AA2004-4

AIRCRAFT ACCIDENT INVESTIGATION REPORT

ASIA AIR SURVEY COMPANY LIMITED
GULFSTREAM COMMANDER 695,JA8604
CRASH DUE TO SPIN
OGAWA,NAKA COUNTY,IBARAKI PREFECTURE,JAPAN
AT ABOUT 10:52 JST,MARCH 24,2003

September 24,2004

Aircraft and Railway Accidents Investigation Commission
Ministry of Land, Infrastructure and Transport

The investigation for this report was conducted by Aircraft and Railway Accidents Investigation Commission, ARAIC, about the aircraft accident of Asia Air Survey Company Limited Gulfstream Commander 695 in accordance with Aircraft and Railway Accidents Investigation Commission Establishment Law and Annex 13 to the Convention of International Civil Aviation for the purpose of determining cause of the aircraft accident and contributing to the prevention of accidents and not for the purpose of blaming responsibility of the accident.

The English version report has been published and translated by ARAIC to make its reading easier for English speaking people those who are not familiar with Japanese. Although efforts are made to translate as accurate as possible, only the Japanese version is authentic. If there is difference in meaning of the texts between the Japanese version and the English version, texts in the Japanese version are correct.

Junzo Sato,
Chairman,
Aircraft and Railway Accidents Investigation Commission

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AIRCRAFT ACCIDENT INVESTIGATION REPORT

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Decision by the Aircraft and Railway Accidents Investigation Commission (Air Sub-committee Meeting)

Chairman	Junzo Sato
Member	Yukio Kusuki
Member	Susumu Kato
Member	Sumio Matsuura
Member	Yukiko Kakimoto
Member	Akiko Matsuo

1. PROCESS AND PROGRESS OF THE ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On Monday March 24, 2003, a Gulfstream Commander 695 of Asia Air Survey Company Limited, registration JA8604, departed Chofu Aerodrome at 10:26 (JST) with the captain and a mechanic on board for a company test flight prior to an airworthiness certification inspection. During the flight at around 10:52, the aircraft crashed into woods at Nishine, Kamiose, Ogawa, Naka County, Ibaraki Prefecture.

The two persons on board the aircraft, the captain and the mechanic, both sustained fatal injuries.

A fire broke out and the aircraft was destroyed.

1.2 Outline of the Accident Investigation

1.2.1 The Organization of the Investigation

On March 24, 2003, the Aircraft and Railway Accidents Investigation Commission (ARAIC) assigned an Investigator-in-Charge and an investigator with responsibility for investigating this accident.

1.2.2 Cooperation by Foreign Authorities

A representative of the United States of America, the state of design and manufacture of the aircraft, participated in the accident investigation.

1.2.3 The Implementation of the Investigation

The investigation proceeded as follows.

March 24–26, 2003	On-site investigation and collection of witness statements.
April 2, 2003	Collection of statements
April 16, 2003	Investigation of wreckage
June 9, 2003	Investigation of wreckage
June 13–24, 2003	Analysis of lubricating oil
June 20, 2003–May 24, 2004	Engine disassembly investigation. (Investigation carried out at engine manufacturer’s facility with the cooperation of the U.S. National Transportation Safety Board.)

1.2.4 Hearings from Persons relevant to the Cause of the Accident

Hearings were held.

1.2.5 Hearing with Participating States

Hearing was held.

2. FACTUAL INFORMATION

2.1 Flight History

On Monday March 24, 2003, a Gulfstream Commander 695, registration JA8604 (hereinafter referred to as “the aircraft”), of Asia Air Survey Company Limited (“the company”) departed Chofu Aerodrome on a company test flight prior to an airworthiness certification inspection. It was planned to return to Chofu Aerodrome by way of Utsunomiya and Nasu.

The test items for the flight included confirmation of the function of the cabin pressurization system and the reception of the VOR/DME receivers.

Preflight checks were carried out at Chofu Aerodrome by a mechanic and again by the captain

The flight plan for the aircraft submitted to the Chofu Aerodrome Office of the Tokyo Civil Aviation Bureau was as follows:

FLIGHT RULES: VFR, DEPARTURE AERODROME: Chofu Aerodrome, START TIME: 10:15, CRUISE SPEED:160kt, CRUISE ALTITUDE: VFR, ROUTE: UTSUNOMIYA～NASU～MI (Omiya NDB), DESTINATION AERODROME: Chofu Aerodrome, TOTAL EET: 1 hours 45 minutes, ENDURANCE: 4 hours 00 minutes, PERSONS ON BOARD: 2.

The aircraft took off with the captain in the left-front seat and the mechanic in the right-front seat.

2.1.1 Flight History based on radar and communications records

At 10:26, the aircraft took off from Chofu Aerodrome’s runway 35.

At 1029:02, the aircraft reported clear of the airport control zone to Chofu Aerodrome Control, which then transmitted approval to leave the control tower frequency.

At 1034:32, the aircraft was flying around 5 nm northeast of Omiya NDB, 200°/33 nm from Nikko NDB at an altitude of 15,700 ft and a ground speed of 140kt.

At around 10:35, the aircraft reported ‘over the Arakawa at 10,000 ft, operation normal’ to the Asia Air Survey company radio station (“company radio”). (Note 1)

Thereafter, the aircraft flew in a straight line on a magnetic heading of around 040°. Its position, altitude and ground speed were as follows:

Time	Altitude (ft)	Ground Speed (kt)	Direction/Distance from Nikko NDB
1035:41	17,500	150	198°/30nm
1036:50	19,000	150	
1037:59	20,600	170	
1039:09	22,100	160	187°/22nm
1040:17	22,200	190	180°/18nm
1042:26	22,200	220	
1043:35	22,300	220	
1044:43	23,300	200	118°/12nm
1045:13	23,200	180	
1045:43	23,000	170	105°/14nm
1046:52	22,400	160	095°/15nm
1048:01	21,900	160	086°/17nm
1049:10	21,400	160	081°/20nm
1049:34	21,100	160	
1050:09	21,100	130	
1050:13	20,900	Unknown	
1050:29	17,000	Unknown	
1050:49	12,600	Unknown	
1051:09	8,600	Unknown	
1051:36	3,200	Unknown	Final radar information

There were no recorded communications with any radio stations after the aircraft reported its position over the Arakawa to the company radio station.

(Note 1) The aircraft communicated with the company radio station at around 10:35. The time at which it passed over the Arakawa was not communicated in the aircraft's report.

2.1.2 Eyewitness statements relating to the accident circumstances

(1) Eyewitness-A, who was around 700m northeast of the crash site

"I was doing farm work in a plastic greenhouse when I heard an unusual wavering sound of an aircraft's engine. As I went out, I saw an aircraft in a spiraling nose-down fall. I thought it might recover, but I lost sight of it in the shadow of some trees and there was the sound of a bang. I immediately called the fire service by cellular phone, but I could not get through, so I called a friend who was a fireman. I did not see any smoke, etc. from the falling aircraft. The weather was fine and there was virtually no wind."

(2) Eyewitness-B, who was around 900m west-northwest of the crash site

“On that day I was doing farm work in the fields since morning. The aircraft came flying over and I supposed it was being used for training because I heard the sound of the engines as powered up. When I looked up, the aircraft was descending from east to west while banking to the right, then pulled up from a steep dive. It then climbed steeply and became inverted with the wings were unsteadily rocking to the left and right, then its nose dropped and it descended while spinning to the right. Just after it disappeared behind the ridge of a mountain, I heard the bang of an impact.”

(3) Eyewitness-C, who was around 500m south-southeast of the crash site

“I saw the aircraft falling in a 45 degree descent while spinning to the right. I didn’t hear the sound of the engines, just the sound of the parting air. I don’t know where from but I saw smoke coming from the aircraft. The aircraft made two rotations and then crashed.

“I immediately drove to the site of the crash. Fire had not yet broken out [when I arrived].

“Both wings had broken off near the roots and separated from the fuselage. The fuselage has also broken in the middle into two separate pieces. Although the windows at the front of the fuselage were white with cracks, they had virtually retained their shape.

“I saw that the person in the pilot’s seat wasn’t wearing a helmet, but I didn’t realize anything else about him.

“Fuel was pouring over the ground, and after a while fire broke out around the left engine which ignited the fuel. Flames 12–13 m high quickly sprang up, and there was nothing I could do.”

(4) Eyewitness-D, who was around 2km south of the crash site

“I was playing gate ball with my friends at a gate ball pitch near my house when I heard the sound of an aircraft’s engines revving high and low. I looked up at the sky at the strange noise and saw an aircraft was flying in the northern sky.

“With the bottom of the aircraft facing us, it made a large right turn tracing the Japanese letter “の” and began to reduce height slowly while turning. While I was watching, the nose of the aircraft lowered and then the aircraft suddenly started to drop straight down. I shouted ‘Oh! Look at that’ to my friends playing gate ball, and they too looked at the falling aircraft and said ‘surely it won’t crash’.

“I don’t know how many times the aircraft spun, but each time it spun I was the sun glinting off the wings. It disappeared behind pine woods, and I heard the sound of a bump.

“A little while after the sound a mass of black smoking rose from around where it fell.”

The accident occurred in a mountain forest at Nishine, Kamiose, Ogawa, Naka County, Ibaraki Prefecture at around 10:52.

(See attached Figures 1, 2 and Photographs 1, 2.)

2.2 Deaths, Injuries or Persons Missing

The two occupants of the aircraft, the captain and the mechanic, were killed in the crash.

2.3 Damage to Aircraft

2.3.1 Extent of Damage

The aircraft was severely damaged.

2.3.2 Damage to Aircraft by Part

Fuselage:	Burned
Wings:	Separated and burned
Tail wings:	Separated and burned
Engines:	Damaged and burned
Propeller:	Separated

2.4 Damage to Other than the Aircraft

Several trees were broken, and some tens of trees were burned. Dead leaves on the ground over a 700m^2 area around the accident site were burned up.

2.5 Crew Information

Captain: Male, aged 56

Commercial Pilot License (Airplane)	Issued December 24, 1971
Type Ratings	
Airplane single-engine (land)	Issued December 24, 1971
Airplane multiengine (land)	Issued May 17, 1975
Instrument Rating	Issued August 15, 1979
Flight Instructor Rating (Airplane)	Issued November 14, 1972
Class 1 Airman Medical Certificate	
Term of Validity	until March 3, 2004
Limitation	Holder shall possess glasses to correct for near sightedness
Total flight time	11,473 hours 03 minutes
Flight time during the previous 30 days	12 hours 10 minutes
Total flight time on the same model of aircraft	Approximately 300 hours
(Estimated from company records since the flight log was destroyed by fire)	
Flight time during the previous 30 days	12 hours 10minutes

2.6 Aircraft Information

2.6.1 The Aircraft

Type	Gulfstream Commander 695
Serial Number	95044
Date of manufacture	November 11, 1980
Certificate of Airworthiness	Tou-14-107
Term of validity	May 13, 2003
Category	Airplane Normal (N)
Total flight time	6,029 hours 55 minutes
Flight time since scheduled maintenance (100 Hr Check on March 9, 2003)	12 hours 10 minutes

(See figure 3)

2.6.2 Maintenance and Test Flight before Airworthiness Certification Inspection

(1) The aircraft was planned to be inspected for airworthiness certification on March 20, 2003, and underwent maintenance from February 10 to March 8. During that time, two windshield panels in front of the pilot seats and four window panels around the pilot seats were replaced, and weather radar was installed.

After this maintenance, the aircraft was ferried to Sendai Airport on March 12, and ground checks of the cabin pressurization system were conducted over the next 14 days. The checks found air leakages in the emergency hatch seal and at the wing root area, and repairs were made. After the repairs were completed, a maximum differential pressure check was conducted but maximum cabin differential pressure could not be achieved due to a problem with the outflow safety valves mounted on the bulkhead forward of the cockpit, which regulate cabin pressure.

(2) On March 18, during a flight from Sendai Airport to Chofu Aerodrome, test items apart from the cabin pressurization were confirmed. Also, the function of the weather radar was not checked. During this flight, a problem was found with the VOR/DME receivers in receiving a specific frequency (Fukushima VOR/DME). Although the airworthiness certification inspection had been planned for March 20, it was postponed until March 25 to allow the outflow safety valves to be replaced.

On March 20, a test flight was carried out to confirm the test items outstanding from the flight on March 18. Thereafter, the outflow safety valves were replaced at Chofu Aerodrome on March 23. On March 24, a test flight was planned to check the reception of the VOR/DME receivers and the cabin pressurization system after replacement of the outflow valves. However, since the test flights on the 18th and 20th had been conducted by the captain and the mechanic who were on board the aircraft at the time of the accident, and the documents concerned were destroyed by fire in the accident, the test items to be conducted other than those described above are unknown.

(3) The company test flight was conducted in accordance with the check sheet prepared by the company, which referred to the manufacturer's flight test procedures. The following is an outline of the functional check items on the cabin pressurization system check sheet:

- At an altitude of 10,000ft
  Cabin depression: Cabin ALT Select; 8,000ft, Cabin Press. Switch; Depress
  Result: Cabin pressure should be dumped and pressure differential should go to 0.
  Ram Air Flow: Cabin Press. Switch; Depress, Defog Blower; Off
  Result: Air should flow from the air outlets beside the pilot seats.
- During climb (from 10,000ft to 23,000ft)
  Cabin ALT. Warning Light: Cabin Press. Switch; Depress
  Record the altitude at which the 'CABIN ALT' annunciator illuminates.
  Result: Should be 13,000ft±500ft
- At an altitude of 23,000ft
  Maximum cabin pressure: 5.10–5.45psi,

Further, the company prescribed the use of oxygen masks while checking the cabin pressurization system as follows:

- Dump cabin pressure at an altitude of 8,000ft to 10,000ft.
- Climb to 13,000ft to confirm the altitude at which the Cabin ALT warning light illuminates.
- Don oxygen masks during the climb. After checking the Cabin ALT warning light, repressurize the cabin, and remove oxygen masks is the cabin altitude is in the range 8,000–10,000 ft. After that, keep oxygen masks to hand when climbing to higher altitudes.

In addition, the same check sheet specifies engine power output checks to be conducted at altitudes of 10,000 ft, 17,000 ft and 31,000 ft.

2.6.3 The Engines

Type: Garrett TPE331-10-511K

	Left	Right
Serial No.:	P-38082C	P-38084C
Date of Manufacture:	August 27, 1980	August 28, 1980
Total time in service:	6,029hours 55minutes	6,029hours 55minutes
Time since overhaul	3,029hours 55minutes	3,029hours 55minutes

(July 29, 1990) (July 29, 1990)

2.6.4 The Propellers

Type:	Dowty-Rotol R306/3-82-F/7	
	Left	Right
Serial No.:	DRG/135/81	DAP0007
Date of Manufacture:	March 27, 1995	December 10, 1999
Total time in service:	5,375 hours 55minutes	1,007 hours 25minutes
Time since overhaul	957 hours 50minutes	NA (Not yet reached 4,000 hour TBO)

2.6.5 Weight and Center of Gravity

The weight of the aircraft at the time of the accident is estimated to have been approximately 9,410 lbs, with the center of gravity at 213.3 inches. It is estimated that both values were within the allowable limits (maximum take-off weight 9,985 lbs, with an allowable center of gravity range corresponding to the weight at the time of the accident of 208.6–218.5 inches).

2.6.6 Fuel and Lubricating Oil

The fuel on board was Aviation Fuel Jet-A-1. The lubricating oil was Mobile Jet Oil II.

2.7 Meteorological Information

2.7.1 Utsunomiya Aerodrome Aviation Routine Weather Report (METAR)

The METAR reports for Utsunomiya Aerodrome, which is approximately 40 km west-southwest of the point at which the accident occurred, for around the time of the accident are as follows:

Time of Observation	10:00 JST	11:00 JST
Wind Direction	220 °	150 °
Wind Speed	02kt	03kt
Visibility	More than 10km	More than 10km
Cloud Amount	FEW	FEW
Height of Cloud Base	3,000ft	3,000ft
Cloud Amount	-	SCT
Height of Cloud Base	-	22,000ft
Temperature	13℃	15℃
Dew Point	06℃	06℃
Atmospheric Pressure	1,023hPa	1,022hPa

Remarks	Cloud Amount: 1/8 Cloud Type: Cumulus Height of Cloud Base: 3,000ft QNH: 30.22inHg	Cloud Amount: 1/8 Cloud Type: Cumulus Height of Cloud Base: 3,000ft Cloud Amount: 3/8 Cloud Type: Cirrus Height of Cloud Base: 22,000ft QNH: 30.19inHg

2.7.2 Weather Observations by Ose Local Meteorological Station

Weather observations provided by the Ose weather Local Station, Mito Regional Meteorological Office, which is around 1.2 km southeast of the point at which the accident occurred, for around the time of the accident are as follows:

10:00; Wind Direction: South- southwest, Wind speed: 2m/s, Temperature: 13.5°C, Precipitation: 0mm, Hours of sunlight: 1.0 Hr
11:00; Wind Direction: West, Wind speed: 1m/s, Temperature: 13.9°C, Precipitation: 0mm, Hours of sunlight: 0.9 Hr

2.7.3 Upper Atmosphere Observatory Radiosonde Observations

The wind direction, wind speed and temperature at below an altitude of 7,394 m (24,400 ft) at 09:00 on March 24, 2003 recorded by the Tateno Upper Atmosphere Observatory, which is around 65 km south-southwest of the point at which the accident occurred, are as follows:

Altitude (m)	Altitude (ft)	Wind Direction (deg.)	Wind Speed (m/s)	Temperature (℃)
7,394	24,400	271	35	-
7,151	23,598	-	-	–34.9
7,048	23,258	273	36	-
6,692	22,083	276	35	-
6,347	20,945	276	32	-
6,002	19,806	276	31	-
5,082	16,770	-	-	–20.8
4,940	16,302	259	19	-
4,049	13,361	247	16	-
3,122	10,302	-	-	–6.7
2,977	9,824	240	8	-

1,896	6,256	257	4	-
1,186	3,913	-	-	3.0
873	2,880	256	3	-
202	666	264	1	-

2.8 The Crash Site and Aircraft Wreckage

2.8.1 The Crash Site

The site of the accident was at the edge of a mountain forest at an elevation of around 130 m at Nishine, Kamiose, Ogawa, Naka County, Ibaraki Prefecture. There were a large number of trees of various species around 20 m high at the site. There was a “step” of 3–4 m down to farm fields bordering the forest.

Private houses were situated around 130 m northeast and 100 m southeast of the crash site. Also, the route 293 expressway ran north/south around 120 m east of the crash site.

The aircraft came to rest with its fuselage pointing along a magnetic heading of 050°. The forward fuselage and right wing were on the “step” at the border between the forest and the fields. A portion of fuselage with the horizontal stabilizer attached had been caught between the roots of two trees and stuck there. The fuselage was almost completely destroyed by fire, as were both wings inboard of the left and right engines. The parts of the wings outboard of the engines were damaged by fire.

The right propeller had separated from the front of the right engine. One blade of the left propeller had separated and was found in the aft vicinity of the left wing tip.

Of the trees at the crash site, while one tree was broken off at the trunk, other trees had no significant damage due to aircraft impact other than branches snapped off, and one tree had lost areas of bark in three places, considered to be due to strikes by blades of the left propeller.

Trees around the aircraft had been burned almost to the top and/or blackened by smoke and soot. Dead leaves and other matter on the ground in a circular area of approximately 30 m diameter around the aircraft had been burned.

(See Figure 1, and Photographs 1 and 2.)

2.8.2 Damage to the Aircraft

Details of the damage to the aircraft are as follows:

(1) The forward fuselage was destroyed by fire with the exception of the floor panels. The windshields in front of the pilot seats were destroyed by fire except for a small fragment of the lower part of the frame, which were fire damaged. Other transparencies around pilot seats, the instrument panels, etc. were destroyed by fire. The pilot seats and areas around the cabin seats were also burned, with fire damage around right pilot’s seat being particularly severe. Because the control columns and

rudder pedals were destroyed by fire, their positions at the time of the accident could not be ascertained.

The lower part of the front instrument panel was deformed. The outflow safety valves were not fire damaged but both were crushed.

The center fuselage was destroyed by fire except for the floor panels and lower skin.

The tailplane had separated from the aft part of fuselage forward of its attachment. The radio communications and navigation equipment installed in the cargo compartment were destroyed by fire. The oxygen supply lines had broken off from the oxygen cylinder and were destroyed by fire, and the oxygen had been discharged.

(2) The inboard sections of both wings between the fuselage and engine nacelles were destroyed by fire. The sections of wing outboard of the engine nacelles were burned and deformed. The tip of the left wing was separated from its attachment. There was no fire damage to the aft portion of right engine nacelle.

The ailerons and flaps were damaged by fire, but had not separated from their hinges.

(3) The left surface of the vertical stabilizer, the upper surface of the left horizontal stabilizer and the elevator were damaged by fire. The outboard portion of the left horizontal stabilizer measuring around 80 cm from the tip had broken away. The outboard portion of the right horizontal stabilizer had broken off at almost its center. Both left and right elevators had separated from their hinges.

The elevator trim was at 55 mm nose up, out of a full stroke of 65 mm aircraft nose up.

The rudder was undamaged and was deflected fully to the right.

(4) Engines

① The left engine propeller shaft had been severed aft of the propeller attachment flange. The forward flange the compressor section case was damaged. The oil tank had been crushed, but was not cracked. The cap of the oil tank had not been locked to the filling port, but there was no damage to either the cap or to the flange of the filling port to which the cap is locked.

Lubricating oil was found sprayed on the engine outer case.

The starter/generator had broken off at its attachment.

② The right engine’s reduction gear case had separated. The front flange of the compressor section case was damaged and the first stage impeller was deformed. The fuel control unit had broken away.

The oil tank was damaged and was empty of lubricating oil. The oil tank cap was locked to the filling port.

(5) Propeller

① Of the three left propeller blades, one had broken off near the hub and its tip was bent forward, another had been destroyed by fire from the middle to the tip, and the other was bent backwards with the tip bent slightly forwards.

② Of the three right propeller blades, one was bent forward from its middle, another was bent forwards greatly and the trailing edge at the tip had wave-like deformations. The tip of the remaining blade was twisted towards the leading edge and the whole blade was bent slightly forwards.

(6) The left main gear with its tire and wheels was destroyed by fire. The right main gear was undamaged. The nose wheel tire was damaged.

(See Photographs 3–7.)

2.8.3 Condition of the Engine Control Levers

Although the power and other engine control levers were damaged, their positions were found to be as follows:

(1) The power levers for both engines, which control engine output, were both found to be in the fully forward position. The knobs to set the engines to ground idle had not been pulled. Further, the positions of the power lever shafts on the fuel control units were at around 92% for the left engine and at the maximum stop position for the right engine.

(2) The propeller condition levers that control propeller rotation, fuel supply on/off and propeller feathering were both found in the most forward position (High RPM). Furthermore, neither the left nor right engine levers had been pulled up to the feather position.

2.9 Medical Information

According to the Ibaraki Prefecture Police Department, autopsies on the captain and the mechanic were conducted by the department of legal medicine at the School of Medicine, University of Tsukuba on March 25, 2003. The cause of death for both was found to be head injuries. Tests for alcohol and drugs found no reactions

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2.10 Post-Crash Fire and Fire Fighting

After the aircraft crashed, fuel that leaked from damaged fuel tanks inside the wings ignited, causing a fire that spread across the surrounding forest.

The Ibaraki Prefecture Omiya Regional Fire Department dispatched a fire engine and an ambulance, while the Ogawa Village fire brigade dispatched 122 firefighters, two fire engines and 16 small pump-equipped fire engines.

2.11 Tests and Research to Find Facts

2.11.1 Outline of the Lubrication System and Propellers

(1) Lubrication System

The Grumman Commander 695's lubrication system in each engine consists of a high-pressure pump, three scavenge pumps, oil filter, pressure regulator and oil tank.

The compressor and turbine bearings and reduction gear train are lubricated and cooled by a high-pressure dry sump type lubrication system.

Lubrication system oil is used also in the propeller control system and torque-sensing component.

Engine oil temperature is maintained within operational limits by an external oil radiator.

(2) Propellers

The hydraulically operated three-bladed propellers are full feathering and reverse pitch capable.

The propeller blades are driven in the low and reverse direction pitch by lubricating oil pressurized by the propeller governor oil pump.

The blades are feathered by the propeller pitch change piston sliding in the high pitch direction by means of a feathering spring and blade counterweight.

2.11.2 Engine Disassembly Inspection

Both the aircraft's engines were sent to a facility of the manufacturer, Honeywell Inc., in Phoenix, Arizona in the United States, and were investigated by a teardown inspection. The investigation was conducted on November 12 and 13, 2003 under the supervision of, and witnessed by, an investigator of the US National Transportation Safety Board.

Based on the results of the investigation, it was found that both engines were rotating at the time of crash, and the following were confirmed as to their operating state.

Further, no preexisting conditions were identified in either engine that would have interfered with normal engine operation.

(1) Left Engine

① Evidence that the engine was rotating

(a) Rotational scoring of the propeller shaft near the propeller shaft nut with corresponding rotational scoring on the forward face of the sun gear.

(b) All four large mount dowels for the ring gear support displaced sideways in the housing with corresponding elongation of their respective mount locations in the ring gear support.

(c) Several blades of the first-stage compressor impeller bent opposite to the direction of rotation.

(d) Rotational scoring on the aft blade platforms of the first-stage turbine rotor blades with corresponding rotational score marks on the forward vane support of the second-stage turbine stator.

(e) Rotational scoring on the second-stage turbine blade tip shroud.

② Evidence that the engine was in an operating state

(a) Compressor shroud metal spray deposits on the suction side of the vanes in the first-stage turbine stator.

(b) Compressor shroud metal spray deposits on the suction side of the vanes in the first-stage turbine rotor.

(c) Compressor shroud metal spray deposits on the leading edge of the vanes in the second-stage turbine stator.

(d) Compressor shroud metal spray deposits on the suction sides of the vanes in the second-stage turbine stator.

(e) Compressor shroud metal spray deposits on the suction sides of the blades in the second-stage turbine rotor.

(f) Compressor shroud metal spray deposits on the leading edge of the vanes in the third-stage turbine stator.

(g) Compressor shroud metal spray deposits on the suction sides of the blades in the third-stage turbine rotor.

(2) Right Engine

① Evidence that the engine was rotating

(a) Rotational scoring of the propeller shaft near the propeller shaft nut.

(b) All four large mount dowels for the ring gear support displaced sideways in the housing with corresponding elongation of their respective mount locations in the ring gear support.

(c) Several blades of the first-stage compressor impeller bent opposite to the direction of rotation.

(d) Rotational scoring on the second-stage turbine blade tip shroud with corresponding rotational scoring on all of the blade tips of the second-stage turbine rotor.

(e) Rotational scoring on the third-stage turbine blade tip shroud with corresponding rotational scoring on all of the blade tips of the third-stage turbine rotor.

② Evidence that the engine was in an operating state

(a) Compressor shroud metal spray deposits on the suction sides of the blades in the first-stage turbine rotor.

(b) Compressor shroud metal spray deposits on the suction sides of the vanes in the second-stage turbine stator.

(c) Compressor shroud metal spray deposits on the suction sides of the blades in the second-stage turbine rotor.

(d) Compressor shroud metal spray deposits on the leading edge of the vanes in the third-stage turbine stator.

2.11.3 Propeller Disassembly Inspection

A propeller teardown inspection was conducted at Chofu Aerodrome. An outline of the investigation results is as follows:

On both propellers, the propeller pitch change piston in the hub was locked by the starting latch, and blades were found to be at ground idle pitch.

There was no damage to the propeller pitch change piston and two feathering springs in either propeller. Lubricating oil for propeller pitch change remained in the cylinders.

In both the left and right propellers, the pin attached to each blade to change the blade pitch had broken off in one blade, and was damaged in another blade.

2.11.4 Lubricating Oil Analysis

The oil in both engines had been changed at the 900 hr check on February 11, 2002, after which about 310 hr had been accumulated up to the day before the accident. During that period, although it is supposed that the oil was topped up depend on its rate of consumption, the top-up quantity is unknown since there were no records.

After the accident, lubricating oil was collected from left and right propeller hubs and left engine oil tank, and was analyzed. Lubricating oil from the right engine oil tank could not be collected since the oil tank was damaged. The analysis of the oil was conducted to detect whether there were sufficient quantities of metallic elements to indicate mechanical abnormality in engine internal parts, and to determine whether the acidity was sufficient to indicate a degree of oil deterioration caused by temperature rise. An outline of the analysis result is as follows:

Iron, copper, and silicone were mainly found in the oil collected from left and right propellers and left engine oil tank, but only in small quantities. There was low value of acidity.

2.11.5 Oil Tank Caps

(1) Pre- and post-flight checks

Preflight and the post-flight checks are specified in the annex “Maintenance Record Form—Gulfstream Commander 695” of the company’s maintenance manual. Pre- and post-flight checks are carried out using this form. The form specifies to “Check the engine oil quantity and that the cap is secure” during both pre-flight and post-flight checks.

The airplane’s flight manual describes as an external check item “oil quantity, cap, and access door check” in the normal operating procedures detailed preflight checklist.

(2) Oil Tank Cap Lock

The cap is secured by hitching two pawls inside the cap on a flange on the oil tank and turning the cap clockwise through about 90 degrees.

(3) The possibility of oil loss if the oil tank cap is not locked

The following is information from Honeywell Inc., the aircraft's engine manufacturer, on the possibility of oil loss if the tank cap is not secured:

> Because the oil tank is kept at a slight positive pressure during operation, there is a possibility that oil will be drawn out of the oil tank if the cap becomes loose. It is possible that oil mist drawn out will wet the engine case and the exterior of the engine with oil. Since the aircraft has an ejector type exhaust system, it is possible for oil mist to spray over the hot main exhaust pipe, and for the resulting smoke to be drawn from the nacelle by the ejector effect.
>
> Because type II oil has a flashpoint of 475°F (247°C), there is little chance of oil on the engine plenum case igniting. However, smoke will be created at the main exhaust pipe if there is oil mist on the surface of exhaust pipe.

2.11.6 Cabin Pressurization System

(1) For normal category airplanes (N), which the aircraft was categorized as, the airworthiness standards manual stipulates that for pressurized cabins, "if certification for operation over 9,500 m (31,000 ft) is required, the airplane must be able to maintain a cabin pressure altitude of not more than 4,500 m (15,000 ft) in the event of any probable malfunction in the pressurization system".

Based on the airplane's flight manual, the maximum operating altitude of the aircraft is 31,000 ft and the maximum allowable differential pressure is 5.4psi.

If pressure differential is:	Barometric Altitude	Cabin Altitude
5.4psi	31,000ft	11,500ft
	28,400ft	10,000ft
	23,000ft	7,000ft
If pressure differential is: 5.2psi (Normally operated)	31,000ft	12,000ft
	27,400ft	10,000ft
	23,000ft	7,500ft
	21,000ft	6,300ft

(2) Outflow control valves are installed at two locations on the cockpit front bulkhead to control cabin pressurization.

Although the valves were not destroyed by fire and were found in their installed locations, both had been crushed and it could not be confirmed whether they had been functioning normally.

The cabin windows including the frames were virtually destroyed by fire, and of the windshields, only a small piece of shattered glass remained near the frames. Consequently, it could not be confirmed whether all of the replaced windows had been installed securely or whether there were any air leaks from them.

2.12 Other Information

2.12.1 Emergency Procedures

The emergency procedures in the Pilot's Operating Handbook are as follows:

(1) Engine Failure/Fire In flight

<WARNING>

Do not retard power lever for failed engine before propeller is feathered. Identify failed engine by asymmetric power and reference to engine instruments. If NTS [Negative Torque Sensor] is not operating, retarding the power lever will increase drag.

① Failed engine: IDENTIFY

② Condition Lever (failed engine): EMERGENCY FEATHER

③ FUEL-HYD switch (failed engine): EMER OFF

<NOTE>

If engine fire does not extinguish when engine is shut down, dive the airplane at maximum allowable airspeed to blow the fire out.

④ Oil Temperature Control Door (Operating engine): TRAIL or CLOSED, as required.

⑤ Inoperative Engine: SECURE

a. Generator Switch: OFF

b. Engine Inlet Heat: OFF, if applicable

c. Prop Sync: OFF

d. Oil Temperature Control Door: CLOSED

e. Engine Control Switch: ENG OFF after EGT decreases to 200℃, or less.

<NOTE>

Feathered propeller may rotate slowly. Flight at approximately 125 KIAS will minimize propeller rotation.

⑥ Operating Engine: ADJUST POWER as required.

⑦ Trim: ADJUST

⑧ Operating Generator: CHECK less than 300 amps. Reduce non-essential electrical load, if necessary.

⑨ Cabin Altitude: CHECK

⑩ Fuel Interconnect Valve: OPEN, if necessary to correct fuel imbalance.

⑪ As Soon As Practical: LAND

(2) Spins

<WARNING>

If a spin is entered inadvertently, immediately and abruptly move control column full forward, apply full rudder opposite to the direction of the spin and reduce power to FLT IDLE. These three actions should be done as near as simultaneously as possible. Hold this control position until rotation stops, then neutralize all controls and execute a smooth pullout. Ailerons should be neutral during recovery.

<NOTE>

Federal Aviation Regulations do not require spin demonstrations in airplanes of this class. NO SPIN TESTS HAVE BEEN CONDUCTED. The recovery technique is based on the best available information.

2.12.2 Descent

Based on the airplane flight manual, etc., the procedures for descent are outlined as follows:

(1) Rate of Descent, etc. for a Normal Descent

The time, fuel, and distance required for a 1,500 ft/min descent in no wind are described. In this condition, engine power is set as necessary to maintain a 1,500 ft/min descent rate.

Also, the speed during descent is lower the higher the altitude; the indicated airspeed (IAS) is 210kt at an altitude of 24,000 ft, 220kt at 22,000 ft, and 230kt below 20,000 ft.

Based on a chart, the time required to descend from 20,000 ft to sea level is approximately 13 minutes, and the distance is approximately 55 nm.

(2) Emergency Descent

Set power levers to FLT IDLE, propeller condition levers to HIGH RPM and descend at the maximum permissible airspeed indicated by the striped pointer on the airspeed indicator. The striped pointer is set up to a maximum of 240kt IAS.

(3) Rate of Descent in a Spin

The following are according to the Gulfstream Commander Company:

There are no data on the rate of descent in a spin since spin tests have not been demonstrated in airplanes of this class and so there are no test data.

Further, it had not been demonstrated that a descent at such a rate as to reach around 400 ft altitude from around 21,000ft in about 1 minute 50 seconds may be carried out without exceeding design limits.

2.12.3 Stall Speed, etc.

The following are outlines based on the airplane flight manual, etc.

(1) It is estimated that the stall speed in cruise configuration at the weight at the time of the accident and with the engines at flight idle was 75kt IAS. The aircraft was equipped with a stall warning system which, when airspeed decreases, operates to give a warning at 4–9kt above the stall speed.

(2) When one engine is set at take-off power and the other engine is inoperative with the propeller wind milling, the minimum control speed (the minimum speed at which the

aircraft is able to maintain straight flight at a bank angle of 5°) is 93kt IAS.

(3) The intentional one engine inoperative speed is a minimum speed selected by the manufacturer for intentionally rendering one engine inoperative in flight for training purposes. This speed provides an adequate margin above the stall speed to prevent an inadvertent stall and possible spin. The safe one engine inoperative speed is 105 kt IAS.

<WARNING>

Simulating one engine inoperative by setting it to FLT IDLE power results in significant asymmetric drag.

The minimum control speed at this time is approximately 102kt IAS.

This kind of flight should therefore not be attempted at below the minimum control speed.

2.12.4 Elevator Trim System and Autopilot

The aircraft was equipped with an autopilot system. Outline descriptions of the elevator trim system and autopilot based on the airplane flight manual are as follows:

(1) The Manual Electric Elevator Trim system utilizes the autopilot pitch trim servo to actuate the elevator trim tabs. The system is operated by a double acting rocker-type control switch in the left the grip of the pilot’s control wheel.

If the control switch is operated when the autopilot is engaged, the pitch and roll axes are automatically disengaged. However, the yaw axis remains engaged.

Placing the switch in the left grip of the pilot’s control wheel to the REL position disengages the autopilot and renders the manual electric elevator trim system inoperative. While the autopilot is disengaged, the elevator trim tabs can be actuated by turning the elevator trim control wheel.

(2) When the autopilot altitude hold mode is selected, the autopilot maintains the aircraft at a selected altitude by varying its attitude. The pilot should set the power to maintain a safe airspeed.

(3) The autopilot may be overpowered by forces on the control wheel or rudder pedals whenever necessary during an emergency. This will not damage the autopilot. The autopilot should be disengaged as soon as practical since an overpower force in the pitch axis with elevator automatic trim will oppose overpowering by driving the trim surface to a position proportional to the duration of the overpower force. Movement of the trim tabs is started after a 3 second delay, and continued while overpower is held.

At high altitude (over 17,000ft±1,200ft), the maximum overpower forces are 10lbs in aileron, 20lbs in elevator and 103lbs in rudder.

<WARNING>

The elevator overpower force described above is the initial force required to overpower the elevator. If the overpower is continued (longer than 3 seconds), the force increases.

2.12.5 Oxygen System

(1) The aircraft was equipped with an oxygen system. Bottled oxygen is supplied from an oxygen cylinder to flight crews and passengers. The regulator assembly is located under the side windows of right pilot's seat, and oxygen flow is regulated according to the flight altitude by an altitude compensating valve. The same valve also shuts off the oxygen flow when oxygen is not used.

The flight crew oxygen masks are of the dilutor demand type, and are equipped with a flow indicator and microphone.

(2) The Pilot's Operating Handbook describes that the oxygen cylinder pressure should be checked during the preflight check, and that the oxygen system should be checked before engine start if the flight will be at an altitude of 13,000ft or more.

2.12.6 The Captain's Recent Flight History

The captain had flown for around 3 years and 5 months since July 1999. However, during that time, he renewed and maintained his Class 1 Airman Medical Certificate.

After that, the captain underwent refresher training on the same model of airplane as was involved in the accident from December 26, 2002, and from that time up until January 29, 2003 he completed six training flights with a total flight time of 9 hours 10 minutes. He then passed the company examination on January 30, 2003 and resumed flying with the company for air transport and commercial operations.

The refresher training and proficiency check were carried out according to the company's operating standards as follows:

(1) Refresher training

This training is to provide flight crews with the necessary knowledge and skills to resume flight operations for some model of aircraft after having not carried out flying duties for longer than a specified period of time.

Training items:

- Classroom training
- Practical training

On each occasion, the practical training items to be carried out are selected from the syllabus as appropriate by the instructor pilot.

(2) Refresher proficiency examination

This proficiency examination is conducted on each occasion a flight crew member resumes flying duties after having not carried out flying duties for longer than a specified period.

Proficiency examination items:

- Classroom examination
- Oral examination
- Practical examination

On each occasion, the items in the practical examination are the same as those selected by the instructor pilot for the refresher practical training, and are recorded.

The training and the proficiency examination are carried out under the following conditions:

- Classroom training is carried out before and after the practical training.
- The practical training consists of a total of six flights, the last of which is a solo flight.
- The flight examination is judged to have been passed when the result is good overall.

2.12.7 Hypoxia and Time of Useful Consciousness

The following descriptions relating to hypoxia are from "Clinical Aerospace Medicine" (by Yasushi Ueda, Aerospace Medicine Research Center, published by Houmeido Bookstore, April 30, 1995):

(1) Hypoxia means clinically a lack of oxygen in human tissues, and develops as the result of various disease conditions and by several other causes. The hypoxia that is a problem in aviation is hypoxic hypoxia, and apart from loss of consciousness caused by acceleration, arises due to an almost total loss of air pressure.

(2) To understand the relationship between altitude and the onset of hypoxia, altitude is classified as follows.

This is based on a healthy person at rest. In the case of heart or lung diseases, anemia etc., hypoxia develops even at low altitudes. Further, it should not be forgotten that there is large variation in individual resistance to hypoxia.

Altitude (ft)	Classification	Symptoms
0–10,000	Indifferent stage	Ambient oxygen concentration reduces to around 2/3, but there are almost no effects of hypoxia. Night vision decreases at altitudes above 4,000ft.
10,000–15,000	Compensatory stage	The frequency of respiration and pulse rate may increase, but hypoxia may not appear for a short time due to physiological compensatory mechanisms.
15,000–18,000	Disturbance stage	Almost all of persons sustain hypoxia despite physiological compensatory mechanisms.
above 18,000	Critical stage	Rapid loss of consciousness with danger to life.

(3) Symptoms of Hypoxia

Although symptoms occur mainly in the respiratory organs, cardiovascular system, and cranial nerve system, it should be especially noted that in many cases the affected person does not notice the symptoms.

While the pulse rate and frequency of respiration may increase as symptoms of the circulatory and respiratory organs, in many cases blood pressure does not change because of peripheral vascular resistance.

The initial symptoms are as follows:

Subjective symptoms: Feeling of heat, feebleness, feeling of headaches, deterioration of visual sensitivity, change in character, deterioration of judgment, and deterioration of speech.

Objective symptoms: Respiration, increase in pulse rate, cyanosis, deterioration of intelligent activity, greater reaction time, disturbance of coordination, convulsions, loss of consciousness.

The disturbance of motor functions and loss of consciousness are the most important problems in the condition of hypoxia. The time of useful consciousness (TUC) is defined as the amount of the time remaining at the same altitude from the onset of hypoxia until loss of consciousness. The following table shows the approximate TUC at various altitudes.

Altitude (ft)	Time of Useful Consciousness
10,000～15,000	less than 1 hour
18,000	30 minutes
22,000	5–10 minutes
25,000	2–3 minute
30,000	1 minute 30 seconds

Furthermore, Advisory Circular (AC) 61-107A (dated on Jan. 2, 2003), issued by the United States Federal Aviation Administration (FAA), describes about TUC as attached in Appendix 1.

3. ANALYSIS

3.1 Aircrew Certificates and Medical Certificates

The captain had valid airman proficiency and airman medical certificates in accordance with applicable regulations.

3.2 Certificate of Airworthiness

The aircraft had a valid certificate of airworthiness and had been maintained in accordance with applicable regulations.

3.3 The Cabin Pressurization System and Oxygen System

(1) As described in 2.6.2(1) after replacement of cockpit transparencies etc. on March 14, air leaks were found and repaired. Further, air leakage from the outflow safety valves was found, and these were replaced with new valves on March 23.

The aircraft had crashed on a company test flight to confirm the function of the replaced outflow safety valves. As described in 2.8.2(1) and 2.11.6(2) the outflow safety valves were found at the accident site; however, both had been crushed by the impact at the crash, and so it could not be determined whether or not the valves had been functioning normally.

As described in 2.1.2 (3), while an eyewitness reported that the pilot's windshield had remained in its frame but was cracked at the time of ground impact, it could not be determined whether or not there had been air leakage from the frames because the windshields had been melted by the post-crash fire or smashed, and the frames of the other windows had been destroyed by fire by the time of the on-site investigation.

(2) The main purpose of the aircraft's flight had been to confirm the function of the cabin pressurization system. As described in 2.12.5(2) the captain and mechanic had checked the oxygen system before flight, and it is considered that they had used oxygen masks according to the procedures described in 2.6.2(3) during the flight. However, the use of the oxygen system and its serviceability could not be determined since, as described in 2.8.2(1), the fuselage was almost totally destroyed by fire and of the oxygen system only the oxygen cylinder remained. Further, it could not be determined whether or not the occupants had been wearing oxygen masks since eyewitness-C, who rushed to the accident site, stated that he did not grasp the condition of the occupants.

3.4 The Engines

(1) Based on the following, it is estimated that the engines had been operating at the time of ground impact.

① Based on the result of the engine teardown inspection, both left and right engines had been in an operating condition.

② As described in 2.8.3, the positions of the power and condition levers of both left and right engines corresponded to of engine running condition.

③ As described in 2.8.2(5), both left and right propellers' tips after ground impact had deformed toward the direction of supposing as the engines had been operating and had made the propellers have rotated.

However, as described in 2.8.2(4), given that the oil tank cap on the left engine was not in a locked state, that there was oil on the outer engine case of the left engine, and that eyewitness-C had stated that smoke had trailed from the airplane as described in 2.1.2(3), it is estimated that the left engine had not been in a normal operating condition due to lubricating oil escaping from the oil filling port.

(2) As described in 2.11.4, given that analysis of the lubricating oil detected only a small quantity of metals, it is estimated that the engine internal bearings, etc. had not been damaged. Further, since there was little deterioration of the lubricating oil, it is estimated that the effect of high temperatures on the lubricating oil had been small. In other words, the lubricating oil temperature had not exceeded the maximum limit specified in the airplane flight manual, or had exceeded the maximum limit only for a short period.

(3) It is considered that if a cap in the locked position were separated from the oil tank by the crash impact, the flanges of the cap and the oil filling port would be damaged and deformed. However, no there was no damage to these areas. Further, if the cap had been in the locked position, it is considered that the possibility that the cap might be rotate 90° from the locked position and removed by the flight loads is remote. Therefore, it is estimated that the cap of the left engine oil tank had not been normally locked at the start of the accident flight.

As described in 2.11.5(1), the mechanic and the captain should have confirmed that the oil tank cap was the locked position. Further, the cap would have been removed and then replaced by both the captain and the mechanic when they checked the oil quantity during preflight checks, but in this case it is thought that the cap was not securely locked when it was replaced.

3.5 The Propellers

As described in 2.11.3, the propeller teardown inspection found that the propeller blades on both the left and right propellers had been at ground fine pitch with the propeller pitch change piston locked by the starting latch.

As described in 2.11.1(2), propeller blade pitch change towards low pitch and reverse is driven by oil pressure. Since the condition levers had not been set to the ground idle position, and since it is considered that the damage to the internal components necessary for pitch change was due to impact at the time of crash, it is estimated that the propeller blades were moved to ground idle when the aircraft struck trees and the ground at the time of the crash.

3.6 The Weather around the Time of the Accident

It is estimated that the weather conditions at the time of the accident had no bearing on the accident.

3.7 Flight History until Ground Impact

Based on air traffic control radar recordings, voice communication recordings etc., it is estimated that the flight history of the aircraft up to the point it crashed was as follows.

(1) From take-off until the position report to company radio

At 10:26, the aircraft took off from Chofu Aerodrome.

At 1029:02, the aircraft reported to Chofu Aerodrome Control that it was clear of the control zone.

At 1034:32, the aircraft was flying around 5nm northeast of Omiya NDB, 200°/33nm from Nikko NDB at an altitude of 15,700 ft with a ground speed of 140kt.

At around 10:35, the aircraft reported 'Over the Arakawa at 10,000 ft, operation normal' to Asia Air Survey on the company radio frequency. It is estimated that the flight was normal at this time.

It is estimated that the cabin pressurization system check was carried out according to the company check sheet, as described in 2.6.2(3). Since at 1034:32 the aircraft was climbing through 15,700 ft, it is estimated that the aircraft passed through 13,000 ft at around 10:33, and that around the time, the cabin ALT warning check had been completed and that the aircraft was re-pressurizing the cabin while climbing.

(2) From reporting to company radio until reaching the highest altitude

After reporting to the company radio, the aircraft continued to climb while flying on a straight track at a magnetic heading of approximately 040°, and at 1035:41, it reached an altitude of 17,500 ft with a ground speed of 150kt. At 1036:50, it climbed to 19,000ft with a ground speed of 150kt. At 1037:59, it climbed to 20,600 ft with a ground speed of 170kt. At 1039:09, it reached 22,100 ft with a ground speed of 160kt.

As described in 2.6.2, there was a test item to check engine power at an altitude of 17,000 ft. However, since the aircraft was not observed to maintain an altitude of 17,000 ft, it is considered that the aircraft continued to climb without leveling off and that the engine power check had not been conducted.

At 1039:09, after the aircraft had reached an altitude of 22,100 ft with ground speed of 160kt, the aircraft maintained the almost a constant altitude and its speed increased, and so it is estimated that the aircraft had leveled off. It is thought that the reason the aircraft leveled off at around 22,000ft rather than at 23,000 ft to check the maximum cabin differential pressure was to avoid the cloud reported with a cloud base of 22,000ft in the 11 o'clock METAR issued by Utsunomiya Aerodrome.

At 1040:17, the aircraft reached 22,200ft with a ground speed of 190kt. At 1042:26, the aircraft reached 22,200 ft with a ground speed of 220kt.

At 1043:35, the aircraft reached with ground speed 220kt 22,300ft, then altitude began to increase, and at 1044:43 the aircraft reached the highest altitude in the flight at 118 degree/12nm of Nikko NDB with ground speed 200kt. For these altitude about 1,000 ft, the aircraft climbed up with about 900ft/min climb rate, and after the aircraft reached the altitude true airspeed (hereinafter referred to as "TAS") decreased by 20kt, as IAS decreased by 15kt. It is estimated that this airspeed decreasing is because of the fact that the captain used pitch control without operating the power lever.

For about 4 minutes and 26seconds from 1039:09 to 1043:35, The aircraft maintained an altitude about 22,000ft, then climbed up to an altitude about 23,000ft. It is estimated that this altitude change was done to perform check about the maximum difference pressure function of the cabin pressure controller according to normal procedure of test flight.

Based on the aircraft's ground speed and the wind strength and direction described in 2.7.3, it is considered that when the aircraft was flying at around 22,000–23,000ft, its TAS would have been approximately 160–180kt and its IAS around 110–125kt.

(3) From reaching the highest altitude until before descending at a high descent rate.

At 1045:13, 30 seconds after the aircraft had reached its highest altitude during the flight of 23,300 ft at 1044:43, the aircraft began slowly to descend and its ground speed began to decrease.

If the cabin altitude warning (13,000 ft±500 ft) had been checked as described in 2.6.2(3) if the cabin had started to be repressurized immediately after checking the warning, It would normally take more than 12 minutes until being able to check maximum differential pressure.

At the time when the aircraft started slowly to descend from 23,000 ft, it is estimated that around 12 minutes had elapsed since the cabin had started to be pressurized, and it is considered possible that the maximum differential pressure had been completed. If the cabin pressurization system functioned normally, it is estimated that the cabin altitude would have been around 7,000–7,500 ft.

However, since the aircraft remained above 21,000 ft for a while after the slow descent, it is considered possible that the maximum differential pressure was checked during this time, albeit at a different altitude from that in the company check sheet.

At 1045:43, the aircraft reached an altitude of 23,000 ft with a ground speed of 170kt, at 1046:52, it had descended to 22,400 ft with a ground speed of 160kt, and at 1049:10, it had descended to 21,400 ft with a ground speed of 160kt. The descent rate during this period was around 500 ft/min.

At 1049:34, the aircraft descended to 21,100 ft, and then maintained that altitude until 1050:09. At the time the aircraft reached 21,000 ft, it is estimated that the ground speed was 160kt, TAS 130kt, and IAS 95kt. Thereafter, at 1050:09, just before starting to descend at a high descent rate, it is estimated that the aircraft's ground speed was around 130kt, TAS 115kt, and IAS 85kt.

(4) From starting to descend at a high descent rate until ground impact

At 1050:09 the aircraft descended from 21,100 ft and reached 20,900ft at1050:13; thereafter it started to descend rapidly.

At 1050:29, it is estimated that the aircraft reached 17,000 ft with a descent rate of 11,700 ft/min, at 1050:49 it had descended to 12,600 ft with a descent rate of 13,200 ft/min, at 1051:09 it had descended to 8,600ft, at 1051:36 it reached 3,200 ft (last radar information) with a descent rate of 12,000 ft/min.

3.8 Descent at a high descent rate

(1) If the maximum cabin differential pressure check had been carried out successfully at 23,000 ft, it is thought the aircraft would have then climbed to 31,000 ft without descending to check engine output, since this had not been confirmed on the previous company test flight due to problems with the cabin pressurization.

The aircraft's estimated speed when it first reached around 23,000 ft to check cabin pressurization was 160kt TAS, 110kt IAS.

However, at 1045:13, around 30 seconds after at 1043:43 reaching 23,300 ft, it is estimated that the aircraft started to descend and its speed began to decrease. Based on the estimated progress of the company test flight up to that time and the flight test items, it is thought to have been unnecessary to reduce altitude and speed at this time. It is therefore considered that events that led to a reduction of engine power had arisen at this time.

(2) Because the oil tank cap had not been in the locked position, it is possible that lubricating oil was drawn from the oil tank as described in 2.11.5(3). This is evidenced by the oil found on the engine external case and an eyewitness report of smoke issuing from the aircraft. It is estimated due to a reduction in the quantity of lubricating oil, the oil temperature rose and the pressure dropped.

Regarding the circumstances in which the altitude and speed of the aircraft gradually decreased at around 1045:13, the aircraft having flown for a while at 23,300 ft, it is estimated that the captain observed abnormal lubricating oil temperature, etc.

indicated on the left engine's engine instruments, and reduced power using the left engine's power lever.

(3) It is estimated that the IAS of the aircraft had been around 85 kt just before it began its rapid descent. While 85 kt IAS would have given a margin of around 10 kt above the stall speed corresponding to the weight of the aircraft at the time, it was below the minimum control speed described in 2.12.3(2) and the safe one engine inoperative speed described in 2.12.3(3).

Regarding the circumstances in which the aircraft entered low speed flight while maintaining altitude, it is thought possible that the aircraft maintained altitude to carry out the cabin pressurization check described in 3.7(3), and it is thought that the aircraft's speed decreased due to the reduced power of the left engine owing to the malfunction indicated on the oil temperature and pressure instruments. However, the reason that the airspeed dropped to around the stall speed could not be identified.

It is considered possible that the captain increased the power of the right engine to recover from the low speed condition near the stall. This would have created a yawing moment and since the aircraft was below the minimum control speed and safe one engine inoperative speed, it is considered possible that the aircraft would have been uncontrollable and inadvertently entered a spin.

(4) It is estimated that after 1050:13 the aircraft descended at a nearly constant rate of around 12,000 ft/min. This far exceeds the normal rate of descent described in 2.12.2(1), and so it is not thought to have been a normal descent. Further, it is thought that during a [controlled] emergency descent the aircraft would have covered some ground distance, but since the ground distance covered during the descent was short, it is estimated that the descent was not an emergency descent.

As described in 2.12.2(3), intentional spins are prohibited for the Grumman Commander 695, and there are no data on descent rate during a spin. However, from the start of its descent until it reached the 3,200 ft altitude recorded in the final radar information, the aircraft had a constant high rate of descent. Based on the account of eyewitness-D that during the final part of its descent the aircraft had rotated an uncountable number of times before crashing, and the accounts of eyewitnesses A and C that the aircraft had dived while spinning just before crashing, it is considered that the aircraft entered a spin from which it was unable to recover and subsequently crashed.

It is thought that the significant maneuvers of the aircraft stated by eyewitness-B, that the aircraft "pulled up from the steep dive, then climbed steeply and became inverted", would have been seen by eyewitnesses A and C, who observed the aircraft in the same condition. Since the statements of neither of these eyewitnesses corroborate such movements, it is estimated that the movements of the aircraft seen by eyewitness-B had been the movements of a spin.

However, provided that the movement of the aircraft had been those as the eyewitness-B stated, it is considered possible that the captain had become incapacitated as described in 3.12, but he had begun to recover from the condition of hypoxia as the aircraft descending to low-altitude, and performed recovery operation from the spin but failed.

3.9 Power lever operation

Based on the positions of the engine control levers described in 2.8.3 and the result of the engine teardown inspection described in 2.11.2, it is estimated that the left and right engines had been rotating without being shut down until the moment of ground impact.

It is thought that in the case of an oil temperature rise and pressure drop indicated on the engine instruments due to a decrease of engine oil quantity, the normal action would be to carry out the "Engine Failure/Fire in Flight" drill described in 2.12.1(1). However, as described in 2.8.3(2) the left condition lever had not been set to the feathered position, and so it is considered that action had not been taken in accordance with the drill.

As described in 2.8.3(1), both left and right power levers were found in their forward most positions, and the fuel control unit power lever shafts had been at 92% for the left engine and at the maximum stop position for the right. It is thought that when the abnormal oil temperature, etc. had been indicated on the left engine instruments, the left engine's power lever was retarded. Later, the right engine's power lever was advanced to recover from the reduced airspeed condition. It is though that the power levers would have been retarded after the aircraft entered the spin, but that both power levers were moved to their forward most positions by the impact of the crash. However, it is also considered possible both power levers had been advanced by the captain.

Moreover, according to their statements described in 2.1.2(1), (2) and (4), the eyewitnesses heard the engine sound from the diving and spinning aircraft varying periodically, and so it is considered that the aircraft had been spinning without a reduction in power of at least either the left or right engine. Based on the condition of the propellers as described in 3.4(1)③, it is thus considered possible that the power levers had not been retarded to reduce engine power before ground impact.

3.10 Smoke coming from the descending aircraft and occurrence of fire

Regarding the statement of eyewitness-C, who was closest to the accident site, that he had seen smoke coming from the aircraft as described in 2.1.2(3), based on the fact that left engine oil tank cap was not found in the locked position, and that in such circumstances smoke might be created from the exhaust outlet as described in 2.11.5(3), it is estimated that smoke was created due to lubricating oil drawn from the oil tank impinging on the exhaust outlet.

Most of the aircraft was destroyed or damaged by fire. According to eyewitness-C's statement that fuel leaking from the aircraft had ignited a little while after the aircraft crashed as described in 2.1.2(3), it is estimated that the fire occurred after the crash.

3.11 Rudder deflection and amount of elevator trim

(1) As described in 2.8.2(3), the aircraft's rudder was found in the full right position. It is thought that the captain first applied right rudder pedal to counter the yawing moment caused by increasing the power of the right engine to recover airspeed. After that, when the aircraft entered a spin, since it is thought that the right power lever was retarded, it is considered possible that right rudder had been applied to recover from the spin.

(2) As described in 2.8.2(3), the elevator trim was found at 55mm nose up out of a full stroke of 65mm aircraft nose up. The following are considered possible reasons as to why such an amount of the elevator trims had been set. However, there was no evidence to pinpoint the reason.

① The captain trimmed the aircraft according to its reducing speed.

② After the aircraft had entered the spin, the captain applied trim to raise the nose as the aircraft neared the ground.

③ The aircraft was equipped with an autopilot. Since it is not thought to have been absolutely necessary to fly the aircraft manually to check the test items on this flight, it is considered possible that the autopilot system may have been used.

When the aircraft entered the spin, if the pilot had not disengaged the autopilot but had continuously overpowered the autopilot to override it, the elevator trim would have operated in the opposite direction to the overpower as described in 2.12.4(3), causing the trim to move to aircraft nose up.

3.12 Condition of hypoxia and Incapacitation

As described in 3.3, although it could not be determined whether or not aircraft's pressurization or oxygen systems had malfunctioned, or how the oxygen system had been used, based on the conditions on the aircraft described below, it is considered possible that the captain fell into the condition of hypoxia, and that he had then been unable to counter a drop in airspeed to close to the stall speed due to the occurrence of the oil temperature and pressure anomalies; that is, he had become incapacitated. Further, the mechanic was also incapacitated by hypoxia.

(1) The pressurization system malfunction had not been repaired before the previous test flight, and so it is thought the engine power check at 17,000 ft remained to be carried out. However, on the accident flight the aircraft was continued to climb without leveling off at 17,000 ft to carry out the check.

(2) Altitude keeping was slightly unstable while the aircraft was flying at 22,000–23,000 ft.

(3) Although it is considered that abnormal oil temperature and pressure were indicated on the left engine instruments, the “Engine Failure/Fire in Flight” drill had not been carried out, and the aircraft had not reported the situation to the company radio or to ATC.

(4) Just before entering the high rate descent, remained above 21,000ft the airspeed dropped to near the stall speed. Further, during the 1 minute 50 seconds until ground impact, the aircraft continued to descend at a high descent rate, but effective recovery maneuvers were not made during that time.

(5) As described in 2.12.7(3) the time of useful consciousness at an altitude of 22,000 ft is 5–10 minutes. The aircraft started to descend around six minutes after reaching 22,000 ft, and then entered a high descent rate dive after around eleven minutes.

3.13 Failure to recover from the spin

The following are considered possible reasons why the aircraft could not recover from the spin. However, the cause could not be determined.

(1) Since the aircraft is prohibited from spins as described in 2.12.1(2), the captain could not have practiced spin recovery on the aircraft due to the inability to carry out spin training.

(2) As a result of not recovering in the early stages of the spin, the spin continued to develop and flight conditions exceeded the aircraft’s design limits so that normal control forces became insufficient to control the aircraft.

(3) Based on fact that according to eyewitness statements the engine sound was heard to vary periodically, the aircraft was in a condition of spinning without reducing engine power, which made recovery difficult.

(4) Since the elevator control force increases when the pilot continues to overpower the autopilot without disengaging it, as described in 3.11(2)③, the pilot was unable to lower the aircraft’s nose sufficiently to effect recovery from the spin.

(5) During the 1 minute 50 seconds from inadvertently entering the spin until ground impact, the pilot was unable to respond physically and psychologically to the critical state of being in an unrecoverable spin.

3.14 Establishing radio contact with an ATC

During the 17 minutes from when the aircraft reported its position to the company radio at around 10:35 until ground impact, the aircraft did not establish radio contact with any ATC.

The aircraft was operating in an area of heavy air traffic, and it is thought that to safely perform the company test flight, it was necessary to establish radio contact with an ATC and to obtain information on other traffic to maintain separation.

The frequencies to which the radio receivers were tuned at the time of the crash could not be determined. However, whatever frequencies they had been set to, it is considered that after the aircraft entered the spin, conditions were such that the pilot was unable to communicate.

4. PROBABLE CAUSE

It is estimated that in this accident, while the aircraft was on a company test flight prior to an airworthiness certification inspection, it entered spin and because it was unable to recover, it crashed, destroying the fuselage and killing the captain and the passenger.

Because the left engine's oil tank cap had not been normally locked, abnormal engine oil temperature and pressure occurred, and it is estimated that the aircraft's airspeed decreased to near the stall speed. The captain increased power on the right engine to regain airspeed, which induced a yawing moment. It is considered possible that the aircraft then entered a spin because either it was uncontrollable due to being below the minimum control speed and safe one engine inoperative speed, or the captain had been incapacitated by hypoxia and was unable to cope with the loss of airspeed.

The following are considered possible reasons as to why the aircraft did not recover from the spin; however, the precise cause could not be clarified.

① Because the aircraft type is prohibited from spins, the captain could not have been practiced in spin recovery for the aircraft.

② The spin developed without being arrested in the early stages, until flight conditions exceeding the aircraft's design limits so that the aircraft could not be recovered by normal control forces.

③ The aircraft was in a state of spinning without a reduction of engine power, which made recovery difficult.

④ The captain had been incapacitated.

Figure 1 Presumed flight route

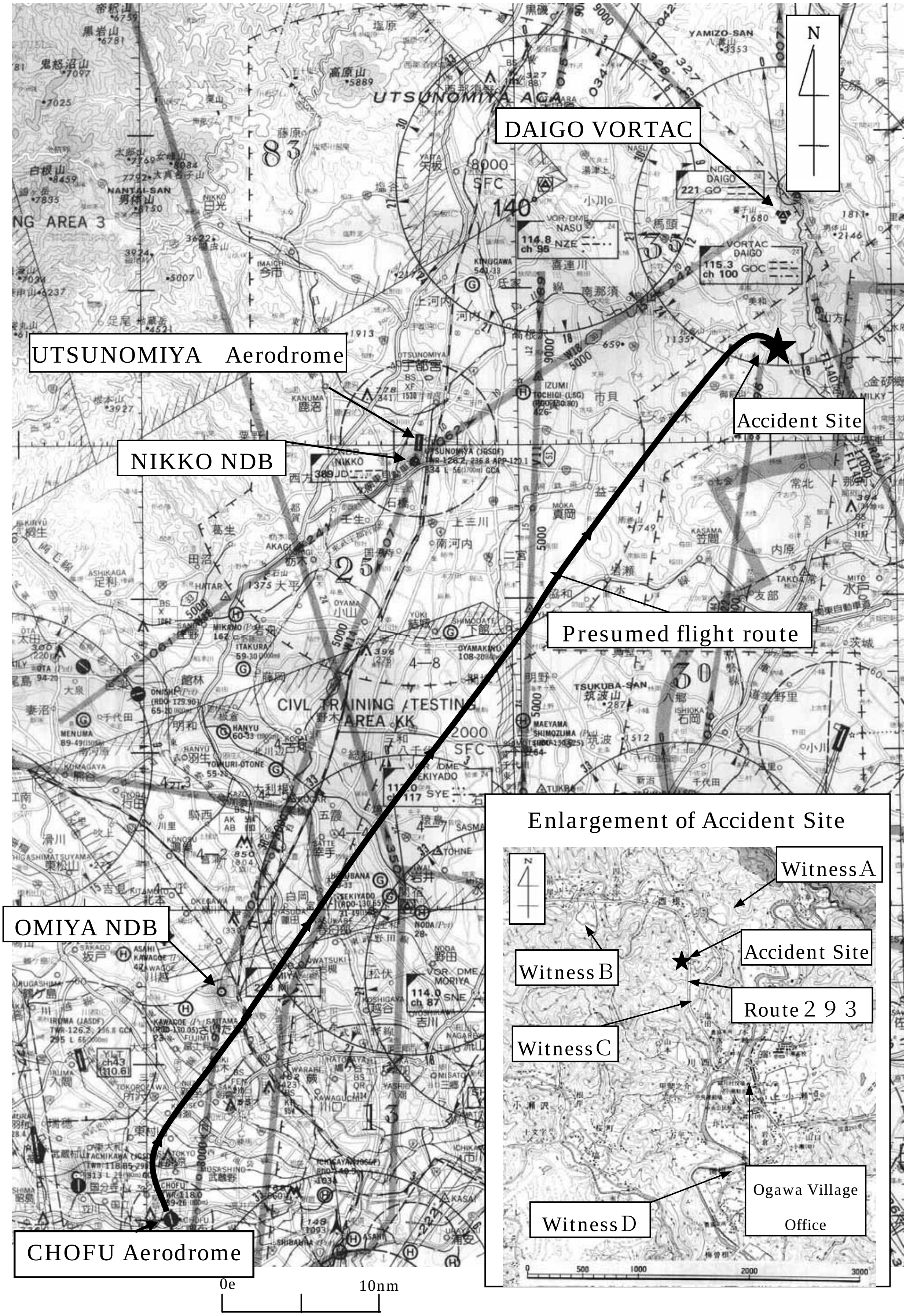


Figure 2 Radar Track

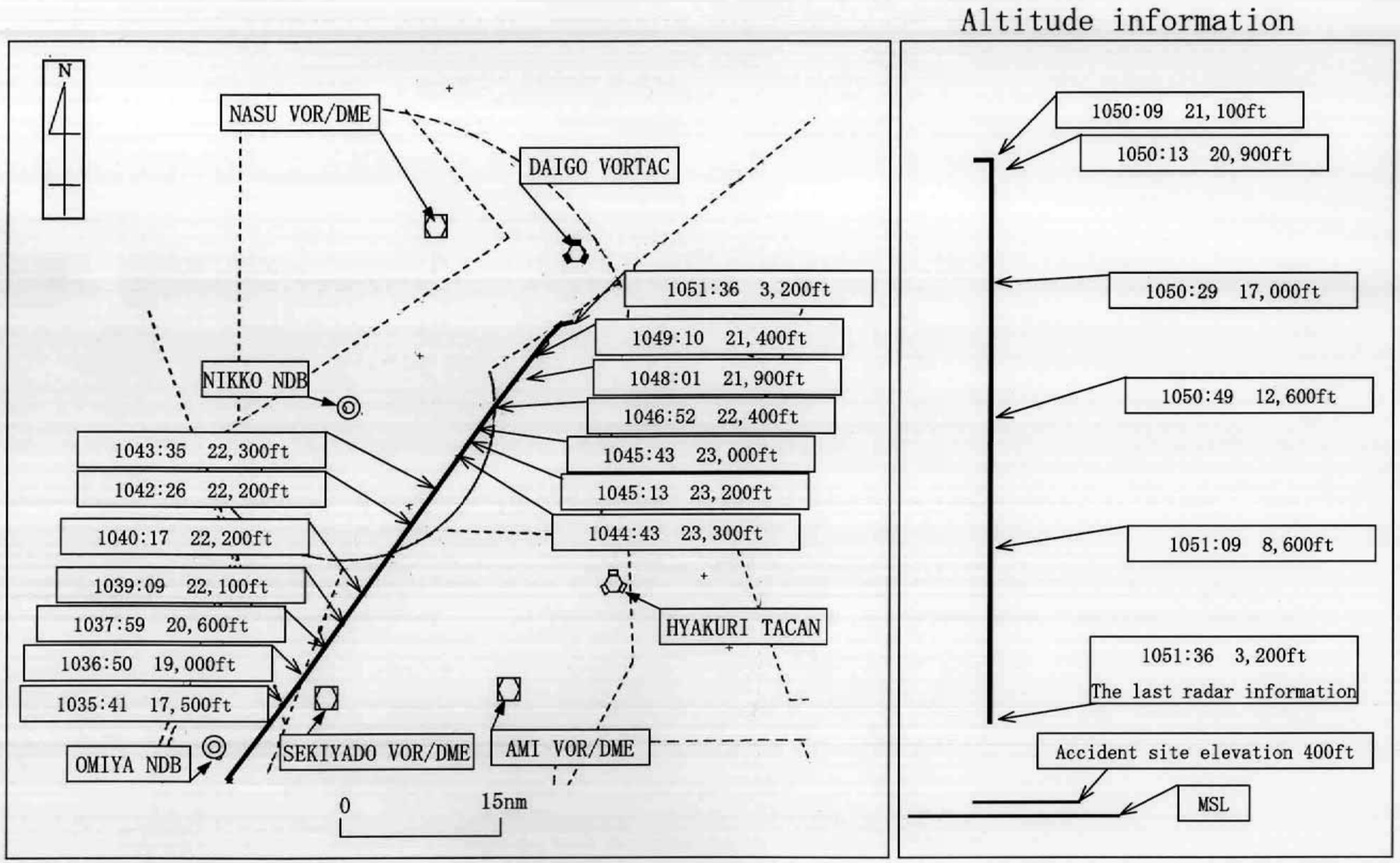
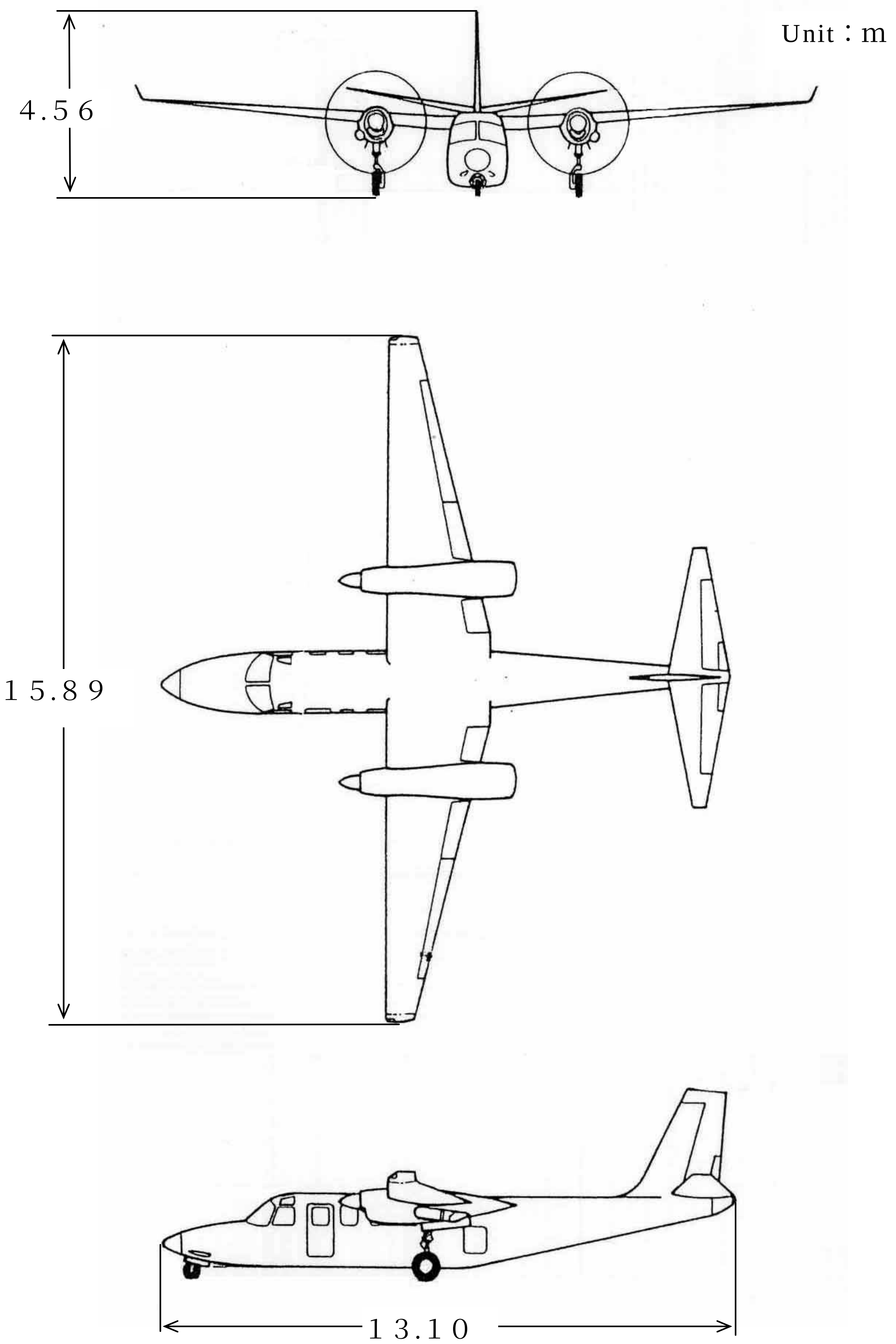


Figure 3 Gulfstream Commander Model 695
Three angle view



Photograph 1　Accident Site（Right Wing）

Photograph 2　Accident Site（Left Wing）

Photograph 3　Left Engine（At Accident Site）

Enlargement of Oil Filler Cap

Photograph 4 Left Engine Oil Filler Port &Filler Cap

Filler Cap Lock Position

The Dipstick was bent after it was removed

Photograph 5 Left Propeller & Right Propeller

Left Propeller

Right Propeller

Photograph 6 Left Engine

Photograph 7 Right Engine

APPENDIX

Describes about Time of Useful Consciousness (TUC) in Advisory Circular 61-107A Subject : OPERATIONS OF AIRCRAFT AT ALTITUDES ABOVE 25,000FEET MSL AND/OR MACH NUMBERS(MMO) GREATER THAN .75

TABLE 1-1 TIMES OF USEFUL CONCIOUSNESS AT VARIOUS ALTITUDES

	Standard Ascent Rate	After Rapid Decompression
Altitude (Feet)	Time	Time
18,000	20 to 30 minutes	10 to 15 minutes
22,000	10 minutes	5 minutes
25,000	3 to 5 minutes	1.5 to 3.5 minutes
28,000	2.5 to 3 minutes	1.25 to 1.5 minutes
30,000	1 to 2 minutes	30 to 60 seconds

(The rest is omitted.)

The rate of ascent directly affects TUC.

Faster rates of ascent result in shorter TUC.