, torq ue zero., Ng raised to 22 and started dropping to 15,Np to 83.

This indicates the Left engine relighting not successful and height continuously dropping. Right engine also brought to idle.

P2 Expressing anguish on reducing power of the live engi ne by P1 .

(i) CVR Time-- -00:44, altitude 6150'

Side slip is 20 degrees to right. Idle Kar do—could be referring to power, possibly referring to right engine. With disc effect prevailing on the left side, the power on the right engine, is the one, causing the noted side slip. (as possibly understood by the crew).

Immediate follow up words of—Ruk, jao.--, indicates, rapidly changing mind set of Pilots while coping up with rapidly changing attitude of the aircraft, as well as the f ast fall in forward speed. Increase of right engine parameters noted.

On left side engine: oil pressure to 26, fuel flow remained 36, Ng 13, Np 85, ITT still 68, almost no torque.

(j) CVR Time –00:33,

Speed reduced to 112 KTS, Height reduced to 5400 feet, E1 Ng-10 %, E2 N g-86 %,

The calculated rate of descent is as high as 12000 feet per min, with fast descend taking place, the crew believes here that they have to have left engine live to cop up the emergency.

P2 and P1 raising alarm voice of drastic reduction of speed. P2 asking P1 to relight immediately.

(k) CVR Time—00:27,

Height 5000 feet,

excess rate of descend ,panics the crew with sayings seen here. The battery discharging warning indicates the action of Second relight attempt on left engine.

(l) CVR Time-- -00:26,

Height- 4800 feet. Side slip to 20 degrees, pitch at –15 degrees, Right engine torque reduced to zero and rapidly and immediately increased to 85 %.

Left engine relight process is on. Np L-77%, Ng –L- 16 %. Rudder pedal force increases as high as 90 kg. Aileron forces too ,seen to raise to 40 kg.

No telemetry link between -0:25 to-0:08

(m) from -0:22 to -0:15

P2 instructing P1 to do the action, which ever it is , which has brought the aircraft to some stable attitude when it was done earlier.

Again anguish is expressed by P2 to P1on the action of cutting off of the live engine. Stressing to keep the live engine in LIVE conditi on only.

(n) CVR Time - -00: 14,

Ng L increasing to 23 %, Np L 80% -- , ITT increased to 96

indication of left engine responding to relight action . Ng R- 102 %.

During 1st un-successful attempt, NP_L reduced from 100% to 83-85% (An increase in EngOilP_L was noticed from telemetry data which showed that EngOilP_L reached the required minimum of 60 psi.) But in this attempt, NG_L rise was not sustained, so EngOilP_L probably started reducing, thereby preventing further mod ulation of blade pitch angle. It could be conjectured that blade pitch is still below PBA.

During 2nd re-light attempt, EngOilP_L increased beyond 60psi as NG_L was sustained and so probably, now prop blade pitch angle might have come to PBA and matching NP_L for ground idle setting. During this, as expected, NP_L reduced from 82% to 61%.

(o) CVR time: last 10 secs

P1 calling aircraft departed repeatedly indicating aircraft fully gone out control. The word used by the pilots " F (unre adable)." repeatedly at last moment indicating, "No control on aircraft and their life is ending"

(p) CVR Time-- - 5 Secs to 1 sec prior to crash

1 sec prior to crash:

Rapid loss of height from 4300' to 3040', speed started increas ing from 60 to 120 . Ng_L increased to 54,Np to 56, oil pressure to 79, ITT increased to 647, fuel flow to 95,but torque started to come out of zero ,
indicating Left engine successfully relighted.

Whereas on right side:

Ng R- 81%,Np: 86,Oil pressure 118, ITT 773, fuel flow 78(came down from 336 which was increased in the 5 secs prior to crash), torque came down to 11 from 81, PLA from 31 to almost zero. Indicating last moment try by the crew on right engine

At the last second of their life P2 calling " F.........,F......" indicating he is seeing last spell of the life. At the same time Battery discharge Warning coming in the background also stopped, indicating engine relighted successfully. But the aircraft almost on ground, P1 calling " Going to ground"

1.12 Wreckage and Impact information

Aircraft crashed at a village called Sehsagirihalli which is close to wonderland amusement park near Bidadi (about 1 Km off Mysore road) and about 37km by road southwest from HAL airport, Bangalore. **It was on a radial of 251° /17 NM from HAL, Bangalore airport having coordinates LAT : N12° 50'56" , LONG: E077°**

23'46"). Aircraft nose was facing east direction. The salient observations recorded during in-situ inspection of the accident/wreckage site are as follows:

1. The aircraft got destroyed due impact and post impact fire.

2. Crash site was wide open residential plot layout area and was a hard terrain with varying slopes surrounded by poles and wild tress/bushes.

3. All three crew were found burnt and dead on their seats. They were found bent forward with head down and not touching their laps.

4. At the time of site inspection, the fuselage was found broken from rear of the main plane and was in the inverted position. The vertical fin leading edge facing the ground and the respective tail mounted engines by the side of it.

5. The extreme tail portion was un-burnt and there was no smoke shoot mark on the vertical and the horizontal tail plane. **This indicates no pre impact fire.**

6. Entire wreckage was found confined to an area covering radius of 20 meter from the main wreckage. All extreme ends of the aircraft were within the main wreckage with fire damage. **This indicates there is no fire or structural failure prior to impact on ground.**

7. Test boom attached on the nose was broken and lying forward away from the main wreckage and un-burnt. Parts of nose radome structures were found lying away from wreckage on its forward right side about 40-45 deg. **This indicates aircraft did not crash on its nose.**

8. **Wreckage inspection ground marks also reveals that there was no forward moment of the aircraft after main plane impacted on the hard ground.**

9. The intensity of the fire was observed diminishing from root to tip on both the wings. **Whereas the effect of fire on the extreme nose and tail was observed to be minimum.**

10. A portion of port wing (measuring approx. 3feet long from the tip) semi burnt found lying adjacent to the cockpit portion at an angle (5 -10°) to the longitudinal axis of the aircraft. Rest of the wing at the same angle as mentioned above but fully burnt leaving only the trail of its presence.

11. The Starboard wing found in two pieces sheared off from fuselage semi burnt condition. The root portion is approx. 6 ft and the tip portion approx. 3 ft. The trailing edge of the tip portion is found facing forward (East).

12. The nose section ahead the instrument panel location found in multiple pieces but with out much burn damage. The avionic equipments like VOR, ADC etc libe rated from its location but with severe impact damage. However one of the ADC found with no evidence of any damage. The entire section from cockpit to empennage was completely burnt into ash and lot of molten materials were lying on the ground.

13. Control column found in place with operating cables attached to it. However they were found burnt without deformation in shape. The entire control cable run with respect to aileron, rudder, elevator are found attached either to its control surface brackets or to the operating belcranks / fittings. The cable run (burnt) found running from cockpit to tail almost straight along the axis of longitudinal direction and no discontinuity was observed

14. Engine controls found attached to the control quadrant in cockpit and the operating mechanism. However, few of the operating levers at operating end found sheared off.

15. Pilot / co-Pilot and flight test engineer's seats were found fully burnt and deformed. Seats structure could not be traced except one of the arm rest.

16. All the three undercarriage were in retracted position and found burnt but retained its solidity. One of the nose tyres was found half burnt and another tyre was having only burnt steel braiding wires.

17. One of the crew parachutes was found deployed and found un -burnt lying away from the wreckage. Rest two parachutes were found burnt one of which was 2 meter away from the wreckage and the another one is within the wreckage in cockpit rear section.

18. Five propeller blades were found liberated from their attachments and found lying at different places away to the left of the main wreckage(viewing from rear)

19. Main door and Port Emergency door Handle was found in Open position and Stbd. emergency door handle was in closed position, affected by fire. Main door was slightly damaged due impact. All the three doors were lying away from the main wreckage and hence not affected with the fire except slight burn marks to port emergency door. Stbd emergency door was not having any impact/fire damage.

20. LH engine (on RH side of the fin in site) found in two pieces. PWR section and Gas generator / RGB separated from each other. The RGB is found to have two of its blade attached to it. Rest of the blades (Qty.3) found located north side of the wreckage. All the blades are found defo rmed.

21. RH engine (on LH side of the fin in site) found in three pieces. PWR section and Gas generator section separated from each other. The blade attachment hub with three blades attached to it found lying approx. 12 m aft of the fin on west side. Rest of the blades (Qty.2) found located north side of the wreckage. All the blades are found deformed

22. The digital CVFDR was located inside the wreckage in the tail portion from its mounted location covered with burnt / half melted frames. The CVFDR container w as found burnt externally and no trace of its connectors. The ULB found installed with CVFDR also burnt externally.

23. Solid State Recorder(SSR) which forms part of the Flight Test Instrumentation system was located near cockpit was fully burnt as it was not fireproof.

24. The ELT could not be recovered however six ELT cells were recovered in burnt condition.

The wreckage was reconstructed and **All parts were mostly identified** . But the ELT could not be traced. Most probably it could have burnt in fire as its housing was not fireproof. The ELT was not fitted on load bearing members/frames and is fitted separately on platform.

1.13 Medical and Pathological information

Test flight No:49 of Saras PT-2 aircraft VT-XRM was commanded by WgCdr,22917S,F(P), who is also chief test pilot. Wg Cdr, 23165H,F(P),test pilot was co-pilot. Sqn Ldr, 24746N,FTE AE(M), was flight test engineer on board. There was no other persons on the test flight. All three were charred to death on their seats in the post impact fire after the accident.

Immediately after the accident all three bodies of the deceased were shifted to the CHAF hospital, Bangalore. The bodies were duly identified by Wg Cdr A.C.Mathews (22893T) Admn of ASTE,IAF, Bangalore and were medically declared dead at 1730 hrs IST on 6.3.2009. Later the bodies were subjected to Postmortem medical examination. The post mortem report of the all three deceased crew concluded that the crew were dead due to multiple soft tissue and bony injuries in an aircraft crash at ground impact.

1.14 Fire

The evidences at accident site proved that there was post impact fire. The intensity of the fire was very high and complete aircraft structure was found burnt. The aircraft was destroyed due to post impact fire. There was no evidenc e of pre-impact fire.

1.15 Survival Aspects

The accident proved non survival and all the three occupants of the aircraft were succumbed to their poly-traumatic injuries in the crash.

After the radar contact was lost around 1005 UTC, radar controller trie d to contact him directly and also through PW461(Chennai - Coimbatore) and further on 122.7 and 243 Mhz also. Meanwhile tower received a call from Saras telemetry to check if Saras is in RT contact. Since aircraft was not in RT contact as well with radar, Tower was advised to activate SAR through ASTE. ALH A-67 was requested for SAR and it departed at 1014 UTC.followed by T45(Chetak) from ASTE at 1020 UTC. After some time T55(Chetak)also departed at 1058 UTC from ASTE. Based on the telemetry last observation A67 after extensive search located the crash site to be B251/17NM from HAL. Earlier HAL tried through police control room also to find out the exact location of the crash site and police force informed that they had just information of an aircraft accident near "wonderland amusement park" in a village "Seshagirihalli" near Bidadi. Later police Sub-inspector –Bidadi informed the landmark details of the site which were conveyed to the A67 and T45 to locate the crash site of the Saras aircraft. At about 1100 UTC A67 confirmed the crash of the Saras aircraft in Seshagirihalli village.

1.16 Tests and Research

1.16.1 Failure analysis of main door and emergency doors

After the accident, National Aerospace Laboratories was asked to provide a repor t on the possible failure of the main door and the emergency doors which were found near the main wreckage of the aircraft. Following this, a committee was constituted by Head, C-CADD comprising various experts members to look in to as to how the doors came off the fuselage structure and whether or not there was any failure of locking pins/mechanisms.

The committee examined the doors and the corresponding structures of the fuselage and other evidences. The findings of the committee are summarized as fol lows.

(a) The main door was in "CLOSE" position during the impact of the aircraft on to the ground. The movement of the handle and the pins to "OPEN" position was caused during the impact by the force created due to breaking of the linkages concurrently with the bending/buckling of the door.
(b) The emergency door (LH) was in "CLOSE" position during the impact of the aircraft on to the ground. The reason(s) for movement of the handle and the locking latches/pins to "OPEN" position appears to be the same as that m entioned in the case of the main door.
(c) The emergency door (RH) was in "CLOSE" position during the impact of the aircraft on to the ground. During impact, the locking latches/pins have come out by damaging the fuselage structure. However, in this case, the handle remained in the "CLOSE" position since there was no bending on the linkages or in the door frames as a whole.
(d) the integrity of the locking mechanisms of the main and the emergency doors were intact at the time of impact of the aircraft on to the ground.

1.17 Organizational and Management information

The ill-fated aircraft was designed and developed and operated for experimental test flight by National Aerospace Laboratories (NAL), Bangalore. National Aerospace Laboratories (NAL), Bangalore is an approved Design Organisation by DGCA, India under CAR-21, subpart JA and its approval is valid till 31.12.2009 vide DGCA certification 5-25/97-RD dated 16th march 2009. It was valid on the day of accident. The design organisation approval provides t he scope to NAL to design and develop light transport aircraft "SARAS" and also NAL to classify changes to type design and repairs as major or minor as per the procedures agreed with DGCA. NAL also to evaluate and propose the conditions under which a "perm it to fly" operation can be carried out in accordance with procedures agreed with DGCA. DGCA also approved list of designers of NAL as authorized signatories ie., Showing Compliance Engineers and Compliance certification Engineers(SCEs and CVEs) for SARAS project, on 13.8.2008, apart from the approval of head of design organisation and other managers as per design organisation manual(DOM). DOM was approved by DGCA only on 1st Dec 2008 under CAR 21, subpart JA, issue -II, revision 0.

There was an MoU between NAL and IAF on 14th may 2003 for implementing Saras project. MoU provides the role and responsibilities of NAL and IAF and they also agreed to establish appropriate project management and monitoring structure. As a part of agreement NAL and IAF set up th e Management Committee(MC) which will be the apex body, responsible for flight testing of SARAS prototype aircraft upto the completion of the certification . This MC will deliberate and decide on all major issues relating to flight test planning, sequencing and supervision of the actual flight tests, flight safety aspects, expansion flight envelope and interaction with the certification agencies.

A joint ASTE(IAF)/NAL Directive has been made effective with effect from 28 th May 2004, which clearly lays down the role, duties and responsibilities of key personnel involved in the Saras flight test programme for efficient and safe conduct of developmental flight tests on Saras prototypes.

However from the records made available to the investigation group reveal ed some of the salient observations:

1) Management committee did not play its role as envisaged in the MoU. After Aug 2006 there was no periodical review by MC. Only the joint meeting between NAL and ASTE,IAF was held on 28 th Aug 2008. After this meeting there were 27 test flights (including ACCIDENT FLIGHT)done. There was nothing reviewed. Similarly In 2009 also there was no review of the project by MC or NAL.
2) Similarly there is no evidence made available to show that Local Mod committee is established and functioning properly for its purpose said in the joint directive .
3) Continuous evaluation of procedures/design modification for safe conduct of test flight is not at satisfactory level.
4) Co-ordination with OEMs of engine and MT propellers is not the re after vetting the relight procedure by ASTE for their comments and guidance.
5) There is no proper interaction between NAL and MT propeller regarding the formulation of the relight procedures.
6) There is no contingency plan in detail available in case of mi ssing aircraft/exigencies/loss of communication and accidents etc.
7) No chase aircraft and film shooting facilities were made available to monitor all critical \test flights especially the test flight involving relight procedure.
8) Failure of regular monitoring and improvement on telemetry monitoring systems and their documentation procedures.
9) Failure of monitoring of CVR and FDR in co-ordination with solid state recorder(SSR) and telemetry data for evaluation of better cockpit procedures and design modifica tion
10) Non-inclusion of critical engine parameters like ITT, engine oil pressure etc., essential for monitoring test procedures, in the vacant slots of FDR
11) **Aircraft was used for flying demonstration in Aero India 2009 show at Bangalore. But no DGCA permissio n was taken by NAL for the purpose.**
12) **There is no effective and continuous monitoring of test programme by MC and no records of monitoring available.**

NAL also subcontracted a private agency named Aircraft Design and Engineering Services Pvt Ltd (ADES), Bangalore for supporting Saras project. Aircraft Design and Engineering services pvt Ltd (ADES), Bangalore was approved as a design organisation under CAR21, subpart JB and it is valid till 31.12.2009. The scope of it includes design and engineering support to NAL in Civil Aircraft projects 14 seater Saras aircraft to the parts and appliances complying FAR 25 standard. NAL entered into an agreement with this private contractor company-ADES on 1.5.2008. The following peculiarity was observed while scrutinizing the agreement and its attachments:

1) Even though agreement was made on 1.5.2008 it was made effective from 1[st] April 2008.

   Contractor will engage experienced aircraft designers, engineers and other technical staff required for task as required during different phase of the project. The work schedule of the project also indicates almost complete work of the design and development of SARAS project is being done by the contractor.

2) This is not in line with DGCA approval given to the contractor that of only giving design and engineering support to the parts and appliances.
3) Since this is the national project, utmost vigil and care shall be taken by CSIR, India while implementing project and also the concept of employing the private contractor involving in each and every stage of the design and development of Saras project requires to be discontinued immediately and only the support for the parts and appliances shall be obtained from them.
4) As per agreement Even though NAL shall retain the absolute right on any patent that may be taken from the result of the work, Confidentiality clause of the agreement did not point out the penalty/ punishment action on the contractor under law in case of the pilferage or theft of any technical information such as design, drawings, wind tunnel testing, flight tests results or any software etc.,

   Apart from the above NAL also subcontracted several agencies for getting support facilities and parts for the Saras project.

1.18 Additional Information

1.18.1 Selection of test pilots:

It is learnt that ASTE,IAF is the only establishment in India and one of its kind in the world to undertake test flying both for upgrades of existing aircraft and for prototype aircraft. Presently the only prototype testing being undertaken is for LCA by NFTC, IJT by HAL Flight test centre and Saras by ASTE. All the test pilots and FTE are Alumni of ASTE test pilot school. The test pilots and test engineers are trained to undertake test flying on fighters and transport aircraft. The pilots and FTEs have experience in test flying of other turboprop previously like Dorniers, Avros and AN - 32 of IAF. The aptitude for test flying is evaluated by IAF test pilot school. As there have no remarks against the pilots of accident flight NAL accepted the pilots nominated by the Commandant ASTE, IAF as per the "Memorandum of Understanding for SARAS Programme, dated 14.05.2003 .The deceased Test pilots and FTE were given training on various systems of SARAS aircraft by respective designer and Test Director at NAL. On completion of the training, a request was made to DGCA by NAL for approval of test pilots and Chief of Trial Team. Similarly acceptance of FTE was obtained from the DGCA. Previous experience of test pilots/FTE are examined as per advisory circular 01/2001 issued by DGCA(AED).

Apart from the above, NAL has neither used its own expertise nor outsourced the expertise from other aviation industries to test the Saras test pilots/flight test engineer for their suitability in the civilian test flight wherein experimental aircraft under development is used . Moreover, as per MOU of SARAS program it is understood that SARAS is the first civil turboprop prototype test flying undertaken by ASTE,IAF for which assessment of crew for human factor is important . Human factor/CRM of the flight crew were not assessed by NAL for the civilian cockpit and flight operation environment as the test pilots are basically from the Air force environment. Similarly test pilots/test engineer also did not undergo any human factors tr aining before operating the test flights on VT-XRM. No documents were provided to the investigation team on the subject matter.

1.18.2 **Preflight and post flight requirements:**

NAL reported that the following arrangement are available for the purpose of Briefing / debriefing:

For each test flight, the team consisting of Flight crew, Flight Test Engineer (FTE), Design group, Flight planning group along with Flight Test Director will discuss the programme and conditions. FTE will convert this programme and conditio ns to test card and test schedule. The test card is approved by Test crew and FTE. During pre - flight briefing any change in test schedule or test points are discussed and incorporated. Also contingency action for specific emergency/precautionary procedures are discussed during pre-flight briefing, attended by Officer in Command - Proto type test squadron (OC/PTS), Flight Test Director (FTD), Test crew, FTE, Chief of Design, APD/FTG, Telemetry monitoring team, Flight operations in -charge, aircraft maintenance in-charge and crash/chase vehicle coordinator. Flight test schedule is signed by Test crew, FTE and Chief of Design. The program and condition for each flight is transmitted to DGCA R&D prior to pre -flight briefing and conduct of test flight. Block of 10 or 20 test flights are normally approved by DGCA -ADE based on test plan submitted by NAL. Individual test flight "Condition and Programme " is submitted just a day prior to actual test flight no 49.

After completion of flight, a hot-debrief is given by the flight crew at the telemetry of ASTE and the same is attended by those who were present in the flight briefing. Once the data has been analyzed by the NAL Flight Test team, a detailed data debrief is conducted at ASTE/NAL where all the observations ar e discussed and the results of test points are accepted or repetition of some of the test points are discussed. Prior to conducting the next test flight aircraft readiness is authorized by individual monitoring and analysis team for the following discipli nes: Aerodynamics, Engine/power-plant, Systems, Electrical/Avionics, Telemetry and Maintenance / Operation and FTD.

As a defined procedure, pre-flight briefing is always carried out by the Flight Test Engineer who is part of the flight crew. For the ac cident flight ,the same was done on 6th March 2009 afternoon. The briefing covered aircraft SOP for this flight, work done on the aircraft prior to this flight, configuration limits, test points & test sequence according to the issued test programme and safety considerations. Details are as per flight test schedule dated 6.3. 2009. Flight crew, including the pilots and the flight test engineers, were present. From NAL side the following were present: flight test director, APD (flight testing), PD (Saras aircraft project), members of real-time monitoring team, inspectors from various trades, ground crew, design representatives from relevant disciplines. At the end of the briefing, the pilots were specifically told by the Flight Test Director that in case of any problem during the relight attempt, the engine should be switched off, propeller feathered and single engine landing executed.

No effort should be made to try the relight a second time. These detailed discussions were nowhere documented/minuted.

It has also been reported that the preflight briefing meeting were done before the accident flight. Scrutiny of documents/records revealed that preflight and post flight debriefing of the test flight /to the test pilots were not effectively documented at each and every flight. Moreover the available documents did not include contingencies plan/procedures for unexpected exigencies/missing/loss of communication/ accidents etc.,

Similarly there is no documents made available to indicate the existence of ef fective prefight and post flight medical requirements and its compliance for the test crew. Also there is no proper system exist to monitor the fatigue level of the test pilots prior to the test flight.

It has been reported by NAL that at any stage of d iscussion including critical flight test like "engine shut down and relight" no DGCA official took part. Only the documents are transmitted to DGCA for approval/acceptance/acknowledgement. As the Saras project is national project and involving country's dignity It is felt necessary that either local DGCA Officers or DGCA HQ officer should have participated for effective guidance and timely implementation of each phase of the project. DGCA being the approving authority of the NAL, design organisation and the Saras experimental aircraft as well production aircraft and Since huge public money is involved in the project, DGCA's serious involvement is a must for effective control on the project.

1.18.3 Effective oversight functioning of DGCA,R&D(AED)

When the prototype is completed, NAL submits test plan for block of 10/20/25 flights along with aircraft definition document/SOP. After scrutiny by DGCA(R&D) Head Quarters / Bangalore office will grant permission for conducting test flights. On completion of approved block of test flights, a summary of the test report together with test plan for next block of flights is submitted to DGCA and clearance obtained for continuing the test flights. Further the test program and conditions are prepared for each individual flight in consultation with test crew and submitted to DGCA local office a day prior to execution of flight. During the scrutiny of various programs and records of Saras project it is revealed that there is no continuous monitoring and effective control over the project by DGCA(R&D). Saras being the national project by NAL, a Govt. of India organisation, and approved by DGCA under aircraft rules, much more participation and effective control by DGCA on the project is essential and important.

Some of the serious lapses noted are:

1. NAL without DGCA's permission took part in Aero India show - 2009 from 11.2.2009 to 15.2.2009 covering test flight no: 40 to 46 using Saras PT2 VT - XRM at Bangalore and demonstrated the flight to public upto low alti tude of 300'AGL over Yelahanka airfield.(actual test area: Bangalore LFA), for which no test report were submitted by the test pilots. Participation in the AERO India show

-2009 was planned in the month of Aug 2008 itself. NAL reported that the information of their participation was however, submitted on 9.2.2009 to DGCA. But there is no documentary evidence provided during the investigation for the approval from DGCA. No action was taken by DGCA(R&D) also to restrict their participation. Saras PT- 2 being the experimental prototype aircraft under test and C of A is not yet given to the aircraft, participation in the public demonstrative flight show and that too at low level of 300' AGL is dangerous to the life of the public and their properties. It is also not understood that how the Show Owners/Conveners accepted the uncertified aircraft for flying demonstration in the public show.

2. While giving flight clearance including engine shut down and relight flight tests there is no restriction made on minimum altitude by DGCA.

3. Uncertified propeller is tested on locally fabricated engine test rig, which does not have DGCA approval. No inspection by the DGCA on these facilities for approval even though papers were submitted to them.

4. There is no periodic monitoring of CVR and FDR by NAL

5. No contingency plan for communication failure, accident, missing aircraft etc.

6. Non-participation and strong guidance in critical flight tests procedure like engine shut down and relight test programme.

1.18.4 **Periodical monitoring of review of CVR and DFDR:**

From the records made available to the investigation team it is clear that CVR and DFDR data was not monitored for each and every flight of Saras PT2 aircraft. There shall be a dedicated experts to do these continuous monitoring for improving the cockpit procedures and discipline apart from evaluating the design modification requirements using DFDR data in collaboration with telemetry data and SSR data.

According to FAR Part 121, paragraph 121.344, no person may operate a turbine powered transport category airplane unless it is equipped with one or more approved flight recorders that use a digital method of recording and storing data and a method of readily retrieving that data from the storage medium. The operational parameters being recorded on the SARAS aircraft by the digital flight recorder as per Vol 10, DR - 36 noted above. All parameters mentioned are being recorded with the ranges, accuracy and resolutions as specified in Appendix M of FAR 121.344. This is also in accordance with the latest NTSB recommendations.**(also AS per note 3 of flight recorder – CAR Sec 2 ser I, Part V)**

However it is understood that DFDR **does not have engine parameters like engine oil pressure, ITT and fuel flow etc to monitor these in relight procedures and the engine performance.** It is also revealed that the SSCVFDR installed in SARAS aircraft has a capacity to record at the rate of 128 words / second. That means 128 parameters of 12 bit resolution can be recorded in one second. At present 100 slots of 12-bit are full and 28 slots of 12-bits are vacant. It means that **SSCVFDR still has**

room for accommodating another 28 parameters of 12-bit each. The above mentioned critical engine parameters like ITT, Oil pressure, fuel flow etc are hence to be included in the FDR.

It is therefore felt that NAL should have prudently included the above mentioned parameters as the slots are still vacant. There is a need to re-look at the parameters being recorded in FDR by a expert team in the field to include additional 28 parameters (could be engine or airframe parameters) .

Similarly it has been reported by the investigation team that the elevator position reading throughout the test flight was noisy probably due to intermittent signal loss in the data. **Hence Elevator position indication needs to be rectified.**

DGCA(AED) office at Bangalore and At HQ also should not exercise the proper control on the matter

1.18.5 Test flights acceptance by AED, DGCA :

There was a request from NAL in Oct 2008 for 15000 feet flight clearance. DGCA(AED),Bangalore Granted flight clearance of 15 flights to SARAS PT1 and PT2 aircraft for higher altitude flight upto **15000'** vide AED letter no.BLR/AED/SARAS/2008-08 dated 21.01.2008 to carryout

a) low speed handling checks including approach to stall and stall test
b) Engine re-light checks(one engine at a time)

subject to certain conditions. In one of the conditions (para c)of the said DGCA letter, it is stated that a copy of the emergency procedure and the flight test schedule/order may be submitted to this office prior to commencement of test flights for acceptance.

But, as per records, it is learnt that NAL did not obtain necessary acceptance from DGCA even upto the last fatal flight no.49 and no information/correspondence received from NAL about carrying out the flight test.

However it is not understood till 49th flight test how DGCA-AED,Bangalore was just sitting as a spectator while all the flight tests were being conducted with their awareness. At no stage of previous test flights and their correspondence also the above lapses were not pointed out to NAL, Bangalore. DGCA-AED failed to ensure the conditions given in their flight clearance in spirit.

1.18.6 Review of SSR –flight instrumentation system:

It is given to the knowledge that the aircraft is also fitted with Solid State Recorder(SSR) for the purpose of assessing the complete flight performance of the aircraft. It records quite large no. of parameters even better than FDR. It is also understood that it was not housed in a fireproof and crash proof unit. In the accident aircraft it was completely burnt and no data could be recovered from that unit.

NAL should explore all the possibilities of having more safer SSR housing unit from the point of fire proof and crash proof till the Saras aircraft is released for production flight.

1.18.7. Electrical system and role of Auxiliary battery

To understand role of auxiliary battery in relight operation electrical system of the aircraft is necessary to be understood

Electrical System Architecture

Electrical System Architecture for SARAS Aircraft is as follows. Two starter / Generators serve as main power supply sources. The same star ter/generators serve as starter motors during starting phase. The capacity of each generator is 400 Amps at 28 Volt; the over load rating of the starter / generator as generator is 600 Amps for 2 minutes and 800 Amps for 5 seconds.

One Main Battery (Ni-Cd) of 44 Ah capacity is used as emergency power source. The same battery serves as internal starting source.

One Auxiliary battery (Ni-Cd) of 16 Ah capacity is used for the following purpose (during starting phase):

To improve voltage supplied to GCPU (Generator Control & Protection Unit), CWP (Central Warning Panel), Fuel flow meters. Also the auxiliary battery serves as additional emergency power source during double generator failure.

Reason for introduction of auxiliary battery.

During starting phase of Saras aircraft development main / emergency bus voltage dips below the operating voltage of Generator Control and protection unit (GCPU), Central Warning Panel (CWP) & fuel flow system due to large motor starting current.

It was found necessary to provide a separate Auxiliary battery and bus bar for these circuits to over come the low voltage problem while starting.

It is to be noted here that Auxiliary battery is not meant to supply starter motor current during starting cycle (on ground and in air).

After starting cycle is completed the auxillary bus bar will be powered by main power source (generator supply) with auxiliary battery under float charge.

The electrical circuit is so arranged that both the emergency bus and auxiliary battery bus are powered by 44 Ah main battery in case of double generator failure (probability is extremely remote) In that case the auxiliary battery bus bar can be isolated and powered by auxiliary battery by selection.

Auxiliary Battery Selection Switch

The Auxiliary Battery is controlled by a three position switch, as follows: The three positions are 'ON', 'OFF', and 'CHARGE'.

1. **Position 'OFF'**
The Auxiliary BATTERY is separated from all bus bars. (This battery does not supply even to Auxiliary battery bus bar). However the Auxiliary Battery Bus bar is connected to the emergency bus bar supplied by the main battery.

2. **Position 'ON'** (The Auxiliary bus bar is isolated from main and emergency bus bars)
The Auxiliary battery is connected to Auxiliary battery bus ba r and supplies (discharge) current to all loads connected to Auxiliary battery bus bar only i.e. GCPU, CWP and fuel flow meters. Hence any voltage dip on other bus bars will not affect the Auxiliary battery bus bar (especially during starting cycle).

3. **Position 'CHARGE'**
The Auxiliary Battery is isolated from Auxiliary bus bar and connected to main bus bar for getting charged by generator. Now the Auxiliary battery bus bar is supplied by main power sources (Generator).

Indications and Warning:

a) Main Battery Discharge Warning.
Main Battery Discharge warning will come 'ON' for the following conditions and when the discharge current sensed by the current sensor in DC master box is more than 6 Amps.

1. During internal starting (Main battery)
2. During cross starting (Main BAT + GEN)
3. During double generator failure.

During this condition battery is supplying power to the loads connected to emergency bus bar. Audio warning comes 'ON' along with indication, in CWP.

b) Battery Indications:

Main Battery:
1. Battery disconnect (RED lamp in CWP).
This lamp comes 'ON' when battery is not connected to emergency bus bar.
2. Battery discharge (RED lamp in CWP with Audio warning)
3. Battery 'HOT' (RED lamp in CWP).
This lamp comes 'ON' if the battery temperatures rises above 71 °±2^{0}C.

Auxiliary Battery:
1. Aux. Battery disconnect (RED lamp in over head panel):
This lamp comes 'ON' when battery is not connected to main bus bar.
2. Aux. Battery 'HOT' (RED lamp in over head panel):
This lamp comes on when the battery temperature rises abo ve 71±2^{0}C

1.18.8 Discussion on Synchronization of Propeller Control and Fuel Control

In Saras PT2 VT-XRM aircraft, concept is Three control levers for power, propeller blade pitch and condition are provided on pedestal in cockpit within the reach of both pilots. The mechanical movement from cockpit is transmitted through flexible ball bearing controls to corresponding levers on engine.

Power lever controls the engine power and also selects reverse pitch by blade pitch variation. Propeller lever controls pitch at max. RPM, min. RPM and feather. Positive stops are provided on quadrant so that inadvertent operation to feather regime is prevented.
The required power is selected by means of power lever in direct proportion to torque. It has max. power, idle and max. reverse.

Condition lever has three positions: off, low idle (53% NG) and high idle (70% NG) with positive stops.

Propeller control lever movement provides smooth propeller operation (pitch change) within control range. The propeller lever has a governing range between max. RPM and minimum RPM positions and feather range.

The blade pitch is controlled automatically in flight to maintain the RPM constant to pre-selected value. The chosen relationship of engine power to propeller pitc h depends on operating requirements. Based on propeller RPM selected, turbine governor section of propeller governor limits engine power according to ability of the propeller to absorb the power at that speed. When lever is pushed fully forward, pitch chan ges from course pitch to fine pitch (high RPM).

Whereas in P.180 Avanti II aircraft. There exists two -lever concept.ie., power and condition levers The engines and propellers are operated by two sets of controls mounted in the control pedestal below the centre instrument panel.

The power levers (left side of pedestal) control engine power through the full range from maximum takeoff power down to full reverse. They also select the propeller pitch (beta control) when they are moved back from the detent. A gate provides unrestricted power lever movement from idle to maximum forward but requires the power lever handle to be pulled up before movement can be made from idle to reverse. Each power lever operates the NG speed governor in the fuel control unit in conjunction with the propeller cam linkages. Increasing NG results in an increased engine power.

The condition levers (right side of pedestal) provide the propeller speed commands as well as the fuel cut-off and propeller feathering functions. (ie combined propeller control and fuel condition lever.) In flight, the condition levers provide the speed commands to the propeller governor for setting the desired propeller speed. The condition levers are utilized to select high (about 70%) or low (about 54%) idle. Ground idle (low) is the normal condition for ground operations. Flight idle (high) is needed on ground for maintaining low ITTs during periods of high generator loads at high ambient temperatures or when increased bleed air flow is necessary. Moving the condition lever aft from the G.I. position, over the gate, and aft to the FTR(Feather) and CUT OFF results in propeller feathering and fuel cut -off.

The above concept of two lever, single control box operation is easier compare to the three lever operation. NAL should explore the above concepts to adopt in future Saras project for achieving well coordinated cockpit control by the pilot.

1.18.9 Status of ATR on Inspection by DGCA authorized inspectors :

As per the instruction of DGCA, Delhi Air India engineering team had visited NAL, Bangalore from 6th Jan to 9th Jan 2009 to review and study the avionics and electrical systems of SARAS aircraft VT-XSD for the purpose of type certification, design, implementation and system architecture. Certain observations were indicated for improvement by NAL.

There were 31 major observations made for implementation. Some of them were pending for implementation. These were regarding provision of spare cables in each loom, flushing of pitot probe and AOA with fuselage, position of pitot probe water drain hole, pitot probe heating, warning for emergency door opening. However these were not contributed to the accident.

1.18.10 Propeller certification

1. *Selection of engine-propeller combination*:

Since PT6A-67A engine that was flying in Beech star was selected for SARAS PT -2 , the obvious choice would have been the same propeller driven by this engine on the BEECH aircraft. McCauley, USA supplied the propeller for the Starship power plant. McCauley have stopped the production of this propeller and they have no interest in starting the production line again only for one customer. The other alternatives were also explored and finally discussion held with MT propellers of Germany and a propeller development programme was finalized. Broad details of the 1200 SHP, 1700rpm propeller for PT2 are given for the purpose. MT propeller has been in business of development of propellers for the past nearly 25 yrs for general aviation aircraft. They also have developed larger propellers for various specific applications and have enough experience in design and development of propellers. They also have a facility in Poland(AVIA) to design and develop large metallic propeller(Since last 75 years). The total system weight of Hartzell propeller is 93 kg with Aluminum hub to be qualified with Aluminum material and 108 kg for MT propeller. After the comparison of propulsive efficiency of the MT and Hartzell propeller, MT propeller was chosen as it has higher efficiency. Because of the competitive cost, aggressive development schedules and the rich experience behind, MT propeller was selected for Saras PT2. The test propeller was delivered and 200hrs of endurance test have been completed successfully at NAL facilities, as part of certification tests, along with PT6A-67A engine. The engine-propeller combination has thus been proven for SARAS PT2 aircraft.

2. On the day of accident, MT Propeller fitted on the accident Saras aircraft is not certified propeller by any competent authority ie.,FAR/EASA or Indian DGCA as on date of accident. It was manufactured in the year 2005,September, as per the requirement part 21 by MTP,Germany . Though it is uncertified NAL opted for it due to the above selection process.

3. NAL reported that the MT propeller fitted on the accident aircraft was made as per their specification. it is yet to be certified by competent authority due to other technical/test requirement like actual vibration test in flight. These propellers when received from MT propeller, Germany by NAL in the year 2006 there is no declaration of airworthiness fitness made by NAL for its usage on Saras aircraft. Nor any *provisional clearance was obtained from DGCA for its fitness to fit on the aircraft till the propeller is certified.*

4. The variable-pitch propeller system must be subjected to the applicable functional tests of this section. The same propeller system used in the endurance test must be used in the functional tests and must be driven by a representative engine on a test stand or on an airplane. The propeller must complete these tests without evidence of failure or malfunction. This test may be combined with the endurance test for accumulation of cycles.

5. To comply with the above requirement, the propeller was fitted on PT6 A-67A engine and the tests (functional test and endurance test) were carried out. However No wind tunnel tests have been called for in FAR 35. NAL at their facilities has successfully carried out 200 hours tests (150 hours endurance tests+50 hours function al tests) during the period between 18th January to 26th July 2006 for the purpose of seeking type certification of the new MT propeller for the SARAS -PT2 aircraft. The tests were carried out based on JAR-P-210 (B)(1)(ii) / CS-P 390(b)(2) / FAR 35.39(c)(2), applying JAR-E 740(c)(1), CS-E 740 (c) (1) and FAR 33.87 valid for turbine engines with standard ratings (Maximum Take-off and Continues Power). Functional test was done according to JAR-P210(b)(2) or FAR 35.41 (2 hrs per stage).

Result of the above tests concluded that All the PT6A-67A engine parameters (both installation and engine indicated parameters) were compared with the limits and found to be satisfactory. Dynamic balancing was done for the MT propeller along with PT6A - 67A engine was done and the vibration levels were brought down from 0.91 ips to 0.11 ips by addition of balancing weight of specified locations. *However the propeller vibration check on the aircraft is kept pending and this also to simulate actual condition of vibration.*
Moreover the engine test stand/rig used for this purpose is locally fabricated and does not have any approval from DGCA.

6. After the endurance test, MT propeller issued "Statement of Compliance and Inspection" Nr 241106 Issue November 24, 2006. Wherein NAL was given the approval for 100 hr. flight and it has also been mentioned a TBO of 72 calendar months. Since the propeller is not yet formally certified, the reason for accepting the long calendar months by NAL is not understood and no other aviation in dustries was consulted prior to its acceptance.

After the accident, MT propeller clarified that :

(a). The TBO of a propeller is always divided into hours and calendar month, because both may have effect to airworthiness. Because it is not yet fully test ed (vibration flight test not completed) only 100 hours initially allowed , full 72 month is used for TBO, because a reduced calendar time limit was not necessary. This is a normal procedure they use with all propellers.

However it is to bear in mind that it is uncertified components going to be used in prototype aircraft it can not be straight away used for 72 months. NAL Should have consulted other aviation industries before following the TBO of 72 months.(Note: first flight test done on 18.4.2007) propeller was purchased in the year 2005, September.

(b). NAL and MTP have conducted a 150 hours type tests with this propeller at NAL test bench in Bangalore and this bench test included also a functional test as well as a vibration test on ground (non-flying) and a tear-down inspection after the run. This was enough for MTP, to show, the propeller could be safely operated within the desired envelop of the aircraft/engine combination. A second vibration test was intended to be done, once the aircraft was cleared for the entire flight envelope, which was never conducted.

(c). Because it did not complete the inflight vibration test, the MTV-27-2-N-C-F-R(P)/LD265-417 was never fully certified by the EASA since MTP could not show compliance of this part per CS-P.

(d). They have to certify the propeller according to CS-P first before they can get FAA Part 35 approval. In order to get the -2 model fully EASA certified, they have to complete the in-flight vibration test and if this does not show any negative r esults, the TBO will be established for 1500 hours.

It must be noted that there are other tests like Fatigue Characteristics,centrifugal load test, lightning strike tests etc., are yet to be completed for EASA certification purpose.

It is hence concluded that NAL used uncertified propeller either by country of manufacture or by the country of test flying. On receipt of the propeller and prior to use on the aircraft it was not declared "Airworthy" by the NAL.

1.18.11 Discussion and clarification by MT Propellers :

After the accident the propeller OEM-MT propeller have been discussed along with investigation team and NAL to provide certain clarifications. As per OEM of the propeller the following are their detailed clarifications/explanati ons:

1) It was informed by MT propeller that the present feathering angle setting (low: 11 deg, high 79 Deg)communicated by MT Propeller to NAL is based on theoretical calculations only. This would be fine-tuned during flight testing. Minimum engine oil pressure needed to start un-feathering the propeller is any thing above zero and min servo oil pressure needed to overcome the feathering spring piston is 80 psi approx.

2) Drop in Np during both relight attempts would occur only with propeller lever pul led back from fully forward position.

3) Flight clearances were given to NAL for 100 flight hrs based on endurance tests. The factory setting was 11 deg for low pitch and 79 deg for feathering. There is no other aircraft fitted with this engine propel ler combination of Saras PT2. Min eng oil pressure required to start un-feathering the propeller is above zero.

4). **Propeller control lever should be in "Feather" position for engine relighting and only to move forward after attaining the stabilized Ng at flight idle (ie 50 -55%)as per engine manufacturer**

5). MT propeller does not have any data on windmilling drag characteristics of Propeller as no testing was done for that and hence not supplied to NAL

6). MT propeller was in constant touch with NAL till the clearance of 100 flight hours of propeller is completed by Fax and Mail, but not for relight procedures.

7) There was no SOP issued by MT Prop to NAL for re -light procedure

8). As per them there can not be any other failure in the propeller/engine which could have led to the situation experienced in the accident except not moving the propeller to feather for relighting procedure.

9). The propeller was not tested for windmilling conditions during design as it is not covered under requirement

10). For the query of When an engine is cut off in flight and propeller remains feathered and Ng is 7% and Np at 1%, the oil pressure at 6psi --what malfunction in the engine propeller system can cause Np to raise continuously from 1% to 100% in about 14 seconds. (the propeller lever is placed in "fine position" towards preparatory for engine re-light) , it is clarified that If a propeller is feathered, it usually should stand still at Vy. The blade angle to get this must be adjust ed during the flight tests, which was not completed, because our chief engineer or me was not present at the first flights, because it was decided to come for the in-flight vibration tests, once the full flight envelope was opened, which was not yet comple ted. Therefore, we could not adjust the feathering angle for a stopped propeller, in particular important for the engine.

11). If the pilot(s) feather the propeller for a single engine test flight, the propeller levers must remain in feather position. Since the propeller lever was moved forward to max rpm (fine pitch), the propeller behaved normal and because of the existing oil pressure from the engine and the rotating propeller (Np) greater than zero %, the propeller unwinded out of feathering, at the beginning slowly because of the low rpm and hence low servo pressure from the propeller governor, but increased the rpm faster with the windmilling reaction until it reached 100% Np (or close to).

12) For why Ng went never to zero % when the co ndition lever was pulled into fuel cut off must be answered by PWC. According to one of their test pilots, which has a Beech King Air rating, an air start is also possible with the PT6A - engines and some ram air, which means to us that at 130/20KIAS there was enough ram air blowing into the gas generator and turning it at 7% in this condition. Essential for them as the propeller people is, that the rpm lever should have been left in feathering position for the engine restart and only moved forward, once the Ng is stabilized at flight idle (50 - 55 % or whatever is specified for the engine in question). Since they do not know, what basic AFM was used for train the pilots (they recommended the Beech 1900 -D because it uses -67 engine) some mistakes should hav e been avoided. Again, this is what I do not know and therefore, it is hypothetical.

13). For the query, Can this situation given at above, occur on account of gradual increase of oil pressure by the propeller governor gear pump to a value which overcom es the opposing spring force and thus results in propeller unfeathering process to commence. It is explained that This is absolutely correct. As explained above, there was engine oil pressure supplied to the propeller governor (the governor need always pre-pressure at the pump inlet) and while the propeller was turning with increased rpm, the governor pump increased pressure and flow and pumped the propeller out of feathering, first slow, but with decreased pitch faster and faster until the propeller blades reached hydraulic low pitch stop and consequently 100 % Np in windmilling configuration at 130 KIAS, creating a lot of drag, perhaps too much for controlling the aircraft. Help would have been to feather the propeller again in order to reduce the excessive drag from the windmilling propeller. Whether the airplane could be still controlled in such a configuration must be answered by the designers.

14) ***It was also confirmed that as the system behaves normal as seen from data (prop control full forward), there was no malfunction of the propeller system.***

15) For the query, there have been two attempts to relight the engine in air. The first attempt was unsuccessful and the second attempt, though successful, was too late --just a few seconds before the crash. However, it is noted that on both attempts when Ng started building up (and oil pressure increased), the Np has reduced substantially during the same period. In the first attempt, Np reduced from 100% to 83%, and in the second re-light attempt, the Np reduced from 85% to 61 %. What would be the possible explanation for this?

    It is expressed that the increased Ng needed some engine oil for lubrication and therefore, the pre-pressure dropped and consequently the servo pressure from the governor, which will move the blades towards high pitch (counterweights and springs) and a drop of Np will occur.

16) For the query , Is it possible under the earlier condition mentioned above , the propeller will not respond to feather command, it is clarified th at No, not at this speed of 130KIAS. At higher speeds, it could be possible, if the counterweight mass is not high enough. But since the propeller initially feathered, it can be assumed, the system functioned normal. Measuring the servo pressure would have been part of our tests requirements, especially at high speeds up to Vd, but this was not possible because we had to wait until the flight envelop was fully opened.

17) For the query, Before the engine re-stated, when the propeller lever is placed in fi ne position and Np starts raising due to unfeather action (even at low oil pressure) it is expected that the propeller blade angle will not go below the PBA setting. If the wind milling Np raises to approximately 90% and with propeller at PBA, would the di sking drag be so high as to make the aircraft uncontrollable at the speed of 130 knots.

    MT propeller clarified that assuming that the system functions properly, there is no way to get the blade angles below the hydraulic low pitch stop and as mention ed above, there will be a lot of drag from the windmilling propeller at the given pitch setting on one side and perhaps a lot of high thrust (depending on power setting of the running propeller) on the other side. This asymmetric thrust must have been calc ulated by the aircraft designers and defined. Again, this will be a certification criteria and cannot be commented from our side. However, that there is a problem also with the P - 180 aircraft but no detailed facts are available.

18) It was further clarified that, when the governor starts pumping the propeller out of feathering, the process starts slowly and as the blade pitch decreased, the rpm increases until at a certain pitch, the wind catches the blades and the rpm increase is quite rapid. This is similar on any installation, so nothing special. This is why it was recommended recommend to pilots that they should not move the rpm lever all the way to max. rpm at an air-restart, but only slightly over the feather gate in order to avoid over speeding at this very second, when the wind catches the blades.

19) It is also reported that Since Ng is already turning at 7% (producing the engine oil pressure for the governor), it is unclear , why Ng of about 12% cannot be reached by the starter-generator for relighting the engine. If you have also recorded the position of the condition lever and if this was moved forward out of the fuel cut -off position, there is no real reason for not getting the engine started at or around 10,000 feet. According to MT propeller test pilot, Beech allows engine restart at altitudes up to 20,000 feet.

20) **As a propeller manufacturer it was reiterated again, the normal procedure for the engine re-start would be with the propeller in feathering.**

21) It was firmly told that Since Np and Ng did not stop in feathered configuration with fuel cut-off, the engine produced still oil pressure, high enough to supply the primary governor with engine oil and hence the propeller behaved as designed and required and pumped the propeller out of feathering into low pitch (full fine), resulting in 100% Np, creating a lot of drag.

The only one action to prevent such a situation would have been to keep the propeller in feathering position, which means the propeller control must stay in feathering position. This was not the case and the consequent result is known.

22) It was also explained that CTM and ATM do not play a factor here, because, there was no attempt from the pilot(s) to feather the propeller again. As the engine is a twin shaft turbo prop, the power turbine run freely from the gas generator and how much influence the reversed airflow from the power turbine (driven by the windmilling propeller) on the gas generator has must be answered by PWC. The same is with the influence of the engine starting procedure with a windmilling propeller, because only the gas generator was started, not the power turbine, must be answered by Engine – OEM. If the beta linkage fails for any reason, the beta valve closes and the propeller is turning towards high pitch (20 feathering) because of the lost servo pressure and the leakage in the oil transfer system at the propeller shaft.

1.18.12 Mismatch of CAS on EFIS.

There has been couple of occasions during the sortie mismatch of CAS on two EFIS. This could be due to the presence of NLG blanking the feed to the pitot head **Suitable modifications on Saras aircraft Pitot system or Nose Landing Gear D - Door mechanism (the D-Doors could be flushed when Nose Landing Gear is extended at certain angle of side slip) to be incorporated by NAL** so that there is no mismatch of CAS between the two EFIS in flight.

1.18.13 Clarification by Engine manufacture on relight SOI:

During the deliberations with engine OEM(P&W), it has been replied by them that "Engine is capable of starting with propeller in any operating position and has nothing to do with the propeller" is not in good spirit as an established engine manufacturer having worked with probably all known propeller industries.

As per OEM engine, as far as propeller concerned , the recommended pre air start check procedure for Normal Air Starts is : ***Propeller Control Lever- anywhere in operating range with Note That: propeller feathering is dependent on circumstances and is at the pilot's discretion.*** Fine pitch selection will provide increased gas generator wind milling speed for emergency starts in the remote event of starter failure. Operating range of the propeller pitch is away from feathered position, during the whole flight profile. The note regarding emergency starts further makes the feeling that the fine pitch is a better choice. NAL and ASTE crew have gone strictly by their documents and answers to their TCM.

For the question of "Why only general engine relight SOP procedures were given when it is known that at least some aircraft can have problems with relighting with propeller other-than-feathered position?", P&W replied that the present Specific

Operating Instructions (SOI) has a Note under relight procedure which talks about feathering function which is under pilot's control. **There are installations where start is achieved with propeller out of feather. However, such evaluation is typically done at the end of development testing by design agency to establish the best re - light procedure. It is opined that no relight should take place until aircraft has flown full envelope and aircraft's aerodynamic characteristics fully understood.**

It was ascertained by P&W that *The present Installation Manual covers 14 engine models which were certified using similar SOI. No issues were reported during relight certification testing.*

However NAL reported that No clue was arrived till the accident day that a turboprop with free turbine configuration, **the propeller lever should be in feathered position to avoid disk Drag and abnormal behavior of the propeller etc., recorded in the** accident flight. Since NAL was concentrating only on relighting of engine in the air, the propeller OEM was not consulted at any stage prior to finalisation of the relight procedure.

As an approved Design organisation this should have been the hindmost sight of whole Saras project team and MC. However they failed in this aspect.

For the likely cause(s) of failure of first relight attempt it has been commented by P&W that From the telemetry there is fuel flow indicated before the engine re - light is initiated. If this is true then it is possible that the igniters became 'wet' with fuel and did not provide the required ignition source during the first re -light attempt. However, this is not considered as likely as the second re-light attempt was successful with no exceedance or rapid rise of ITT during this relight. It is opined by P&W that a more likely scenario is that the re -light procedure on the first attempt was not completed .The start sequence appears to be completed on the second attempt. This resulted in a normal air re-start with all parameters being as expected.

It is also now clarified by engine OEM- P&W for foot note of SOI "Relight normally should be obtained within 10 secs". It means that it should be obtained within 10 secs of Ignition ON and fuel ON command. Please note that it is not related to the time for an engine to reach idle speed. 50% threshold is recommended min Ng to cut-off starter motor during the start, after that engine Ng will keep accelerating till normal idle is reached and start sequence is completed.

1.18.14 STATUS OF TELEMETRY SYSTEM USED FOR SARAS FLIGHT TRIALS

The telemetry ground station being used for the Saras Program is stationed at ASTE and comprises of RF system (tracking and proximity antenna, receivers and demodulator) provided by ASTE and PCM decommutation system and PC based monitoring stations, video camera, LAN and H/F R/T sets provided by C -CADD. The ranges obtained with the telemetry system are generally in the vicinity of 60 km with the main tracking antenna and 5-10 km with the proximity antenna, which is considered quite poor compared to the ranges close to 250 km provided by the telemetry system at HAL Flight Test Centre being used for LCA and IJT. Factors which affect the telemetry range are the receiver chain on ground, telemetry transmitter being used and the antenna configuration on the a/c as well as on ground.

On the day of accident it was reported that the Autotracking func tion of the telemetry system was unserviceable and elevation control was not available. The tracking in azimuth was being done manually by monitoring the signal strength and aircraft position. The monitoring group is stationed along with Flight Director in the 2nd floor while tracking group is stationed in 3rd floor (Rx room). When aircraft taxies out the aircraft is tracked closely by the antenna by maximizing Rx signal strength. The control unit has also that AZ / EL display on the panel. Whenever the tra cking engineer loses the position of aircraft in flight, he seeks the help of Flight Director to get the aircraft location.

The ground telemetry station has the following weak areas: -

(a) Tracking unit and antenna control unit (ACU) of the RF system do not have any redundancy. The elevation control of ACU was unserviceable. Auto tracking was possible only in azimuth.

(b) Though two telemetry receivers were available, the RF input to the receivers was given independently from tracking antenna and proximity antenna, and automatic source selection was not available.

(c) There was only one demodulator in the telemetry chain and its failure would result in a complete link breakdown.

From the discussions held with the various members of the telemetry group it is inferred that the height and distance for carrying out various critical test points was governed largely by the coverage area of the telemetry system. During the sortie there were frequent link breaks, which increased towards the later part. This probab ly affected the proper monitoring of the parameters by the telemetry group. Further, due to the absence of any R/T calls from the crew towards the end, there was a total lack of situational awareness among the telemetry group. Availability of a hot mike sy stem in the cockpit would have helped the test director to be in constant communication touch with the test crew. This would especially be helpful in high workload conditions wherein a pilot may not have the time to press the PTT to transmit.

There is a telemetry link break every time during engine start up. This is probably due to the fact that the telemetry transmitter operates in the voltage range of 25 -32 volts and during startup the bus voltage dips below 25 V. As the voltage is restored the transmission restarts. Hence, it is suspected that the two telemetry link breaks of approx 20 sec during relight attempts prior to the accident are due to this reason.

In view of the above, the following is to be considered for the telemetry system: -

(a) The ground telemetry tracking and RF system should be replaced / upgraded with an advanced system with adequate redundancies.

(b) The telemetry transmitter in the a/c should be replaced with a better transmitter, which would be able to give better ranges.

(c) The antenna configuration on the a/c should be optimized in order to give better coverage in all attitudes and directions.

(d) A hot mike system should be introduced in the cockpit in order to give continues hands free transmission of all communication between the crew as well as with the telemetry ground station.

(e) Recording facility should be provided in the telemetry station for the R/T communication between the aircraft and telemetry station.

(f) Necessary modification may be carried out on the aircraft to isolate the telemetry and FTI system from the main bus bar during an engine start up and put it on a standby battery in order to avoid loss of critical data during engine start up.

1.18.15 Emergency Locator Transmitter

ISRO Satellite Centre, Peenya, Bangalore did not receive signal from the ELT fitted on the accident aircraft on 06.03.2009 after the accident. Also during the examination of the wreckage at site the ELT unit was not traceable. Only six batteries of the ELT unit were recovered from the wreckage site in burnt out condition. ELT could have been burnt in post impact fire as its housing is not fire proof. ELT antenna was also found disconnected.

1.18.16 Statements, collection of evidences and investigation:

DGCA, New Delhi vide order No. AV15013/1/2009-AS dated 13-03-2009, apart from appointing inspector of accidents who was also investigator-in-charge, the following investigation groups were also formed to provide input to the inspector of accidents.

1. Operations group
2. Engineering group
3. Wreckage investigation group
4. Recorder group
5. Medical group

NAL provided all the technical assistance to the group members.

The inputs provided by the various investigation group have been taken into consideration and is carefully studied with various other evidences of the inputs.
Also Pratt & Whitney, Canada (Engine OEM), MT Propeller (Propeller OEM) and NAL (Aircraft Designer) had been discussed on face-to-face method and by e.mail/fax etc. All their valid views and comments/clarifications are also taken while finalizing the investigation report.

1.19 Useful or effective investigation techniques :
Nil

2. ANALYSIS

2.1 Serviceability of the aircraft

The SARAS PT-2 aircraft VT-XRM is an experimental aircraft under development by M/s National Aerospace Laboratories, Bangalore. The Certificate of Registration issued on 5.12.2006 bears Cert. No. 3460, under category A,. The aircraft serial number is SP002 and the year of manufacture is 2006. The aircraft is fitted with certified two Pratt & Whitney, Canada ,PT6A-67A Turboprop engine . However MT propeller fitted is yet to be certified. The weight schedule was not yet finalized. However the restriction was fixed for the 49th i.e the accident test flight as in test schedule. Aircraft is yet to be issued with C of A. On 6.3.2009 aircraft was inspected by the airframe, engine, avionics, instruments, electrical system inspectors approved by DGCA as per daily inspection/preflight/engine ground run schedule. Also telemetry serviceability was reported signed by separate person as per DI. No snag was reported. Aircraft was certified airworthy for test flight 49 in the form "daily inspection and clearance for Test flight-Saras aircraft" by concerned DGCA approved inspectors. Aircraft was also accepted by the pilots in the form IAFF(T) 700D. Aircraft production and maintenance documents did not reveal any significant findings except reported high control forces, flap operation issues . From the aircraft flight test records and post flight pilot reports the following observations are noted: Rudder Force feel inadequate , rudder response sluggish, During Asymmetric Torque handling, Rudder Force reported heavy, Poor Aircraft controllability during approach, flare out & touchdown and Exceedance of ITT & Ng reported high at high Torque settings at high altitude. In general, there are Controllability issues and high control forces exist. 50 hrs scheduled servicing was carried out after 48th flight and the engine ground run up was given . All the onboard systems were found satisfactory. Auto-feather engine cut-off was also checked on both engines.

Since the aircraft is under developmental stage NAL informed the above design issues of high control forces are being studied continuously for better design evaluation . There is no other known major maintenance defects or structural defects, which were left unattended.

2.2 Inflight procedures , Role of the crew and Cockpit emergency exit provision

NAL clarified that P1 is the Captain of the aircraft. As per ASTE standard operating procedure, FTE reads out the command/ test point/ check list and P1 or P2 as pre-decided by P1 will execute the action. But it was not documented properly anywhere in the relight procedures. Saras PT2 quick reference handbook mention only challenge method, but Standard Aviation practice is "challenge and response" method. Further it does not speak clearly that at each and every stage of flight who challenges and who responses. CVR also revealed that there is no proper crew co - ordination in the cockpit in handling the controls and achieving the action during the accident flight because of lack of cockpit checklist procedures.

The values/ limits of engine oil pressure and ITT that are to be monitored during engine relight exercise is not included in the detailed test points and NAL should include in the future test schedule.

Aircraft records revealed that aircraft was placed with 3 parachutes for emergency evacuation purpose. During wreckage inspection this was also confirmed. Howev er, cockpit checklist procedure does not include checks for parachutes.

At about 5 mins prior to crash , when something abnormal behavior of the aircraft was felt by the pilots Co-pilot was hilariously telling commander "road is there for emergency" and also advised FTE for placing readiness of parachute for emergency. *These parachutes were not used by the pilots/FTE in the accident. It is not known that whether the pilots are trained to operate the parachutes in case of exigencies. Records provided to the investigation is insufficient to show their training on parachutes exercise.*

2.3 Procedural Lapse of project team and Management committee (MC) .

(a) The relight SOP was derived based on a SOI issued by the engine manufacturer P&WC, which did not take the airframe-engine integration aspects into consideration. These SOIs are issued to all P&WC operators (PT6A -67A) worldwide and does not take into account the fact that SARAS was an experimental a/c. The copy of SOI Manual (Part No. 3037028 Revised 11 July 2001) issued from P&WC is attached in attachment folder. The relight document was only vetted and approved by ASTE on 6th Mar 09 even though the trial planner was remarked by CRPO,IAF on 22 nd Jan 2009. ***This document was not sent to the engine and p ropeller OEMs i.e. M/s P&W,C and M/s MT Propellers respectively for getting their comments*** and guidance.

(b) Prior to the conduct of the Relight Tests, NAL had sought certain clarifications from PW&C on 30th Dec 08, on the exact procedure to be follo wed for a relight. The reply was received after a reminder on 26th Feb 09 and it stated that the procedure laid down in the SOI should be followed. The SOI mentions that prop cont rol lever can be in any position in the entire operating range of the lever during a relight. There is also a footnote mentioning that ***"propeller feathering is dependent on circumstances and is at the pilot's discretion.*** **Fine pitch selection will provide increased Gas Generator (Ng) windmilling speeds for emergency starts in the remote event of the starter failure".**

As a well established Aviation engine industry , This lacks the clarity from Engine OEM considering the aircraft being experimental aircraft and NAL was in constant touch with them. P&W should have given clear cut in struction whether to keep the propeller in "feather" or "Fine".

As per OEM of propeller-MTP during the meeting with DGCA investigation team, the Prop Lever should ideally been kept in FEATHER position during relight.

In all this time there has been no interaction between NAL and the propeller manufacturer (MT Prop Germany) regarding the formulation of the relight procedure as the NAL and ASTE attention was only on engine relighting ie., presumed propeller having no role to play.

It is hence clear that there is a Lapse of project team and Management Committee (MC) in finalizing the correct procedure for engine relight procedure in flight.

2.4. The confusing instruction and guidance of Engine OEM -Pratt & Whitney, Canada :

Investigation team felt the incorrect position of the Prop lever "FINE" for relighting procedure in a way might have contributed to some extent to the accident. Considering that this was an experimental prototype aircraft with a certified P&WC engine, and uncertified MT propeller, the Engine OEM cannot absolve themselves of the responsibility of giving critical information which could adversely affect the safety of aircraft during the relight. Also, there was no caution provided by the OEM in the SOI in this regard. Considering the very definitive and clear instructions by P&WC to follow the procedure as laid down in the SOI, which specifies the position of the Prop lever to any where in the operating range, the trial team and designers could have been possibly misled by this information and have not realized the repercussions resulting from the placement of the prop lever in the "Fine" position **As a well established Aviation engine industry , This lacks the clarity from Engine OEM considering the aircraft being experimental aircraft and NAL was in constant touch with them. P&W should have given clear cut instruction whether to keep the propeller in "feather" or "Fine"for engine relight in air.** However the P&W still maintains the instructions given in SOI.

It is strongly felt that Indian-Aviation regulatory authority ie DGCA should take up the issue to Pratt & Whitney, Canada through the regulatory body of their country.

2.5 Engine Relight procedures-Revision:

It has been observed from the records and statements that pre-flight briefing meeting was done in the afternoon of 6.3.2009 prior to the test flight 49 in which NAL and ASTE took part of it . This meeting covered SOP for the flight, aircraft serviceability, configuration limits, test points, and test sequence etc as per the test program. Flight crew were also present. It is also understood that at the end of the briefing the pilots were specifically told by FTD that in case of any problem during the relight attempt, the engine should be switched off, propeller feathered and single engine landing executed. No effort should be made to try the relight at second time. This was also repeated to them orally near the aircraft before the crew got into the aircraft.

However the above discussion was nowhere recorded or documented in the relight test procedure.

Saras specific intentional engine shut down and relight procedure has been studied and it revealed some of the following salient points:

1. There is no mentioning of role responsibility of the individual crew, of who will check what and who will act and respond etc.,
2. Relight procedure check list or its note at the bottom does not mention How much should be engine oil pressure to Check. Similarly no mentioning of action on "Engine Start Switch" only mention about Start Mode Switch.
3. Propeller control lever -- fine .(as per engine OEM, any where in the operating range). But not cross checked with MT propeller.
4. Since this is the first relight test procedure nowhere cautioned about prohibition of 2nd relight attempt and that too at low level.
5. No altitude restriction was also highlighted for relighting.

It has been reported by NAL that adequate practice of re -light drill was done by the test crew on ground. Dummy drills in the cockpit were also carried. But it is not clear that whether these drills included the simulation of relighting in air conditions. No records were made available to the investigation group.

In view of the above complete system of test procedure including Engine shutdown and relight procedures is to be revised taking into consideration of all the factors mentioned here or elsewhere in the report.

2.6 Role of Auxiliary Battery in relighting operation:

It has been doubted whether Auxiliary battery in "OFF" position played any role in non-restarting of the engine. From the detailed study of electrical system architecture of Saras PT2 aircraft the following three condition under that Functioning of the engine starting system involved are evaluated and are as follows:

It was reported by NAL that, in view of the above design condition architecture:

- The cross start in air or on ground when the auxiliary battery switch is ON position is always successful.
- On ground, Auxiliary battery must be selected 'ON' as given in the existing procedure (Vol. 28, TB-04, Quick Reference Handbook, page 4 –11, dated March 2007).
- The cross start in air when the auxiliary battery switch in OFF or in CHARGE position will also be successful.

In view of the above it is inferred by NAL that

i) Auxiliary battery is not required for relight in air.

ii) Re-light in air will be successful without auxiliary battery.

iii) Three internal/cross starts/ air starts are possible with the main battery.

iv) A time gap of 3 minutes for ground start and 2 minutes for air start to be obse rved between successive attempts to start (on account of limitations of starter contactor unit).

Further Electrical, Battery capacitance records verified and found both Main & auxiliary batteries were periodically Capacity tested and recharged and are val id on the day of accident.

However, it is not understood the above explanation of NAL when Auxiliary battery is not required for engine start in air, why and how it has been included for the ground start when main battery itself is sufficient for grou nd start. It is hence felt that NAL should come out with clear cut procedure for AUX. battery for engine start (internal) or increasing the capacity of Main battery is to be explored and hence removal of Aux.battery from the electrical architecture.

2.7 Review Of Starting And Electrical System Of Saras Aircraft:

1. After the accident a lot of Discussions were held between NAL design team and DGCA investigation committee members regarding the function of aux. battery during cross start on ground and in flight. The following points were discussed. The auxiliary

battery selection switch position and the bus arrangement were explained. With the auxiliary battery switch in any one of the following positions: ON / OFF / CHARGE position. The plausible reasons for engine not starting during the first relight attempt could be;

(a) Aux battery not on line.
(b) Start mode switch selected to motor position.
(c) Fuel mixture rich during relight.

2. Functioning of the electrical and starting system, under the above-mentioned cases is explained as under;

(i). <u>**Case (a) Aux. battery switch in 'OFF' position**</u>
The aux battery is isolated from the rest of bus bars. Hence no current would be drawn from the Aux. battery. Auxiliary bus (which is supplying power to GC PU during start operation) is connected to the emergency bus and also to the main bus which is being supplied by the live generator. During the cross start in air, a dip in the auxiliary bus bar voltage is expected. In air start, the voltage dip is likely to be less than that during cross start on ground. The air start could be successful because of wind milling effect.

(ii) <u>**Case (b) Aux battery switch the 'ON' position**</u>

The aux battery is connected to auxiliary busbar and it supplies current (discharge) to all loads connected to that bus bar. In this case, the auxiliary bus is isolated from the main and the emergency bus bars. During the cross start in air / on ground the aux battery voltage is close to 24 volts for all the loads connected to the aux bus bar. However, dip in aux battery voltage due to motoring action would not arise. Hence, relight would be successful in air.

(iii) <u>**Case (c) Aux battery switch in 'CHARGE' position**</u>

The aux battery is connected to the main bus bar and charged by the generator. Aux bus bar is connected to the emergency bus and also to the main bus which is supplied by the live generator. During cross start in air, a dip in voltage is expected in the aux. bus bar. The dip in voltage during air start would be less than that on ground start and relighting could be successful (for reasons explained in case (a) above).

3. **View of Design Team and Investigation group Members:**

(i) The cross start in air or on ground when the aux battery switch is 'ON' position is always successful. <u>**Hence recommended for all air starts**</u>. **But it is not required to be done so, as the main battery is sufficient to take the load as already other generator was working during cross start.**

(ii) The cross start in air when the aux battery switch in OFF or in CHARGE position could be successful because of the wind milling effect. However, it is felt that the cross start with aux battery in OFF / CHARGE position needs to be tested on the ground by simulating 13% Ng wind milling effect, to confirm (ii) above <u>**without the effect of dynamics in the air**</u>.

4. While perusing the flight data it was quite apparent that they were two engine relight attempts carried out by the crew on 06th Mar 09 during the course of the sortie. The first attempt was initiated at $\simeq$ 7200 ft AMSL and the other at $\simeq$ 5100 ft AMSL. It is also evident that the first relight attempt was unsuccessful however during the second attempt while engine parameters were approaching close to idle conditions, the aircraft crashed into the ground. Hence between the two relight attempts possibly some switch selections were made by the crew which resulted in the successful relight in the second attempt. The committee also discussed all the possible reasons for the unsuccessful relight in air during the first attempt at an approx height of 7200 ft AMSL.

(i) It could be possible that the **start mode selector switch was in the 'Motor' position instead of 'Start'.** This condition would result in dry motoring only (no ignition). This would also increase generator current by about 200 A. This is also corroborated by the data wherein Ng increases to 25% and then drops down gradually. The start switch could have been unintentionally deflected to 'Motor' position by any of the flight crew member during the ensuing dive and unsettling of crew in the cockpit (due to excessive yaw rate, sharp pitch down and effect of negative 'g') caused due to spin up of propeller RPM to $\simeq$ 100%..**Moreover there is no mentioning of "Engine Start switch – to Start" in the CVR during this situation. It is quite possible engine was not started at all ie., ignition not started. This is clear from the no minus load current and drop in generator voltage.**

(ii) The aux **battery switch may have been selected to ON position** during the second relight. The short break (about 22 sec) in telemetry data do not permit to check out the discharge current of aux battery which returns to normal state during this break in telemetry link. **However no mentioning of it in CVR . Hence this can be ruled out.**

(iii) The cause of the unsuccessful relight could have been **because of the rich mixture.** The fact is that the fuel condition lever was not moved during the two relight attempts and there has been a constant fuel flow of 30 kg / h. As the conditions with respect to fuel condition remained identical during the two relight attempts, hence, **this factor can be ruled out, as the cause for engine not starting in the first attempt**

5. **Inference:** The successful second relight confirms that functioning of the starting and ignition system in the aircraft was normal. There is no mention of the selection of aux battery to 'ON' position during the air start in the relight document especially prepared by the NAL Engine team for the sortie, indicating no requirement of the same. Also other designers and ASTE Flight Crew were not very clear on this aspect whether aux battery is required to be put 'ON' for cross start in air except designers from Electrical Group.

   Hence, either wrong selection of mode switch or non pressing of Engine start switch to start the engine during the first relight attempt is the most probable cause for engine not relight in the first attempt.

   It is also inferred that NAL should increase the capacity of main Battery and removing the auxiliary battery and review the electrical system of the aircraft

2.8 Probable Cause of the First Failed Relight:

After the aircraft had gone into a sudden dive and abnormal attitude, it lost height from 9000 ft to 7000 ft and briefly stabilized. At this point a relight was attempted.

However, the relight was not successful. It was seen from the FDR data that the Ng had risen upto 26% RPM and then wound down. The FDR data did not have the ITT or fuel flow. However, by interpolating the telemetry data du ring the link break, it appears that there was no rise in ITT or fuel flow. The reason for the engine not lighting up in the first attempt could be one of the following: -

(a) Wrong selection of the MODE SWITCH to MOTOR instead of START. From the transcript, at time 00:31:47, it is seen that as there is a call for checking the Start mode switch in Start position, the a/c suddenly yaws and dips viciously (from the pilot's reaction at 00:31:57). If during this time the pilot's hand is on the Mode Switch, there is a possibility that accidentally the switch might have moved to the MOTOR position, thereby resulting in a false start. **From the FDR data, it is seen during this period that the Ng has risen to about 25% rpm, stabilized for about 12 -14 sec and then again wound down, which may be indicative of a motoring action without light up. Moreover there is no mentioning of "Engine Start switch – to Start" in the CVR during this situation. It is quite possible engine was not started at all ie., ignition not started. This is clear from the no minus load current and drop in generator voltage. And also at last moment during second attempt crew was calling for engine start. This indicates LH engine was yet to be started.**

(b) **Aux Battery not changed over to ON from CHAR GE position.** This is a mandatory requirement during ground start. But not for on air start. However , in air the loads are expected to be lower due to wind milling and hence the engine may or may not start with Aux Bat in 'Charge" position. This is a man datory requirement during ground start. But not for on air start. The electrical system architecture however revealed that Auxiliary battery is not required for relight in air. Re -light in air will be successful without auxiliary battery. Three internal/c ross starts/ air starts are possible with the main battery with time difference of 2 minutes in air for second start and 3 minutes in ground. So irrespective of Auxiliary battery position engine should start provided main battery is healthy.

(c) The Fuel Condition lever was not selected ON when the Ng had crossed 13% rpm.

From the CVR transcript, it emerges that the crew was in preparation for the relight and about to set the Start Mode switch to START position when the a/c went out of control. Subsequently, after stabilizing at about 7000 ft altitude, they attempted to start the engine by selecting Start mode Switch to the START . but no conformity of that. From the FDR data, it is seen during this period that the Ng has risen to about 25% rpm, stabilized for about 12-14 sec and then again wound down. The associated parameters of fuel flow and ITT are not available in the FDR and due to a break in telemetry link during the start attempt; the same data is not available from telemetry also during this period. By interpolating the data before and after the link loss, it appears that there has been no change in the ITT and Fuel Flow during this period, indicating a dry crank, which can happen if the Fuel Conditioning Lever is not moved forward. Also, there is no call given by the pilots also in the CVR transcript regarding operation of the fuel lever. However, since the fuel -conditioning lever has not been instrumented, this cannot be corroborated.

(e) From the telemetry data, it is seen that there is an increas e in fuel flow from 6 kg to 35 kg just before the unusual situation took place. On correlating this with the CVR transcript, this point matches with the call of 'BOOSTER PUMP ON' given by the pilot.. Thereafter, the fuel flow has been steady at this value with minor variations till the second relight attempt, after which it has risen due to successful relight just before the crash. However, the reason for this rise in fuel flow could not be established as the fuel flow will start only when Fuel Condition Lever is moved forward, for which there was no call given by the pilot. It is possible that the FCL was already in slightly forward position which allowed the fuel to flow. This fuel flow could have resulted in a wet start in the first attempt. However, the condition was the same even during the second relight attempt and should have resulted in a wet start again. **This needs to be reviewed in detail by the designer.**

2.9 Control forces and controllability issues:

Saras is being a prototype aircraft wherein the control forces could be marginally higher than the prescribed values of FAR-25. Fine tuning of control forces in a prototype aircraft is a constant evolving phenomenon. In a prototype, optimization of control forces (& controllability aspects) is a process of development through flight testing and progressive design changes are made to meet the FAR requirements. A number of modifications to the control surfaces to meet these requirements are to be continuously assessed and are planned to be flight tested in due course. During development of a prototype, such a process is acceptable, unless perceived as unduly higher or abnormal by the Test Crew. In which case, correction should be made prior to further testing.

FAR 25.143,sub-section (d) stipulates the max control forces permitted for controllability and maneuverability. As per that **permissible limit of the various control forces are given in a tabulated form for conventional wheel type controls during the testing.**

Forces in pounds applied to the control wheel or the rudder pedals	**pitch**	**roll**	**yaw**
For short term application for pitch and roll control-two hands available for control	**75**	**50**	
For short term application for pitch and roll control- one hand available for control	**50**	**25**	
For short term application for yaw control			**150**
For long term application	**10**	**5**	**20**

As it has emerged from the CVR transcript of the 49th flight, the pilots have commented on the excessive control forces experienced during the asymmetric torque conditions in OEI simulation as well as when the left engine was actually switched off. The forces on the rudder were very high and it would have been impossible to fly the aircraft when there is a sudden increase in the control forces both in yaw and roll channel.

Aircraft post flight pilot report records also revealed most of the time ineffectiveness or sluggishness of control forces and high forces were experienced by pilots. Scrutiny of aircraft test records and various reports by Engineering team revealed that Rudder Force feel inadequate in flight no.6. During Asymmetric Torque handling, Rudder

Force reported heavy in flight 36. Poor Aircraft controllability during approach, flare out & touchdown was also reported in flight no.47.

It is hence established that there are unresolved Controllability issues and high control forces are persisting beyond the permissible limit of controllability on the accident flight.

Investigation also established that

1. The rudder pedal and aileron forces during asymmetric torque conditions have been very high and a fair amount of compensation was required to maintain the aircraft in level flight condition. This has been brought out by the crew time and again during the flight as has emerged from the CVR transcript of the 49th flight, wherein the pilots have commented on the lack of control margins during the asymmetric torque conditions in OEI simulation as well as when the left engine was actually switched off.

2. Due to Rudder Stretch, the available full rudder deflection was expected to be ~22 degrees instead of 30 degrees. This aspect needs to be looked into as this could have affected the safe recovery of aircraft. This could have been one of the critical factors which affected the recovery of the aircraft during the critical phase of flight prior to the crash.

3. The control harmony requires aileron to be least control force for piloting. However it can be seen that the aileron forces were also very high after Np >60%The control forces experienced by the pilots during the critical phase, when the Np_L shot up to 100%, were extremely high and reached values as high as 75 -90 kgf in rudder pedal and 65-70Kgf in aileron. Under such high sustained forces, it would be almost impossible for the pilot to control the a/c. These forces are also well beyond the permissible limits as prescribed in the above said FAR 25.143,sub -section (d)

4. The control calibration by the pilots with telemetry prior to take off shows that a severe hysterisis existed in the rudder which could result in a reduction in the rudder range of movement in one direction. This data needs further examination

It is hence clear that NAL as a designer failed to design suitable control surfaces to attain the prescribed limit of control forces as prescribed in the FAR 25.143,sub-section (d) even after 48th test flight and prior to formulating the engine relight procedures in air.

Design improvement on control surfaces is hence required to be done such that even for flight testing purpose the magnitude of forces should be such that it is possible by the flight crew to manually fly the aircraft without getting into fatigue level.

Similarly NAL should not look for the Maximum limit provided in the said FAR 25. Rather it should consult other aircraft manufacturing industries to explore the convenient limit of control forces for easy controllability and maneuverability by the pilots. This needs to be ensured by NAL on all prototypes.

2.10 Propeller Pitch Change Mechanism.

Initially, it appeared that there was a malfunction o f the pitch change mechanism of the propeller, due to which the pitch of the propeller had changed from FEATHER to FINE after the Propeller lever was moved forward to fully Fine position as a preparatory step towards relighting the engine. It was assumed t hat the pitch change mechanism operated at pressures above 60 psi, which would happen only after the engine had relighted and adequate oil pressure had built up in the engine oil system. However, after discussions with the propeller manufacturer M/s MT Pro pellers, Germany it emerged that the behaviour of the propeller was **absolutely normal and as expected under the given conditions and selection of propeller control lever**. In case there was any residual oil pressure in the supply line and the propeller was windmilling at that instant, then selection of the Prop lever out of FEATHER position would release this pressure to the inlet of the propeller governor, which would amplify this pressure and supply it to the feathering spring. Once the oil pressure builds up to an extent where it can overcome the spring force, the propeller would unfeather and gradually move towards FINE position till it reached the low pitch stop. At approximately 35-40 deg of blade angle, the wind forces (due to the dynamics of air speed) would start acting on the blades thereby resulting in a rapid movement towards FULLY FINE position and rapid rise in the propeller rpm. ***As inferred from the telemetry and FDR data, this is exactly what had happened and had resulted in excessive drag due to the flat disk effect of the propeller wind milling at 100% rpm*** .

Prop OEM further reiterated that as a matter of normal practice, the relight should be done with propeller in feathered condition and the pitch lever should be moved to FINE only after successful relight and engine reaching the flight idle parameters

2.11 Propeller Windmilling drag :

No data has been provided by MT propeller as it is not available with them.

Evaluation of abnormal drag from the propeller in the windmilling conditi on neither done by NAL nor by MT propeller before cleared for 100 hrs flight operation. There was also no wind tunnel testing done for assessing the normal as well abnormal behavior of propeller under various conditions including wind -milling situations and propeller blade below PBA limit leading to Propeller windmilling drag or abnormal Disk drag.

This drag could be due to spinning propeller at pitch angle well below primary blade angle(PBA ie 11 deg) and lead to the aircraft to behave the way it had in the accident flight where the propeller RPM went to 100% with engine switched off condition.

It was clarified by NAL that till PBA, drag due to propeller is not excessive . They said that it was experienced by them many times PBA was reached in flight , particularly when engine was in flight idle and no adverse conditions were reported by their crew. Therefore it could be possible that most probably the blade pitch has gone below PBA. However there are no recorded documents made available to prove the above claim of NAL.

It was also clarified by NAL that as a part of engine -relight procedure given by P&WC (Specific Operating Instructions, Model PT6A -67A, Part No. 3037028 dated 11.07.2001 and Technical Coordination Memo No. PWC065 dated 02.05.2008), propeller lever was moved to fine pitch setting. The propeller RPM has reached more than 90% before an attempt was made at relight. This wind milling condition of the propeller resulted in significantly higher drag, resulting in increased yaw and side slip. Sideslip always leads to pitch down moment, which can be substantiated by existing wind tunnel results on SARAS. In the usual range of sideslip encountered in flight, the resulting pitch down moment can be controlled with ease using normal elevator action . The rapid increase of sideslip to excessively high value (~30 deg) in 3 seconds could have led to severe initial nose down pitching.

The above aspects must be studied in detail with wind tunnel tests or shop tests or both and other relevant procedures whichever is most appropriate, including trial assessment test prior to the next flight of Saras project.

2.12 CONDITION UNDER WHICH PROPELLER EXCEED 100% RPM

Distinction is made between Engine oil pressure and servo oil pressure. Engine oil pressure is measured at oil sump whereas servo pressure exists at Servo pump (positive pressure pump: in Saras installation it is a gear pump which will keep boosting pressure that is being fed to it.). Servo pump is directly connected to propeller shaft through gearing. Therefore, if propeller shaft is rotating, servo pump gears will be rotating.

Propeller reaching High RPM from feathering:

Situation 1: Initial state taken is when aircraft was flying in controlled level flight condition with LH engine shutdown, propeller in feathered condition (residual RPM ~ 2% implying approximately 35 RPM), Engine oil pressure ~6 psi. This implies that oil will be flowing to propeller system and on the way, it will go through the servo pump. The servo pump pressure is rotating because propeller shaft is rotating but its pressure boost has no effect, since the oil flow path is open to sump. Hence, no pressure build - up takes place.

Situation 2: Now the situation is taken when aircraft was flying in controlled level flight condition with LH engine shutdown, propeller in feathered condition (residual RPM ~ 2% implying approximately 35 RPM), Engine oil pressure ~6 psi and the propeller lever is shifted to FINE condition (flight FINE pitch, this was in accordance with procedure published by engine OEM). Non-zero engine oil pressure (~6 psi) means that there is small but positive pressure being applied to input side of servo pressure pump. Propeller lever in FINE condition is a condition that enables the propeller to come to/remain in FINE pitch condition. In this setting, servo pump is rotating slowly and increasing the pressure of oil going to propeller housing with each rotation. This pressure rise per rotation is very low in the beginning. The oil with this increased pressure is now going to propeller housing and not being dumped to oil sump (which was happening in situation (1). Therefore, propeller feathering spring will feel increased oil pressure and start compressing. Consequently, propeller blade pitch will tend to reduce and its RPM will tend to increase. (This is based on information provided by propeller manufacturer during accident investigation). If this process continues, propeller RPM increase will take place monotonically. At certain stage of blade pitch angle, the 'wind catches the blade' (OEM's phrase; within this time engine should be started-up) and takes it quickly to higher RPM. Beyond the stage of 'wind catching the blades', propeller will be in truly wind milling condition and start producing increasing drag (due to low blade pitch angle).

If the engine does not start-up, propeller is likely to go on increasing RPM till some other mechanism controls it. Gradual RPM increase would be controlled by the propeller governor at 100% RPM. But if RPM increases faster than response time of propeller governor, over-speed governor (OSG) would come into play for RPM>106%. In case of Saras, OSG did function as expected and contained propeller RPM to 109% and brought it to lower value also.

Evaluation of fail-safe engine relights procedure in air – Saras aircraft

After the unfortunate accident on 'SARAS' PT2 prototype aircraft, extensive studies were done on what could be a fail safe engine relight procedure in air for 'SARAS' aircraft which employs a free turbine engine. Detailed discussions were also held with both Pratt and Whitney, Canada (P&W), the engine manufacturer, as well as with MT Propeller, Germany, the propeller manufacturer. The following paragraph outlines such a procedure.

Single Shaft Turbo-Prop Vs Free Turbine Engine

There is a subtle difference between single shaft turboprops (used in aircraft like Avro HS-748, Dornier-228. etc.,) and free turbine engine configuration (SARAS). In the case of former, the gas generator and propeller turbines are mechanically coupled to a single shaft. Therefore, whether engine relight is starter assisted or wind milling started, it is a recommended practice to put the propeller in 'un -feather' position. This has two advantages as below

a)In case of starter assist, it prevents a very high rotational drag on the starter. If on the other hand, the propellers are kept feathered, it may lead to starter/generator burn of the two engines.
b)In case of wind milling start, it improves the wind milling efficiency (higher RPM) due to finer pitch of the propeller.

Also, since all rotating masses are on single shaft, inertia is high and when fine pitch is selected, the propeller does not go to high disking drag position immediately, allowing sufficient time for the pilot to relight. For this reason, there is a separate unfeathering pump in single shaft engine configurations.

However, in the free turbine configuration (which is the case with 'SARAS'), the propeller turbine and gas generator turbine are only aerodynamically coupled and as a result, the inertia of the propeller- turbine combination is relatively low. Therefore, if the fine pitch or 'unfeather' mode is selected, there is a tendency to go very easily to high disking drag situation. To avoid this and also due to the fact that the propeller is not directly driven by the starter, it is recommended that engine relight in flight be done with propeller in 'feathering' mode only. Also, starter assist is mandatory for almost the whole of flight envelope except in a very small region at the high speed end of the flight envelop where it is optional.

Propeller Feathering Operation

Following points may be noted before the operation is studied in detail:

- The oil which operates the propeller system is the same that lubricates and cools the main engine
- In the engine oil system, there is an engine driven oil gear pump
- The propeller shaft has a separate gear pump which takes in oil from the engine gear pump
- Both the gear pumps are of positive displacement type
- As long as pressure at inlet to propeller gear pump is above zero and wind milling is taking place, it is possible that oil pressure at the outlet from this pump builds up over a period of time even at very low RPM of the propeller, when selected to fine position. This result in a closed system scenario (because the oil dumping ceases), a condition that happens when we select 'fine' or "unfeather", position, the resulting oil pressure goes to a very high value sufficient to unfeather the propeller.

In a normal operation, the propeller servo pressure acts on one side of the servo piston against the mechanical spring force. This adjusts the pitch of the propeller for various engine demands, by keeping the propeller speed constant.

The feathering of propeller is done through operation of the feathering valve, which is a pilot action, when he moves the propeller lever to feathering position. The dump valve opens the hydraulic system to dump and pressure on the servo piston falls to dump pressure value and consequently no oil pressure build up takes place in the propeller system.

The spring force (when feathered position is selected by the pilot) drives the propeller to feathering mode and it remains there until the feathering valve is operated again.

The following points may be noted which can ensure fail safe engine relight operation in air, once the propeller is in 'feathering' mode.

a) The feathering valve is a purely mechanical valve with a plunger and a spring; it is pilot operated and even if its spring fails, it will remain in the dump position, which is safe.
b) As long as the gas generator keeps running (due to wind milling) even with Ng at low RPM of 6 to 8 percent, there will be some positive pressure at inlet to the propeller pump; but when propeller is selected to feathering mode, oil pressure will reach the value of dump pressure and hence can never reach a value sufficient to un-feather the propeller
c) The spring mechanism in the SARAS propeller servo system comprises of two co-axial springs. This feature has been incorporated to ensure safe operation even if one of the springs fails. Discussions with MT propeller have revealed that the reliability level of spring mechanism is very high; they have not noticed any such failure in service.

To summaries, it is stated that engine inflight re-start is safest when it is starter assisted and the propeller is in 'feathering' mode. This must be a mandatory procedure for all engine re-starts in future.

2.13 Monitoring of Telemetry facilities and FTD role :

Telemetry is an effective tool for online monitoring of prototype test flying wherein test crew could be warned by the Test Director in case of any exceedences in flight parameters or a potential hazardous situation leading to an unsafe flight condition. The reliability of the telemetry system has been poor in general throughout the sortie and the auto tracking system has been unserviceable. The same has been expressed by all designers of various monitoring groups at telemetry station.

The tracking antenna of ASTE works in azimuthal dire ction only and in elevation it is to be operated manually. Also the software used currently needs to be enhanced for additional functionality. These points to be addressed prior to next Saras operation. Even if the telemetry station were to be working tota lly in auto tracking mode, when the aircraft makes rapid maneuvers, a mechanical tracking antenna system can never react so fast and link break is likely to occur. This will lead to short term fluctuations in monitoring screen display during the test flig ht. This is a known phenomenon in the telemetry system. As long as fluctuation frequency is not too high , the parameters can be read and test can be continued. This hence emphasizes the importance of reliable and strong RF communication between aircraft a nd telemetry station, FTD desk. But as of now RT communication is also limited and telemetry station do not have recording of communication. The existing present system of communication between the monitoring desks to FTD by PTT switch is not valid recordi ng system. Moreover there is no proper logbooks/records maintained for each desk of monitoring. Hence there is no accountability of the desk person.

Suitable advance system should be developed to resolve the telemetry issue.

The regular link breaks at the crucial juncture when the relight was being attempted; probably lead to a lack of situational awareness at the telemetry station. Better awareness at that point might have enabled the telemetry team to give the required inputs to recover from the situatio n safely. Regular changes in the telemetry monitoring team may result in the team not being familiar with the intricacies and finer nuances of the test plan. Continuity, close inter -action and well-versed communication between the trial team (test crew) an d the monitoring team is essential for the optimal conduct of prototype test flying. The aircraft OEM (NAL) needs to set up a system in place wherein the people in the monitoring team should be formally trained to a certain basic level on aircraft systems as well as certain aspects of prototype flight testing, prior to being cleared to sit in the monitoring team.

Informal training was reportedly conducted by a Sq.Ldr. of ASTE,IAF prior to 1 st flight of PT1 for initial telemetry team members, including back up team. The present team has undergone on-the-job training along with the trained team members and the same personnel have been accepted by FTD and flight crew. *But no training records were made available. **Telemetry system, its facilities and their perso nnel are required to be brought under DGCA approval system so that the efficiency of the system is under monitoring.***

A formal training syllabus should be formulated for training of new incumbent under supervision for a minimum set criteria before cleari ng them for independent operations. Similarly some sort of refresher training is also required to be imparted to these personnel.

Probably frequent breaks and disturbances in the telemetry data has resulted in all the ground telemetry monitoring group as well as Test Director missing the rise in Np_L prior to the relight attempt. The trigger for the sequence of all the events on the fateful day has been "this unexpected increase in Np_L" which was not monitored by concerned. **Therefore, necessary up gradation or revamping is required in the telemetry system to make it more purposeful.**

Since during relight operation, the most important parameters like ITT, Oil pressure and Ng were given full attention it was never expected that propeller will unfeather even before engine has started and oil pressure build up.

May be due to telemetry link loss and fluctuations of parameters, the individuals monitoring various system parameters could not appreciate the situation, including the Flight Test Director when there was unexplainable increase in Np-L reaching 100% when Ng was around10% and oil pressure was 6-7 psi.

However from telemetry data it is understood apart from frequent telemetry link failure there were following abnormal situations under his close monitoring when telemetry link was available immediately after starting of relight procedure, for which FTD could have called off the flight test:

1. The Torque required on right engine to maintain the aircraft in stabilised level flight condition with left engine switched off was about 90% and required about 12 – 13° of rudder control input (up to 60% of total travel). This was higher than the predicted value of 50-60% Torque. There was high asymmetric Torque value or excessive rudder input could have been taken.

Aircraft crashed at 3330 secs telemetry time, Altitude: 3016'.

2. Telemetry time: 3234 secs to 3246: aircraft went into dive and loss the height from 9200' to 7300',speed gone from 125 to 181 kts, ROD : 10,000FPM(emergency ROD 3000FPM) – **about 100 secs prior to crash.**

3.TELE time:3273 to 3302 secs, Aux Battery current charging remained nearly Zero., Ng-L reducing and engine parameter showed relight attempt failed. Altitude loss from 7050' to 5300' with speed 130 kts. Pedal force above 60 k g reached 90. The aileron forces were 30-40 kg.--- **about 60 secs prior to crash**

4. Tele time 3321-3329: telemetry link restored after 17 secs from 3302. Aircraft speed 120 kts, height 4600' and continuously reducing.

FTD has the authority to advise the aircrew to abandon any particular test, if he considers it necessary to do so in the interests of safety. As per Annexure-I to appendix- C of joint Directive between NAL and ASTE,IAF , based on NO GO Items, he could have called off or aborted the flight for the above said situations involving telemetry link problems, abnormal aircraft behavior or doubted towards that, safe conduct of Test not feasible. But FTD failed to do so.

From CVR recordings it is also clear that at no time during the engine relight exercise did the crew inform the Test Director regarding controllability problem. All communication during that period was on intercom between the crew and not transmitted to the Test Director. He was not consulted on the requirement to call off the flight. **Crew were also not responding to the doubts raised by FTD on three occasions even at one stage after the initiation of first relighting at about 37 secs prior to crash. FTD also failed to call for the aborting off flight after the abnormal telemetry link as well as abnormal flight situation including rapid loss of predetermined height and not getting response from the pilot at critical stages.**

Similarly ASTE supervisor also failed in his responsibilities for flight safety in co - ordination with FTD as the situation warranted.

It is also informed that alongwith FTD Wg Cdr Jaiswal,Test pilot -Saras,Wg Cdr G.D.singh, FTE_Saras were also monitoring the flight at Telemetry. They also failed to advise FTD for calling off the flight seeing the abnormal situation in the monitor.

The role and responsibility of telemetry monitoring team and Test Director and ASTE supervisor in the Saras test programme needs to be reviewed .

2.14 CVR, DFDR and TELEMETRY Data analysis:

As the crew died in the accident an d no other eye witnesses were available to ascertain the facts of the accident the only available effective tool for investigation is CVFDR(CVR& FDR) of the aircraft. Though the aircraft was gutted in fire the flight recorder could be safely recovered an d the data were also retrieved. The other effective means of data available for the accident is that Telemetry data recorded by ASTE,IAF. Even though Telemetry link was intermittent especially at critical phases of the flight, the available data was effe ctively corroborated with flight recorder data/voice recordings and analysed to bring out certain salient facts of the accident.

The following are the salient annotations/ findings derived from the above data/cockpit voice /CVFDR analysis:

1. There were mainly the crew concern about control surfaces in -effectiveness and the felt excessive drag and hence the requirement of more power.

2. Till 1:41min prior to crash, there have been no alarming situation in the cockpit. With preparation for restart of left engine done up, as per procedure, the final command of the MODE SWITCH to START has been called at the Time of 5 secs before, But after that there is no call for "ENGINE START SWITCH to START." At 1:22min prior to crash there was an excited voice of FTE " Start..Start..Start Engine.." At this stage ***aircraft lost height from 9223' to7266' ie almost 2000' in 20secs. Subsequently there was a momentary control of the aircraft that was indicated by the pilot laughing. But the height lost continued thereafter.***

3. Alarm has been raised by P2 at 01: 41 min prior to crash, with the aircraft getting in to unexpected attitude changes. There has been a large bank , side slip , pitch and roll. The rates of these motions also remained at high level.

4. There has been no growth in Ng-L, indicating that the engine has not yet started. In addition, the battery discharge call appears only about 25 secs later. Battery discharge call has been designed to rise along with starter motor engaging and large current drawn.

5. There has been a steep raise in Np-L, producing excessive drag. The blades cannot be expected to go to un-feathered state with oil pressure remaining only about 5 psi. However the propeller RPM can increase only if blade pitch angle reduces and the blades un-feathers.

6. **The presence of high drag effect on the left side due to disc effect, probably caused an upward force and consequent nose down attitude. As the right side not having similar upward force, a case of asymmetric tail vertical load could have caused the recorded excess roll also.**

7. To counter the largely building up sideslip and course change, the crew took to the action of throttle down the right live engine. This happened, after one or two secs , after the first sign of emergency at the time of 1:41 prior to crash.

8. With reduction of thrust asymmetry, and with possibly corrective control in puts given by the crew, the aircraft was probably momentarily brought under control, at the time of about 01 : 24min prior to crash

9. **The status of battery current EOP-L, Ng-L, and LC-R, together indicates that the relight probably has not been succeeded, or could have been aborted.**

10. With Np -L continuing in range of above 90%, during a large part of remaining flight time, there has been, a repetitive attempt / wrong handling by crew, with control inputs and throttle of both the engine. There has been continuous drop of altitude and speed.

11. **The possible second relight attempt seems to have taken place at the time of -26secs prior to crash. And the growth in Ng -L, the drop in Np-L, the growth in EOP-L and the drop in side slip, all together indicates the probable success in this attempt.**

12. **However the fast induced variation in power on live engine, and not having enough height, to recover, the aircraft, has de parted from the controls and balance.**

13. There is no planned and proper crew co-ordination between the pilots and as well FTE. Some times commander was on control and other times the copilot on control. Especially after the initiation of relighting procedur e copilot was cautioning the commander for his wrong handling of live right engine at least twice at about 55 secs prior to crash when aircraft was loosing speed . Similarly at critical stage of last moment at about 20 secs prior to crash again P2 was **cautioning the P1 " do not cut live engine" as the aircraft was loosing height rapidly and viciously.**

14. **For each and every stage of test procedure, role and responsibility and their action for the situation is not proper and situational awareness and seriousness of the action were missing. Moreover cockpit sterility is not satisfactory.**

15. About 6 mins prior to crash commander was commenting "something get drastically wrong-something is not OK". Pilots had not given seriousness to higher drag than expected at that situation. About 30 secs **after this doubting**

performance of the aircraft, when FTE suggested for going back to base, it is blindly rejected by the copilot. Commander also commented "we will switch off and later show to the Ground". Co-pilot also hilariously telling commander "road is there for emergency" and advised FTE for the placing readiness of parachute for emergency, without assessing the risk of the situation.

16. Crew exceeded their limits and limitations of the test flight and its test poin ts in tackling the risk. Aircraft being under experimental stage they must not have crossed the predetermined limits and limitations . As soon as the first relight attempt at appr. 7100' failed and aircraft started loosing the height viciously pilot should have shut down the involved engine and aborted the flight to come for single engine inoperative landing which they have successfully simulated in the starting of the test flight. Aircraft was continuously loosing height. But crew went ahead with 2 nd relight attempt at about 5000' which was successful just 2 secs prior to crash by the time aircraft almost near the ground. Relight procedure was not done at safe altitude as prefixed at 10000'AMSL

17. Crew were not responding to the doubts raised by FTD on three occasions even at one stage after the initiation of first relighting at about 37 secs prior to crash .. FTD also failed to call for the aborting off flight test due to the abnormal telemetry link as well abnormal flight situation including rapid loss of predetermined height and not getting response from the pilot at critical stages.

18. Crew were not using the internationally accepted aviation language and terminology. Most of the time using Hindi and that too broken and unaccepted level creating lot of misunderstanding of the flight deck environment.

19. Crew never attained the flight level of 100 as cleared by radar. Maximum reached by the aircraft was 9528'AMSL at 3min 40 secs prior to crash. Similarly at time 09:48(about 15:25 mins prior to cr ash) UTC when radar asked for the level confirmation crew gave wrong level 90 even though they were on level 70. ATC instruction at 0942 UTC for level clearance to 100 from 5000' was not adhered. They reached about 9236' and then descend to 7200' at 0948 UTC.

20. DFDR recording also revealed that Radio Altimeter registered erroneous recording most of the time especially below altitude 5200' and also constantly recorded as 2600' as Radio altitude for 3670' to 3150' during the accident flight.

2.15 Non- functioning of ELT:

It has been observed during the investigation ELT signal was not recorded by ISRO satellite. Causes for the Emergency Locator Transmitter not Operating after the Accident of SARAS PT2 Aircraft VT-XRM on 06.03.2009 has been probed.

The Emergency Locator Transmitter (ELT) used in SARAS PT2 aircraft was procured from *M/s.* AmeriKing Corporation, USA (Model No. AK-450). The set is designed to transmit at two radio frequencies, VHF (121.5 MHz) and UHF (243.0 MHz). The ELT is activated on impact .As per the installation procedures suggested by OEM and guidelines in TSO C91a, all the components of ELT were installed in PT2 in the rear fuselage (forward of rear pressure bulkhead).

The unit has a built-in G switch and the same is automatically activated upon sensing a change of velocity of 3.5 +/- 0.5 FPS (2 +/- O.3G), along its longitudinal axis. The unit can be removed from the aircraft and used as a personal locating device when it is necessary to leave the scene of the accident.

To ensure reliable operation, the equipment was inspected periodically and the internal batteries in the main unit were replaced on 21.01.2009. Periodic maintenance was carried out as per the guidelines of FAR 91.52 and 91.169. The co -axial connection between main unit and antenna was checked during maintenance and found to be good. The switch on the main unit was selected at "ARM" position. This is the switch position to be selected at all times in normal operation. In this position, ON and RESET functions of remote control unit located on MIP was checked and observed the ON/OFF of LED. This is a part of daily inspection and was carried out on 6.3.2009 as per the laid down procedures before clearing the aircraft for flying. ELT was fully functional at that point of time as confirmed by the approved inspector.

As stated above, the ELT unit has a built-in G switch and it is designed to automatically activate upon sensing a change of velocity of 3.5 +/- 0.5 FPS (2 +/- O.3G), along its longitudinal axis. During the investigation It was confirmed from FDR investigation group that the maximum normal acceleration recorded was 2.12 G in flight (88 seconds prior to crash) and - 6.07 G at impact. The longitudinal and lateral accelerations were - 3.04 G at impact. With these G levels the ELT would have transmitted signal at 121.5 MHz.

All ELTs installed on the aircraft are required to comply with current DGCA, CAR, SEC 2, SER I, PART II. Details of capability are mentioned in CAR SEC2 , SER 'O', Part II,III,IV,V with regard to type of operations. ICAO Annex 10, part 3, referred in CARs also clearly stipulate that after year 2005, all ELTs should be capable of operating on both frequency 121.5 MHz AND 406 MHz. However this fact has been overlooked by NAL and ELT fitted on accident Saras PT-2 aircraft was capable of operating only on frequency 121.5 MHz.

On enquiring at the ISRO Satellite Centre, Peenya, Bangalore it is learnt that, from 01.01.2009 the distress frequency for reception by both SARSA -T and INSAT has been shifted from 121.5 MHz to 406 MHz and thus no signal has been recorded by ISRO on 06.03.2009.

Also during the examination of the wreckage at site the ELT unit was not traceable. It could have been burnt in post impact fire as its housing is not fire proof. However, only six batteries of the ELT unit were recovered from the wreckage site. The disconnection of antenna due to impact in the crash might also be a reason for the unit not emitting the distress signal at 121.5 MHz, in addition to the fire that broke out after the crash.

It is also understood from NAL that ELT was not installed on load bearing primary structure as per standard aeronautical practice but installed separately on a suspended platform attached with fuselage.

It is hence concluded that an inappropriate selection of ELT which is not capable of operating on 406 MHz compatible with satellite tracking system is the cause for ISRO satellite not picking up the ELT signal.

2.16 Operation of doors by crew in emergency

During the wreckage inspection and analysis it was observed that Main door and Port Emergency door Handle was found in Open position and stbd emergency door handle was in closed position, affected by fire. Main door was slightly damaged due impact. All the three doors were lying away from the main wreckage and hence not affected with the fire except slight burn marks to port emergency door. Stbd emergency door was not having any impact/fire damage. This has created the doubts whether the crew operated doors in emergency or came out due to structural failure on impact.

National Aerospace Laboratories was hence asked to provide a report on the possible failure of the main door and the emergency doors, which were found near the main wreckage of the aircraft. Following this, a committee was constituted by Head, C-CADD comprising various experts members to look into the subject as to how the doors came off the fuselage structure and whether or not there was any failure of locking pins/mechanisms.

The committee examined in details the doors and the corresponding structures of the fuselage with available other evidences. The expert committee concluded that the integrity of the locking mechanisms of the main and the emergency doors were intact at the time of impact of the aircraft on to the ground.

It is therefore inferred that handle positions and breakage/distortion of linkages and doors are post impact. Moreover wreckage evidences showed that the charred bodies of the flight test crew were on their respective seats. Cockpit voice recorder also revealed that there is no sufficient time for the crew to attempt opening the doors. **It is hence evident that flight crew did not open the doors in emergency and came out due impact.**

Since there was no much impact damage to the doors it is highly questionable why the doors including emergency doors came out of the fuselage without crew operation. It could be possibly due to the weak locking mechanism of these doors. NAL should hence improve upon the locking mechanism of these doors including emergency doors.

2.17. Structural integrity of Saras aircraft :

During the investigation and analysis of CVR recordings pilot called "aircraft departed" several times prior to the crash indicating the aircraft lost complete control. NAL was asked to assess whether any structural failure of the aircraft led to the cause of the above complete loss of aircraft control.

Based on the nature of impact damage in the accident, HAL structure specialist along with NAL designers studied detailed drawings and stress analysis of the following areas of Saras aircraft structure :

Engine mounts and engine pylon attachment to fuselage
Rear pressure bulkhead

All door attachments and lockings
Fin attachment to fuselage
General cross section in fuselage area

It was found by the structural specialist that normal structural detail design practices have been followed and load diffusion paths are found to be in order. Stress analysis reports showed adequate safety margin. In view of the above findings, It is infer red by them that the specific structural areas are safe from structural integrity point of view for design flight envelope.

It is hence inferred that there is no in-flight structural failure of the aircraft involved in the accident.

2.18 The rationale behind selection of 10,000 feet for the relight exercise:

NAL has clarified that how the altitude selection was done for relighting procedure. It was clarified by them that Relight boundary given by P&WC was upto a maximum of 25,000 ft. and max. speed of 200 kts. Also as the fuselage was not yet pressure tested for PT2, DGCA has cleared operation only up to 15000ft. Since this was the first test for relight in the air, we chose both altitude and speed near the mid band of the engine re-light envelope given by P&WC. This was to give best chance for a successful relight, due to higher pressure and temperature.

Trial planner documents of the in-flight shutdown and relight test programme revealed that even though the engine OEM gave flight envelope for relight operation as maximum of 25000' and speed(EAS) 200 kts, NAL restricted this to 15000' and 200kts due to the reason that Saras PT2 is yet to be commissioned with CPCS and ECS system. DGCA, Bangalore also cleared provisionally to operate the a ircraft upto 15000' while according the approval for the block of next 25 flights. DGCA, Bangalore also did not fix the altitude restriction for engine shut down and relight procedure.

DGCA had extended the flight envelope of Saras aircraft to 15,000 ft A MSL The height of commencement of relight test point ie 9400 ft AMSL (6400 ft AGL) as recommended by designer's (vide relight document) and executed by flight test crew (vide test programme of 49th flight) did not provide the crew with sufficient height to take safe recovery actions, incase of some unforeseen circumstances. Pratt & Whitney, Canada as well as MT Propeller have also indicated that height selected for the trial sortie was inadequate in case of any emergency. This height is considered very low for conducting a critical exercise like engine relight for the first time.

The same documents also mentioned under the heading "Flight Safety Consideration" that minimum altitude in sector for engine shut down and relight trials is 13000'indicated(10000' AGL) as the max. limit is 15000' indicated.

However after the deliberation on the Trial Planner CRPO,ASTE,IAF has made remarks on 22 Jan 2009 that capability of engine on both positions for relight in air at different altitudes above 10000'AGL(13000'AMSL) may be progressed/established. Most of the test documents simply mention 10000' only but never mentioned whether AMSL or AGL. Flight test schedule on 6.3.2009 of 49th test flight also mentioned under "objective" only 10000' altitude for the inflight eng ine shutdown and relight procedure. It might be possible that Saras test team presumed wrongly this as 10000'AMSL and fixed finally as such for the 49th test flight on 6.3.2009.

CTP,IAF also commented that clear procedures for windmilling start in flight (not Starter assisted) and all limits for the same need to be laid down by NAL in consultation with P & W. Nowhere MT propeller was considered for discussion on the relight procedure.

Normally all civilian transport aircraft operate safely upto 14000' wit hout any pressurization requirement and no discomfort to its occupants. This was also not taken into consideration while finalizing relight altitude requirements. Management Committee(MC) of the Saras project also failed to act suitably on the issue.

Taking all the factors into account, the reason for selecting 9400 ft AMSL altitude for the relight test profile was appeared to be inadequate for the flight crew to take suitable recovery actions.

From the above it is inferred that the selection of 10000'AMSL for engine shut down and relight procedure is not prudent. It requires immediate attention and is to be revised prior to the next flight.

2.19. Circumstances leading to the Accident:

At about 0956 UTC aircraft reported "OPS NORMAL" at 20Nm in sector Southwest 2. **This was the last contact of aircraft with radar but was in contact with FTD telemetry desk of ASTE,IAF.** After successful left engine shut down and its securing procedure, at about 1001 UTC **left engine relight procedure was initiated at about 9200'AMSL. During the relighting of left engine, FTD desk also lost contact with aircraft for about 37 secs. prior to crash.**

CVR revealed that after shutdown of LH engine securing of engine was called for. As per the procedure, propeller control lever was kept in "feather", fuel condition lever—OFF. After that, from 2:37 mins prior to crash aircraft was prepared for engine restarting. As a pre-relight check procedure, pilots carried out: auto feather: Off, propeller control lever: Fine, Power control lever : Idle, fuel condition lever: OFF, Fuel shut off valve: Open, Booster pump: ON, ECS; Already kept Off, fuel low pressure warning on CWP : Off. This was carried at about 9200'AMSL at about 1:47 mins prior to crash. At that stage FTE asked the pilots in suspicion **"what is happening"** At this instant Rudder, elevator, sideslip are all steady at the values which were maintained till then. There was no change in Heading also. Followed this, as an engine relight procedure check, FE called for "Engine Start Mode switch to Start". But for this there was no action from the pilots as heard in the CVR. At 1:41 mins prior to crash ie., 5 secs after the above Start mode switch call by FE, P2 shouting in alarming tone, "........," . This Alarm has been raised by P2 with the aircraft getting into unexpected attitude changes. There has been a large bank , side slip , pitch and roll. The rates of these motions also remained at high level. At this stage ***aircraft lost height from 9223' to7266' ie almost 2000 ' in 20secs. Subsequently there was a momentary control of the aircraft , which was indicated by the pilot laughing. But the height lost continued thereafter.*** But at no time the call was given for action "ENGINE START SWITCH to START." At 1:22mins prior to crash (ie 24 secs after mode switch selection call)there was an excited voice of FTE " Start.. Start. .Start Engine.." to start the engine. However CVR as well flight recorder and telemetry data did not show engine started. There has been no growth in Ng-L, indicating that the engine has not yet started. Telemetry data did not show minus Load current(Lc) of left engine(negative implies current received for starting the left engine) and drop in Generator voltage (from 28.4 to at least 22.4 volt) at any duration of first relight attempt.

There has been a steep raise in Np-L, producing excessive drag. The blades cannot be expected to go to un-feathered state with oil pressure remaining only about 5 psi. However the propeller RPM can increase only if blade pitch angle reduces and the blades un-feathers. **The presence of high drag effect on the left side due to propeller disc effect, probably caused an upward force and consequent nose down attitude. As the right side not having similar upward force, a c ase of asymmetric tail vertical load could have caused the recorded excess roll also.** To counter the largely building up sideslip and course change, the crew took to the action of throttle down the right live engine. This happened, after one or two secs , after the first sign of emergency at the time of 1:41 prior to crash. With reduction of thrust asymmetry, and with possibly corrective control in puts given by the crew, the aircraft was probably momentarily brought under control, at the time of about 01 : 24min prior to crash.

55 secs prior to crash engine oil pressure-left increased to 56 and subsequently started reducing to 38, ITT still 68 deg, Fuel flow remained 36, torque zero, Ng raised to 22 and started dropping to 15,Np to 83. This indicates the Left engine relighting not successful and height continuously dropping. Right engine also brought to idle. **P2 Expressing anguish on reducing power of the live engine by P1 .The status of battery current EOP-L, Ng-L, and LC-R, together indicates that the relight probably has not been succeeded.** With Np –L continuing in range of above 90%, during a large part of remaining flight time, there has been, a repetitive attempt/ wrong handling by crew, with control inputs and throttle of both the engine. There ha s been continuous drop of altitude and speed. Aircraft lost to 5200' and speed 110kts. 33 secs prior to crash , Speed reduced to 112 Kts, Height reduced to 5400 feet, E1 Ng -10 % , E2 N g-86 %, the calculated rate of descent is as high as 12000 feet per min,. With fast descend taking place, the crew believes here that they have to have left engine live to cope up the emergency.P2 and P1 raising alarm voice of drastic reduction of speed. " speed ....speed.......speed......speed...." and P2 asking P1 " Oye .. yaar.. do light up..., relight..." to relight immediately. This indicates that earlier first relight attempt was not done successfully. 27 secs prior to crash, aircraft losing to Height 5000 feet, excess rate of descend ,panics the crew with sayings " going down" in exhausted voice of P2 seen here.

15 to 22 secs prior to crash P2 instructing P1 to do the action which ever is , which has brought the aircraft to some stable attitude when it was done earlier. Again anguish is expressed by P2 to P 1on the action of cutting off of the live engine and stressing to keep the live engine in LIVE condition only. The second relight attempt seems to have taken place at the time of just 8 secs prior to crash which was indicated by Minus Lc and drop in Generator voltage . The growth in Ng –L, the drop in Np-L, the growth in EOP-L, increase of fuel flow and the drop in sideslip, all together indicates the probable success of relighting of engine at second attempt. However the fast induced variation in power on live engine, and not having enough height, to recover, the aircraft has completely lost its controls and hence the pilots comments in fully exhausted voice P1-" aircraft has departed...aircraft going to ground".

During last 10 secs of the crash **P1 calling aircraft departed repeatedly indicating aircraft fully gone out of control.** At the last second of their life P2 calling in exhausted voice" F....., F,., F.., F...."" indicating aircraft is crashing. At the same time Battery discharge Warning coming in the background also stopped, indicating engine relighted successfully. But the aircraft almost on ground, P1 calling " Going to ground". Last 5 secs prior to crash Rapid loss of height from 4300' to 3040', speed started increasing from 60 to 120 . Ng_L increased to 54,Np to 56, oil pressure to 79, ITT increased to 647, fuel flow to 95, but torque started to come out of zero , indicating Left engine successfully relighted. Whereas on right side Ng R - 81%,Np: 86,Oil pressure 118, ITT 773, fuel flow 78(came down from 336 which was increased in the 5 secs prior to crash), torque came down to 11 from 81, PLA from 31 to almost zero. Indicating last moment try on right engine.

There is no planned and proper crew co-ordination between the pilots and as well FTE. Some times commander was on control and other times the copilot on control. Especially after the initiation of relighting procedure copilot was cautioning the commander for his wrong handling of live right engine at least twice. Crew exceeded their limits and limitations of the test flight and its test points in tackling the risk. Aircraft being under experimental stage they must not have crossed the predetermined limits and limitations for engine relight procedures .

From the preceding analysis, it is certain that engine was not relighted at first attempt at an appropriate altitude of 10000' AMSL instead done at 7100' AMSL and correct procedure of completing electrical start cycle and engine start cycle was not done by the pilots by selecting mode switch to "Start" and pressing "Engine Start Switch- to start" at first attempt. Due to which aircraft behaved in abnormal way, speed was reaching very high and losing altitude rapidly out of relight envelope. During the first relight attempt live engine was also handled injudiciously by the pilots. Aircraft viciously came down to about 5000'. **As soon as the first relight attempt at appr. 7100' AMSL failed and aircraft started loosing the height viciously pilot should have shut down the involved engine and aborted the flight to make single engine inoperative landing, which they have successfully simulated in the starting of the test flight.** Aircraft was continuously loosing height. **But crew went ahead with 2nd relight attempt just 8 secs prior to crash at about 5000' which was successful just 2 secs prior to crash. Speed was almost washed off Just 2 secs Prior to the crash and then started rising. This was again done outside the relight envelope(speed and altitude). Even though the second relight attempt was successful aircraft almost reached near the ground and crashed.**

Absence of any emergency call from the aircraft was possibly due to pilot remaining occupied in controlling the aircraft till last moment of the critical situation.

3. CONCLUSIONS:

3.1 FINDINGS:

1. Aircraft was duly registered in India with effect from 5.12.2006 and issued with Certificate of registration under Category A,. Aircraft is yet to be issued with C of A as it is still under developmental stage. 49th flight on 6th march 2009 is the first test flight, which covered the test point of engine, relight procedure.

2. There was no evidence of any defect or malfunction in the aircraft due maintenance, which could have contributed to the accident. There were in general controllability issues and high control forces exist in Saras PT2 accident aircraft. There is no other known major maintenance defects or structural defects.

3. Accident took place in a broad day light and Weather is not a contributory factor to the accident.

4. Crew were appropriately licensed and qualified to undertake the flight. They were also medically fit and taken adequate rest prior to operate the flight.

5. Test crew did not undergo approved human factors/CRM training and the NAL/ASTE also did not ensure CRM training of the pilots/test crew before using them.

6. **There was no pre impact fire.** All extreme ends of the aircraft were within the main wreckage with fire damage. **This indicates there is no fire or structural failure prior to impact on ground. Aircraft did not crash on nose and there was no forward moment of the aircraft after main plane impacted the hard ground.**

7. The cable run (burnt) found running from cockpit to tail almost straight along the axis of longitudinal direction and no discontinuity was observed. All the three undercarriages were in retracted position and found burnt but retained its solidity.

8. Crew did not use the parachute on board as there was no time for that in the accident situation. The crew did not operate Main doors and emergency doors and it got opened in the crash.

9. **Aircraft was used for flying demonstration in Aero India 2009 show from 11.2.2009 to 15.2.2009 at Bangalore. But no DGCA permission was taken by NAL.**

10. **There is no effective and continuous monitoring of test programme by NAL-ASTE(IAF) Management Committee and no records of monitoring available.**

11. NAL also subcontracted a private agency named Aircraft Design and Engineering service Ltd.Bangalore. The work schedule of the project indicates almost complete work of the design and development of SARAS project is being done by the contractor, which includes flight testing analysis also. **This is not in line with DGCA approval given to the contractor that of only giving design and engineering support to the parts and appliances.**

12. **As per agreement between NAL and ADES-subcontractors, Even though NAL shall retain the absolute right on any patent that may be taken from the result of the work, Confidentiality clause of the agreement did not point out the penalty/ punishment action on the contractor under law in**

case of the pilferage or theft of any technical information such as design, drawings, wind tunnel testing, flight tests results or any software etc.,.

13. There is no effective pre-flight briefing to the crew and no records available to indicate the same on the day of accident. There is no contingency plan for unexpected emergencies like accident, missing aircraft, loss of communication etc.,

14. **There is no meaningful and effective supervision and control on the Saras project by DGCA-AED.**

15. **There is no periodic monitoring of CVR and DFDR by NAL. DFDR does not have critical engine parameters like engine oil pressure, ITT and fuel flow etc to monitor these in relight procedures and the engine performance.** The elevator position reading throughout the test flight was noisy probably due to intermittent signal loss in the data. **Hence Elevator position indication is also to be rectified.**

16. **Several observations made in the inspection report of Air India engineering team in 2009 are pending action by NAL**

17. Aircraft was fitted with certified P&W engine . However the MT propeller fitted is under the process of certification and is yet to be certified. **On receipt of the propeller and prior to use on the aircraft it was not declared FIT by NAL.**

18. **Propeller manufacturer confirmed that Propeller control lever should be ideally kept in "Feather" position for engine relighting and only to move forward to "Fine" after successful relighting and engine attaining the stabilized Ng at flight idle (ie 50 -55%)as per engine manufacturer. Propeller manufacturer reiterated Again and again that the normal procedure for the engine re-start would be with the propeller in "feathering" which was "Fine" in the accident flight for relight procedure.**

19. There has been no interaction between NAL and the propeller manufacturer (MT Prop Germany) regarding the formulation of the relight procedure as the NAL and ASTE attention was only on engine relighting ie., presumed propeller having no role to play. NAL at any stage did not consult MT propeller for instruction and guidance before finalizing the engine relight procedures

20. ***It was also confirmed that as the propeller system behaved normal as seen from data (prop control full forward), there was no malfunction of the propeller system.***

21. **There was no malfunctioning of the engine system.**

22. Facilities, functioning and training of monitoring personnel of telemetry system requires immediate review as there is no proper documentation of monitoring, frequent link interruption etc.,

23. There is no proper recording system of RF between the FTD and the crew as well telemetry monitoring personnel on ground. M oreover there is no proper logbooks/records maintained for each desk of monitoring. Hence there is no accountability of the desk person.

24. CVR revealed that at no time during the engine relight exercise did the crew inform the Test Director regarding con trollability problems. All communication during that period was on intercom between the crew and not transmitted to the Test Director. He was not consulted on the requirement to call off the flight.

25. **Crew were not responding to the doubts raised b y FTD on three occasions even at one stage after the initiation of first relighting at about 37 secs prior to crash. FTD also failed to call for the aborting off flight testing due to the abnormal telemetry link as well abnormal flight situation including rapid loss of predetermined height and not getting response from the pilot at critical stages.**

26. **Similarly ASTE supervisor also failed in his responsibilities for flight safety in co-ordination with FTD as the situation warranted.**

27. **Some Test pilot-Saras,FTE_Saras were also monitoring the flight at Telemetry. They also failed to advise FTD for calling off the flight seeing the abnormal situation during monitoring.**

28. **There is no "challenge and response" method formulated by NAL and adopted by the crew for carrying out checklist procedures.**

29. The relight document was only vetted and approved by ASTE on 06 Mar 09 and ***was not sent to the engine and propeller OEMs i.e. M/s P&W,C and M/s MT Propellers respectively for getting their comment s*** and guidance.

30. **As a well established Aviation engine industry , There is a lack of clarity from Engine OEM considering the aircraft being experimental aircraft and NAL was in constant touch with them. P&W should have given clear cut instruction whether to keep the propeller in "feather" or "Fine" for relight procedures.**

31. **There is a Lapse of project team and Management committee(MC) in** finalizing the correct procedure for engine relight in flight.

32. Test documents available with NAL di d not mention about aborting of flight in case of failure of engine relight at first attempt.

33. "Saras specific intentional engine shut down and relight procedure" was not well planned and prepared and did not include the following:

a) There is no mentioning of role and responsibility of the individual crew, of who will check what and who will act and respond ,etc.,

b) Relight procedure checklist or its note at the bottom does not mention how much should be engine oil pressure. Similarly no mentioning of action on "Engine Start Switch" only mention about Start Mode Switch.

c) Propeller control lever -- fine .(as per engine OEM, any where in the operating range). But not cross checked with MT propeller.

d) Since this is the first relight test procedure nowhe re cautioned about prohibition of 2^{nd} relight attempt and that too at low flight level.

e) No altitude restriction was also highlighted for relighting.

34. It has been reported by NAL that adequate practice of re -light drill was done by the test crew on ground. Dummy drills in the cockpit were also carried. But it is not clear that whether these drills included the simulation of relighting in air, using the internal start method. No sufficient records were made available.

35. **NAL should increase the capacity of main Battery and to remove the auxiliary battery and review then the electrical system of the aircraft to avoid unwanted confusion in the operational procedures.**

36. Control forces for rudder and aileron were very high. The rudder pedal and aileron forces during asymmetric torque conditions have been very high This has been brought out by the crew time and again during the flight as has emerged from the CVR transcript of the 49^{th} flight, wherein the pilots have commented on the lack of control margins during the asymmetric torque conditions in OEI simulation as well as when the left engine was actually switched off. **NAL should not only look at the Maximum limit of FAR 25. Rather it should consult other aircraft manufacturing industries to explore the convenient limit of control forces. This needs to be looked in by NAL on all prototypes.**

37. **After moving propeller to "Fine"** The propeller RPM has reached more than 90% before an attempt was made at relight. This wind milling conditi on of the propeller resulted in significantly higher drag, resulting in increased yaw and side slip. ***As inferred from the telemetry and FDR data, there was excessive drag due to the flat disk effect of the propeller wind milling at 100% rpm .***

NAL should study this abnormal behavior of propeller leading to the situation of disk drag effect when it is windmilling.

38. **Technical evaluation study by NAL concluded that engine inflight re -start is the safest when it is starter assisted and the propell er is in 'feathering' mode. This must be a mandatory procedure for all engine re-starts in future.**

39. The procedure given by P&W lacked clarity and did not give any Advice / caution particularly with respect to free turbine configuration. This was not clearly spelt out by Engine OEM(P&W) in their SOI for engine shut down and relight procedure. At any stage of finalization of engine relight procedure in flight, MT propeller had not been consulted by NAL for their instruction and guidance. Now MT propeller also reiterated that Propeller Should be in "FEATHER" position for relighting of engine in air. However this should have

been finalized by the designer ie., NAL before undertaking such critical exercise.

40. During the first relight attempt, it could be possible that the **start mode selector switch was in the 'Motor' position instead of 'Start'.** This condition would result in dry motoring only (no ignition). This would also increase generator current by about 200 A. This is also corroborated by the data wherein Ng increases to nearly 25% and then drops down gradually. The Start Mode Switch could have been unintentionally deflected to 'Motor' position by any of the flight crew member during the ensuing dive and unsettling of crew in the cockpit (due to excessive yaw rate, sharp pitch down and effect of negative 'g') caused due to spin up of propeller RPM to $\simeq$ 100%..**Moreover there is no mentioning of "Engine Start switch – to Start" in the CVR during this situation. It is quite possible engine was not started at all ie., ignition not started. This is clear from the no minus load current and drop in generator voltage.**

41 The successful second relight confirms that functioning of the starting and ignition system in the aircraft were normal. There is no mention of the selection of aux battery to 'ON' position during the air start in the relight document especially prepared by the NAL Engine team for the sortie, indicating no requirement of the same. Also other designers and ASTE Flight Crew were not very clear on this aspect whether aux battery is required to be put 'ON' for cross start in air except designers from Electrical Group.

42 **Hence, either wrong selection of mode switch or non -pressing of Engine Start switch or non selection of Both to start the engine during the first relight attempt is the most probable cause for engine not relighting in the first attempt.**

43 Till 1:41min prior to crash, there have been no alarming situation in the cockpit. With preparation for re start of left engine done up, as per procedure, the final command of the MODE SWITCH to START has been called at the Time of 5 secs before, But after that there is no call for "ENGINE START SWITCH to START." At 1:22 mins prior to crash there was an exci ted voice of FTE " Start..Start..Start Engine.." At this stage ***aircraft lost height from 9223' to7266' ie almost 2000' in 20secs. Subsequently there was a momentary control of the aircraft which was indicated by the pilot laughing. But the aircraft lost height continued thereafter.***

44 **The presence of high drag effect on the left side due to disc effect probably caused an upward force and consequent nose down attitude. As the right side not having similar upward force, a case of asymmetric tail vertical load could have caused the recorded excess roll also.**

45. **The status of battery current, EOP-L, Ng-L, and LC-L, together indicates that the relight probably has not been succeeded at first attempt.,**

46. With Np –L continuing in range of above 90%, during a large part of

remaining flight time, there has been, a repetitive attempt/ wrong handling by crew, with control inputs and throttle of both the engine. There has been continuous drop of altitude and speed.

47. **The possible second relight attempt seems to have taken place at the time of 26secs prior to crash. And the growth in Ng–L, the drop in Np-L, the growth in EOP-L and the drop in side slip, all together indicates the probable success in this attempt. However the fast induced variatio n in power on live engine, and not having enough height, to recover, the aircraft, has departed from the controls and balance.**

48. There is no planned and proper crew co-ordination between the pilots and as well FTE. Some times commander was on control and other times the copilot on control. Especially after the initiation of relighting procedure copilot was cautioning the commander for his wrong handling of live right engine at least twice at about 55 secs prior to crash when aircraft was l oosing speed . Similarly at critical stage of last moment at about 20 secs prior to crash again **p2 was cautioning the P1 " do not cut live engine" as the aircraft was loosing height rapidly and viciously.**

49. **For each and every stage of test procedure, role and responsibility and their action for the situation is not proper and situational awareness and seriousness of the action were missing. Moreover cockpit sterility is not satisfactory.**

50. ***Crew were not using the internationally accepted aviation language and terminology. Most of the time using Hindi and that too broken and unaccepted level creating lot of misunderstanding of the flight deck environment.***

51. At about 6 mins prior to crash commander was commenting "something getting drastically wrong-something is not OK". Pilots had not given seriousness to higher drag than expected at that situation. **About 30 secs after this doubting performance of the aircraft, when FTE suggested for going back to base, it is blindly rejected by the copilot. Comm ander also commented "we will switch off and later show to the Ground". Co -pilot also hilariously telling commander "road is there for emergency" and advised FTE for the placing readiness of parachute for emergency, without assessing the risk of the situat ion.**

52. **Crew exceeded their limits and limitations of the test flight and its test points in taking the risk. Aircraft being under experimental stage they must not have crossed the predetermined limits and limitations. As soon as the first relight attem pt at appr. 7100' failed and aircraft started loosing the height viciously pilot should have shut down the involved engine and aborted the flight to come for single engine inoperative landing which they have successfully simulated in the starting of the t est flight. Aircraft was continuously loosing height. But crew went ahead with 2 nd relight attempt at about 5000' which was successful just 2 secs prior to crash by the time aircraft almost near the ground. Relight procedure was not done at safe altitude as prefixed at 10000'AMSL**

53. **Crew never attained the flight level of 100 as cleared by radar. Maximum reached by the aircraft was 9528'AMSL at 3min 40 secs prior to crash. Similarly at time 09:48 UTC(about 15:25 mins prior to crash) when radar asked for the level confirmation crew gave wrong level 90 even though they were at level 70. ATC instruction at 0942 UTC for level clearance to 100 from 5000' was not adhered. They reached about 9236' and then descend to 7200' at 0948 UTC.**

54. **DFDR recording revealed that Radio Altimeter registered erroneous recording most of the time especially below altitude 5200' and also constantly recorded 2600' as Radio altitude for 3670' to 3150' pressure altitude during the accident flight.**

55. **ELT was not installed on the load bearing primary structure as per standard aeronautical practice but installed separately on a suspended platform attached with fuselage.**

56. **An inappropriate selection of ELT, which is not capable of operating on 406 MHz compatible with satellite tracking system, is the cause for ISRO satellite not picking up the ELT signal after the accident.**

57. Door handle positions and breakage/distortion of linkages and doors are post impact. Moreover wreckage evidences showed that the charred bodies of the flight test crew were on their respective seats. Cockpit voice recorder also revealed that there is no sufficient time for the crew to attempt opening the doors. **It is hence evident that flight crew did not open the door s in emergency and came out due impact.**

58. There is no inflight structural failure of the aircraft involved in the accident

59. **Taking all the factors into account, selecting 9400 ft AMSL altitude for the relight test profile is inadequate for the flight crew to take suitable recovery actions. The *selection of 10000'AMSL for engine shut down and relight procedure is not prudent. It requires immediate attention and is to be revised prior to the next flight.***

60. **It is certain that engine was not relighted at first attempt at an appropriate altitude of 10000' AMSL instead done at 7100' AMSL and correct procedure of completing electrical start cycle and engine start cycle was not done by the pilots by selecting Start Mode Switch to "START" and pressing "Engine Start Switch- to start" at first attempt.** Due to which aircraft behaved in abnormal fashion, speed was reaching very high and losing altitude rapidly out of relight envelope. During this first attempt live engine was also wrongly handled by the pilots without following proper procedures. Aircraft viciously came down to about 5000'AMSL.

61. **As soon as the first relight attempt at appr. 7100' AMSL failed and aircraft started loosing the height viciously pilot should have shut down the involved engine and aborted the flight to make single engine**

inoperative landing, which they have successfully simulated in the starting of the test flight. Aircraft was continuously loosing height. **But crew went ahead with 2nd relight attempt just 8 secs prior to crash at about 5000' AMSL which was successful just 2 secs prior to crash. Speed was almost washed off Just 2 secs Prior to the crash and then started rising. This was again done outside the relight envelope (speed and altitude). Even though the second relight attempt was successful aircraft reached almost near the ground and crashed.**

3.2. PROBABLE C A U S E (S):

Incorrect relight procedure devised by the designer and adopted by the crew at insufficient height leading to rapid loss of altitude and abnormal behavior of aircraft resulted into accident.

Contributory factors:

a) Lack of crew coordination and cockpit procedures
b) Handling of the controls
c) Non-aborting of flight by the crew in coordination with the flight test Director after failure of first relight attempt.
d) Devising engine relight procedures by NAL without consulting the propeller manufacturer.

4.0 S A F E T Y R E C O M M E N D A T I O N S:

1. Saras Project shall be monitored by the high level group consisting of eminent personnel from aircraft design, safety and operational discipline on regular basis.

2. Any abnormality reported/observed by the crew has to be rectified immediately prior to the subsequent flight.

3. Since Saras is the national project, utmost vigil and care shall be taken by CSIR, India while implementing project and the concept of employing the private contractor involving in each and every stage of the design and development of Saras project requires to be discontinued immediately and only the support for the parts and appliances shall be obtained from them. The contracting system followed by NAL is to be reviewed by competent authority.

4. DGCA should get the project overseen regularly by team of officers from Airworthiness, R & D and Air Safety. IAF representative may be associated.

5. Appropriate action shall be taken on the findings pertaining to NAL, IAF (ASTE) and other agencies.

6. NAL should explore all the possibilities of having more safer SSR housing unit from the point of fire proof and crash proof till the Saras aircraft is released for production flight.

7. Synchronization of propeller control and fuel control in the cockpit should be explored by NAL for better flight management.

8. ELTs capable of operating on 406 MHz frequency be installed for monitoring purpose on the Saras aircraft at suitable location.

9. Suitable modifications on Saras aircraft Pitot system or Nose Landing Gear D-Door mechanism are to be incorporated by NAL so that the re is no mismatch of CAS between the two EFIS in flight.

10. Telemetry system, its facilities and their personnel are required to be brought under DGCA approval system for proper monitoring.

11. Engine shutdown and relight procedures shall be revised taking into consideration of all the relevant factors.

Mumbai — **C. P. M. P. Raju**
6.12.2009 — **Inspector of Accident**

GLOSSARY

t :Time : secs
CAS_L :Speed kcas
ALT_L :Altitude ft
Rad_Alt :Radio Altitude ft
VG_L :Nz In term of g
HDG_L :Heading deg
HDG_R :Heading deg
VS :vertical speed ft/min
Stick :control column deg
St_Ail :Wheel deg
RudPed : mm
Elev :surface deg
Ail_L :surface deg
Ail_R :surface deg
Rud_Pos :surface deg
Rud_Tm :rudder trim deg
AIL_TM :Aileron trim deg
P_Tm :pitch trim deg
bank :bank angle deg
PR :Pitch rate deg/s
YR :Yaw rate deg/s
RR :Roll rate deg/s
PA :pitch attitude deg
Boom_AOA :Angle of attack deg
Boom_SS :Side slip deg
Boom_Speed: kcas
FQty_L :Fuel quantity kg

AMSL : above mean sea level
AGL : above ground level
FL : flight level
Kts : Knots
UTC : Universally coordinated time
BIAL : Bangaluru International airport Ltd
FTD : Flight test director
NM : nautical mile
L : left
R : right
FF : fuel flow
EOP : engine oil pressure
CAS : calibrated airspeed
OEI : one engine inoperative
s,secs : seconds
PBA : primary blade angle
ASTE : aircraft and system testing establishment
C-CADD: centre for civil aircraft design and development
DGCA : Director General of Civil Aviation
AZ : azimuth
EL : elevation
OPS : operations
LAT : latitude
LONG : Longitude
PFPR : post flight pilot report

FQty_R :Fuel quantity kg

Gen_L :generator, left volt

Gen_R :generator, right volt

HydPr :Hydraulic pressure bar

FFlow_L :Fuel flow, left kg/hr

FFLOW_R :Fuel flow, Right kg/hr

NG_L :gas generator, left %

NG_R :gas generator, right %

NP_L :propeller rpm, left %

NP_R :propeller rpm, right %

OIL_T_L :oil temperature, left deg

OIL_T_R :oil temperature, right deg

PLA_L :power lever angle, left deg

PLA_R :power lever angle, left deg

EngOilP_L :Engine oil pressure, left, psi

EngOilP_R :Engine oil pressure,right, psi

Torq_L :torque, left %

Torq_R :Torque, right %

ITT_L :inter turbine temperature deg C

ITT_R :inter turbine temperature deg C

CVR : cockpit voice recorder

D/FDR: digital/flight data recorder

LH : Left hand

RH : right hand

ATC : Air traffic control

min/s : minute/s

ELT :emergency locator transmitter

ATR : action taken report

KIAS : knots indicated air speed

OEM : original equipment manufacturer

PTT : press to talk

prop : propeller

SOI : standard operating instruction

SOP : standard operating instruction

ft :feet

RPM : revolution per minute

03/05/2011

2011 Antonov An-148 crash

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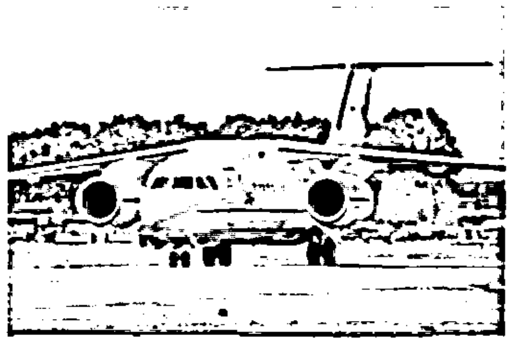
2011 **Antonov An-148** crash



An **Antonov An-148**, similar to the **accident** aircraft.

	Accident summary
Date	5 March 2011
Type	Structural failure of wing in flight
Site	Garbuzovo, Alxeevsky Region, Belgorod Oblast, Russia 50°28′30″N 38°44′40″E / 50.4750°N 38.7444°ECoordinates: 50°28′30″N 38°44′40″E / 50.4750°N 38.7444°E
Crew	6
Fatalities	6
Survivors	0
Aircraft type	**Antonov An-148**-100E
Operator	**Antonov** / Voronezh Aircraft Joint Stock Company
Tail number	61708
Flight origin	Pridacha Airport, Voronezh, Russia
Destination	Pridacha Airport, Voronezh, Russia

On 5 March 2011, an **Antonov An-148 crashed** at Garbuzovo, Alxeevsky Region, Belgorod Oblast, Russia, killing all six crew. The aircraft was operating a test flight prior

to delivery to the Myanmar Air Force. Witnesses reported that a wing detached from the aircraft in flight.

Contents

[hide]

Aircraft

The **accident** aircraft was **Antonov An-148**-100E,[1] c/n 41-03,[2] carrying test registration 61708. The aircraft was operating its 32nd flight.[3]

Accident

The aircraft was operating a test flight from Pridacha Airport, Voronezh, Russia,[3] when it crashed at Garbuzovo, Alexeevsky Region, Belgorod Oblast,[1] some 560 kilometres (350 mi) south of Moscow,[4] and 160 kilometres (100 mi) east of Belgorod.[5] The **accident** occurred at 11:05 local time (08:05 UTC) and the aircraft was destroyed in the subsequent fire. Witnesses stated that a wing had separated in flight. Russia's Ministry of Emergency Situations (Russian: Министерство по чрезвычайным ситуациям) confirmed that there was wreckage in two separate locations, 3 kilometres (1.9 mi) apart. Further wreckage was found between the two sites. This included material identified as coming from the cabin of the aircraft. A photograph of the wreckage away from the main crash site apparently shows a horizontal stabiliser.[3] The **Antonov An-148** had only just been granted extended certification. The **accident** has been compared to the December 2002 crash of an **Antonov** An-140 in Iran.[6] The six people killed were four Russian and two Burmese citizens.[7]

Investigation

Ministry of Industry and Trade of the Russian Federation (Ministry of Industry of Russia) (Russian: Министерство промышленности и торговли Российской Федерации (Минпромторг России)) have opened an investigation into the **accident**. [8] A criminal investigation was launched by Russia's Investigative Committee (Russian: Следственный комитет Российской Федерации) to decide whether violation of flight regulations occurred, leading to charges of negligent homicide.[7] The first meeting took place on 6 March.[9] The flight recorders were recovered from the wreckage.[10] The wreckage of the aircraft is to be transported to VACO (Russian: ВАСО) in Voronezh for examination. Information from the recorders should be available to the investigation by 12 March.[11]

Preliminary examination of data from the Flight Data Recorder shows that the airspeed indicator failed, showing too low an airspeed. In response to this, the pilots increased the speed of the aircraft past V_{NE} and the aircraft then broke up in flight.[12] Amongst the areas being covered by the investigation are pilot error and fuel quality. There was no call to ground the **An-148** following the **accident**.[13]

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External links

- Photograph of the aircraft involved

Antonov An-148 Crashes In Russia.

Air Transport Intelligence (3/5, Kaminski-Morrow) reported that despite "sketchy" information, an Antonov / crashed in Russia, "the first involving the newly-developed regional twinjet, deliveries of which only started for the plane. Another Air Transport Intelligence (3/5, Kaminski-Morrow) article reported, "The loss of the a reminiscent of Antonov's previous airliner programme, the An-140 turboprop, an early production example based manufacturer KSAMC's test pilots - crashed in Iran in December 2002."

04/02/2011

Solar Impulse Preparing For First International Flight.

The AP (4/28) reported the Solar Impulse team is "preparing their solar-powered plane for its first international flight next month." The flights will be made from Switzerland to Belgium and France. Andre Borschberg, a Solar Impulse pilot, "said Thursday the success of the first cross-border flights depends on the team receiving authorization from national authorities."

New Drones Could Drop Dust to Help Track People.

Adam Rawnsley at the Wired (4/28) "Danger Room" blog writes the US Air Force "issued a call for help making a miniature drone that could covertly drop a mysterious and unspecified tracking 'dust' onto people, allowing them to be tracked from a distance." Rawnsley calls the uses listed in the request "random" but noted it is likely has "to do with painting a target on the backs of tomorrow's terrorists." Rawnsley also commented that this request "may be a signal that the smart-dust technology is at least feasible enough to plan a vehicle around."

Prototype Hindustan Aeronautics Trainer Crashes.

Flight International (4/28, Rao) reported, "A prototype of the Hindustan Aeronautics HJT-36 Sitara intermediate jet trainer has crashed during a routine test flight over a sparsely populated area in the south Indian state of Tamilnadu." Reports say the pilots ejected successfully. The article noted "the development schedule of the HJT-36 has already been delayed because of the need to replace the design's original Snecma Larzac 04H20 engine with an NPO Saturn 55I powerplant."

Babbitt Rejects Napping During Shift.

Aviation Week (4/28, Shannon) reports, "FAA Administrator Randy Babbitt is dismissing calls to allow controllers to sleep during shifts to mitigate the effects of fatigue." Meanwhile, the FAA "is currently reviewing 12 recommendations to offset fatigue proposed by the National Air Traffic Controllers Association that include breaks of up to 2.5 hours, reduced work hours on certain rotations and increased training on the effects of sleep deprivation and disorders." But Babbitt, appearing at the US Chamber of Commerce Aviation Summit in Washington, DC said, "We are not going to have people sleeping at work." The proposed "recommendations...do not call for naps during shifts, instead proposing recuperative breaks."

Moon Express Testing Radar On Zeppelin Eureka Airship.

The UK's The Register (4/29, Page) reports Moon Express "has announced that it is flight testing new NASA-funded robot moon lander technology aboard a rented airship with the aid of an iPhone app intended to exploit social networking." The "Mini-Radar" system will be flown on the Zeppelin Eureka based out of the Ames Research Center. According to the article, Moon Express "is headed up by three trustees of 'Singularity University', the brainstorming tech-visionary jabbershop and seminar-fest set up at NASA Ames a couple of years ago. ... The trio are Bob Richards of the International Space University, philanthropist entrepreneur Naveen Jain, and Barney Pell – Chief Architect of Bing Local Search."

SPACE AND ASTRONAUTICS

AVIATION WEEK

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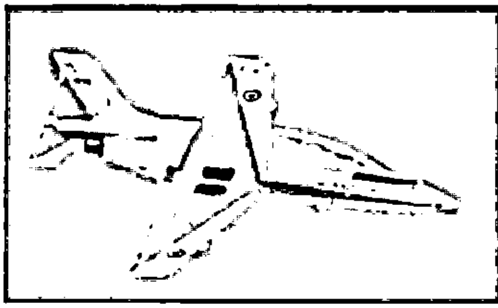
By Jay Menon jaymenon68@gmail.com
NEW DELHI



A Hindustan Aeronautics Ltd. (HAL) trainer jet crashed Thursday in southern India during a routine sortie barely a week after an advanced l helicopter, also developed by the state-owned company, went down ne: the Indo-China border.

"The intermediate jet trainer [IJT], prototype aircraft S-3466, was carry out routine flight testing when it met with a mishap in the afternoon. Bo of the test pilots onboard ejected safely," HAL says in a statement. The company has begun an accident investigation.

The IJT was designed and developed by HAL to replace its Kiran aircraft. The IJT is the Stage 2 trainer for the Indian air force and is fitted with the Russian AL-55 I engine.

The air force trains pilots in three stages using different aircraft. In the first stage, primary training is on a simp HAL HPT-32 propeller aircraft, while Stage 2 is undertaken on a basic jet with a higher degree of complexity enable the trainee to master flying. Stage 3 is conducted on an advanced jet trainer.

On April 21, the Dhruv advanced light helicopter crashed in Sikkim in northeastern India killing four Indian ai personnel. The aircraft was flying at 15,000 ft. Bad weather was given as the reason for the crash.