Department of Transport and Regional Development

Bureau of Air Safety Investigation

INVESTIGATION REPORT
9400096

Aero Commander 690 VH-BSS
Sydney, New South Wales
14 January 1994

BASI
Bureau of Air Safety Investigation

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TERMS AND ABBREVIATIONS

Altitude	Height above mean sea level in feet.
APP(S)	Sydney Approach South.
DME	Distance-measuring equipment.
Flight level	Level of surface of constant atmospheric pressure related to datum of 1,013.25 hectopascals (29.92 in mercury), expressed in hundreds of feet; thus Flight Level 255 indicates 25,500 feet.
GPS	Global Positioning System.
Height	Vertical distance in feet above a fixed point.
Octa	Cloud amount expressed in eighths.
QNH	The altimeter sub-scale setting in hectopascals which when set on the altimeter, provides the pilot a reference in height as related to mean sea level.
SEC4	Sydney Sector 4.
V_{MO}	Maximum operating limit speed.

All bearings are in degrees magnetic unless otherwise stated.

Throughout this report 'miles' are nautical miles unless otherwise stated.

All times are Eastern Standard Summer Time (Co-ordinated Universal Time plus 11 hours) unless otherwise stated.

SYNOPSIS

On 14 January 1994 at 0114, Aero Commander 690 aircraft VH-BSS struck the sea while being radar vectored to intercept the Instrument Landing System approach to runway 34 at Sydney (Kingsford-Smith) Airport, NSW. The last recorded position of the aircraft was about 10 miles to the south-east of the airport. At the time of the accident the aircraft was being operated as a cargo charter flight from Canberra to Sydney in accordance with the Instrument Flight Rules. The body of the pilot who was the sole occupant of the aircraft was never recovered. Although wreckage identified as part of the aircraft was located on the seabed shortly after the accident, salvage action was not initially undertaken. This decision was taken after consideration of the known circumstances of the occurrence and of the costs of salvage versus the potential safety benefit that might be gained from examination of the wreckage.

About 18 months after the accident, the wing and tail sections of the aircraft were recovered from the sea by fishermen. As a result, a detailed examination of that wreckage was carried out to assess the validity of the Bureau's original analysis that the airworthiness of the aircraft was unlikely to have been a factor in this accident. No evidence was found of any defect which may have affected the normal operation of the aircraft.

The aircraft descended below the altitude it had been cleared to by air traffic control. From the evidence available it was determined that the circumstances of this accident were consistent with controlled flight into the sea.

No safety recommendations resulted from this investigation.

1. FACTUAL INFORMATION

1.1 History of the flight

On 14 January 1994, at 0114, Aero Commander 690 aircraft VH-BSS struck the sea while making a night approach to runway 34 at Sydney (Kingsford Smith) Airport, NSW. The last recorded position of the aircraft was by radar bearing 147 degrees, at a range of about 10 miles from the airport. At the time of the accident the aircraft was being operated as a cargo charter flight from Canberra to Sydney in accordance with the Instrument Flight Rules.

After taking off from Canberra at 0034, the aircraft climbed to Flight Level 150 and was cleared to track to Sydney via the Shellys non-directional beacon. At 0056 the aircraft was cleared by Sydney Air Traffic Control to descend when ready from Flight Level 150 to 7,000 feet. This was acknowledged by the pilot. The pilot subsequently reported to Sydney Approach at 0107:36 and was advised to expect a left circuit for runway 34, with about 35 miles to run, and to turn right onto a heading of 070 degrees. At 0109:28 the pilot reported leaving Flight Level 150. The aircraft was cleared to continue descent to 4,000 feet and to turn right onto a heading of 080 degrees. At 0112:00 the pilot was instructed to turn left heading 030 degrees for a pilot intercept of the runway 34 localiser. He was also instructed to descend to 2,000 feet and cleared for final approach. At about that time the aircraft was descending through 6,000 feet.

The aircraft was subsequently observed on radar to pass through the localiser at an altitude of about 5,000 feet (see figure 1). At 0112:57 the pilot was instructed to continue the left

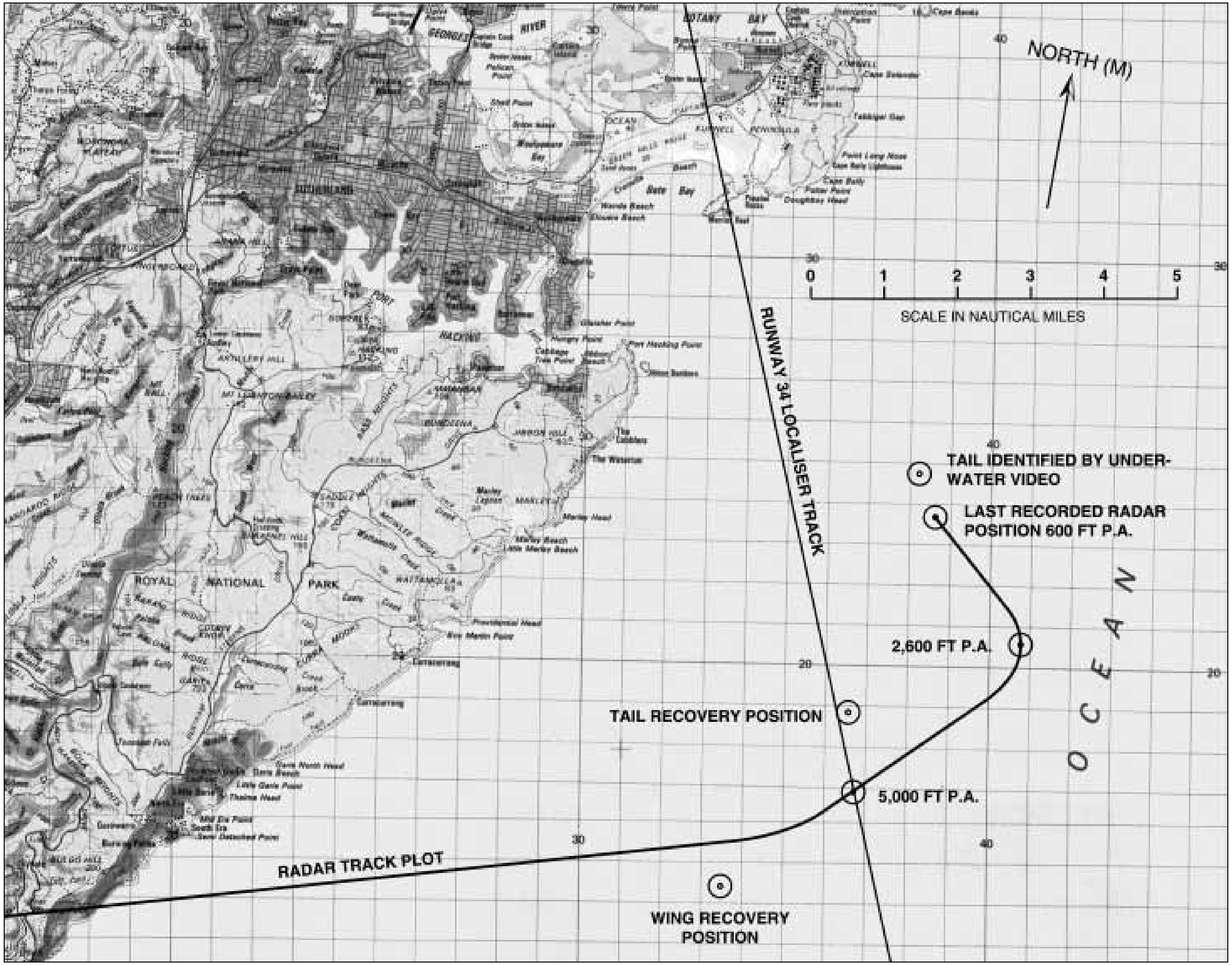

Figure 1. Accident location map.

turn onto a heading of 290 degrees to re-intercept the localiser from the right, and was asked to report in-flight conditions. He replied that he was in cloud. At that time the radar label indicated the aircraft was at 1,800 feet. The approach controller advised the pilot that the aircraft was 1 mile to the right of the localiser with 10 miles to run. This was acknowledged by the pilot at 0113:41. About two seconds later the altitude label changed to 600 feet which was not observed by the approach controller. Those were the last recorded radar indications and radio transmissions from the aircraft. At 0114:20 the approach controller asked the pilot of VH-BSS to report in-flight conditions, but received no reply.

Another pilot said that he had just taken off from Sydney and had talked with the pilot on a discrete radio frequency for some minutes. He reported that the pilot of VH-BSS sounded quite normal and had reported no operational problems with that aircraft. The conversation ended when the pilot of VH-BSS was reported to have said '10 miles, hold on', as though he were receiving a transmission on another frequency. The radio transmissions on the discrete frequency were not recorded.

Wreckage identified as a large section of the tail of VH-BSS was subsequently located on the seabed on 19 January 1994 at GPS position 34° 06.33' south, 151° 14.72' east near the last recorded radar position of the aircraft at 34° 07.05' south, 151° 14.81' east.

1.2 Injuries to persons

Injuries	Crew	Passengers	Other
Fatal	1	–	–
Serious	–	–	–
Minor	–	–	–
None	–	–	–

1.3 Damage to aircraft

Destroyed

1.4 Other damage

None

1.5 Personnel information

Pilot in command

Sex/age	Male, 23 years
Highest licence	Air transport pilot licence
Medical certificate	Class 1, valid to 29 January 1994
Instrument rating	Multi-engine, command, valid to 31 October 1994

The sole occupant of the aircraft was the pilot in command whose licence was endorsed for the Aero Commander 690. At the time of the accident his total flying experience is reported to have been about 1,800 hours, including some 45 hours on Aero Commander 690 aircraft. A pilot logbook report for the period 1 January 1992 to 13 January 1994 indicated that during that period he had flown a total of 673.08 hours, including 67.31 hours of instrument flight time, and 159.73 hours as pilot in command. A significant proportion of his flying during that period was undertaken as co-pilot in Merlin aircraft.

The flight and duty records of the pilot indicated he had flown about 3.3 hours in the previous 72 hours, and that he was on his second duty period following two days off. There is no evidence to suggest that he was other than well rested prior to commencing duty.

During his endorsement training on the Aero Commander on 2 December 1993, the pilot had been taught to use a descent profile for the aircraft calculated on an allowance of 3 miles for every 1,000 feet of height to be lost, which normally provided a rate of descent of about 1,500 feet per minute. He was later told by a senior company pilot that the usual descent profile was 2 miles per 1,000 feet, which provided a rate of descent of about 2,500 feet per minute. However, he also was told he should revert to 3 miles per 1,000 feet if he was not comfortable with the steeper descent profile.

1.6 Aircraft information

1.6.1 Aircraft

Manufacturer	Rockwell International Corporation
Model	Aero Commander 690
Serial number	11044
Registration	VH-BSS
Year of manufacture	1972
Certificate of airworthiness	No. 6125, issued 9 November 1973
Certificate of registration	No. KSA 06125/08, issued 24 May 1993
Maintenance release number	191733
Valid to	15 November 1994 or 7,983.6 hours
Total airframe hours	7,975.6 at 13 January 1994
Allowable take-off weight	4,649 kg
Weight at occurrence	Within limits (estimated)
Centre of gravity at occurrence	Within limits (estimated)

1.6.2 Engines

	Left	Right
Manufacturer	Garrett	Garrett
Model	TPE 331-5-251K	TPE 331-5-251K
Serial number	P-06010C	P-06947
Total time in service	8,516.9 hours	4,650.1 hours
Time since last overhaul	5,489.9 hours	4,650.1 hours
Last inspection type	100-hour	100-hour
Date of last inspection	15 November 1993	15 November 1993
Authorised fuels	Avtur/petrol	Avtur/petrol
Fuel used	Avtur	Avtur

1.6.3 Propellers

	Left	Right
Manufacturer	Hartzell	Hartzell
Model	HC-B3TN-5FC	HC-B3TN-5FC
Serial number	BV3838	BV3622
Total time in service	4,354.34 hours	4,877.74 hours
Time since last overhaul	741.1 hours	1,264.5 hours
Last inspection type	100-hour	100-hour
Date of last inspection	15 November 1993	15 November 1993

1.6.4 Other aircraft information

The aircraft was configured for freight operations and was fitted with approved radio communications, altitude alerting, and navigation systems appropriate for the intended operation.

Sufficient fuel was carried for the flight from Canberra to Sydney. A fuel sample taken from the last refuelling point at Melbourne Airport was analysed and found to be satisfactory.

The weight and balance of the aircraft were not factors in this accident.

An examination of the aircraft's maintenance documentation was carried out which included the current maintenance release recovered from the sea shortly after the accident. A number of anomalies were found, including no record of compliance with Airworthiness Directive AC/73 (wing fastener modification). In the maintenance-required section of the maintenance release, Airworthiness Directive GEN/37 (emergency exits operation), due on 7 January 1994, had not been complied with. The only significant defect recorded was that the autopilot was unserviceable. Civil Aviation Orders section 20.18.4.1.1(b) permitted an aircraft to be operated in accordance with the Instrument Flight Rules in the charter category, without an autopilot. The previous maintenance release also recorded the first-officer horizontal situation indicator as being unserviceable. No logbook or maintenance worksheet entry could be found to indicate that these defects had been rectified.

1.7 Meteorological information

An analysis of the estimated meteorological conditions in the vicinity of the crash site at 0115 hours indicated there was no significant weather affecting the area. There was no reported turbulence in the area at the time.

Wind direction/velocity	Surface	Variable/02 knots
	3,000 feet	340/05 knots
	5,000 feet	300/10 knots
Visibility	15 kilometres in smoke haze associated with bushfires	
Cloud	2 octas strato-cumulus at 2,000 feet	
Temperature	24 degrees Celsius	
Dew point	20 degrees Celsius	
QNH	1,008 hectopascals	

1.8 Aids to navigation

Runway 34 was equipped with an instrument landing system and associated radio navigation aids and approach lighting to provide for instrument approaches to that runway using the procedures published in Aeronautical Information Publication/Instrument Approach and Landing Charts. Aircraft could expect to be radar vectored to intercept final approach, normally intercepting the glidepath at 14 DME from an altitude of 4,000 feet. The inbound track of the instrument landing system was 336 degrees, with a glidepath angle of 3 degrees to a landing minimum of 270 feet and/or 1.5 kilometres.

Aeronautical Information Publication/Operations specifies that a flight operating under the Instrument Flight Rules must conform to the published instrument approach procedure nominated by Air Traffic Control, unless the pilot is authorised to make a visual approach. Furthermore, a 'clear for final' instruction by Air Traffic Control is a clearance for a pilot to descend, once established on the final leg of an instrument approach.

Sydney (Kingsford-Smith) Airport was also equipped with terminal approach radar for air traffic control purposes. At the time of the accident, aircraft equipped with an appropriate transponder generated a radar signal which resulted in the aircraft call sign and pressure altitude being displayed as a label on a radar screen, in addition to the normal aircraft return. VH-BSS was equipped with such a transponder. The aircraft symbol was displayed every 3.38 seconds which coincided with each sweep of the radar. The radar label was updated and displayed every sixth sweep to minimise radar clutter. Secondary Surveillance Radar returns from the flight of VH-BSS were recorded at Sydney Airport. These data were analysed as part of the investigation.

All relevant aids to navigation were reported to have been operating normally at the time of the accident.

1.9 Communications

1.9.1 General

The aircraft was fitted with approved radio communication systems appropriate for the intended operation. The quality of all recorded transmissions between Air Traffic Control and the aircraft was good. All transmissions made by the pilot appeared to be normal.

1.9.2 Summary of recorded radio communications, including Secondary Surveillance Radar altitude label

Altitude label (x 100)	Time	From	To	Text
–	0045:22	BSS	SEC4	VH-BSS makes initial contact with Sydney Control and reports passing 9,700 feet on climb to Flight Level 150, tracking direct to Bindook.
–	0045:34	SEC4	BSS	Sydney Control requests the distance of VH-BSS from Canberra.
–	0045:39	BSS	SEC4	VH-BSS reports 12 miles.
–	0045:41	SEC4	BSS	VH-BSS is cleared to climb to Flight Level 110 and advises that track via amended route to Shellys, direct Sydney is available.
–	0045:48	BSS	SEC4	VH-BSS accepts the amended track.
–	0045:51	SEC4	BSS	VH-BSS is re-cleared direct to Shellys then Sydney at Flight Level 150.
–	0045:59	BSS	SEC4	VH-BSS correctly reads back clearance.
–	0046:50	SEC4	BSS	VH-BSS is identified and instructed to squawk transponder code 3607.
–	0056:09	SEC4	BSS	VH-BSS is cleared, when ready, to descend to 7,000 feet on QNH 1,009 hectopascals.
–	0056:17	BSS	SEC4	VH-BSS acknowledges descent clearance to 7,000 feet.
–	0107:03	SEC4	BSS	VH-BSS is instructed to turn right onto a heading of 060 degrees for vectoring to final approach, and to contact Sydney Approach on 126.1 megahertz.

Altitude label (x 100)	Time	From	To	Text
–	0107:38	BSS	APP(S)	VH-BSS makes initial contact with Sydney Approach and reports maintaining Flight Level 150, cleared to 7,000 feet, and has received the current ATIS.
–	0107:46	APP(S)	BSS	Sydney Approach instructs VH-BSS to turn right heading 070 degrees and to expect a left circuit for runway 34, giving the aircraft about 35 miles to run.
151	0109:28	BSS	APP(S)	VH-BSS reports having left Flight Level 150.
134	0109:56	APP(S)	BSS	VH-BSS is cleared to descend to 4,000 feet.
120	0110:29	APP(S)	BSS	VH-BSS is instructed to turn right onto a heading of 080 degrees.
070	0112:00	APP(S)	BSS	VH-BSS is instructed to turn left onto a heading of 030 degrees for a pilot intercept of the runway 34 localiser, to descend to 2,000 feet, and is cleared for final approach.
070	0112:07	BSS	APP(S)	VH-BSS reads back 2,000 feet.
034	0112:57	APP(S)	BSS	VH-BSS is instructed to continue its left turn onto a heading of 290 degrees to re-intercept the runway 34 localiser from the right (after failing to intercept the localiser).
018	0113:24	APP(S)	BSS	VH-BSS is requested to report in-flight conditions.
018	0113:27	BSS	APP(S)	VH-BSS reports in cloud.
018	10113:32	APP(S)	BSS	VH-BSS is advised it has 10 miles to run and is 1 mile to the right of the localiser.
018	0113:41	BSS	APP(S)	VH-BSS acknowledges. This is the last recorded transmission from the aircraft.
–	0114:20	APP(S)	BSS	VH-BSS is requested to report in-flight conditions. No reply is received from the aircraft to this and subsequent queries.

1.10 Aerodrome information

Not relevant to this investigation.

1.11 Flight recorders

The aircraft was not equipped with a flight data recorder or cockpit voice recorder, nor was it required to be.

1.12 Wreckage and impact examination

1.12.1 Introduction

Initially a post-accident examination of the aircraft could not be carried out, apart from the examination of small amounts of wreckage recovered from the sea in the vicinity of the

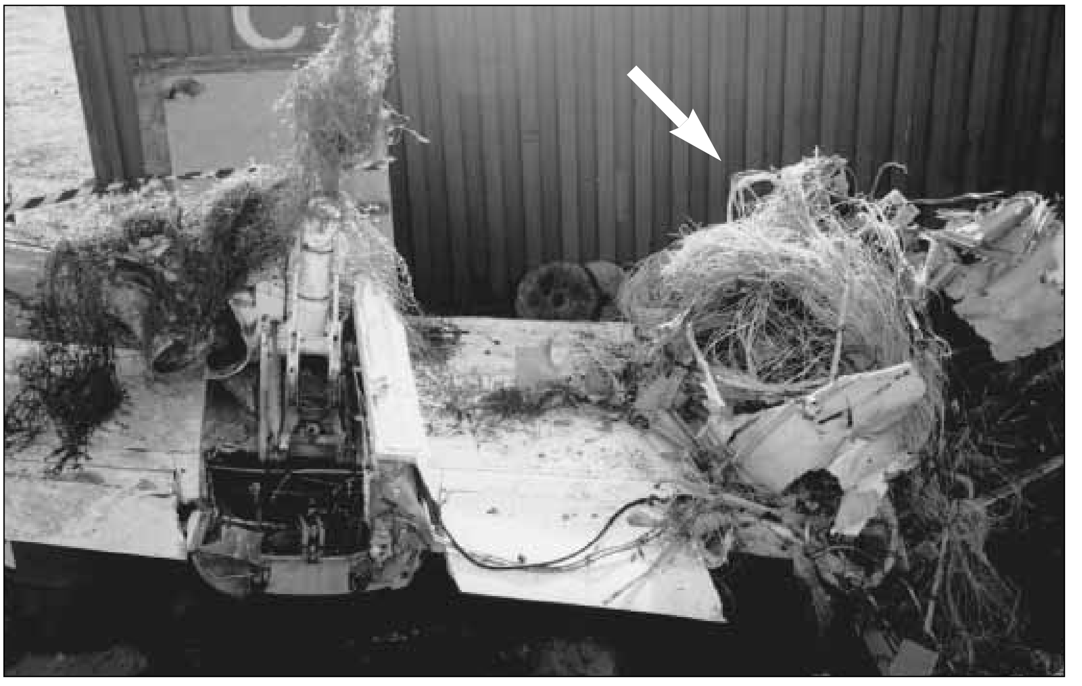

Figure 2. Massive destruction evident to fuselage centre section (arrowed).

last recorded position of the aircraft. A video recording of wreckage lying on the seabed, including the tail of the aircraft, was examined. The degree of damage observed was consistent with high-speed impact into the sea.

The wing and tail sections of VH-BSS were subsequently recovered from the sea during June 1995 from a depth of about 400 feet. The GPS positions of those components at the time of recovery were:

- *Tail section: 34° 09.50' south, 151° 13.65' east*
  The tail section was found about 5.7 miles, bearing 196 degrees true north from the original position at which the tail was located shortly after the accident. This was probably due to the relatively light tail structure being dragged by the nets of fishing trawlers during the intervening period.
- *Wing (1st recovery attempt): 34° 11.885' south, 151° 11.659' east*
  The complete wing section, together with the engines, main landing gears, and some cockpit structure, was located some 6.04 miles, bearing 208 degrees true north from the last recorded radar position of the aircraft. This was probably due to the relatively buoyant wing structure gradually filling with water and sinking to a depth of about 400 feet, affected by a current estimated to be in the direction of 220 degrees true north/1.5 knots. The weight and mass of the wing structure would have thwarted inadvertent towing by fishing trawlers.
- *Wing (2nd recovery attempt): 34° 11.892' south, 151° 11.605' east*
  During the initial recovery attempt the wing structure could not be secured. It was therefore allowed to sink back to the sea bed to await a second recovery attempt.

1.12.2 Fuselage structure

Portions of the cockpit were recovered. These comprised structural components and portions of the plexiglass screens of the right upper cockpit structure. The engine throttle quadrant, overhead switch panel, sections of the main instrument panel and one control column were also found. Additionally, attached to the wings were components of the forward and rear fuselage (see figure 2), including the forward and rear bulkheads supporting

Figure 3. Right aileron (inverted) showed no evidence of ‘flutter' or 'snatch'.

the wing structure (with attached hydraulic and fuel plumbing) and a significant amount of electrical looming.

The electrical looming found had inconsistent areas of blackening of the outer insulation sheathing. A research laboratory was provided with samples of this wire to determine the most probable cause of the discolouration. The circuit breaker panel indicated a significant number of breakers had tripped. Two undamaged light bulbs, one from the instrument panel and the other from the position light mounted on the vertical tail, were also removed and sent to the laboratory for examination.

Hydraulic and fuel plumbing showed obvious signs of lengthy immersion in salt water. Rubber components had perished, and pipes and fittings were corroded. Due to the total disruption of the fuselage, no conclusions could be drawn regarding the serviceability of either the hydraulic or fuel systems in this area of the fuselage.

Fragments of the forward fuselage attached to the forward pressure bulkhead (Fuselage Station 178.81) and wings were bent outward from the centreline of the aircraft. Additionally, the pressure bulkhead was bent rearwards below the lower wing skin abutment.

The overhead switch panel, main flight instrument panel, and some instruments were recovered. All instruments exhibited impact damage and corrosion. Recognisable dial faces were removed for more detailed examination. The left engine control switch (rotary type) indicated ‘ENGINE OFF’, and the right engine switch indicated ‘GND’. The position of all other switches, be they toggle or rocker type, were not read, as the effects of forces acting upon them during impact and recovery could have altered their position. Of note was the fact that neither airspeed indicator was recovered, thus necessitating the use of radar data to estimate airspeed.

The throttle quadrant was recovered. Both power levers were at ‘FLIGHT IDLE’ and both condition levers were at ‘LOW RPM’. The undercarriage selector handle, located on the left side of the throttle quadrant, indicated it had been selected down. The flap position lever, located on the right side of the quadrant, was located between ‘NEUTRAL’ and ‘UP’.

1.12.3 Wing structure

The right wing main spar had failed on the lower surface at approximately Wing Station 183.50, with associated failures of the two stringers immediately aft (in a diagonal line culminating at Wing Station 160.00). As a result of the main spar failure, the right wing had bent down and slightly aft, along a line of the failures of the main spar and stringers. There was corresponding tearing and buckling of the wing lower skin. The right main spar lower cap had failed at approximately Wing Station 24.00. No upper wing skin buckling or creasing was evident in the region of Wing Station 24.00. All right wing control surfaces were structurally attached and, except for the aileron, were in good condition. The right aileron was bent consistent with the damage to the right wing (see figure 3).

The main feature of the left wing was the crushing of the leading edge outboard of Wing Station 178.00 (see figure 4). This crushing extended rearward and upward to the main spar of the wing. The left outboard flap and aileron, and a large portion of the inboard flap, were missing. The left aileron control pushrod was bent towards the wing tip, having fractured in the threaded area of the rod-end attachment point. Also, one arm of the aileron control horn assembly had failed and had been pulled through the cable run holes on several inboard wing ribs. The failure surfaces of the hinges for both the missing flap and aileron indicated failure due to bending in an outboard direction. Finally, the left aileron cove exhibited signs of being torn towards the wing tip. This tearing exhibited little evidence of corrosion on the exposed surfaces.

Examination of the hinge locations on both ailerons revealed no evidence of control surface overtravel. There was no evidence of any creasing on either wing.

Figure 4. View of left wing (inverted). Crush damage to outer leading edge consistent with high speed water impact.

1.12.4 Empennage structure

The empennage wreckage consisted of the tailcone (rear fuselage), the complete vertical tail, the right horizontal tail, and the inboard section of the left horizontal tail extending

Figure 5. Shattered rear fuselage as recovered from sea.

out from the root for approximately 2.03 metres. The empennage had broken off the aft fuselage at approximately Fuselage Station 366.00 (see figure 5). Skin fractures and rivet pull-outs indicated failure was due to overload in bending (forward and to the right side of the aircraft).

The rudder and right elevator were intact, along with their respective balance weights, but 1.14 metres of the outboard section of the left elevator was missing. The outboard section of the left horizontal tail was deformed up and inboard, and exhibited numerous dents along its leading edge (see figure 6). The left elevator control torque tube was broken off at its connection with the inboard edge of the elevator. The aft control horn for this elevator had impacted the top of the bulkhead at Fuselage Station 437.19, indicating a severe upward load on the elevator. The vertical tail had broken away from the aft fuselage at the root, but was still attached via control and antenna cables. The vertical tail leading edge exhibited numerous minor dents.

1.12.5 Flight controls

The aileron control circuit is a closed loop system within the wings and fuselage. As a result of forward fuselage break-up, no assessment of control system continuity and functionality could be made. As the left aileron was missing, no assessment of the (electrically driven) aileron trim position could be made.

The elevator control circuit is cable and rod operated, with rods providing the input force from the control column to the control surface via the cable system. Due to break-up of the fuselage, no assessment of control system continuity and functionality could be made. The right elevator trim tab was deflected up 20 degrees, which was beyond the travel limits of the surface (maximum limit 7.5 degrees). The left elevator trim was at the neutral position. Elevator trim is also cable operated, although the cable movements convert to tab deflections via chains, sprockets, flexible shafts and jackshaft mechanisms. Therefore, an

Figure 6. Left tailplane exhibited damage consistent with high speed water impact. Rudder (removed) and elevators showed no evidence of inflight failure.

accurate assessment of the pre-impact position of these tabs could not be made due to cable stretch prior to failure (during the break-up sequence).

As the rudder control circuit was also cable operated, assessment of control system continuity and functionality was impracticable. The rudder trim was deflected right approximately 22 degrees (maximum limit 27 degrees). However, as the rudder trim tab operates using a system similar to that of the elevator trim, accurate assessment of its pre-impact position was also not possible.

A hydraulic system conveys the pilot's flap selection to the actuator located in the rear fuselage near Fuselage Station 209.15. This actuator then activates the flaps via cables, pulleys and control rods. However, as the hydraulic system ruptured during impact, and because the actuator attachment point moved during impact, its position was not considered to be indicative of flap selection. Examination of the flap cables and surfaces indicated that the flaps were retracted at impact.

1.12.6 Engines and propellers

Both engines remained in their respective nacelles on the wings. Neither of the propellers nor the complete engine reduction gearboxes were recovered. However, attached to each engine were items of reduction gearing, engine accessories and oil hoses. All accessories exhibited extensive impact damage and corrosion, making examination and analysis impracticable. The magnesium alloy reduction gearbox would have corroded away rapidly as a result of salt water immersion.

Examination of the leading edges of both compressor disks revealed extreme corrosion product build-up. Removal of this corrosion revealed that the left engine centrifugal compressor vanes had moderate tip rub. The right engine exhibited very little evidence of impact damage. Examination of the inner face of the first stage centrifugal compressor forward casing of the left engine revealed erosion, consistent with vane impact over a 160-degrees (approximately) arc of the surface. No such erosion was present on the right engine compressor casing. The turbine sections did not exhibit discernible damage to the blades or cases.

1.12.7 Fuel system

Due to the extent of structural break-up, and the length of time of immersion in the sea, examination and analysis of the fuel system and its contents was not feasible.

1.12.8 Landing gear

Both main landing gear struts were still attached to the airframe and the right maingear was extended. It was reported that the left main landing gear retracted during recovery. No mainwheel assemblies were present, having corroded away due to salt water immersion (magnesium components). The nose landing gear wheel and strut were recovered.

1.12.9 Instruments

Most instruments recovered were in poor condition having suffered extensive damage as a result of impact loads and corrosion. As preliminary inspections found no obvious needle position indications, a specialist laboratory was requested to perform a detailed examination. (Results of this examination are at paragraph 1.12.11.)

The aircraft flight director control panel was also recovered. The main rotary dial was in the left-turn position. However, due to impact damage and extensive corrosion, determination of system activation and/or mode selection was not possible.

1.12.10 Electrical system operation

Light bulbs from the position light on the vertical tail and from the main instrument panel were examined to determine whether they were illuminated at the time of impact. As both were required to be illuminated for normal night-flight operations, it was considered that they would provide an indication of whether the aircraft electrical system was functioning at the time of impact.

Detailed specialist examination of the fracture surfaces of the failed filament wires using a scanning electron microscope indicated that both bulbs were probably illuminated at the time of impact. The filament in the vertical tail position light had broken twice, one being a hot fracture indicative of electrical power being on, and the other being a cold fracture. It was considered that the cold fracture could have resulted from additional loading as the aircraft tumbled during the break-up sequence or during the recovery operation. From examination of the instrument panel bulb, it was concluded that the arcing present at the base of the filament pole was indicative of electrical power being on at impact.

A specialist examination of the blackened electrical wiring was also undertaken. This showed the discolouration was only present in the thin outer sheath of the wire. It is believed that this vintage and type of outer sheath of wiring was used to thermally label individual wires in a loom. However, this fact could not be confirmed by the manufacturer or by reference to applicable military specifications. Hence, the research laboratory concluded that the discolouration was a result of elevated temperatures in the affected areas.

To produce this discolouration, a low-intensity or flash fire would be necessary. A low-intensity fire prior to impact would produce generalised discolouration of the wiring, and most probably melt the outer sheath and insulation layers. Such a fire would also discolour surrounding aircraft structure and leave tell-tale fire shadows. Conversely, a flash fire, resulting from fuel spray igniting during the aircraft break-up sequence, could produce the localised low intensity random 'heating' of the wire looms. Accordingly, as there was no generalised discolouration or melting of the looms or fire shadowing on aircraft structure, a flash fire during fuselage break-up was considered to be the most likely cause of the discolouration of this wiring.

1.12.11 Summary of results of laboratory tests

(a) Instrument face readings were either indecipherable or too unreliable to use.

(b) The gyroscope in the standby artificial horizon instrument showed clear evidence of rotating at high speed at the time of impact.

(c) The vertical tail position light bulb had a hot fracture, and the instrument panel bulb had electrical arcing evidence on one pole, consistent with both bulbs being illuminated at impact.

(d) All samples of structural components showed clear evidence of overload failure,

(e) The left inboard flap failure was relatively old (occurring at the time of impact) compared to the failure of the left aileron outboard hinge (which occurred sometime after impact).

(f) The left elevator torque tube showed evidence of several overload events prior to failure.

1.13 Medical information

There was no evidence found of any physical condition which could have affected the performance of the pilot.

1.14 Fire

No evidence consistent with a pre-impact fire was found.

1.15 Survival aspects

The accident was not survivable.

1.16 Additional information

1.16.1 Examination of recorded radar data

A specialist examination of recorded Secondary Surveillance Radar data at Sydney was made to determine the flight path, ground speed and altitude of the aircraft prior to the accident. Radar data quality was good. The altitude data were referenced to 1,013 hectopascals (pressure altitude) and were accurate to ± 125 feet. The accuracy of the radar was proportional to the range from the radar head, and was about ± 0.5 miles at 50 miles.

The aircraft was observed to commence descent from 15,000 feet at 0109:24, about 22 miles south-west of Sydney. It maintained an average rate of descent of 3,325 feet per minute until the last recorded radar altitude of 600 feet at 0113:44. Between 0113:00 and 0113:39 the calculated rate of descent varied between 4,695 feet per minute and 3,130 feet per minute. During that period the groundspeed of the aircraft varied between 255 knots and 227 knots.

The recorded Secondary Surveillance Radar data showed that about two seconds after the last radio transmission was received from VH-BSS, the aircraft altitude label changed to 600 feet.

1.16.2 Structural aspects of Aero Commander 690 aircraft

The phenomena of aileron snatch, flutter and structural failure in the context of the Aero Commander 690 aircraft are described in the following paragraphs.

(a) Aileron snatch

The Aero Commander 690 series aircraft is fitted with frise-type ailerons. On this type of aileron the hingeline is positioned to the rear of the leading edge such that when the aileron is deflected trailing edge up, the forward part of the aileron is exposed to the force of the slipstream. This results in a balancing hinge moment that reduces the pilot control force required for lateral control. However, very careful synchronisation of the up-deflected and down-deflected ailerons is required to achieve the degree of balance desired. Stretch in the control system linkages under load, particularly at high angles of attack, or distortion and flexing of the wing under load, may destroy the normal static relation of the two ailerons. This can cause a sudden abnormal overbalance of the ailerons as they are deflected, resulting in an uncommanded rapid roll. This effect is called 'aileron snatch'.

The United States National Transportation Safety Board recently investigated an accident involving an Aero Commander 690 (Bishop, California) suspected of suffering aileron snatch. This aircraft suffered structural failure of the right horizontal tail as a result of an uncommanded roll at high speed in moderately turbulent air. Additionally, the aircraft exhibited permanent deformation (creasing) of the lower skin of the vertical tail (opposite side to direction of roll), and impact damage on the aileron cove structure resulting from gross over-travel of the ailerons. Finally, there was impact damage to the elevator torque tube and associated structure. The National Transportation Safety Board's factual report attributed this accident to aileron snatch.

As a result of the above accident, Twin Commander (who held the aircraft type certificate at the time of the accident) undertook an extensive flight test program supervised by the United States Federal Aviation Administration. The aim of this program was to demonstrate the lack of susceptibility of this aircraft to snatch when the aileron control circuit was progressively mis-rigged from criteria specified in the maintenance manual. This testing verified that the Aero Commander 690 aircraft did not suffer from aileron snatch, despite deliberately excessive aileron control system free-play, at speeds up to V_{MO} and with rapid control movement.

(b) Control flutter

Flutter can be characterised as an instability phenomenon involving self-excited oscillations of control surfaces, wings, stabilisers, rotor blades or propellers. Its occurrence is dependent upon the relationship of aerodynamic, inertia, and elastic forces of the system. There are several important variables that influence flutter. These are airspeed, wing (or tail) loading, and design stiffness of the structural members involved. These variables are considered during the design and flight testing phases of the initial aircraft certification process. However, as the aircraft ages, the wear on flight control hardware (hinges, push-pull rods, bellcranks and cable pulleys) becomes a significant factor affecting the flutter characteristics of the airframe.

Typically, flutter will create signs of repetitive cyclic overloads on the affected structure. The common signatures are over-travelled hinges, pushrods, bellcranks, and control surface stops. Cyclic twisting of the wings may introduce 45-degree creases in both directions on the upper and lower skins, or the working loose of rivets and other fasteners. Pilots who have experienced flutter incidents have reported violent shaking of the airframe and instruments, and rapid motion of the control yoke and/or rudder pedals.

(c) Structural failure

The Aero Commander aircraft series has a history of wing fatigue and corrosion-related problems. From original design and manufacture in 1944 until the end of production in 1985, about 2,000 Aero Commanders were manufactured. Of these, 24 suffered in-flight wing separation as a result of corrosion, stress corrosion cracking, and/or fatigue and all of these defects affected the mainspar lower cap. Additionally, a further 35 aircraft were discovered with spars cracked/corroded before final failure. All spar failures recorded to date were associated with Wing Stations 24.00, 39.00, 81.00 or 98.20.

In all reported instances of Aero Commander lower spar cap failures, the wing concerned separated from the aircraft. This was because the lower spar cap area is generally where the main in-flight loads are concentrated in the wing, and failure of the cap renders the wing incapable of carrying normal flight loads.

1.16.3 Manufacturer's descent data

The Aero Commander 690 manufacturer's data provide descent data for flight planning purposes. Two sets of data are given, the first for a rate of descent of 1,000 feet per minute, and the second for a rate of descent of 2,000 feet per minute. The scheduled variables for both rates of descent provide for a descent speed of 220 knots, using variable engine power to achieve the desired rate.

The data indicates that a descent from Flight Level 150 to sea level, made at 1,000 feet per minute in nil wind conditions, requires a distance of 60 nautical air miles. This equates to a descent profile of 4 miles per 1,000 feet. A similar descent made at 2,000 feet per minute requires a distance of 30 nautical air miles, equal to a profile of 2 miles per 1,000 feet.

2. ANALYSIS

2.1 Introduction

The circumstances of this accident were consistent with controlled flight into the sea at night. There was no evidence found to indicate that the pilot was affected by any physical condition likely to have affected his ability to safely control the aircraft. Evidence derived from wreckage examination, recorded data, and other sources, indicates that the aircraft was capable of normal operation at the time of impact.

The following analysis discusses the elements associated with this occurrence.

2.2 Flight crew performance

The pilot was appropriately qualified to conduct the flight. However, despite having a total flying experience of about 1,800 hours, he was relatively inexperienced in single pilot Instrument Flight Rules operations in Aero Commander 690 aircraft, having flown a total of some 45 hours in this capacity. Despite this, the flight from Canberra to Sydney should not have presented any difficulty to the pilot. There was no significant weather. With the exception of the unserviceability of the autopilot and the co-pilot horizontal situation indicator, the aircraft was reported to have been capable of normal operation, and all relevant aids to navigation were operating normally.

At 0056:09 the pilot of VH-BSS was cleared, when ready, to descend from Flight Level 150 to 7,000 feet. However, it was not until 0109:28 that the pilot actually reported leaving Flight Level 150. The distance from Sydney at that point was about 22 miles. Assuming an average ground speed of 260 knots, the decision of the pilot to delay commencing descent for about 13 minutes equates to an estimated distance of 58 miles. Therefore, it would have been possible to commence descent about 80 miles from Sydney, if desired by the pilot.

From the evidence available, the pilot had been taught to use a descent profile of 3 miles per 1,000 feet. However, a senior company pilot had told him that the usual descent profile to be used was 2 miles per 1,000 feet, but only if the pilot was comfortable with the steeper descent. If a profile of 2 miles per 1,000 feet had been intended to be used on this flight, the descent should then normally have been commenced no later than 30 miles from Sydney.

A common practice of pilots is to adjust their descent point to allow for the aircraft to be slowed for landing and to intercept the glidepath from below. The pilot of VH-BSS may have taken into account the extra track miles to be flown, in order to intercept the runway 34 localiser, and delayed his descent point. However, this did not provide him with any margin for slowing the aircraft for landing, if a 2,000 feet per minute descent profile were to be followed. The only remaining option to intercept the instrument landing system for an approach was to increase the average rate of descent in order to place the aircraft below the glidepath. This would allow the aircraft to be slowed to approach speed prior to intercepting the glidepath. The recorded radar data indicated that the average rate of descent used by the pilot was about 3,325 feet per minute which was well in excess of that recommended by the manufacturer for descent planning, and well in excess of that used by other company pilots.

The effect of this relatively high rate of descent would have been to increase the workload of the pilot beyond the normally high level which could have been expected during that phase of flight. This effect would have been compounded when the pilot failed to intercept the localiser, indicating he may have been having difficulty in staying ‘ahead’ of the aircraft. Moreover, at that critical time, the distraction of communicating with another company aircraft would have reduced the capacity of the pilot to adequately monitor the operation of the aircraft.

The pilot was then directed by the approach controller to turn left onto a heading of 290 degrees to intercept the localiser from the right, having already been instructed to descend to 2,000 feet, and cleared for final approach. The aircraft was observed on radar to take up a heading of 290 degrees and apparently to descend to 1,800 feet, giving the approach controller no cause for concern. At 0113:24, with the altitude label showing 1,800 feet, the pilot was requested by air traffic control to report in-flight conditions and replied that he was in cloud. At 0113:32, with the altitude label still indicating 1,800 feet, the pilot was advised the aircraft had 10 miles to run and was 1 mile to the right of the localiser. He acknowledged that transmission at 0113:41, and almost immediately the altitude label changed to 600 feet. This was not observed by the approach controller, who was probably distracted by having to monitor other traffic and had reasonably assumed that the aircraft was maintaining its cleared altitude prior to commencing final approach.

With hindsight it can be seen that the aircraft was still descending, despite the altitude label continuing to indicate 1,800 feet. The altitude readout on the radar was only updated on every sixth sweep of the display, equivalent to about every 20 seconds. As a result, at 0113:41, when the pilot made his final acknowledgment, the aircraft was about 1,400 feet below its assigned altitude. Despite this, the response of the pilot indicated no concern. It could not be determined whether the pilot had set the altitude alerting system to provide a warning that the aircraft had descended below its assigned altitude. In addition, the heading of the aircraft immediately prior to impact should have permitted the pilot to observe lights associated with the nearby coastline, although it is likely those lights would have appeared higher up the windshield than normal, due to the nose-down attitude of the aircraft. However, the workload of the pilot may have constrained him from looking outside the cockpit.

It is evident that the pilot lost awareness of the vertical position of the aircraft, probably whilst distracted by other factors, and inadvertently descended into the sea. Those factors included a high rate of descent, the need to re-intercept the localiser, reducing the speed of the aircraft and extending the landing gear, pre-landing checks, and communications with another aircraft.

2.3 Aircraft structural considerations

(a) Aileron snatch

By comparing data from the ‘Bishop CA’ Aero Commander 690 accident with that observed on this aircraft, an assessment could be made as to whether VH-BSS had suffered from aileron snatch. Neither the aileron nor elevator hinges showed evidence of overtravel. The horizontal and vertical tails exhibited no evidence of being overstressed (for example, skin creasing) as a result of a rapid, uncommanded roll manoeuvre typical of aileron snatch. Finally, loss of the outboard section of the left horizontal tail was clearly a result of impact loads. This evidence is sufficient to indicate that the aircraft did not suffer aileron snatch prior to impact.

(b) Control flutter

There is sufficient evidence to show that VH-BSS did not suffer flutter during this flight. The aircraft did not suffer any in-flight structural failures, nor were any control surfaces missing from the aircraft at impact. Neither the control surfaces nor lifting surfaces (wings and empennage) displayed any of the classic signs of flutter, such as control surface over-travel, creasing of skins, etc. These factors indicate that the aircraft did not suffer catastrophic flutter resulting in structural failure and subsequent loss of control.

(c) Structural failure

Examination of the wreckage of VH-BSS indicated three areas of potential structural failure. They were the right wing failure at Wing Station 24.00, the right wing failure at Wing Station 183.00, and the separation of the empennage from the rear fuselage.

The actual location and type of failure at Wing Station 24.00 was not determined due to the degree of structural disassembly necessary to access the area. However, given the high speed of the aircraft prior to impact, and the resultant high wing loading, an in-flight failure of the main spar at this location would have resulted in a loss of the wing. There was no distortion of the upper wing skin to indicate the spar failure had occurred just prior to impact. Accordingly, the structural failure on the right wing at Wing Station 24.00 was probably initiated by impact forces, and/or resulted from the recovery process. An in-flight failure of the lower main spar at Wing Station 183.00 should have resulted in the outboard portion of the right wing bending up or separating from the aircraft due to the wing loading involved. However, there is no evidence of upper skin creasing associated with upward movement of the outer panel, relative to the remaining wing. Accordingly, this failure is again considered consistent with damage arising from impact forces and/or recovery.

Due to the observed damage to the left horizontal tail and elevator, it is reasonable to conclude that this side of the empennage impacted the water first. Given this large side loading on the empennage, the rear fuselage failed in bending at Fuselage Station 386.82 on the left side, and Fuselage Station 346.00 on the right side. Symmetrical skin tear-outs around rivet locations on the left side attest to the bending failure of the fuselage to the right and forward. As the empennage (and rear fuselage) failed in bending due to impact loads, in-flight structural failure is not a consideration. Accordingly, there is considerable evidence to support the conclusion that the aircraft was structurally intact prior to impact with the water.

2.4 Flight control system

The contribution of flight control systems to the crash of VH-BSS could not be ascertained due to the disintegration of the fuselage. This is applicable to both primary control surfaces and trim tabs.

2.5 Instrumentation system

Little could be concluded from the remaining flight instruments regarding the attitude of the aircraft at impact. However, the standby attitude indicator gyro clearly showed signs of rotating at high speed during impact. From this information, a reasonable conclusion to be drawn is that the pilot had essential attitude reference instrumentation, with sufficient illumination, for the control of the aircraft prior to impact.

2.6 Electrical system

The electrical system of the aircraft was functioning at the time of impact with the water. This was evidenced by normal radio communications from the aircraft just prior to impact, the operation of the electrically powered standby attitude indicator, and by the results of specialist examination of light bulbs.

2.7 Asymmetric flight considerations

Initial examination of the overhead switch panel showed the left engine control switch was in the 'ENGINE OFF' position. As this is a detented rotary switch, with no evidence of impact forces acting upon it, its position could have been indicative of the engine condition selection prior to impact. In isolation, the position of this switch would suggest that the left engine had been shut down. However, examination of the left engine first stage compressor impeller revealed tip rub and corresponding front compressor case wear. Both are indicators of the engine rotating at impact, either under power or windmilling if the propeller had not been feathered.

Had the pilot been responding to an engine emergency during the last moments of the flight, he should have carried out the emergency shutdown checklist. After identifying the failed engine, the next action item was to move the condition lever to the emergency feather position before selecting the engine control switch to engine off. If those checklist items had been carried out, the left engine condition lever should have been found in the emergency feather position, at the extreme lower end of the throttle quadrant. To accomplish this, the pilot needed to pull the condition lever out and down (to engage a gate that prevented unintentional feathering of the propeller). Due to the geometry of the levers and cables of the throttle quadrant, pulling of the cables during aircraft break-up would tend to pull the power and condition levers towards the bottom of the quadrant. Hence, if the pilot had intentionally selected emergency feather, the condition lever would remain in this selected position after impact.

That was not the case. All quadrant levers were found at the bottom of their normal range of travel, and the left condition lever was not engaging its feather 'gate'. Because the other switches used in this emergency procedure were rocker or toggle type, their as-found position could not be used to indicate their position prior to impact.

The right engine compressor and casing exhibited little evidence of impact loading. However, energy dissipation during break-up, and/or symmetrical water impact loads, could have eliminated the evidence needed to confirm the right engine was producing power.

Notwithstanding the as-found setting of the left engine control switch, the evidence indicates that both engines were operating at the time of impact. Accordingly, asymmetric flight due to failure of one engine is not considered to have been a contributing factor in this accident.

2.8 Wreckage examination summary

Although the wreckage of VH-BSS was not complete and had suffered extensive salt water corrosion, it retained sufficient material to enable a reasonably detailed examination to be undertaken. This examination looked at factors considered as possible causes of loss of control of the aircraft, such as flutter, aileron snatch, electrical failure, instrumentation failure and asymmetric flight conditions.

The examination and subsequent analysis of the available wreckage and data concluded that VH-BSS had not suffered from, nor displayed characteristics indicative of, in-flight structural failure, aileron snatch, or flutter. The aircraft maintained primary system (instrumentation and electrical), structural and aerodynamic integrity and was capable of normal operation until the time of impact with the water.

3. CONCLUSIONS

3.1 Findings

1. The pilot held a valid pilot licence, endorsed for Aero Commander 690 aircraft.
2. The pilot held a valid multi-engine command instrument rating.
3. There was no evidence found to indicate that the performance of the pilot was adversely affected by any physiological or psychological condition.
4. The aircraft was airworthy for the intended flight, despite the existence of minor anomalies in maintenance and serviceability of aircraft systems.
5. The aircraft carried fuel sufficient for the flight.
6. The weight and balance of the aircraft were estimated to have been within the normal limits.
7. Recorded radio communications relevant to the operation of the aircraft were normal.
8. Relevant ground-based aids to navigation were serviceable.
9. At the time of impact the aircraft was capable of normal flight.
10. The aircraft was fitted with an altitude alerting system.
11. The aircraft was not fitted with a ground proximity warning system.
12. The aircraft was equipped with a transponder which provided aircraft altitude information to be displayed on Air Traffic Control radar equipment.

3.2 Significant factors

1. The pilot was relatively inexperienced in single-pilot Instrument Flight Rules operations on the type of aircraft being flown.
2. The aircraft was being descended over the sea in dark-night conditions.
3. The workload of the pilot was significantly increased by his adoption of a steep descent profile at high speed, during a phase of flight which required multiple tasks to be completed in a limited time prior to landing. Radio communications with another company aircraft during that critical phase of flight added to that workload.
4. The pilot probably lost awareness of the vertical position of the aircraft as a result of distraction by other tasks.
5. The aircraft was inadvertently descended below the altitude authorised by Air Traffic Control.
6. The secondary surveillance radar system in operation at the time provided an aircraft altitude readout which was only updated on every sixth sweep of the radar display.
7. The approach controller did not notice a gross change of aircraft altitude shortly after a normal radio communication with the pilot.

4. SAFETY ACTIONS

No safety recommendations resulted from this investigation. However, it should be noted that shortly after this accident, the radar system at Sydney was significantly improved with the introduction of the Interim Radar Display System. One of the features of that system is that the presentation of aircraft speed and altitude information is now upgraded with each sweep of the radar. As a result, controllers are provided with immediate information concerning trends in speed and height of aircraft.

Furthermore, after reviewing the recent history of accidents involving aircraft engaged in single-pilot night freight operations, the Bureau is considering this issue as a topic to be included in its safety research program.