SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division Accident and Incident Investigation Division

Form Number: CA 12-12a

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/8894
Aircraft Registration	**ZS-GAA**	**Date of Accident**	8 February 2011	**Time of Accident**	1433Z
Type of Aircraft	Pilatus PC-12/47 (Aeroplane)		**Type of Operation**	Private (Part 91)	
Pilot-in-command Licence Type	Commercial Pilot	**Age**	32	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	2 662.3		Hours on Type	582.2
Last point of departure	Queenstown Aerodrome (FAQT), (Eastern Cape Province)				
Next point of intended landing	Plettenberg Bay Aerodrome (FAPG), (Western Cape Province)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
Crashed into the sea near Plettenberg Bay (GPS position; South 34°06'.954 East 023°23'.522)					
Meteorological Information	Surface wind; light/variable, Temperature; 20℃, Overcast, light drizzle/mist.				
Number of people on board	2 + 7	**No. of people injured**	0	**No. of people killed**	9

Synopsis

The aircraft, which was operated under the provisions of Part 91 of the Civil Aviation Regulations (CARs), departed from Queenstown Aerodrome (FAQT) at 1329Z on an instrument flight plan for Plettenberg Bay Aerodrome (FAPG). On board the aircraft were two (2) crew members and seven (7) passengers. The estimated time of arrival for the aircraft to land at FAPG was 1430Z, however the aircraft never arrived at its intended destination, nor did the crew cancel their search and rescue as per flight plan/air navigation requirements. At ±1600Z an official search for the missing aircraft commenced. The search was co-ordinated by the Aeronautical Rescue Co-ordination Centre (ARCC). The first phase of the search, which was land based, was conducted in the Robberg Nature Reserve area. Progress was slow due to poor visibility associated with dense mist and night time. A sea search was not possible following activation of the official search during the late afternoon and night time, but vessels from the National Sea Rescue Institute (NSRI) were able to launch at first light the next morning. Floating debris (light weight material) was picked up from the sea and along the western shoreline of the Robberg Nature Reserve where foot patrols were conducted. On 11 February 2011 the South African Navy joined the search for the missing wreckage by utilizing side scan sonar equipment to scan the sea bed for the wreckage. All the occupants on board the aircraft were fatally injured in the accident.

Probable Cause

The aircraft crashed into the sea following a possible in flight upset associated with a loss of control during IMC conditions.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	**:** Majuba Aviation (Pty) Ltd
Name of Operator	**:** Majuba Aviation (Pty) Ltd
Manufacturer	**:** Pilatus Aircraft Limited
Model	**:** PC-12/47
Nationality	**:** South African
Registration Marks	**:** ZS-GAA
Place	**:** Sea, Plettenberg Bay (S 34°06'.954 E 023°23'.522)
Date	**:** 8 February 2011
Time	**:** 1433Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is produced without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight:

1.1.1 On 7 February 2011, the aircraft ZS-GAA was refuelled to capacity at Lanseria Aerodrome (FALA) in preparation for the flight the next day and 1 215 litres of Jet A1 fuel was uplifted. The flight, which was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CARs) and departed from FALA at 0403Z on 8 February 2011 for Newcastle where the delegation (passengers) attended a meeting. On board the aircraft were two (2) crew members and seven (7) passengers. From Newcastle Aerodrome (FANC) they flew to Queenstown Aerodrome (FAQT) where they also attended a meeting. At 1329Z the aircraft departed from Queenstown Aerodrome for Plettenberg Bay Aerodrome (FAPG) on an Instrument Flight (IF) plan with an estimated time of arrival for FAPG to be

1430Z. According to secondary surveillance radar (SSR) footage the aircraft disappeared from radar at approximately 1433.31Z. The Google Earth map below displays the route that was flown by the aircraft on 8 February 2011. The blue block values reflect the estimated fuel consumption for each leg flown based on data that was obtained from the aircraft flight folio, which was recovered from the sea (the average fuel consumption used for these calculations was 400 pounds per hour).

This Google Earth map displays each leg of the flight and the associated fuel consumption.

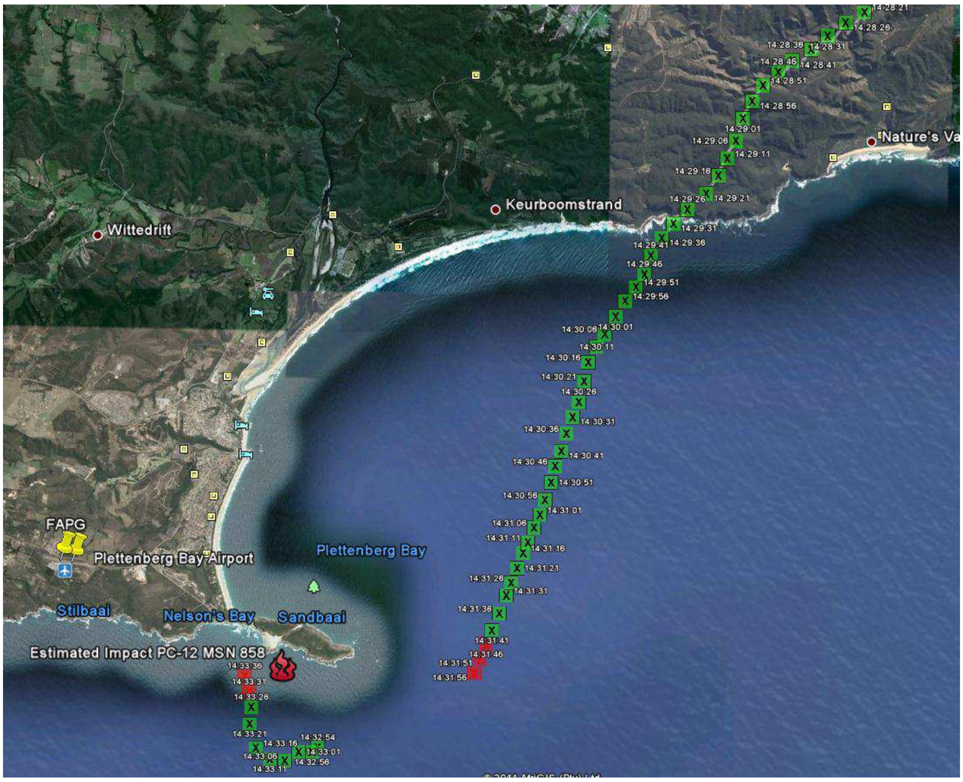
1.1.2 According to a person who went to the Plettenberg Bay aerodrome to collect some of the passengers who were on the aircraft ZS-GAA, he arrived at the aerodrome at approximately 1428Z. At the time it was overcast with drizzle. He met another person at the aerodrome who also had come to collect one of the passengers. That person was waiting in his vehicle to escape the rain. They had a short conversation through the car window and he made the comment that the aircraft would probably not land at FAPG and would probably re-route to George instead. At approximately 1436Z he received a cell phone call from his wife who informed him that she had just received a cell phone call from one of the passengers on board the aircraft informing her that they were diverting to George, which was 47 nm towards the West of FAPG and that they should arrange transport for them from George to Plettenberg Bay. In a statement received from the person who received the cell phone call, she indicated that the duration of the call was approximately 37 seconds and it was received on her phone at 1431Z (the person further stated that the time on her cell phone might not have been accurate and could have been slightly behind by a minute or two) and that the actual time when she received the call could have been around 1433Z. The cell phone service provider was contacted in order to obtain the actual time of the call. According to them the call was made at 14:32:52Z (16h32 and 52 seconds - local time) and the duration of the call lasted 38 seconds.

1.1.3 The person who received the call relayed the message to the person who was waiting in his vehicle outside the terminal building, whereupon he drove from the aerodrome to his office in town where he arranged for a mini-bus from a vehicle rental company via a travel agent, for collection at George aerodrome. At approximately 1510Z he phoned one of the passengers to inform him about this arrangement, but the phone went straight to voice mail. At approximately 1515Z he phoned George Aerodrome, Air Traffic Control (ATC) to ask if the aircraft had landed at George, and if not, when they were expected to land. George ATC had no information on the flight and suggested that he phone Cape Town ATC in order to establish if they had any communication with the aircraft and its intended routing. He was informed by Cape Town that the aircraft had landed at FAPG, upon which he informed them that it hadn't. A few minutes later Cape Town ATC phoned him back, requesting more information.

1.1.4 During radio contact with Cape Town Area East at 14:27:03Z the crew of ZS-GAA had indicated to ATC that they would cancel search and rescue once on the ground. According to available information the last communication between the aircraft and Cape Town Area East was at 14:33:03Z, at which period search and rescue was still active. Following the last communication with the aircraft Cape Town Area East tried to establish radio contact with the aircraft several times thereafter but all efforts were in vain and an Incerfa (uncertainty phase) was declared, which was upgraded a short while later directly to a Detresfa (distress phase).

1.1.5 An official search and rescue operation was activated by the Aeronautical Rescue Coordination Centre (ARCC) in Johannesburg at ±1600Z in order to start searching for the missing aircraft. The last known position of the aircraft according to secondary surveillance radar (SSR) was used as a basis for the search. Two South African Air Force (SAAF) aircraft was placed on standby to participate in the search. One would have conducted the sea search and the second the land search. Due to inclement weather conditions in the Plettenberg Bay area at the time it was not possible to dispatch either of the aircraft to start with the search nor was it possible to dispatch any boats to start with an official sea search as visibility was described as 'poor in dense fog'. Several pieces of floating debris were located towards the western side of the Robberg Nature Reserve and were being picked up from the sea by search vessels of the National Sea Rescue Institute (NSRI) that were able to dispatch at first light the next morning. Several pieces of debris (light weight material) were also located along the shoreline on the western side of the Robberg Nature Reserve by people doing foot patrols in the area. These foot patrols were conducted for several days after the accident had occurred with only minor pieces of debris (light weight material) being picked up on the western side of the Robberg Nature Reserve.

1.1.6 Radar footage was obtained for the accident aircraft (ZS-GAA) as well as a Cessna Citation that had landed at FAPG at approximately 1210Z, ± 2½ hours prior to the expected time of arrival of the accident aircraft. It is clear from the radar track of the accident aircraft, which had approached Plettenberg Bay from the northeast that the crew had flown a different approach to that of the Cessna Citation crew, which also approached the aerodrome from the north-east (inbound from FALA to FAPG). The Cessna Citation crew joined overhead the aerodrome and then flew the cloud-break procedure for runway 30 twice prior to landing at FAPG. According to a statement that was obtained from both crew members of the Cessna Citation they initiated a go-around on their first approach due to limited forward visibility, associated with low cloud and rain while on final approach for Runway 30. The accident aircraft approached Plettenberg Bay from the northeast and between Keurboomstrand and Nature's Valley descended over the sea in a south-westerly direction for a distance of approximately 7.3 nautical miles (nm), which was followed by a right turn around the Robberg Nature Reserve point (see radar trajectory below). Prior to radar coverage being lost with the aircraft there was no indication that the crew had initiated any change in course, which could be associated with a diversion to George aerodrome (FAGG).



A clip of the radar footage reflecting the accident aircraft's approach path for an intended landing at FAPG.

1.1.7 The aircraft crashed into the sea approximately 1 000m off shore, on the western side of the Robberg Nature Reserve during daylight conditions on 8 February 2011. There were no eye-witnesses to the crash, which could be attributed to the inclement weather conditions that prevailed in the area at the time. Weather conditions were reported to be overcast with a cloud base of approximately 200 feet above sea level with dense fog and drizzle at the time. Several people were interviewed who stated that they saw the aircraft flying over their houses, but this information appeared to be erroneous as the aircraft never flew over land once it went over the sea between Keurboomstrand and Nature's Valley.

1.1.8 Following confirmation of the accident a team of South African Police divers who were mainly from within Western Cape were dispatched to Plettenberg Bay. The teams arrived in Plettenberg Bay on Wednesday, 9 February 2011, but due to rough conditions at sea were unable to commence with any diving until mid-day on Thursday, 10 February 2011.

1.1.9 On Friday afternoon, 11 February 2011 the South African Navy joined the search for the missing wreckage after an official request by the South African Civil Aviation Authority had been made to the SA Navy. The vessel that was dispatched for this purpose carried specialised equipment that could scan the seabed, utilizing a side scan sonar. The side scan sonar proved to be very effective and a substantial percentage of the aircraft's wreckage (large pieces) could be located and recovered by analysing the data and diving in the areas specified. Navy divers who were dispatched with the vessel assisted the police divers with the recovery of the wreckage. The majority of large pieces that were floating were lifted onto the vessel where they were rinsed with fresh water. The vessel remained on anchor in the area until Monday, 14 February 2011 at 1600Z, where after it sailed to the port of Port Elizabeth where all the recovered pieces of wreckage were off loaded onto a truck and were taken to a secure location the following morning.

1.1.10 The crew of the Cessna Citation that had landed at FAPG at approximately 1210Z indicated in their statements that on their approach for FAPG, which was from the northeast overcast (8/8 of cloud) conditions prevailed along the coast, with the cloud ceiling (top of cloud) being at approximately 5 500 feet. Once over the NDB beacon, Pappa Yanky (PY) at FAPG, they followed the published cloudbreak procedure for runway 30. The crew indicated the cloud base to have been at approximately 1 400 feet as they descended on the approach with forward visibility varying between 1 000 and 2000 metres with scattered rain showers. During their first approach to land they initiated a go-around as their forward visibility was substantially impaired when they encountered low cloud and rain on the final segment of the approach. According to the pilot-in-command (PIC), Robberg was clearly visible during the second approach which they flew, but visibility towards the west of the aerodrome was described as poor. According to their onboard flight director/GPS the indicated wind at 2 000 feet above mean sea level (AMSL) was ±18 knots from the west at that stage. On their second approach they had the runway visual and proceeded with an uneventful landing. According to the crew the NDB beacon at FAPG was serviceable during both the approaches and the landing.

1.1.11 The accident occurred during daylight conditions at an estimated geographical position determined to be South 34°06'.954 East 023°23'.522. Most of the wreckage was located at a depth of between 28 to 35 metres below the sea. The majority of floating debris that was picked up, was located on the western shoreline of the Robberg Nature Reserve. The majority of the floating debris in the sea was picked up by crew members of the National Sea Rescue Institute (NSRI) boats, and were mostly concentrated towards the West of the Robberg Nature Reserve. All the occupants onboard the aircraft were fatally injured in the accident.

1.2 Injuries to Persons:

Injuries	Pilot	Crew	Pass.	Other
Fatal	1	1	7	-
Serious	-	-	-	-
Minor	-	-	-	-
None	-	-	-	-

1.3 Damage to Aircraft:

1.3.1 The aircraft was destroyed during impact with the sea.

1.4 Other Damage:

1.4.1 Apart from a minor fuel spill, no other environmental damage was caused.

1.5 Personnel Information:

1.5.1 Pilot-in-command (PIC)

Nationality	South African	Gender	Female	Age	32
Licence number	0270500333	Licence type	Commercial		
Licence valid	Yes	Type endorsed	Yes		
Ratings	Instrument Rating, Instructor’s Rating Grade 2				
Medical expiry date	31 March 2011				
Restrictions	None				
Previous accidents	None				

Flying Experience:

Total hours	2 662,3
Total past 90 days	34,7
Total on type past 90 days	34,7
Total on type	582,2

*NOTE:

The hours reflected in the table above were obtained from a copy of the pilots logbook that was made available to the Accident and Incident Investigation Division (AIID). The last entry in the logbook was dated 23 December 2010. There were a few additional flights that were recorded in the aircraft flight folio, which was recovered from the sea, which indicated that the pilot had flown an additional 3.5 hours on the Pilatus PC-12 (ZS-GAA) until the time of the accident.

Brief Flying History:

According to the available information (CAA Pilot file) the pilot had flown her practical flight test to obtain her private pilot's licence on 29 June 2001. On 4 July 2001 all the required paperwork was submitted to the regulating authority and her private pilot's licence (aeroplane) was issued.

On 6 November 2003 she was subjected to a flight test (skills test) in order to obtain her commercial pilot's licence. The following day the required paperwork (application for a professional pilot's licence - commercial) was submitted to the regulating authority and her commercial pilot's licence (aeroplane) was issued. Her pilot's licence as well as her instrument rating were valid for a period of one year and were renewed annually thereafter.

On 25 April 2004 she was subjected to a practical flight test (initial) for her flight instructor's rating grade III, which she passed. The rating was endorsed on her licence on 4 May 2004, following submission of the required paperwork to the regulating authority. On 29 April 2005 she had conducted a practical flight test to upgrade her flight instructor's rating to grade II level, which was subsequently issued.

The pilot commenced with her Pilatus PC-12 type conversion training on 8 February 2008 and had submitted her "Application for Flight Crew Licence Conversion" (form CA61-13.02) to the regulating authority on 7 March 2008. Her application form reflects that she had flown a total of 14.5 hours dual flight training during her type conversion onto the Pilatus PC-12. A copy of her syllabus as well as practical flight test report on the Pilatus PC-12 was available on her CAA pilot file. She also had a Boeing 767-300 (Co-pilot restricted) as well as eleven (11) smaller general aviation aircraft endorsed on her pilot's licence.

Her last practical flight test/skills test (renewal of instrument rating - aeroplane) prior to the accident flight was conducted on 29 March 2010 on a Cessna 210 type of aircraft.

According to an entry in the pilot's logbook as well as flight folio entries (page reference numbers. 7202 and 7203) the last time the pilot had landed at Plettenberg Bay aerodrome was on 16 March 2010 with a Pilatus PC-12. The flight folio indicated that they departed from FAPG the next morning for a flight to Cape Town.

1.5.2 First Officer (F/O)

Nationality	South African	Gender	Female	Age	30
Licence number	0271076135	Licence type	Commercial		
Licence valid	Yes	Type endorsed	Yes		
Ratings	Instrument Rating, Instructors Rating Grade 3				
Medical expiry date	30 June 2011				
Restrictions	Must wear suitable corrective lenses.				
Previous accidents	None				

Flying Experience:

Total hours	351,8
Total past 90 days	18,7
Total on type past 90 days	6,8
Total on type	112,6

*NOTE:
The hours reflected in the table above were obtained from a copy of the pilot's logbook (hard copy) that was made available to the Accident and Incident Investigation Division (AIID). The last entry in the logbook was dated 9 December 2010. It was noted that her last flight on a Pilatus PC-12 according to the logbook copies was on 31 October 2010. It came to the attention of the investigating team that the pilot had conducted another flight on the aircraft type on 26 December 2010 as first officer. The routing of this flight was as follows: FALA to FAJS to Buffalo Range (FVCZ) in Zimbabwe and back to FALA, with a total flight duration of 3,6 hours. The pilot's next flight(s) on the aircraft type was on 8 February 2011, which included the accident flight. Following her conversion onto type she was required to fly 50-hours as pilot-in-command under supervision (PICUS) before she could act

as PIC (believed to be an insurance requirement). It was noted that the pilot had never flown the Pilatus PC-12 as pilot-in-command. Her logbook was kept in electronic format (on a laptop), which was onboard the aircraft at the time of the accident. The laptop was not recovered from the sea.

Brief Flying History:

According to available information (CAA Pilot file and pilot's logbook) the pilot had flown her practical flight test to obtain her private pilot's licence on 23 July 2006. On 31 July 2006 all the required paperwork was submitted to the regulating authority and her private pilot's licence (aeroplane) was issued.

On 15 July 2009 she was subjected to a flight test/skills test in order to obtain her commercial pilot's licence. On the same day she also conducted her flight test (skills test) for her Instrument Rating. On 21 July 2009 the required paperwork (forms; CA61-15.06 and CA61-05.02 along with the forms CA61-05.02.1 and CA61-15.06) was submitted to the regulating authority and her commercial pilot's licence (aeroplane) as well as her instrument rating was issued. Her pilot's licence as well as her instrument rating were valid for a period of one year and were renewed annually.

On 24 July 2009 she completed her type conversion onto the Pilatus PC-12 under the auspices of an approved Aviation Training Organisation (ATO). This was her first conversion onto an HPA (High Performance Aircraft {gas turbine engine driven aircraft}). On 29 July 2009 the form CA61-13.06 (Application for Class, Warbird or Type Rating) was submitted to the regulating authority. The authority then endorsed the aircraft type rating onto her pilot's licence, which was also endorsed in her pilot logbook. According to the available information (form; CA 61-13.06) she had flown a total of 2.3 hours dual (one flight) to complete her conversion onto the aircraft type.
The ATO under, which the type conversion was conducted, was consulted by the investigating team, as the team required clarity with reference to the Pilatus PC-12 type conversion.

The following information was requested from the ATO during a visit to the facility on 17 March 2011;

(i) A copy of the approved Pilatus PC-12 syllabus.
(ii) Pilatus PC-12 training/course material.

(iii) The pilots training file, that was required to contain her written examinations (i.e., technical, performance, procedures and emergencies).

(iv) Skills/Flight Test Report.

None of the information requested could be made available for evaluation purposes, nor was it available on the pilot's file in possession of the regulating authority. The ATO was required in accordance with the Civil Aviation Regulations (CAR's) to have kept all records in safety for a period of at least five (5) years calculated from the date of the last entry made in such records as follows;

Part 141.02.15 (Documents and records)

"(3) The holder of the approval shall establish procedures to identify, collect, index, store and maintain all records which may be necessary –
(a) for the specified aviation training conducted by such holder;
(b) to determine compliance with the appropriate requirements prescribed in this Subpart.
(4) The procedures referred to in sub-regulation (3) shall ensure that –
(a) a record is kept of each quality control review of the holder of the approval;
(b) a record is kept of each person who conducts the specified aviation training, including particulars of the competence assessments and experience of each such person;
(c) a record is kept of each student being trained or assessed by the holder of the approval, including particulars of enrolment, attendance, modules, instructor comments and any flight or similar practical sessions and assessments of each such student;
(d) all records are legible; and
(e) all records are kept for a period of at least five years calculated from the date of the last entry made in such records".

It was noted that the ATO through which the pilot received her Pilatus PC-12 conversion was in possession of a valid ATO Accreditation and Approval Certificate for Standard Aviation Training at the time. The ATO Approval certificate was issued on 8 June 2009 and expired on 30 June 2010. The certificate was issued following an audit that was conducted at the facility on 8 May 2009.

The pilot's last practical flight test prior to the accident flight was an evaluation for her flight instructor's rating. The flight was conducted on 9 December 2010 on a Cessna 172 type aircraft. Following an evaluation of the test the flight examiner found her proficient to act as a flight instructor grade III. This rating was endorsed in the pilot’s licence on 13 December 2010, following submission of the required paperwork to the regulating authority.

1.6 Aircraft Information:

1.6.1 Description of the Aircraft.

The Pilatus PC-12 is a single-engine turboprop passenger and cargo aircraft with its primary application being corporate transport as well as emergency medical services (air ambulance). It is certified for single-pilot IFR operations, though operators may choose to utilize a second flight crew member. Pilatus offers the PC-12 in a standard nine-seat airliner form, in a four-seat/freight Combi version, and as a six-seat corporate form of transport. The aircraft, serial number 858 was type certified under the EASA (European Aviation Safety Agency) requirements.

A photo of the Pilatus PC-12.

1.6.2 Airframe:

Type	Pilatus PC-12/47
Serial number	858
Manufacturer	Pilatus Aircraft Ltd
Year of manufacture	2007
Total airframe hours (At time of accident)	1 096,2

Last MPI (hours & date)	1 065,2	16 November 2010
Hours since last MPI	31,0	
C of A (Issue date)	22 November 2007	
C of A (Expiry date)	21 November 2011	
C of R (Issue date) (Present owner)	22 November 2007	
Operating categories	Standard	

*NOTE:
The aircraft had sustained some damage during a hail storm on 23 October 2009 while it was parked outside at Lanseria Aerodrome. According to the maintenance records, Job Notice No. 1702 that was opened on 28 October 2009, both aileron and elevator assemblies were replaced by new assemblies following the assessment of the damage. An aircraft airframe logbook entry on page 105 reflects that these control surfaces were indeed replaced. The work was carried out by a maintenance organisation, which had been approved by the CAA.

The last known defect on the aircraft prior to the accident flight was a flap-related event. On 23 December 2010 the aircraft was scheduled to return to Lanseria aerodrome with passengers from Cape St. Francis, but after start-up the pilot was unable to select 15° of flaps, which was required for take-off. The pilot then attempted to reset the flaps onboard the aircraft following a discussion via cell phone with a maintenance engineer, but was unsuccessful in doing so. The passengers were left behind and a flapless take-off was performed and the aircraft was ferried back to FALA, where a flapless landing followed. On 4 January 2011 the aircraft was ferried from FALA to Rand aerodrome (FAGM) where an aircraft maintenance organisation (AMO) attended to the problem by resetting the flap computer (re-zeroed) by making use of a laptop. The maintenance intervention rectified the defect and the aircraft was flown back to FALA on the same day. It should be noted that this defect was not entered in the aircraft flight folio as called for in Part 91.03.5 of the CAR's but came to the attention of the investigating team during an interview with an individual. The interview was then followed-up with the maintenance organisation that had rectified the defect. No documented evidence in the form of a logbook entry was made by the person(s) who had carried out such maintenance, which did not meet the requirements as stipulated in Part 43.03.1 (Maintenance records) of the CAR's.

A comprehensive overview of the aircraft flight folio was conducted after the aircraft arrived in South Africa in December 2007, as a copy of each and every flight folio entry was on record with the last few entries still in the flight folio, which was recovered from the sea. It was noted that very few defects were entered into the aircraft flight folio's section 'Description of Defect'. The process of how defects on the aircraft were reported to the AMO was discussed during an interview with members of the AMO. It was noted that the method used to report defects had shifted from the documented format (hard copy entry in the aircraft flight folio) to a more electronic format. It was noted that most of the defects that were reported took place either via e-mail or SMS (short message service) utilizing a cell phone or a laptop. This led to a lack of historical maintenance-related information being available on this aircraft.

1.6.3 Engine:

Type	Pratt & Whitney PT6A-67B
Serial number	PCE-PR0747
Hours since new	1 096,2
Cycles since new	912
Hours since overhaul	T.B.O. not yet reached (3 600 hours)

1.6.4 Propeller:

Type	Hartzell HC-E4A-3D
Serial number	KX 522
Hours since new	1 096,2
Hours since overhaul	T.B.O. not yet reached

1.6.5 Weight and Balance:

The investigating team was unable to determine a detailed weight and balance of the aircraft at the time of the accident. The aircraft was refuelled to capacity on the day prior to the flight at Lanseria aerodrome (FALA) where 1 215 litres (972 kg) of Jet A1 was uplifted. Taking the total flight time into account (3.2 hours), from the time when the aircraft departed from FALA until the accident it could be determined that approximately 975 litres (780 kg) of fuel had been used, which include the two landings and take-offs. The fuel consumption was based on a consumption rate of approximately 400 pounds per hour (228 litres / hour), which was obtained following consultation with the aircraft manufacturer. The respective weights of the occupants and luggage could not be determined with certainty following impact with the sea.

1.7 Meteorological Information:

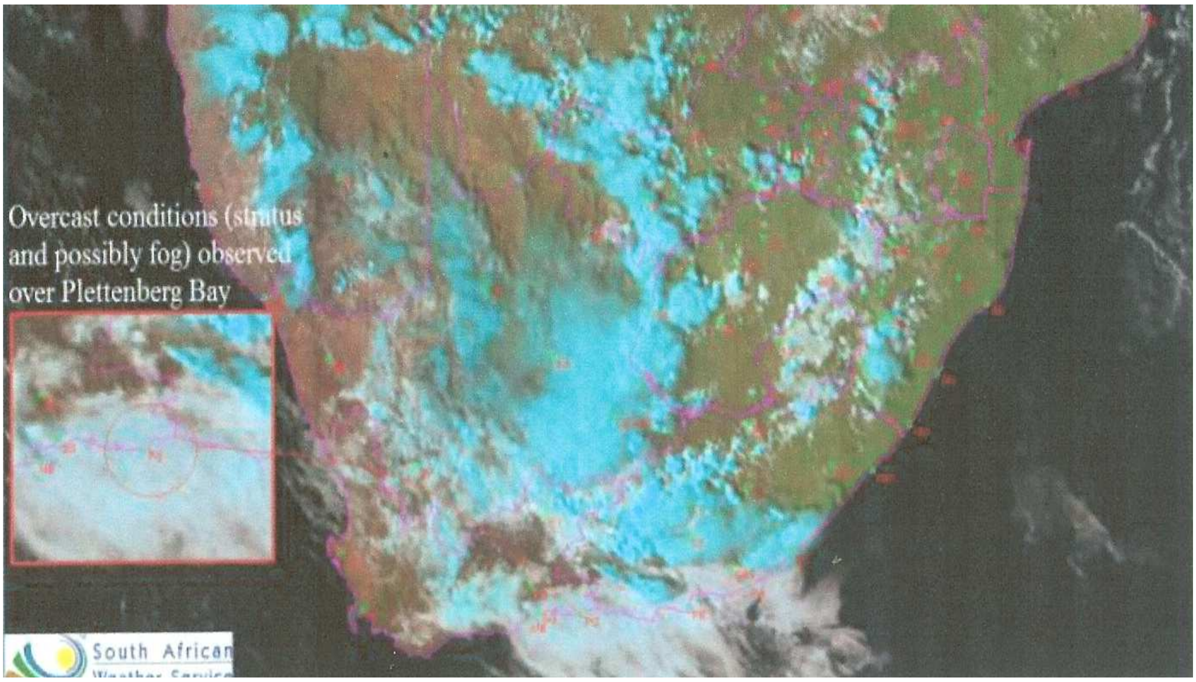
1.7.1 An official weather report was obtained from the South African Weather Services (SAWS) for the Plettenberg Bay area for 8 February 2011.

Surface Analysis (1200Z 08 February 2011)

A surface trough over the interior extended to the south-east coast into a coastal low which was propagating eastwards. A high pressure system south-west of the country pushed in low clouds along the south coast behind the coastal low. Moderate south-westerly to southerly winds were observed and were pushing moist maritime air in with low Stratiform clouds.

Satellite Images (1400-1500Z 08 February 2011)

The satellite image below reflects overcast conditions along the south coast extending to the adjacent interior, low cloud demarcating the adjacent mountains also indicative of the presence of low Stratiform clouds and possible thick fog with drizzle.



A satellite image of the country that was taken at 1430Z on 8 February 2011.

Recorded weather about the time of the aircraft accident (1400-1500Z METAR), with George being the closest weather station to Plettenberg Bay provided weather records which were representative of the Garden Route. The official meteorological aerodrome report (METAR) closest to the time of the accident on the day was the one valid for 1430Z at George, which indicated reduced visibility in light drizzle and fog.

The Meteorological Aerodrome Report (METAR) for George was as follows:

Date: 8 February 2011 – Time: 1430Z

FAGG 081430Z 20004KT 170V230 4000 -DZ BR BKN002 20/20 Q1015=

FAGG	-	ICAO location indicator for George Aerodrome
081430Z	-	Date and time of issue (UTC)
200°	-	Wind direction (from True North): in degree s
04kt	-	Wind strength (knots)
4000m	-	Visibility - 4km
DZ BR	-	Light drizzle (DZ) and mist (BR)
BKN002	-	broken cloud (5 - 7 eights) at 200 feet AGL
20℃	-	Dry bulb temperature
20℃	-	Dew-point temperature
1015hPa	-	Barometric pressure: (QNH in hPa)

According to members of the first search and rescue teams that were activated to search for the missing aircraft, dense fog prevailed in the area with forward visibility limited at times to only 5 m. However, these conditions improved at daybreak, which allowed for an official sea search to commence.

According to a member of Cape Nature, which manages the Robberg Nature Reserve, 5 mm of rain was measured at the reserve over a 24-hour period on the day of the accident (8 February 2011). This measurement was taken at the office located at the entry gate to the reserve.

According to the South African Weather Services (SAWS) their automatic weather station, (which is used for synoptic and climatological data purposes only), which was located at the Plettenberg Bay aerodrome measured 4 mm of rain for the day. According to the rainfall chart for the 24-hour period on the day of the accident it was raining at the aerodrome at the time when the aircraft ZS-GAA was expected to land there. This observation was confirmed in a statement by two persons who were at the aerodrome at approximately 1430Z waiting for the aircraft to land in order to collect the passengers.

According to a lightning verification report that was obtained from the SAWS, no lightning strikes were detected within a 20 km radius from the Plettenberg Bay aerodrome on 8 February 2011.

1.8 Aids to Navigation:

1.8.1 The aircraft was equipped with the following navigational aids;

(i) Very High Frequency Omni-directional Radio Range (VOR)
(ii) Automatic Direction Finding (ADF)
(iii) Instrument Landing System (ILS)
(iv) Distant Measuring Equipment (DME)
(v) Transponder
(vi) Global Positioning Systems (GPS) (Garmin GNS 430, and GNS 530)
(vii) Weather radar.

1.8.2 The aerodrome navigational aids at FAPG consisted of a single non directional beacon (NDB) with reference Pappa Yanky (PY), active frequency 227.5 KHz. According to the crew of the Cessna Citation that had landed at FAPG at approximately 1210Z on 8 February 2011, the NDB was fully functional/serviceable at the time as they flew the cloudbreak procedure for runway 30 twice before they landed.

1.9 Communications:

1.9.1 The aircraft was in radio contact with Cape Town Area East on the VHF frequency 124.7 MHz prior to its disappearance from radar. A transcript of the communication with the aircraft could be found attached to this report as Annexure A.

1.9.2 No record could be found that the aircraft broadcasted any communication on the common traffic advisory frequency for the Plettenberg Bay area on the VHF frequency 124.8 MHz during the approach for FAPG.

1.9.3 No distress call was received by any station from the accident aircraft at any stage of the flight.

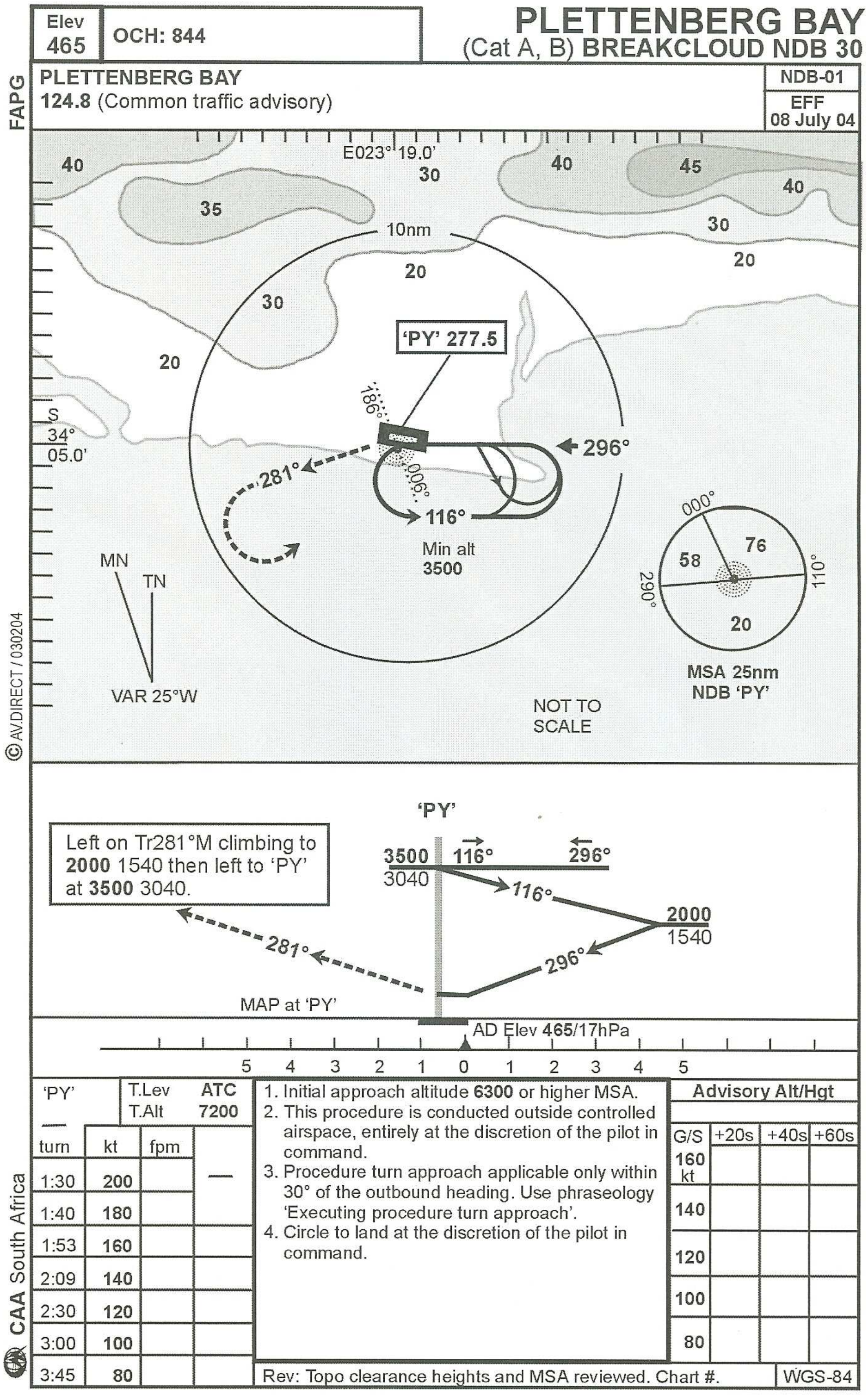
1.9.4 The aircraft was equipped with an emergency locator transmitter (ELT), however, no distress signal was picked up by the designated service provider that might have emanated from the device.

1.10 Aerodrome Information:

1.10.1 The aircraft was expected to land at Plettenberg Bay aerodrome (FAPG) at approximately 1430Z, but never arrived at the aerodrome. It was later determined that the aircraft had crashed into the sea approximately 2.9 nm southeast of the aerodrome.

Aerodrome Location	2 nm WSW of the town of Plettenberg Bay	
Aerodrome Co-ordinates	South 34°05’17.37” East 023° 19’43.02”	
Aerodrome Elevation	465 feet above mean sea level (AMSL)	
Runway Designations	12/30	
Runway Dimensions	1 240 x 20 m	
Runway Used	Not applicable	
Runway Surface	Asphalt	
Approach Facilities	Non-directional beacon (NDB)	
Aerodrome Status	Licensed	

Plettenberg Bay Aerodrome was in possession of a valid aerodrome licence No. 234 that was renewed by the regulating authority on 31 January 2011, with the period of validity indicated on the aerodrome licence certificate as, ‘1 February 2011 to 31 January 2012’. An approved cloud-break procedure NDB for Runway 30 was published on the website of the regulating authority and was also available in the aeronautical information publication (AIP). See the next page for a copy of such a procedure.



1.11 Flight Recorders:

1.11.1 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR). Neither was it required by regulation to be fitted to this type of aircraft.

1.11.2 The aircraft was equipped with an Engine Indication System (EIS), which contained a non volatile memory (NVM) in the form of a memory card. The memory card was normally used to download Engine Condition & Trend Monitoring (ECTM), which records engine trend data, but also engine exceedance data, if applicable. The EIS display was recovered from the sea after several days and after recovery was immediately rinsed in fresh water.

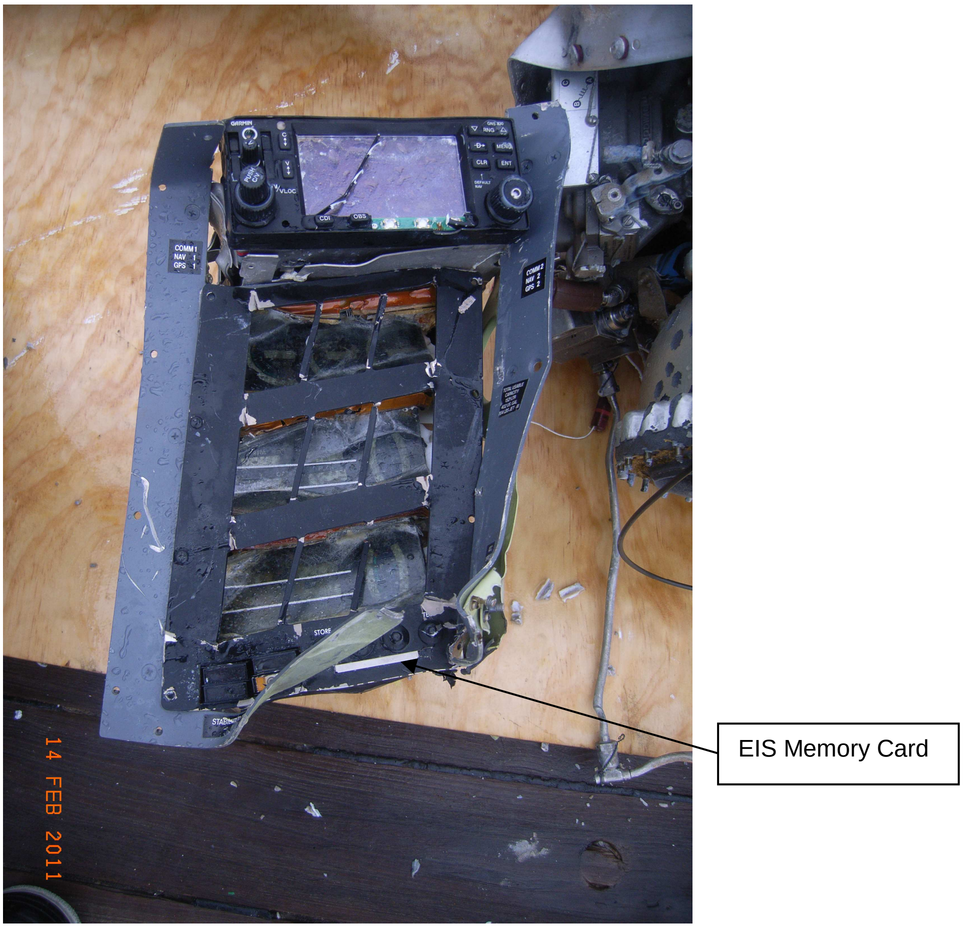


Figure 1. EIS Display

The memory card primarily records engine trend data, but also records engine exceedance data, if applicable. Downloading of the EIS data requires special software. The memory card was transported to Switzerland where it was downloaded on 22 February 2011 at Pilatus Aircraft Ltd under the supervision of a member of the Swiss Bureau d'enquêtes sur les accidents d'aviation.

Figure 2. EIS Memory Card

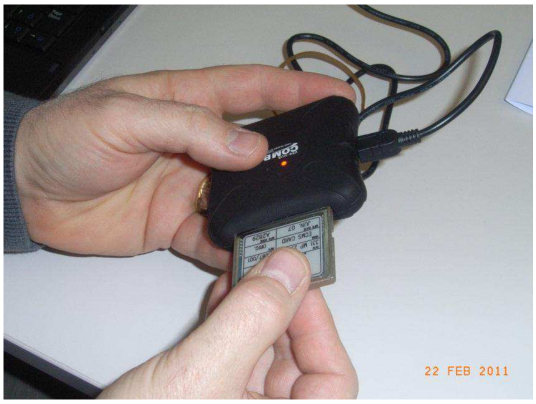


Figure 3. Card Reader

Conclusion

"The EIS memory card most likely sustained internal damage to such an extent that normal data download using the normal tooling was not possible. The reason for this damage was most likely the penetration of salt water into the card itself".

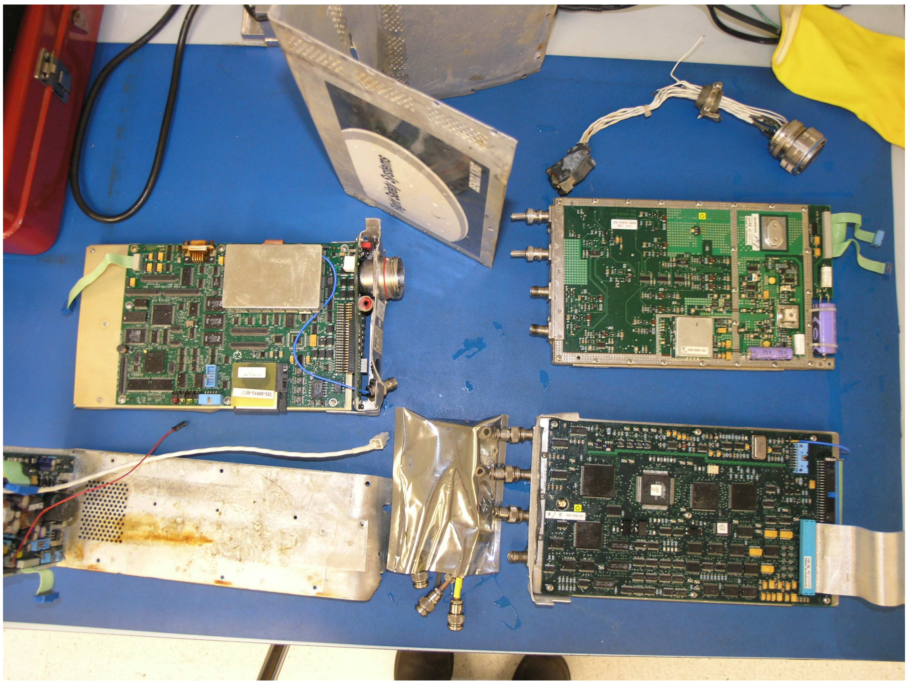
The actual vendor/manufacturer of the memory card was contacted following the download attempt of the memory card referred above. They indicated that the memory card was not designed nor manufactured as a waterproof unit and by being exposed to the sea water for several days, the flash chip inside most probably deteriorated/broke, with the result that the downloading/retrieval of data was not possible.

1.11.3 Enhanced Ground Proximity Warning System (EGPWS) Examination:

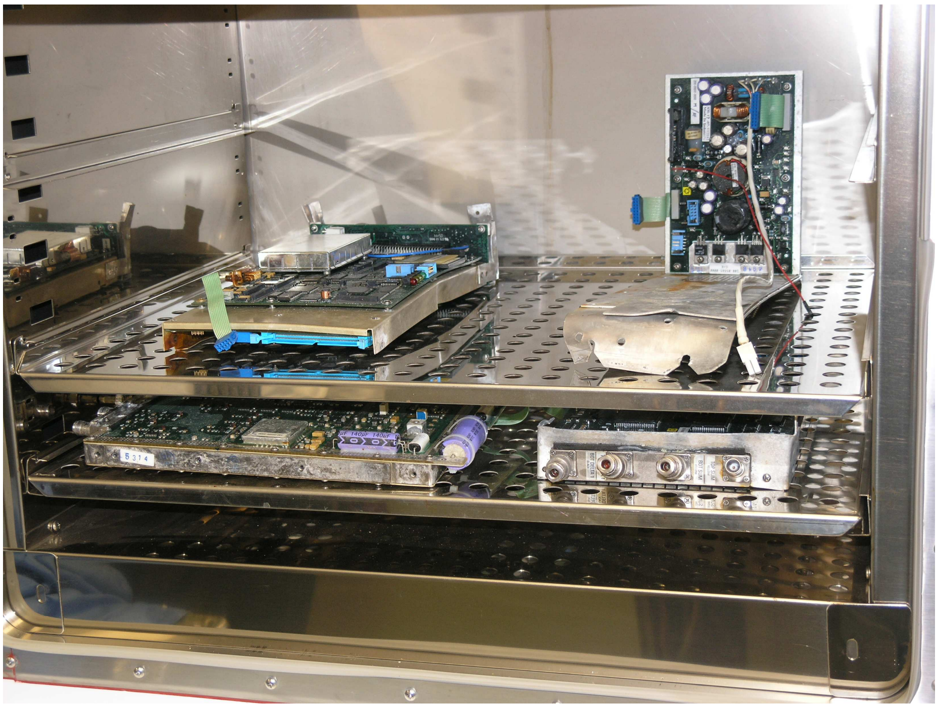
A Honeywell KMH 820 Multi-Hazard Awareness System computer Part No. 066-01175-2101, Serial No. KMH820-A2992, containing EGWPS module Part No. 965-0702-001, Serial No. 03585 was recovered from the sea. The unit was properly rinsed with fresh water after recovery and was placed in a container filled with fresh water. After the unit was offloaded from the Navy vessel it was placed in a sealed container filled with fresh water and was shipped to Honeywell in the United States of America (U.S.A.) in order to establish if any data could be retrieved from the unit.

In accordance with ICAO Annex 13, Honeywell was requested by the South African Civil Aviation Authority (SACAA) via the accredited representative of the National Transportation Safety Board (NTSB) with oversight provided by the US Federal Aviation Association (FAA), to assist in the investigation.

A view of the sealed container that was used for transporting the unit to the U.S.A.



A view of the unit after it was dismantled and cleaned at the Honeywell laboratory.



The dismantled unit being prepared for the drying out phase at the Honeywell laboratory.

The unit KMH820 was removed from the shipping container on 30 March 2011 where after the cleaning and the drying-out process started. The data retrieval process started on 12 April 2011.

Analysis of Fault Data

"Based on the analysis of the EGPWS flight history data the following findings are presented:

This EGPWS module had accumulated 1302 hours of operation since it was originally manufactured in 2007, of which 1078 hours were in flight. This represents 900 flight legs (from take-off to the next take-off). The remaining 224 operating hours were on the ground.

Of the 900 flight legs in the flight history record, at least 180 had EGPWS INOP conditions for part or all of the flight legs. The fault history does not record the length of time a unit is faulted for a particular fault – only that it occurred. The INOP faults that were recorded were due to internal EGPWS computer failures for Terrain Database or Application Database (executable code). The EGPWS was INOP for 37 of the first 100 flight legs, 23 of the last 100 flight legs, and 120 of the 700 intermediate flight legs according to the flight history record. Additionally, there is no evidence of EGPWS "Self Test" being performed in the last 10 flight legs when the data was viewed on the test rig computer screen. However, the data containing *the self test history was not captured to a log file during the investigation.*

The unit did operate on many flight legs as there is flight history data that indicates that terrain alerts were provided to the crew on those flights.

In the event of a malfunction, the unit is designed to provide a signal to activate the cockpit TERR INOP annunciator. According to the Terrain Function (EGPWS) Pilot's Guide Addendum, the KMD 850 multi-function display (MFD) will also provide inoperative terrain indicators including:

- *"Terrain Inactive" in the Available Functions Legend of the display.*
- *Terrain Awareness State on the Terrain Display Page indicating TERR FAIL when terrain id INOP due to a fault.*

The EGPWS module installed on ZS-GAA was inoperative (INOP) at the time of the accident due to a failure of the internal Terrain Database. Honeywell has not determined any probable cause for the internal failures as the unit had been submerged in salt water and was mechanically damaged during the accident"

An official report was compiled on the findings and observations that were made during the examination and analysis of this unit. The report could be found attached to this report as Annexure B.

1.11.4 Another unit that was recovered from the sea that could possibly have stored flight data was the Garmin GNS 430. Correspondence with the manufacturer of the unit revealed that the damage and the salt water ingress would have prevented a power up of the unit. Therefore it was not possible to determine the last loaded flight plan from the unit.

1.12 Wreckage and Impact Information:

1.12.1 Due to the fact that the aircraft crashed into the sea no official wreckage diagram could be drawn up as, it was essential to recover as much of the debris in the shortest possible time frame. No underwater video or photos were taken of the wreckage. This decision was supported by the fact that the wreckage was at a substantial depth, which limited diving time, and made the recovery of wreckage parts a priority. The last known heading that the aircraft was tracking before it disappeared from radar was approximately 006°M (341 °T + variation of 25°).

Figure 1. Estimated impact location (viewed from land).

Figure 2. A view from the sea of the estimated impact location.

1.12.2 The image (see figure 3 on next page) was made available by the South African Navy, and indicates the images that were picked up by the side scan sonar that was being utilized in order to locate the wreckage. The image provides reflections and no actual components/parts could be allocated to a certain object as reflected, but it does provide the reader with some insight into the wreckage field.

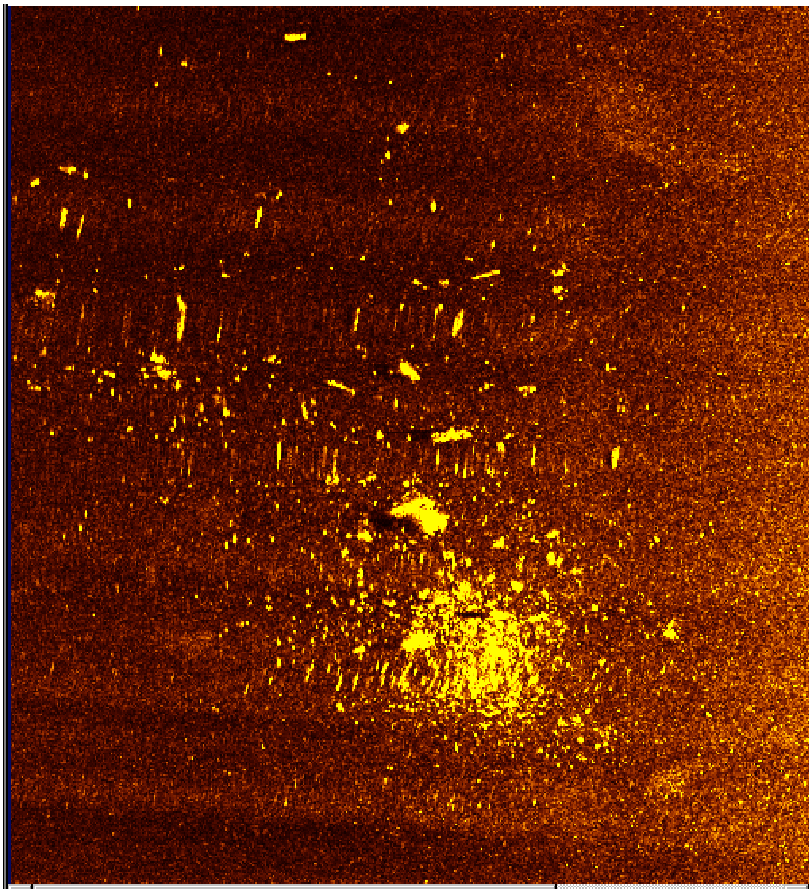


Figure 3. Side scan sonar image of debris field under the water courtesy of SA Navy.

1.12.3 Forward, Centre and Aft Sections of the Aircraft

The propeller, with two of the four blades still attached to the hub assembly and the reduction gearbox of the engine were recovered, and so was the engine.

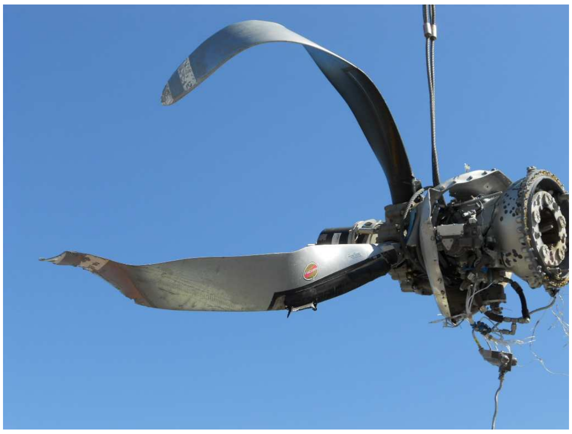


Figure 4. A view of the propeller.

Figure 5. A view of the engine

Several parts of the fuselage section were recovered, however, except for a few parts, the entire section from frame 10 (firewall) to approximately frame 27 (in front of the cargo door) is still missing (see figure 6 for reference to the frame numbers). This include the right wing, from which only the weather radar dome/cover and the flap assembly were located.

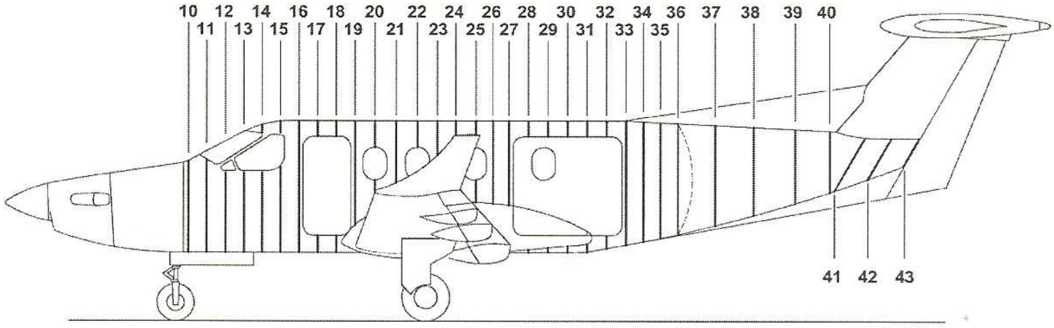


Figure 6. Fuselage Structure Identification

A section of the left wing was recovered (see figure 7). The inner part of the wing up to rib 5 is missing (refer to Figure 8). The outer part of the wing is fractured in the area of rib 16. Except for the wing tip none of the pieces of this section was found. The inner leading edge is missing and the tank area had burst open. The rear spar of the wing was fractured at the landing gear attachment. Both wing fuselage/wing attachments are missing. No pieces of the left main landing gear were found.

Figure 7: A view of the left wing that was recovered with a section of the flap attached.

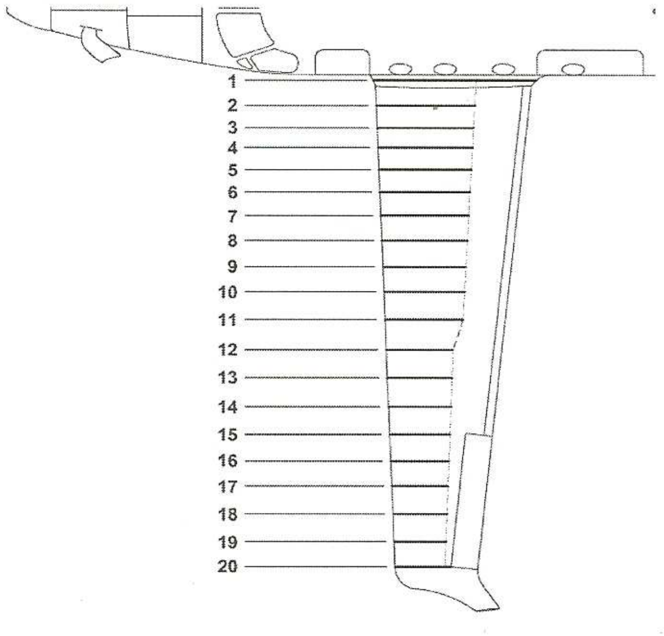


Figure 8. Left wing sections.

The outer flap screw actuator of the left wing was still attached to the rear spar. The actuator was found in the flap up position.

Except for one bellcrank (see Figure 9) (left-hand outer), no other parts of the aileron system, including the surfaces itself were found. The aileron trim actuator, (located on the left side) was not recovered either, therefore aileron control continuity could not be established.

Figure 9. The left-hand outer aileron bellcrank.

As none of the three landing gear actuators or any other landing gear component was found it was not possible to determine the landing gear configuration at the time of impact with 100% certainty. The left-hand side landing gear attachment point at the rear wing spar did not show any signs of torsion (see Figure 10).

Figure 10: Left-hand landing gear attachment point at the wing main spar.

Fuselage Structure (Cargo door {station 27} and aft)

The cargo door area and associated structure were recovered from the sea. The cargo door was found still attached to the hinge on the top fuselage. The 3 hooks were free to rotate, as the locking mechanism reflected damage to the individual units. One shoot bolt was found out and jammed, which was an indication that the door was closed and locked at the time of impact.

Figure 11. Cargo door with shoot bolt.

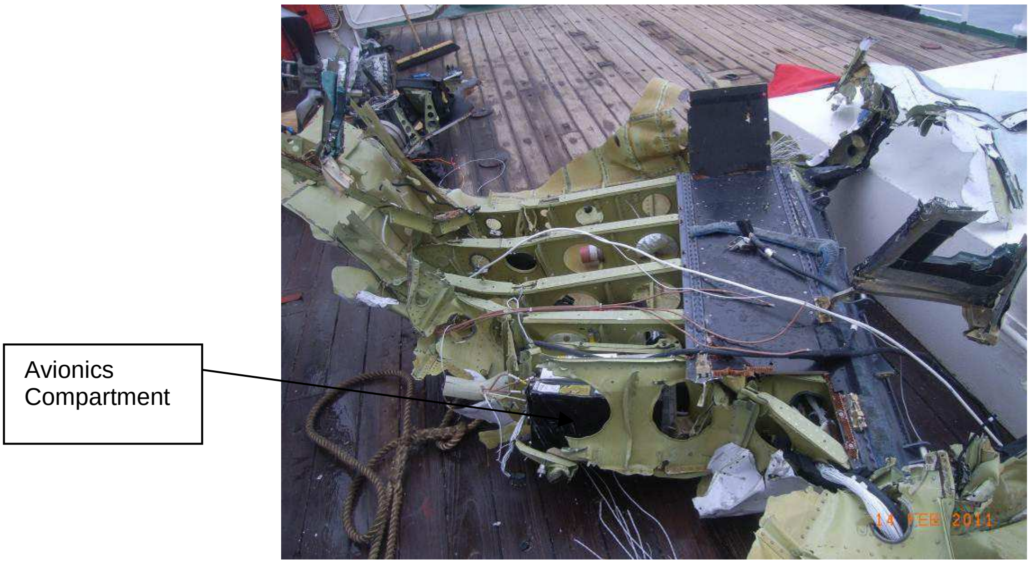


Figure 12. Bottom part of the cargo door, fuselage section.

Figure 13. Top part of cargo area fuselage section.

The forward section of the empennage, the vertical stabiliser including the rudder as well as the horizontal stabiliser were recovered from the sea. The rudder and flight control cables were still attached to the horizontal stabiliser with minor damage observed. The cables were found to have fractured under tension/overload. The horizontal stabiliser had separated at its attachment to the vertical stabiliser with substantial damage observed on the right-hand surface, which could be associated with impact. The elevator was still attached to the horizontal stabilizer and the hinges were damage by impact forces. Approximately half of the left-hand surface was missing; this was associated with impact damage. The push-pull rod from the bell-crank to the elevator was found to be fractured and bent. The control cables were still attached to the bell-crank. The cables were found to have fractured in overload mode. Up to this point continuity was established. As no other pieces of the elevator control system were found the continuity of the forward part of the system could not be established.

Figure 14. Forward section of the empennage.

Figure 15. The vertical stabiliser including the rudder.

Figure 16. Horizontal stabiliser

1.13 Medical and Pathological Information:

1.13.1 The post-mortem examinations of seven (7) of the occupants who perished in this accident were conducted in George on 12 February 2011 by a forensic pathologist.

1.13.2 The remaining two occupants who perished in the accident were identified by DNA (deoxyribonucleic acid) profiling after several tissue samples had been evaluated by a forensic laboratory in Cape Town.

1.13.3 The cause of death of all nine (9) occupants was concluded to be as a result of multiple injuries sustained during the impact sequence.

1.13.4 Toxicological tests were performed only on the PIC as it was possible to attain eye fluid during the post-mortem examination. The test indicated that the concentration of alcohol in the blood specimen was 0.00 grams per 100 millilitres. No sodium fluoride analysis was possible as the specimen size was too small.

1.13.5 No toxicological tests were performed on the co-pilot as no bodily fluid could be obtained in order to perform such tests.

1.14 Fire:

1.14.1 According to the debris that was recovered from the sea no evidence could be obtained that indicate any possibility of a pre- or post-impact fire.

1.15 Survival Aspects:

1.15.1 This was not considered a survivable accident due to the high kinetic energy associated with the impact sequence that was well above that of human tolerance.

1.16 Tests and Research:

1.16.1 The Engine

The engine a Pratt & Whitney PT6A-67B, Serial No. PCE-PR0747 was recovered from the sea and was transported on a SA Navy vessel to the port of Port Elizabeth where it was offloaded and transported to an approved engine maintenance facility at Lanseria Aerodrome. The engine was continuously rinsed with fresh water once it was recovered from the sea. While being transported on the vessel to port it was rinsed on a regular basis as corrosion had a profound effect on the engine casing material.

The Accident and Incident Investigation Division (AIID) requested assistance with the teardown of the engine from Pratt and Whitney Canada (P&WC) via the Transport Safety Board (TSB) of Canada. An Investigator and Field Service

Representative of P&WC were made available and the engine investigation was performed over the period 22 - 23 February 2011.

The engine displayed severe impact and salt water immersion damage, including complete structural separation of the reduction gearbox forward housing. The propeller assembly remained attached to the propeller shaft. Portions of the airframe shrouding and pneumatic bleed system remained attached.

"A brief summary of observations, engine displayed deformation to the compressor 1st stage blades and contact signatures to the compressor axial stages, compressor impeller and shroud, compressor turbine, 1st stage power turbine vane ring and shroud, 1st stage power turbine, 2nd stage power turbine vane ring shroud, 2nd stage power turbine, and torsional fracture of the reduction gearbox propeller shaft coupling webs characteristic of the engine producing power at impact, likely in the middle to high power range. There were no indications of any pre-impact mechanical anomalies or dysfunction to any of the components observed."

Photo No. 1
General view of the engine (right-hand side).

Compressor Section

Compressor Discs and Blades: The 1st stage blade airfoils were deformed randomly forward and away from the direction of rotation. The blade airfoil leading edges displayed nicks and deformation. The 2nd stage blade airfoils displayed slight nicks and deformation. The 3rd and 4th stages were intact. Please refer to photos No. 2 to 5.

Photo No. 2
Compressor 1st stage disc.

Photo No. 3
Compressor 1st, 2nd, 3rd, and 4th stage discs.

Centrifugal Impeller: The vane airfoils tips displayed circumferential rubbing, with light frictional heat discoloration, due to contact with the impeller shroud. Refer to photo No. 4 on the next page.

Centrifugal Impeller Shroud: The shroud face displayed circumferential rubbing, with frictional heat discoloration and material transfer, due to contact with the impeller. Refer to photo No. 5 on the next page.

Photo No. 4
Centrifugal impeller detail.

Photo No. 5
Centrifugal impeller shroud, detail.

Combustion Chamber Liner: Displayed no indications of operational distress. The outer liner flame pattern indications appeared normal. Please refer to photo No. 6.

Photo No. 6
Combustion chamber liner and compressor turbine, in-situ.

Turbine Section

Compressor Turbine: The blade airfoils displayed no indications of distress. The upstream side blade platforms displayed circumferential rubbing due to contact with the compressor turbine vane ring inner drum. The downstream side blade platforms and disc outer rim were circumferentially machined due to contact with the 1st stage power turbine vane ring. The hub face was circumferentially rubbed due to contact with the inter-stage baffle. Please refer to photos No. 7 to 9.

Photo No. 7
Compressor turbine, in-situ.

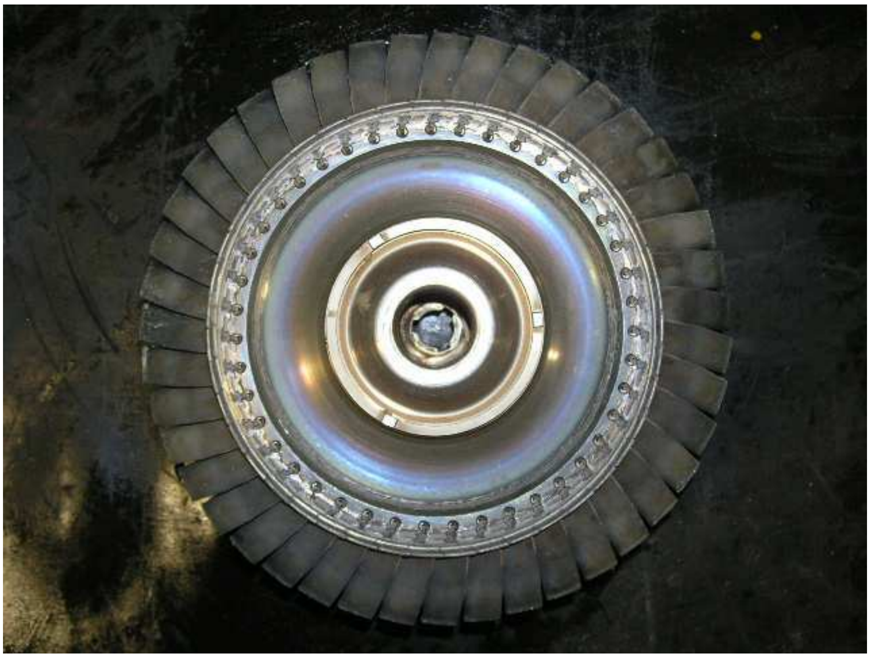


Photo No. 8
Compressor turbine, downstream side.

Photo No. 9
Compressor turbine downstream side, detail.

1st Stage Power Turbine: The upstream side blade roots and the blade tip shrouds displayed circumferential rubbing and machining due to contact with the 1st stage power turbine vane ring. The downstream disc outer rim and blade outer spans were circumferentially rubbed, and the outer spans deformed and fractured, due to contact with the 2nd stage power turbine vane ring. The blade tips were circumferentially rubbed due to contact with the shroud. Please refer to photos No. 10 and 11.

Photo No. 10
1st stage power turbine, upstream side.

Photo No. 11
1st stage power turbine upstream side, detail.

2nd Stage Power Turbine Vane Ring: The vane airfoil leading edges and vane ring inner drum were circumferentially rubbed and machined from the approximate 6:00 to 10:30 positions due to contact with the 1st stage power turbine. The vane ring downstream side displayed heavy circumferential rubbing and machining, with the heaviest concentration from the approximate 1:00 to 3:00 positions due to contact with the 2nd stage power turbine. The interstage abradable air seal displayed heavy circumferential rubbing, with frictional heat discoloration, due to contact with the air seal rotor knife edges. Please refer to photos No. 12 and 13.

2nd Stage Power Turbine Shroud: Displayed heavy circumferential rubbing due to contact with the 2nd stage power turbine blade tips. Please refer to photo No. 14.

Photo No. 12
2nd stage power turbine vane ring, upstream side.

Photo No. 13
Interstage abradable airseal detail, approximate 9:00 position.

Photo No. 14
2nd stage power turbine vane ring downstream side and shroud, approximate 2:00 position

2nd Stage Power Turbine: The blade airfoils were circumferentially fractured at heights varying from the root to approximately 1/4 span due to contact with the duct, shroud, and 2nd stage power turbine vane ring. Fractured blade material remained in the exhaust duct. The recovered blade tips displayed circumferential rubbing. The upstream side blade platforms displayed circumferential machining due to contact with the vane ring. The downstream side blade platforms and disc face displayed circumferential rubbing due to contact with the power turbine shaft housing and exhaust duct inner shroud. Under unaided visual and macroscopic inspection all of the blade fractures displayed course dendritic features and displayed no indications of fatigue or other progressive fracture mechanism. Please refer to photos No. 15 and 16.

Photo No. 15
2nd stage power turbine and power turbine shaft, upstream side.

Photo No. 16
2nd stage power turbine downstream side, detail

Photo No. 17
Recovered 2nd stage power turbine blades.

Power Turbine Shaft and Shaft Housing: The power turbine shaft was fractured from the reduction gearbox coupling. The shaft face displayed severe circumferential rubbing and deformation. The power turbine shaft housing was not recovered. The exhaust duct inner shroud displayed circumferential scoring due to contact with the 2nd stage power turbine. Please refer to photo No. 18.

Photo No. 18
Power turbine shaft forward section compared to exemplar shaft.

Reduction Gearbox

The 2nd stage gearing was observed in-situ in the reduction gearbox forward housing. The gearing displayed severe corrosion damage as a result of sea water. The 2nd stage planet gear carrier to propeller shaft spline mounting webs was fractured in torsion. The fractured webs displayed counter-clockwise torsional deformation. The reduction gearbox rear housing and 1st stage gearing were not recovered. Please refer to photos No. 19 and 20.

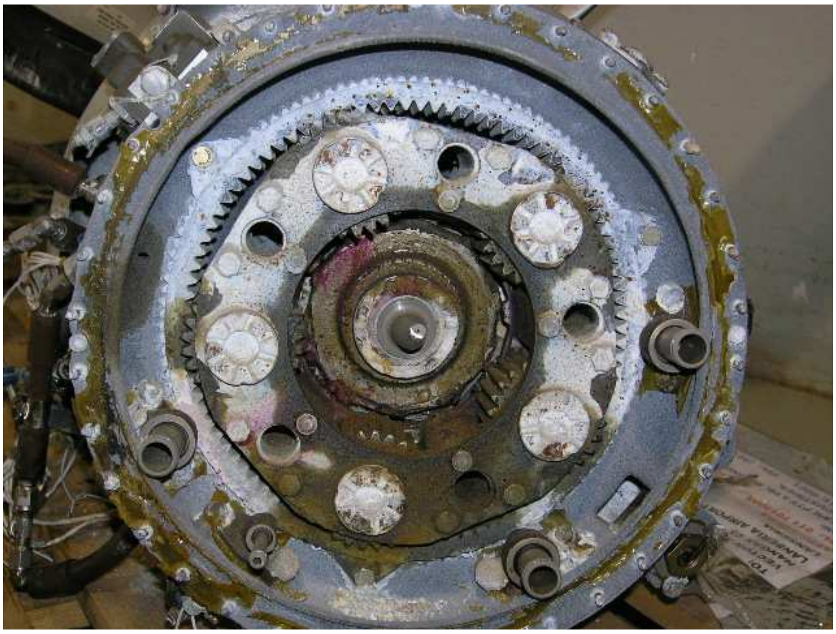


Photo No. 19
Reduction gearbox 2nd stage gearing.

Photo No. 20
2nd stage planet gear carrier propeller shaft coupling

Accessory Gearbox

Severe corrosion damage precluded disassembly of the accessory gearbox. The reduction gearbox coupling was intact.

Evaluation of Controls and Accessories

Salt water immersion damage precluded evaluation of the controls and accessories. The fuel control unit was separated from the high pressure fuel pump for inspection of the governor drive shaft. The shaft was intact and could be rotated by hand. Please refer to photos No. 21 and 22.

Photo No. 21
Fuel control unit and high pressure pump, right hand view

Photo No. 22
Fuel control unit governor drive shaft.

1.16.2 Left Elevator Examination:

The horizontal tail plane of the aircraft was recovered from the sea. It was noted that the right horizontal stabilizer had suffered some impact damage on the leading edge, however the right elevator assembly remained attached to the stabilizer surface. It was however, noted that the outer section of the left elevator had failed and was unaccounted for. The horizontal tail plane was inspected by a metallurgist and the left elevator assembly was removed in order to establish the failure mode of the flight control surface.

Discussion and Conclusion

"The possibility of failure due to in-flight flutter of the elevator was contemplated. However, the results from this investigation point towards impact rather than flutter-induced failure during operation, based on the following observations:

(i) In the majority of cases where flutter resulted in the failure of control surfaces during operation, the entirety of the surface will show comparable damages. In this case the right-hand section of the elevator failed to reveal the same.

(ii) The top and bottom elevator movement stops revealed no clear evidence of excessive impact wear or damages.

(iii) The elevator counter weight proved to be in relative good condition with no clear indications of exposed train typical to flutter inputs.

(iv) The connecting bracket fracture surface points towards failure on impact and not during operation, which may have resulted in loss of elevator control and/or flutter thereof.

The full investigation report on the failure mode of the left elevator could be found attached to this report as Annexure C.

1.16.4 Analogue Flight Instruments Examination:

The aircraft was equipped with an electronic flight instrument system (EFIS) on the left instrument pedestal and analogue flight instruments on the right pedestal. It also had installed an analogue standby artificial horizon (AH) on the left pedestal. Three analogue instruments were recovered from the sea and were submitted for further examination. The instruments were as follows:

(i) Attitude Indicator, Part No. 504-01110-930, Serial No. 504 011193025230
(ii) Directional Indicator, Part No. 066-3060-01, Serial No. 12080,
(iii) Directional Indicator, Part No. 066-3046-07, Serial No. 96910.

"The investigation results from the Attitude Indicator (Artificial Horizon) point toward a right wing down, approaching inverted aircraft attitude on impact. The pitch attitude could not be determined conclusively from the Attitude Indicator but was assumed to be nose down at an undetermined angle.

Although the visual investigation revealed extensive impact and corrosion damage to both Directional Indicators, the extent of damages proved to be sufficient to arrest the inner gyroscopic parts for impact analysis purposes. However, both Directional Indicators revealed comparable readings of 115° and 105° SE. This could not be confirmed conclusively as the actual direction of impact".

The full investigation report on these three instruments could be found attached to this report as Annexure D.

1.17 Organisational and Management Information

1.17.1 The flight was conducted under the provisions of Part 91 (Private) of the Civil Aviation Regulations of 1997. The services of a first officer were obtained for this flight, even though the aircraft was certified for single pilot IFR.

1.17.2 The last maintenance that was carried out on the aircraft was certified by a CAA Approved AMO (Aircraft Maintenance Organisation). The facility was in possession of a valid AMO Approval certificate that was issued on 1 April 2010 by the regulating authority and it remained valid until 31 March 2011.

1.18 Additional Information:

1.18.1 The Radar Trajectory of a Cessna Citation over the Plettenberg Bay area.

As part of the investigation, the Accident and Incident Investigation Division (AIID) obtained the radar trajectory that was flown by the crew of a Cessna Citation (ZS-

PAJ). This aircraft had departed from Lanseria aerodrome (FALA) on a flight to FAPG. The aircraft landed at FAPG at approximately 1210Z approximately 2½ hours before the accident aircraft (ZS-GAA) was expected to land at FAPG. On the Google Earth map on the next page it can be seen that the aircraft (ZS-PAJ) approached FAPG from the northeast, flew over the NDB beacon "Pappa Yanky (PY)" at the aerodrome and then turned out left, outbound over the sea and after some distance turned left inbound to intercept the beacon. On final approach the crew performed a missed approach as they encountered low cloud and rain, which reduced their forward visibility considerably and it was decided by the PIC to climb out and enter the pattern for a second landing attempt. On the second leg they extended their outbound leg over the sea and turned left to intercept the beacon followed by an uneventful landing on Runway 30.

Radar observations ZS-PAJ inbound to FAPG from FALA on 8 February 2011.

ZS-PAJ was inbound to FAPG from the north at FL430.

Descent was commenced at 1142Z and was observed descending through FL110 at 1152Z.

ZS-PAJ leveled off at 6000 ft at time 1155Z and maintained until 5 nm from PY.

ZS-PAJ crossed overhead PY passing 4 900 ft and made a descending left turn onto the outbound leg of the break cloud pattern, slowly descending to 1 800 ft.

At 6,2 nm PY, ZS-PAJ made a left turn and on completion of the turn, commenced descent towards PY.

At 1201Z radar contact was lost with the aircraft. ZS-PAJ was 3,9 nm inbound to PY, passing 1 400 ft.

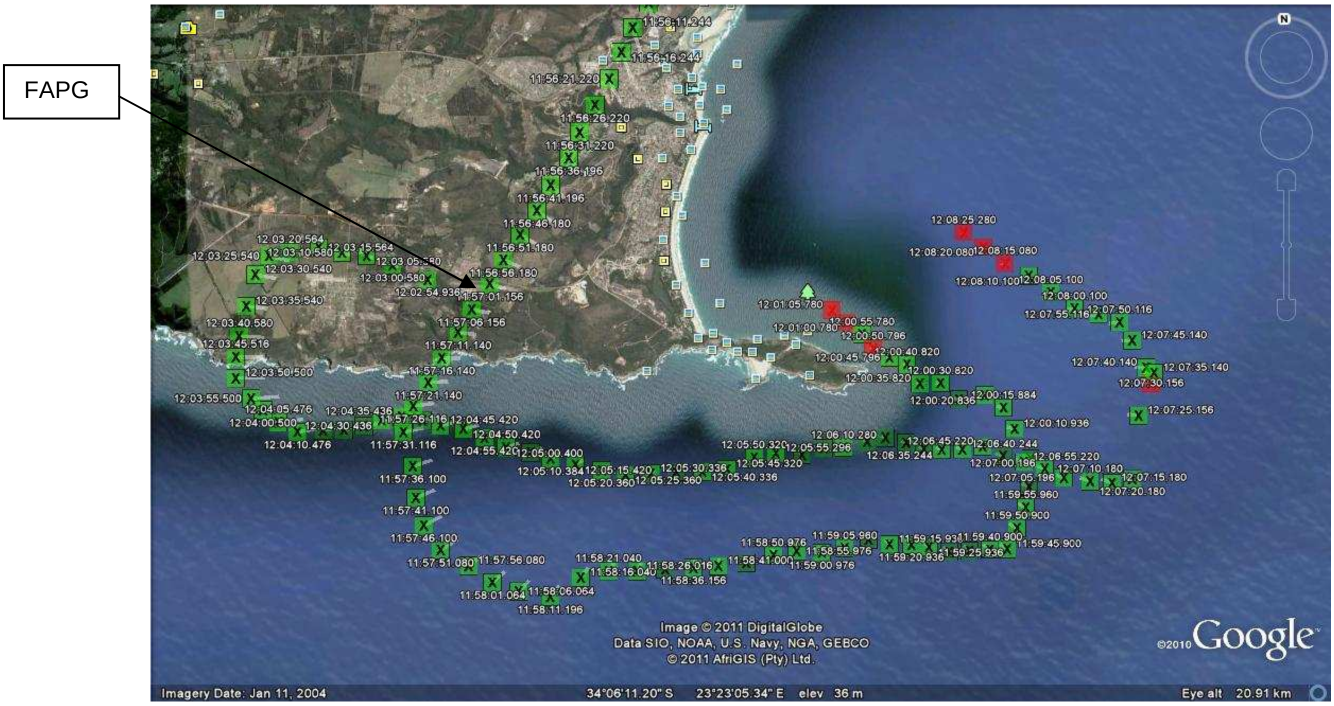
At 1203Z ZS-PAJ reappeared on radar passing 3 500 ft and commenced a left turn back into the pattern climbing to 4 000 ft.

ZS-PAJ then descended to 1 800 ft on the outbound leg and turned inbound again at 7,5 nm PY.

Once inbound, ZS-PAJ commenced descent again and radar contact was lost at 1208Z, 5,5 nm PY passing 1 400 ft.

At 1240Z ZS-PAJ was observed airborne from FAPG in an easterly direction.

On both the inbound legs (approach phase) radar contact with the aircraft was lost, which could be attributed to the aircraft being on the descent (relatively low) as well as terrain (mountainous area) interference.



The radar pattern reflects the trajectory that was flown by the aircraft ZS-PAJ that landed at FAPG at ±1210Z.

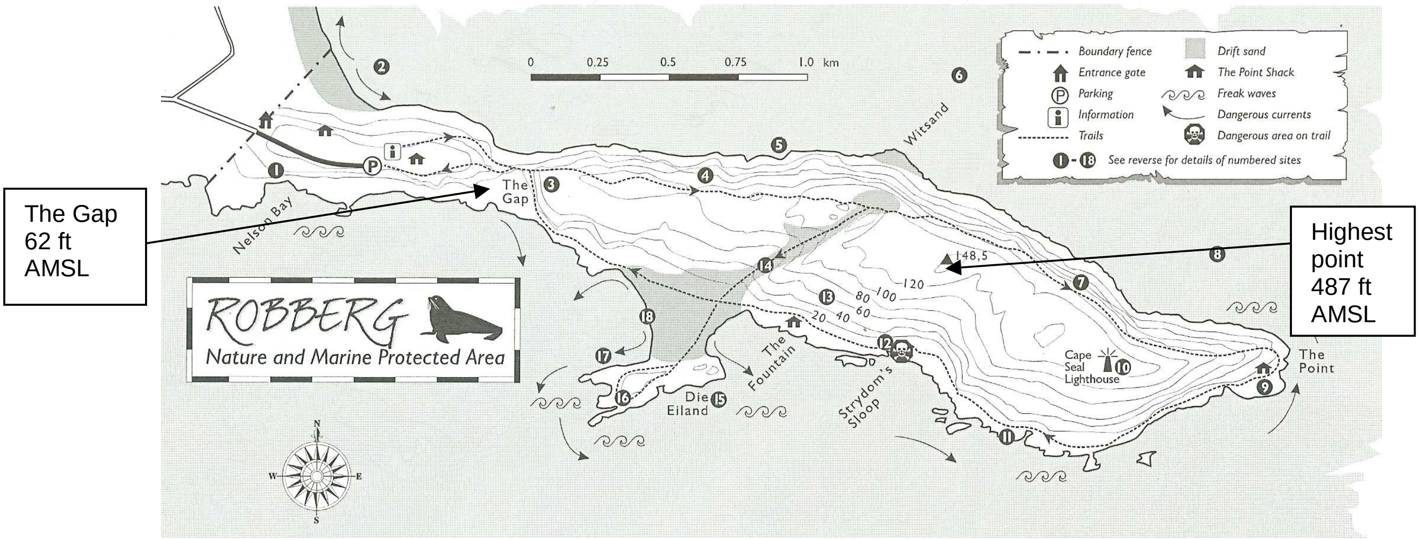
1.18.2 The Radar Trajectory of ZS-GAA over the Plettenberg Bay area.

The radar trajectory/track that was flown by the crew of the accident aircraft was obtained and assessed. From the data it was possible to determine the track that was flown by the aircraft ZS-GAA after it departed from Queenstown until it disappeared from radar coverage over the sea near the Robberg Nature Reserve.

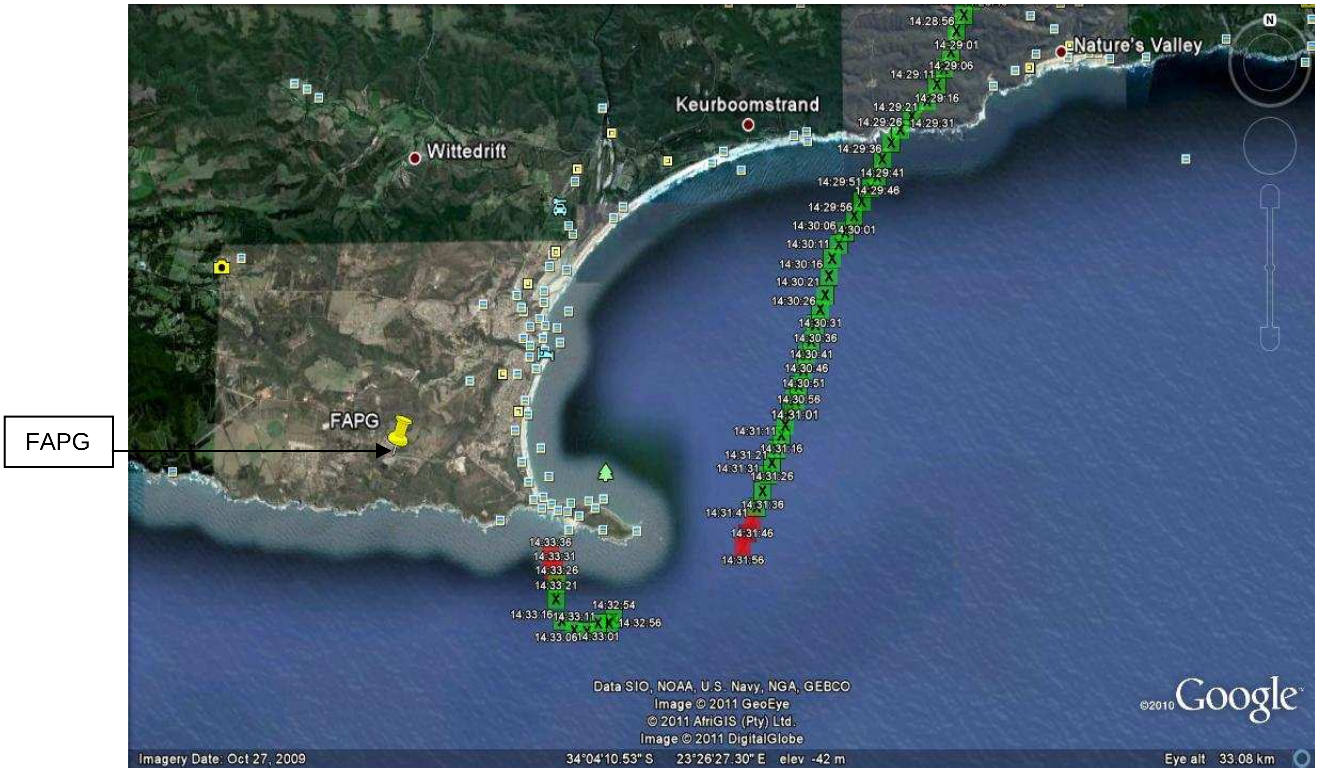
On the Google Earth map below it can be seen that the aircraft had approached the Plettenberg Bay area from the north-east. The aircraft continued with the descent while flying in a south-westerly direction and went over the sea between Keurboomstrand and Nature's Valley. The radar track indicates the first leg of the descent over the sea to be a distance of approximately 7.3 nm. Radar coverage with the aircraft was then lost for a distance of approximately 2.2 nm. For the last 4 nm prior to the aircraft's disappearance from radar, another 10 radar positions were recorded of which two were '*red dots'*, which indicate that the radar had lost the target but made an official prediction of where it would have been next, which is referred to as *coasting.*

The last height reflected on the straight line approach's last 'green dot' was 1150 feet. Thereafter radar coverage with the aircraft was lost for a period of approximately 1 minute and was then re-established for a period of 1 minute before the aircraft disappeared from radar permanently.

The loss of radar coverage around the Robberg point could be attributed to high ground/mountainous terrain, with the highest point on the Robberg Nature Reserve indicated as 487 feet (148.5 m) above mean sea level (AMSL). The height of the terrain in the area of "The Gap", which was the lowest point in the reserve (apart from the sandy beach area point 18 on the map below) is 62 feet (19 m) AMSL, according to information obtained from Cape Nature. Both locations are pointed out on the map of the Robberg Nature Reserve below.

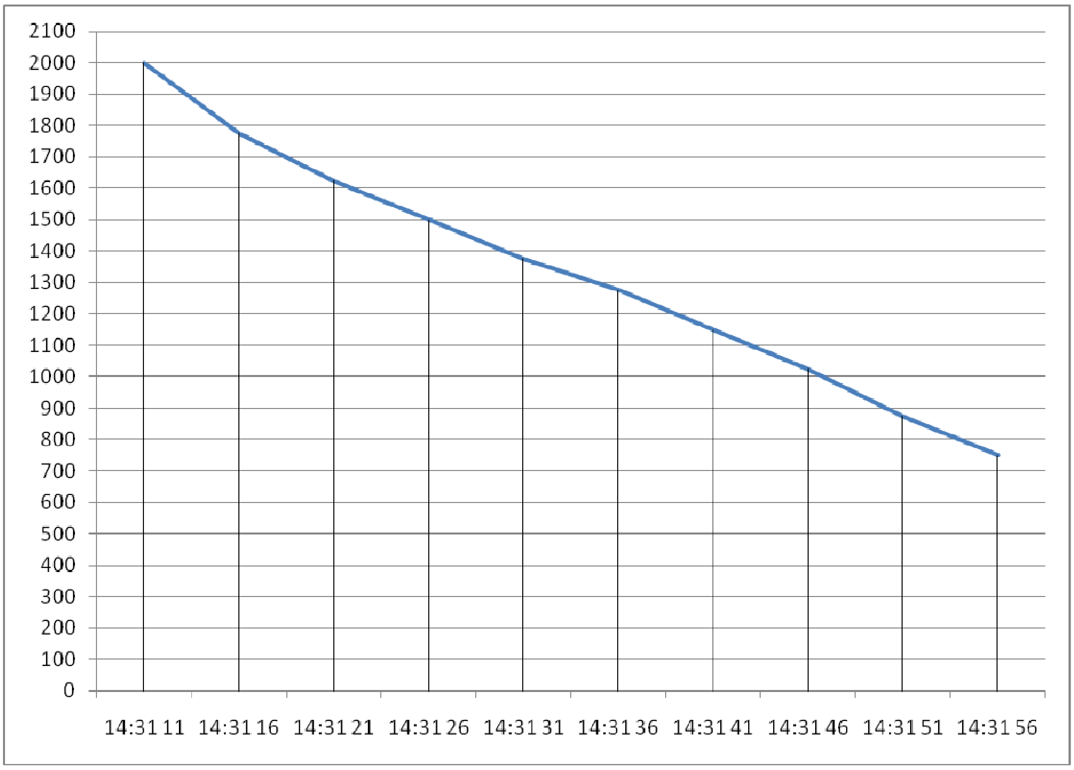


A map layout of the Robberg Nature Reserve with the "Highest Point" and "The Gap" indicated.



The radar pattern reflects the trajectory that was flown by the aircraft ZS-GAA before disappearing off radar.

The graph below was compiled utilizing the last ten radar points while the aircraft was descending over the sea in a south-westerly direction prior to it commencing with the right turn around the Robberg Nature Reserve. From the graph it was possible to ascertain that the aircraft was indeed in a constant rate of descent.



The graph depicts the height (y-axis) of the aircraft in relation to the time (x-axis) of the last ten radar points.

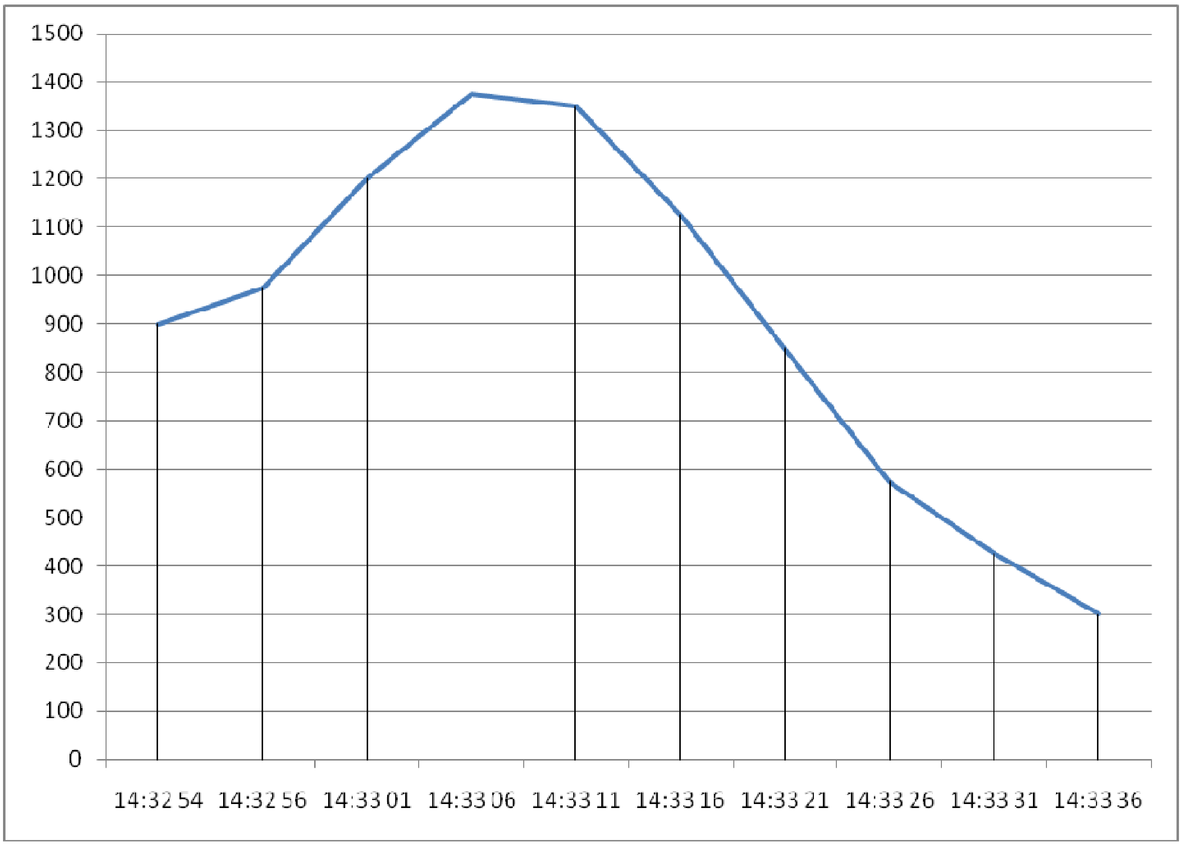
The table on the next page reflects the last ten positions that were captured prior to the aircraft disappearing from radar permanently. These positions were plotted on Google Earth and are indicated by eight green square blocks, each with a time stamp and two red squares.

*NOTE:

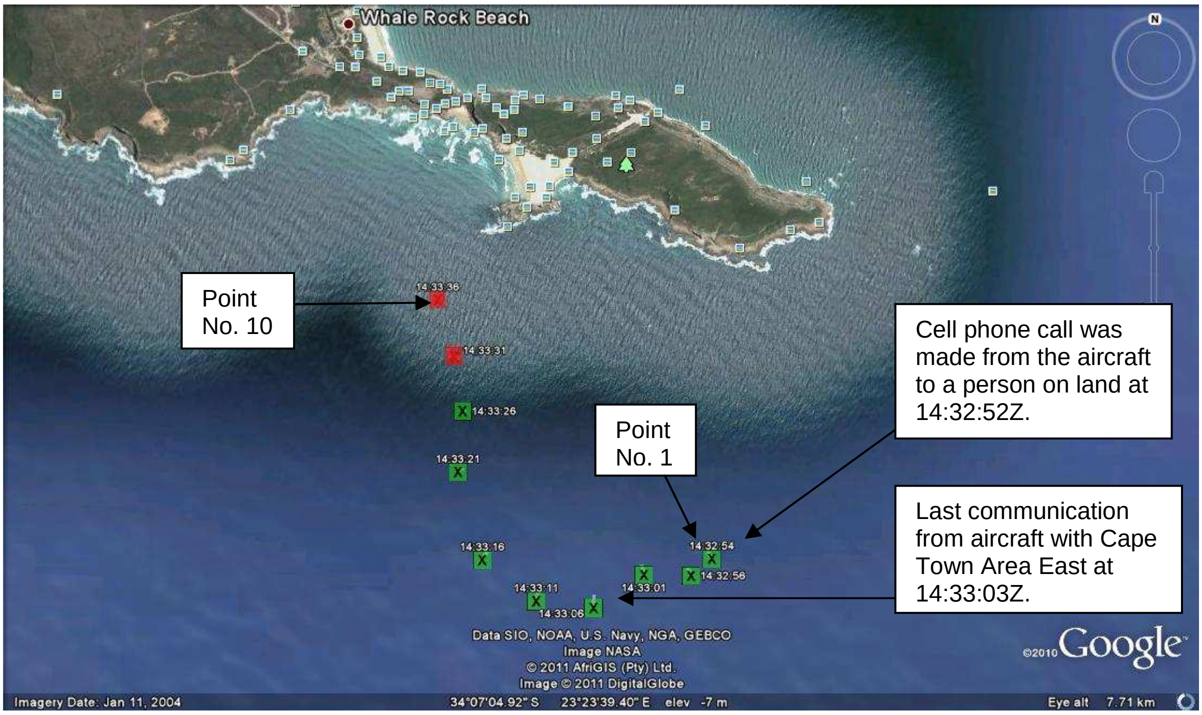
The speed displayed on the radar that was entered into the table is referred to as "*Calculated Track Velocity Speed"*.

It is of interest to note that the aircraft was on the descend and during the right turn it pitched up from a height of 900 feet AMSL (position 1 of 10) to a height of 1 375 feet within a period of 12 seconds. This accounts to a rate of climb (ROC) of 39.6 feet per second or 2 375 feet/min. During these few seconds the speed decayed from 168 to 151 knots. The pitch-up event was followed by an immediate pitch-down event with an associated rate of descent (ROD) of approximately 2 400 feet/min. Between points 6 and 8 the ROD increased to 3 300 feet/min (this data was obtained by only utilizing data from the green track radar points). The aircraft continued to descend until it disappeared from radar. At no stage was the aircraft flown at or near the stall speed which may have varied between 84 to 90 knots.

No.	GPS Position	Time (HH:mm:ss)	Speed (kts)	Height (ft) (amsl)
1	South 34°07'51.23" East 023°24'12.22"	14:32:54	168	900
2	South 34°07'.55.55" East 023°24'06.09"	14:32:56	168	975
3	South 34°07'55.48" East 023°23'51.55"	14:33:01	156	1 200
4	South 34°08'04.01" East 023°23'36.43"	14:33:06	151	1 375
5	South 34°08'02.79" East 023°23'18.84"	14:33:11	155	1 350
6	South 34°07'53.12" East 023°23'02.84"	14:33:16	157	1 125
7	South 34°07'31.71" East 023°22'55.80"	14:33:21	163	850
8	South 34°07'17.37" East 023°22'57.51"	14:33:26	163	575
9	South 34°07'04.36" East 023°22'55.21"	14:33:31	160	425
10	South 34°06'51.37" East 023°22'50.12"	14:33:36	160	300



The graph depicts the height (y-axis) of the aircraft in relation to the time (x-axis) of the last ten radar points.



The radar pattern reflects the aircraft trajectory of the aircraft (ZS-GAA) indicating the last 10 points/positions.

1.18.3 Civil Aviation Regulations (CAR's)

Emergency Locator Transmitter (ELT)
Part 91.04.26

"(1) "No owner or operator of –

(a) an aircraft to be operated on extended flights over water or over areas where search and rescue would be especially difficult;

(b) an aeroplane with a maximum certificated mass exceeding 5 700 kg;

(c) a helicopter with an approved passenger seating configuration of more than 19 seats; or

(d) any South African registered aircraft engaged in an international commercial air transport operation;

shall operate such aircraft unless it is equipped with one or more approved emergency locator transmitters (ELTs)".

(4) The Commissioner shall maintain a register of all aircraft equipped with 406 MHz ELTs, which shall contain the following particulars:

(a) The nationality and registration marks of the aircraft;

(b) Particulars of the manufacturer's designation and serial number of the aircraft;
(c) The full name and contact details of the registered owner of the aircraft;
(d) The make and model number/s of the ELT/s;
(e) The 15-digit Unique Identification Number (UIN) provided by the manufacturer of the ELT, or the aircraft's Mode S transponder code; and
(f) The name/s and contact details of the person/s who know/s the aircraft's itinerary and who may be contacted 24 hours a day.

(5) On the payment of the appropriate fee as prescribed in Part 187, an excerpt of the ELT register shall be furnished by the Commissioner to any person who requests such an excerpt".

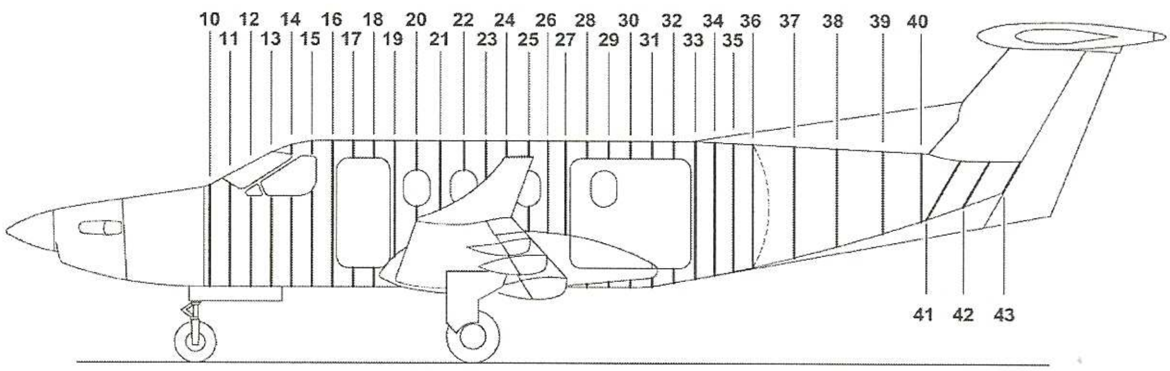
It was found that the aircraft was equipped with a Serpe-IESM Kannad 406 MHz ELT, however, the unit was not registered on the database as called for in subpart 4 of Part 91.04.26 of the CAR's. Nor did any station report any emergency signal being picked up at the time of the accident or subsequent to the accident that could have been associated with the aircraft ZS-GAA. Due to the high energy impact associated with the accident the connection between the ELT itself and the antenna broke during the impact sequence, which resulted that the ELT signal could not be sent anymore.

1.18.4 Underwater survey and salvage

During the initial salvage period after the accident occurred a substantial part of the wreckage was recovered from the sea with the assistance of the South African Navy and South African Police Services (SAPS) dive unit (Western Cape region). The search for the wreckage and subsequent salvage continued over a period of ten (10) days, with eighteen (18) divers participating. The average dive dept according to the SAPS dive master varied between 28 to 36 metres. The aircraft was found to have broken up on impact in a substantial number of pieces varying in size. All the light weight material that was recovered was taken to shore by rubber ducks and the larger pieces were floated and lifted by crane from the sea onto the SA Navy vessel the SAS Protea. These pieces were offloaded at the port of Port Elizabeth on 15 February 2011. During the operation the underwater debris field was subjected to a scan by the SA Navy making use of side scan sonar.
Following the withdrawal of the SA Navy and SAPS from the underwater salvage operation the authority had to source a private service provider who was able to conduct an underwater survey and salvage of the parts of the aircraft that was not

recovered. The following components/parts were of interest to the investigation process:

1. The right wing;
2. Both the left and right ailerons;
3. Both the left and right cockpit seats;
4. The instrument panel (only minor parts of the panel were located);
5. The throttle quadrant;
6. The undercarriage (Nose and both main landing gear assemblies);
7. Central Advisory and Warning System (CAWS);
8. The Altitude Heading and Reference System (AHRS);
9. Fuselage parts from station 10 to 27 (cockpit area to the area in line with the cargo door, as illustrated on the airframe layout below).



Following the appointment of a private service provider an underwater survey of the area was conducted over the period 25 and 26 February 2012. The survey had identified eleven (11) possible targets. The next step was to dive to these targets in order to determine the origin of the targets, was it indeed targets/parts related to the aircraft or was it from another origin. If it was identified as parts related to the aircraft the parts needed to be salvaged for examination.

On 29 November 2012 a team of divers from the SA Navy conducted several dives in the area. The eleven targets identified during the underwater survey as well as co-ordinates that were identified by the SA Navy during the initial scan and recovery period, immediately after the accident occurred was dived on. The diver's reports indicated nothing other than flat, sandy surfaces with some marine biological life on the seabed.

1.19 Useful or Effective Investigation Techniques:

1.19.1 None.

2. ANALYSIS

2.1 Flight crew

2.1.1 The pilot-in-command (PIC)

The PIC was the holder of a valid commercial pilot's licence with the aircraft type endorsed in her licence. She was also in possession of a valid instrument rating and instructors rating – grade 2.

2.1.2 Training

On 7 March 2008 the pilot applied to the regulating authority to have the Pilatus PC12 type aircraft endorsed on her license. According to the application form she had accumulated 14,5 hours of dual flying training during the two months preceding submission of the application for flight crew licence conversion form. She was well familiar with the aircraft (ZS-GAA) as she had flown it for the past three years on a regular basis. She had accumulated approximately 582,2 hours on the aircraft type.

2.1.3 Language knowledge

The PIC was proficient in the English language as it was also her mother tongue. She complied with the language proficiency requirements and a language certificate was issued to her on 3 April 2007, which indicated that she never had to repeat the exam again. Her pilot licence reflects her proficiency as level 6.

2.1.4 Medical aspects

According to available documentation, the PIC, who was 32 years-old was in good health at the time of the flight as far as it could be determined. Neither her medical history nor the risk profile make it possible to assume an increased risk of an acute adverse disturbance of flying capability (sudden incapacitation) occurring. From the recorded air traffic control communications, there was no positive clue to such a disturbance.

2.1.5 First officer (F/O)

The F/O was the holder of a valid commercial pilot's licence with the aircraft type endorsed in her licence. She was also in possession of a valid instrument rating and instructors rating – grade 3.

2.1.6 Training

The regulating authority had endorsed the Pilatus PC-12 on the pilot's licence after submission of the required documentation on 29 July 2009. Unlike with the PIC where all the relevant documentation was available to the investigating team on the CAA pilot file the team had to engage with the aviation training organisation (ATO) under which license the conversion was conducted. However, the ATO was unable to provide the team with any documented evidence pertaining to the type conversion. According to available records her last skills test for the revalidation of her instrument rating was conducted at 14 August 2010. This test was conducted on a Cessna 172. On 9 December 2010 she conducted a skills test to revalidate her flight instructors rating, which was submitted to the regulating authority on 13 December 2010.

2.1.7 Language knowledge

The F/O was proficient in the English language as it was also her mother tongue. The relevant documentation which reflects her being proficiency in the English language was submitted to the regulating authority on 21 July 2009. Her pilot licence reflects her proficiency as level 6.

2.1.8 Medical aspects

According to available documentation, the F/O, who was 30 years-old was in good health at the time of the flight as far as it could be determined. Neither her medical history nor the risk profile make it possible to assume an increased risk of an acute adverse disturbance of flying capability (sudden incapacitation) occurring.

2.2. The flight crew environment

2.2.1 Social environment

Both pilots had been living in Gauteng, where the flight originated. It was however the first time they had flown together as a crew. The service of the F/O was obtained on a freelance basis for this specific flight. Both crew members were fit to fly. It was however not possible to determine if anyone's condition had changed during the flight. According to the person that transferred them to the Queenstown aerodrome everybody appeared to be in good spirit.

2.2.2. Times of flying duty

The limitations on flying time were complied with. The accident occurred on the third leg of the flight, with Plettenberg Bay being their intended final destination for the day. The schedule indicates that they would have continued from there the next day.

2.2.3 Language and communication

Communication was regulated and published; English was the prescribed language for communication within the framework of checklists and procedures. Both pilots complied with this regulation throughout the entire progress of the flight. With English being the mother tongue of both crew members no verbal difficulties where foreseen.

2.2.4 External influences

The reason as to why the crew have deviated from standard operating procedures by not flying the published cloudbreak procedure for runway 30 at FAPG and opted to approach the aerodrome from the sea side (south-easterly direction) could not be determined. The decision by the crew to have flown this approach raised certain questions. (1) Was this type of approach flown before, under similar type of conditions where they were able to land the aircraft safely at FAPG? (2) Or was it purely a decision to approach over the sea and let's *'look and see'* if we are going to be able to see the aerodrome/runway and proceed with the approach and subsequent landing.

It is a well known fact that a certain percentage of aviators in certain parts of the country/world, where weather conditions change fairly quickly or is prone for IMC conditions, create their own 'letdown' procedures, based on the assistance of automation onboard the aircraft, especially GPS devices, which has became substantially more advance within a short period of time. You will find most aircraft are equipped with one or more of these devices in order for the pilot to ensure he/she has a backup should one device fail. There is however, always a risk associated with this type of flying. It is believed that Plettenberg Bay aerodrome was no exception to such an unapproved procedure.

With reference to the cell phone call from one of the passengers onboard to a person in Plettenberg Bay indicating that they would be diverting to George aerodrome (FAGG) it was clear that a decision was made onboard the aircraft that they would be diverting to an alternate aerodrome. However, it could not be determined who made the decision, but it was believed to be the pilot-in-command.

It was noted that after the cell phone call was made the aircraft started to climb as one would expect following the decision to divert to FAGG, however the radar data indicate that the aircraft continue to turn to the right, which was in conflict to their intended diversion aerodrome, which was located to the west of their current position. From the radar data the aircraft was observed to climb from a height of approximately 900 feet above mean sea level (AMSL) to approximately 1 375 ft (AMSL) in a period of 12 seconds. It is believed that the aircraft was being flown manually at that stage of the flight. According to available information the aircraft was flying in IMC conditions associated with dense fog at the time. Once it reached a height of approximately 1 375 ft above sea level an in flight upset occurred which resulted in a loss of control. The crew was unable to recover the aircraft before it crashed into the sea. It should be noted that at no time during the last phase of the flight was the aircraft flown at or near the stall speed. The possibility that the pilot-flying (PF) at the time lost situational awareness was considered by the investigation team to have had a significant bearing to the accident (Attached to the report as Annexure E additional information on spatial disorientation was considered as essential). A loss of bank angle awareness in this case should have been promptly observed by the monitoring pilot (PNF) and corrected by the pilot-flying. Timely intervention was of the essence by the PF to have ensured a successful recovery was possible.

Critical aspects to the accident, which unfortunately could not be determined, were; (i) who was actually flying the aircraft at the time of the accident, and (ii) malicious interference (persons onboard interfere with aircraft controls resulting in loss of control), and (iii) were both crew members actually in the cockpit at the time.

2.3 Aircraft

2.3.1 Airworthiness

The aircraft, ZS-GAA was handed to the crew in an airworthy condition for the scheduled flight, which comprised of three flight sectors for the day. The accident occurred on the last leg of the day. According to available documentation, which include the aircraft flight folio that was recovered from the sea there was no entry made in the flight folio that indicate any changes occurred in the airworthiness status of the aircraft from the time the flight commenced earlier that morning at FALA until the time the accident occurred. Further to that no evidence could be obtained that the crew had broadcast a distress call received by any station or another aircraft at the time indicating a malfunction had occurred, which resulted in a loss of control.

2.3.2 Engine

The evidence obtained from the engine teardown inspection revealed that the engine was operating within the medium to high power range during impact with the sea, which eliminates any engine related problem as a contributory or actual causal factor to the accident.

2.3.3 Wreckage recovery from the sea

Due to the fact that a substantial part of the wreckage was not recovered from the sea it was not possible for the investigating team to come to any conclusion on what the structural integrity of the aircraft was at the time of impact. The investigating team was therefore unable to determine with certainty if the accident could have been induced/caused by a structural failure resulting in a loss of control. Although all four points of the aircraft was accounted for, the absence of essential flight controls (i.e., both ailerons) were unaccounted for as well as the right wing, however the tip section of the right wing was found as well as a substantial section of the left wing. The absence of these parts not being recovered from the sea had a direct effect on the investigation process. Should a service provider had been able to have proceeded with the recovery process of the wreckage that remained in the sea when the SAPS and SA Navy withdrew from the scene it is believed that a more accurate assessment could have been made with reference to the structural integrity of the aircraft following impact with the sea.

2.3.4 Cell phone call

It was a known fact that a cell phone call was made from the aircraft shortly before it crashed into the sea by one of the passengers to a person in the town of Plettenberg Bay. It was reasonable to assume that the transmitting cell phone would not have had any adverse effects on the aircraft systems, which are important for the control of the aircraft.

2.4 Environmental factors

Prevailing weather conditions at the time and place of the accident was associated with IMC conditions (light rain, fog and low clouds at approximately 200 feet AGL). The possibility of the aircraft encountering a lightning strike, or multiple lightning strikes, hail or severe turbulence due to thunderstorm activity was eliminated, so was the probability of icing (i.e., airframe/pitot static, propeller/engine intake). The aircraft was IF certified and both crew members were IF rated. The weather related conditions at the time was well within the capabilities of the aircraft. It was evident from the cell phone call that the crew had made a decision to divert to George aerodrome (FAGG) but failed to arrive at FAGG.

3. CONCLUSION

3.1 Findings:

The Crew

3.1.1 The pilot-in-command (PIC) was the holder of a valid commercial pilot licence and had the aircraft type endorsed in her logbook. She was also the holder of a valid IF rating as well as a grade II flight instructors rating.

3.1.2 The PIC was in possession of a valid aviation medical certificate that was issued by an approved CAA medical examiner.

3.1.3 The first officer (FO) was the holder of a valid commercial pilot licence and had the aircraft type endorsed in her logbook. She was also the holder of a valid IF rating.

3.1.4 The FO was in possession of a valid aviation medical certificate that was issued by an approved CAA medical examiner.

3.1.5 It was not possible to obtain any documented evidence with reference to the FO type conversion training onto the Pilatus PC-12 aircraft from the Aviation Training Organisation (ATO) that was utilized for this purpose. Even though Part 141.02.15(4)(e) of the CAR's stipulated it must be kept in safety for at least five years following such training.

3.1.6 It was not possible to determine who was manipulating the flight controls at the time of the accident.

The Aircraft

3.1.7 The aircraft was maintained in accordance with the approved maintenance schedule and was in possession of a valid Certificate of Airworthiness.

3.1.8 The Maintenance Release for the aircraft was valid.

3.1.9 The aircraft was equipped with an ADF. (The only ground navigational aid available at FAPG at the time was an NDB).

3.1.10 The engine teardown inspection indicate that the engine was producing power likely to be in the middle to high power range on impact.

3.1.11 The propeller deformation could be associated with a power on, on impact.

3.1.12 The aircraft was equipped with a Kannad 406 MHz ELT, however, no emergency signal was picked up by any station following the accident sequence. The ELT was also found not to be registered on the official data base.

3.1.13 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required to be in accordance with the regulations.

3.1.14.Two of the units that contained non volatile memory (NVM) were recovered from the sea. No data could be retrieved from the Engine Indication System (EIS) memory card due to the fact that the unit was not waterproof. The report on the EGPWS indicates that the unit was inoperative at the time of the accident due to the failure of the ‘terrain database’.

3.1.15 The structural integrity of the aircraft at the time of impact could not be ascertained as a substantial percentage of the wreckage was never recovered from the sea.

3.1.16 The aircraft was certified for single-pilot IFR operations, however the flight was conducted by a multi crew (two pilots).

Aerodrome

3.1.17 The aerodrome was in possession of a valid aerodrome licence that was issued by the regulating authority at the time of the accident.

3.1.18 According to the flight crew of a Cessna Citation that landed at FAPG at approximately 1210Z on 8 February 2011, the NDB (navigational aid - ground station) at the aerodrome was fully functional at the time as they had flown the approach twice prior to landing at FAPG.

Weather Conditions

3.1.19 The prevailing weather conditions at Plettenberg Bay between 1400-1500Z on the day of the accident reflect low stratiform clouds with light drizzle and thick fog.

3.1.20 According to an official rain chart that was obtained from the SAWS for the day of the accident it was raining at the Plettenberg Bay aerodrome at the time when the accident aircraft was scheduled to land there (±1430Z).

3.1.21 According to a lightning verification report that was obtained from the SAWS, no lightning strikes was detected within a 20 km radius from the Plettenberg Bay aerodrome on 8 February 2011.

Additional Information

3.1.22 At 14:32.52Z a person onboard the aircraft made a cell phone call to a person on land (in Plettenberg Bay) whereby she indicated that they will be diverting to George aerodrome and if they can make transport arrangements accordingly. The call lasted 38 seconds according to available information.

3.2 Probable cause:

3.2.1 The aircraft crashed into the sea following a possible in flight upset associated with a loss of control during IMC conditions.

3.3. Contributory factors:

3.3.1 Deviation from standard operating procedures by the crew not flying the published cloud-break procedure for runway 30 at FAPG, but instead opted to attempt to remain visual with the ground/sea (comply with VMC requirements) by descending over the sea and approaching the aerodrome from the southeast (Robberg Nature Reserve side).

3.3.2 Inclement weather conditions prevailed in the area, which was below the minima to comply with the approved cloud-break procedure for runway 30 at FAPG (minimum safety altitude of 844 feet according to cloud-break procedure) as published at the time of the accident.

3.3.3 Judgement and decision making lacking by the crew. (The crew continued from the seaward side with the approach during IMC conditions and not diverting to an alternative aerodrome with proper approach facilities timeously although a cell phone call in this regard indicate such an intention).

3.3.4 The possibility that the pilot-flying at the time became spatially disorientated during the right turn while encountering / entering IMC conditions in an attempt to divert to FAGG should be regarded as a significant contributory factor to this accident.

3.3.5 This was the first time as far as it could be determined that the two crew members flew together.

4. SAFETY RECOMMENDATIONS

4.1 It is recommended to the Director of Civil Aviation that the Civil Aviation Regulations (CAR) with reference to Part 91.04.26, Emergency Locator Transmitters (ELTs) be revised.

The current regulation as contained in Part 91.04.26(1) of the CAR's was found to be lacking content. It is recommended that the regulation be revised to include the following:

All aeroplanes and helicopters that are being operated under the provisions of either Part 121, 127 and 135 (commercial use) shall be equipped with at least one serviceable ELT unit at all times, irrespective of the number of seats fitted to such an aeroplane or helicopter.

This investigation further highlighted the fact that aircraft carrying a substantial number of passengers, flying under the provisions of Part 91 (Private / Industrial Aid) and from time to time engage in flights that extend for some distances over the sea. It is recommended that aircraft utilized in these types of flights be equipped with at least one serviceable ELT unit at all times.

The CAA should enhance safety oversight in order to ensure ELT compliance is met.

4.2 During the investigation process it became evident that Part 61 of the CAR's contained contradictory information with reference to who should conduct a practical/skills flight test for a pilot who converts onto a high performance aircraft (HPA) / turbine engine driven aircraft.

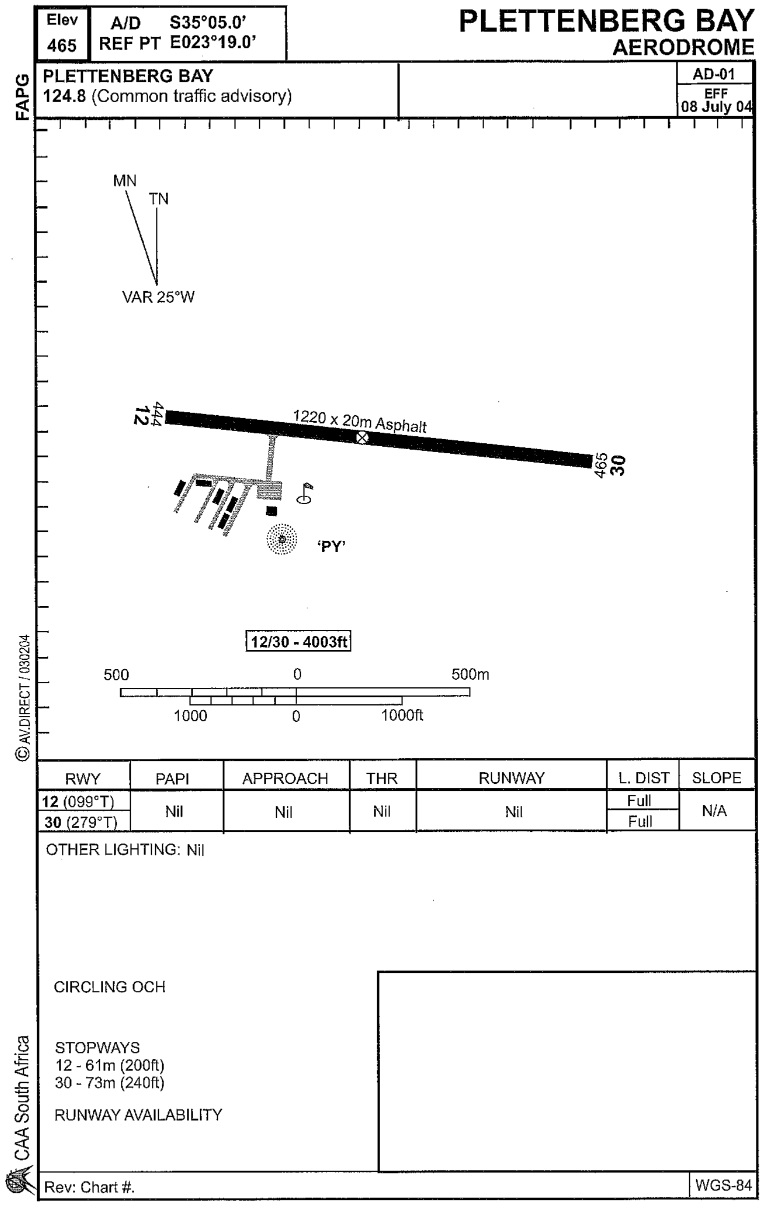
It is recommended to the Director of Civil Aviation that a task team be appointed to review Part 61 of the CAR's.

4.3 It is recommended to the Director of Civil Aviation that the ATO that was utilized for the type conversion training of the FO be subjected to a comprehensive special audit by the regulating authority responsible for the Part 141. The fact that the ATO was not in a position to provide the Investigating team with any training records when they were required to keep all documentation for a minimum period of five years raised a serious concern and resulted in a shortcoming by which the training of the FO could not be properly evaluated/assessed.

4.4 It is recommended that the Plettenberg Bay aerodrome layout chart, which is available on the SACAA website as well as being published in the Aeronautical Information Publication (AIP) be corrected by the Authority as it contains the following error:

The GPS position for the aerodrome location in the top left-hand text box, which indicates the aerodrome's position as S 35.05.0" is in error and should read S 34.05.0'.

See below the active aerodrome layout chart which was active at the time of the accident.



4.5 It is recommended to the Director of Civil Aviation that the authority appoint an external service provider (apart from the SA Navy and SAPS), which the Accident and Incident Investigation Division (AIID) can utilized without delay when an aircraft has crashed into the sea/dam/lake/river. Such a service provider should be able to conduct an underwater survey and recovery of the wreckage without delay.

The urgency of this recommendation cannot be over emphasized as the absence of such a service provider had a direct effect on the outcome of this investigation, due to the fact that the remainder of the wreckage was never recovered.

4.6 It is recommended to the Director of Civil Aviation to make flight recorder equipment mandatory for High Performance Aircraft, designed for carrying persons and/or cargo for the purpose of accident investigation.

5. APPENDICES

5.1 Annexure A (Transcript of communication between ATC and the aircraft ZS-GAA)
5.2 Annexure B (EGPWS Flight History Report - Honeywell)
5.3 Annexure C (Examination Report - Left elevator failure mode)
5.4 Annexure D (Examination Report – Analogue Instruments)
5.5 Annexure E (Spatial Disorientation)

Compiled by:

....
J.P. Grobbelaar Date: 8 January 2013
For: Director of Civil Aviation

Investigator in charge: .... Date:

Co-investigator: .... Date:

Co-investigator: .... Date:

Co-investigator: .... Date:

ANNEXURE A

Air Traffic Services Audio Transcript between the aircraft ZS-GAA and Cape Town Area East (124.7 MHz) on 8 February 2011

- Transcript contains only communication between ATC, ZS-GAA and other aircraft.
- Times in HH:MM:ss UTC;
- Source may be either of the following: RTF, Intercom, ATS DS, composite;
- Station refers to any aircraft, ATC position or vehicle making the transmission;
- Text of transmission is the contents of the transmission for that specific time;
- For easy reading letters in the phonetic alphabet should be transcribed as uppercase italic letters only, even though the full word is used on the radio transmission (RT);

Time	Station	Text of transmission
13:34:06	**CAW104**	Cape Town, Comair 104 request both left and right for the next one hundred miles.
13:34:10	**ATC1**	Comair104, left and right approved, once clear, direct APRAX.
13:34:14	**CAW104**	Left and right approved, once clear APRAX, Comair 104.
13:34:22	**ZS-GAA**	Cape Town Good afternoon, Golf-Alpha-Alpha.
13:34:30	**ATC1**	Golf-Alpha-Alpha, Cape Town, good day, go ahead.
13:34:33	**ZS-GAA**	Afternoon sir, PC12 airborne out of Queenstown at 1329 passing flight level one-zero-zero and we've got flight level one-eight-zero on request, Golf-Alpha-Alpha. **(Airborne)**
13:34:43	**SAA346**	Cape Town Springbok three-four-six, good afternoon.
13:34:50	**ATC1**	Springbok three-four-six, Cape Town, good day climb to flight level four-one-zero.
13:34:54	**SAA346**	Climb level four-one-zero Springbok three-four-six.
13:34:59	**ATC1**	Golf-Alpha-Alpha squawk one-five-zero-two, report your airborne time and level on request.
13:35:06	**ZS-GAA**	Squawk one-five-zero-two and our airborne time at one-three-two-nine and flight level one-eight-zero on request please, Golf-Alpha-Alpha.
13:35:14	**ATC1**	Golf-Alpha-Alpha no reported traffic for the climb flight level one-eight-zero routing Papa-Yankee.
13:35:22	**ZS-GAA**	Thanks no reported climb for the traffic, sorry, no reported traffic for the climb flight level one-eight-zero routing Papa-Yankee, Golf-Alpha-Alpha.
13:40:50	**CAW901**	Cape Town good afternoon Comair nine-zero-one, level three-two-zero.
13:40:55	**ATC1**	Comair nine-zero-one Cape Town, good day, cleared Golf-Romeo-Victor flight level three-two-zero, runway one-one.

Time	Station	Text of transmission
13:41:00	**CAW901**	Runway one-one, Golf-Romeo-Victor, level three-two-zero and if you wouldn't mind, the surface data please.
13:41:08	**ATC1**	Give it to you shortly.
13:41:10	**CAW901**	Thank you.
13:41:12	**ZS-GAA**	Cape Town, Golf-Alpha-Alpha can we request right of track for weather?
13:41:16	**ATC1**	Golf-Alpha-Alpha right of track is approved, once clear route direct to Papa-Yankee, report setting course.
13:41:20	**ZS-GAA**	Thanks, right of track approved once clear report routing Papa Yankee, Golf-Alpha-Alpha.
14:18:14	**ZS-GAA**	Golf-Alpha-Alpha, ready for descent. **(Request for descent)**
14:18:17	**ATC2**	Golf-Alpha-Alpha, no reported traffic for the descent into Plettenberg Bay and standby, I'll give you the update of the QNH and surface wind shortly.
14:18:27	**ZS-GAA**	Thank you, no reported traffic for the descent into Plett and standing by, Golf-Alpha-Alpha**.**
14:18:33	**ATC2**	Expressway zero-one-seven, contact approach one-one-nine-seven, cheers.
14:18:48	**ATC2**	Golf-Alpha-Alpha, the surface wind is light westerly, south westerly the temperature two-zero, dew point one-nine, one-zero-one-six and the only, the closest weather is George which at the moment has a southerly wind less than ten, visibility two-thousand-five-hundred meters in drizzle, and some mist, overcast at three-hundred, temperature also two-zero, dew point one-nine, one-zero-one-five. **(Weather Information)**
14:19:14	**ZS-GAA**	Thank very much Golf-Alpha-Alpha.
14:25:42		(Carrier wave)
14:25:46	**ATC2**	That was a double transmission, other traffic calling Cape Town.
14:26:02	**RNX111**	Cape town, Next-time one-one-one, level three-four-zero.
14:26:06	**ATC2**	That transmission, confirm it is Golf-Alpha-Alpha calling?

Time	Station	Text of transmission
14:26:12	**RNX111**	Next-time one-one-one.
14:26:17	**ATC2**	Golf-Alpha-Alpha, I'm not reading you. I have no reported traffic in the Plettenberg Bay area, your squawk for the next leg, to broadcast one-two-four decimal eight and confirm you are getting airborne again in just a short while from Plett?
14:26:31	**ZS-GAA**	Negative sir. Golf-Alpha-Alpha, we're going to spend the night in Plett and going to George tomorrow morning.
14:26:38	**RNX111**	Cape Town, Next-time one-one-one?
14:26:39	**ATC2**	Okay, double transmission, Next-time one-one-one standby break, break Golf-Alpha-Alpha copy, you only going to George tomorrow morning and broadcast your intentions one-two-four decimal eight. If you don't land at Plett and need to divert to George for any reason, if you'll just remain overhead of Plett and to the east until you make contact with George for an inbound routing and I will be standing by your cancellation of search and rescue.
14:27:03	**ZS-GAA**	Thank you very much. If we can't make it into Plett we'll remain to the east of Plett until we've made contact with George and we'll cancel search and rescue on the ground. Thank you very much Golf-Alpha-Alpha.
14:27:14	**ATC2**	Thank you.
14:33 03	**ZS-GAA**	Cape Town, Golf-Alpha-Alpha. **(Last radio call to ATC)**
14:33:10	**ATC2**	Golf-Alpha-Alpha, Cape Town?
14:33:19	**ATC2**	Golf-Alpha-Alpha, Cape Town?
14:33:46	**ATC2**	Springbok three-five-two, contact Johannesburg central one-two-zero-three, good bye.
14:33:48	**SAA352**	one-two-zero-three, Springbok three-five two, bye, bye.
14:34:06	**ATC2**	Golf-Alpha-Alpha, Cape Town?

ANNEXURE B

Honeywell

Final Report

08 February 2011 Pilatus PC-12 (ZS-GAA) Accident
near Plettenberg Bay, South Africa
Investigation of Enhanced Ground Proximity Warning System Flight History Data

Prepared For: FAA, NTSB and SA CAA
Reviewed By: David Studtmann, Honeywell Product Integrity
Date: May 11th, 2011

Unit Data:

Honeywell KMH 820 Multi-Hazard Awareness System computer Part Number 066-01175-2101, Serial Number KHM820-A2992, containing EGPWS module Part Number 965-0702-001, Serial Number 03585 and Terrain Data Base Version 445-Atlantic.

In accordance with ICAO Annex 13, Honeywell was requested by the South African Civil Aviation Authority via the National Transportation Safety Board Accredited Representative with oversight provided by the US Federal Aviation Association (FAA) to assist in the investigation of the February 2011 Pilatus PC-12 accident near Plettenberg Bay, South Africa. Specifically, Honeywell was asked to retrieve and analyze any flight history data that might have been recorded in the EGPWS portion of the computer that was installed in the subject aircraft.

The KMH 820 computer contains an EGPWS module that is designed to store certain flight history data surrounding EGPWS caution, warning, or fault events. Fault Data is recorded as it is recognized by either the unit self tests or the continuous monitor. If the EGPWS detects a condition that warrants a “Caution” or “Warning” message, the flight history data, consisting of several different parameters is recorded. This data is recorded at one second intervals, for the period 20 seconds before until 10 seconds after the event. Any data recorded is stored to a Non Volatile Memory (NVM) or Flash Memory and retained, even if power is lost to the unit. This data was retrieved and analyzed for this report.

The accident unit was received by Honeywell in Phoenix Arizona in a sealed, water-tight container. The KMH 820 unit was immersed in fresh water to minimize corrosion due to salt water exposure as result of the accident. On March 30, 2011, the unit was removed from the shipping container, rinsed with hot 110 F tap water and received a final rinse with 10 M-ohm de-ionized water to neutralize corrosive agents. The unit was partially disassembled by removing the housing cover and the CCA boards from the chassis. This enabled a more thorough rinsing and neutralizing of inaccessible areas like connectors. The unit was then dried in a calibrated and micro-processor controlled clean room oven for approximately 5 days (126 hours) at 95 degrees Centigrade to evaporate all moisture from the plastic components and FR-4 board. Staying below 100 C guaranteed no water to steam delamination of the components or board laminate. The boards were then packaged with silica gel and moisture indicator for transport to Redmond.

This report describes the investigation, analysis and findings as performed by Honeywell. The report is outlined as follows:

- Summary Findings
- Participants
- Analysis of Flight Data
- Analysis of Fault Data
- Investigation Steps
- Investigation Photos
- EGPWS Flight History Data

Summary Findings:

The KMH 820 unit as received had been slightly damaged in the accident. Honeywell, with the investigation team as witness, removed the EGPWS module and installed it in a test rig. The module powered up without error and flight history data from the module was then downloaded and analyzed. There were several types of flight history data stored in memory; Fault Data associated with the unit health, Status Data associated with the unit configuration and aircraft takeoff/landing and Alert Data associated with alerts generated based on the aircraft flight.

Status Data indicated the unit took off from FAQT (Queenstown) with the predictive functions inoperative due to a Terrain Database internal fault.

Alert Data indicated the unit provided a Mode 3 ("Don't Sink") alert 1 hour and 37 seconds after detected takeoff at coordinates S34.02107, E23.49008. Based on time-stamped radar track data provided by South African CAA, this alert occurred in the radar track between data points time stamped 14:29:51 and 14:29:56. The EGPWS recorded the activation of the cockpit EGPWS Inhibit switch 1 second after the alert. Honeywell believes this alert to be a nuisance alert caused by the existing Terrain Database internal fault.

Fault Data indicated that numerous internal faults for APPLICATION DATABASE FAILED, TERRAIN DATABASE NOT COMPATIBLE, and TERRAIN DATABASE FAILED were recorded in the last 200 flight legs flown.

During these fault conditions the Self Test function would have indicated unit failure accompanied by a cockpit INOP annunciation. Honeywell has no record of this unit being returned for service. It was also noted the terrain database was never updated as the version installed in the unit was the same database the unit originally shipped with in 2007.

Participants:

Meeting and examination of EGPWS – April 12, 2011, Honeywell, Redmond, Washington, USA

- Rene Tovar — Aviation Safety Inspector, Seattle MIDO, FAA
- David Studtmann — Air Safety Investigator – Product Integrity, Honeywell
- Kevin Allen — EGPWS Technical Manager, Honeywell
- Gary Ostrom — EGPWS Systems Engineer, Honeywell
- Jim Mulkins — EGPWS Systems Engineer, Honeywell
- Bill Pickens — EGPWS Technician, Honeywell

Analysis of Flight Data

Based on the analysis of the EGPWS flight history data the following findings are presented:

1) The aircraft landed at FAQT (Queenstown) at EGPWS system time 1301:05:28.
2) The aircraft departed FAQT at EGPWS system time 1301:11:34.
3) On the final flight, a Mode 3 "Don't Sink" alert activated at EGPWS system time 1302:12:11 (1 hour 37 seconds after takeoff from FAQT) at position S34.02179, E23.48956. The aircraft parameters at this time:

   Altitude: 4176 feet (from GPS)
   Groundspeed: 183.6 knots (from GPS)
   Vertical Speed: -1430 feet/minute
   True Track: 211.1 degrees

   Honeywell believes this alert is a nuisance alert, caused by the internal Terrain Database failure at takeoff. Without valid database input, the EGPWS would be stuck in takeoff mode (instead of switching to approach mode as is typical). Mode 3 is armed in takeoff mode, and uses a snapshot calculation of field elevation at takeoff, along with loss of barometric altitude to activate the alert. Honeywell notes that FAQT has a field elevation of 3637 feet, so altitude loss would be triggered above that altitude. When the aircraft descended toward FAPG (Plettenberg Bay), the descent rate caused an altitude loss sufficient to trigger the Mode 3 alert
4) The crew activated the EGPWS Inhibit switch 1 second after the Mode 3 alert was issued, indicating some familiarity with the use/location of the inhibit switch.
5) As the aircraft approached impact with the water, no terrain alert was issued by the EGPWS due to the existing internal Terrain Database fault.

A copy of the complete flight history data is provided as an accompaniment to this report.

Analysis of Fault Data

Based on the analysis of the EGPWS flight history data the following findings are presented:

This EGPWS module had accumulated 1302 hours of operation since it was originally manufactured in 2007, of which 1078 hours were in flight. This represents 900 flight legs (from takeoff to the next takeoff). The remaining 224 operating hours were on the ground.

Of the 900 flight legs in the flight history record, at least 180 had an EGPWS INOP condition for part or all of the flight leg. The fault history does not record the length of time a unit is faulted for a particular fault – only that it occurred. The INOP faults that were recorded were due to internal EGPWS computer failures for Terrain Database or Application Database (executable code). The EGPWS was INOP for 37 of the first 100 flight legs, 23 of the last 100 flight legs, and 120 of the of the 700 intermediary flight legs according to the flight history record. Additionally, there is no evidence of EGPWS "Self Test" being performed in the last 10 flight legs when the data was viewed on the test rig computer screen. However, the data containing the self test history was not captured to a log file during the investigation.

The unit did operate on many flight legs as there is flight history data that indicates that terrain alerts were provided to the crew on those flights.

In the event of a malfunction, the unit is designed to provide a signal to activate the cockpit TERR INOP annunciator. According to the Terrain Function (EGPWS) Pilot's Guide Addendum, the KMD 850 multi-functional display (MFD) will also provide inoperative terrain indications including:

- "Terrain Inactive" in the Available Functions Legend of the display
- Terrain Awareness State on the Terrain Display Page indicating TERR FAIL when terrain is INOP due to a fault

The EGPWS module installed on ZS-GAA was inoperative (INOP) at the time of the accident due to a failure of the internal Terrain Database. Honeywell has not determined any probable cause for the internal failures as the unit had been submerged in salt water and was mechanically damaged during the accident.

Investigation Steps

Despite the damage to the KMH 820, the EGPWS module was functional when placed on a test rig and no unexpected faults were present when the unit was queried via the maintenance interface. No configuration module was included in the set-up to prevent further writing to the flight history, but system time did accrue while the unit was powered. EGPWS system time 1302:16 was logged as the start of laboratory testing.

To perform the flight history download, it was required to remove the existing Terrain Database compact flash card. The card was removed with some difficulty and replaced by a compact flash card that had been programmed only with a kernel file that instructs the EGPWS to copy flight history to the flash card. The flight history download was successful, and the download compact flash card was removed and the original terrain database compact flash card was again installed.

Investigation Photos

All of the photos taken during the investigation process can be found on the media with this report including:

Drying Activity in Phoenix Arizona - March 30, 2011
EGPWS Data Retrieval – April 12, 2011

EGPWS Flight History Data

The EGPWS flight history data can be found on the following files which are included on the media with this report:

Counts.txt
Event.txt
Fault.txt
Status.txt
Warn.CSV
Warn.xls

End of Report

COMPILED BY	Crash LAB	PAGE 1 OF 1	
COMPILED FOR: Civil Aviation Authority	INVESTIGATION REPORT: SELECTED COMPONENTS FROM PILATUS PC12 ZS-GAA	DOCUMENT NUMBER MET-009-06-11	
		DATE 2011-06-08	ISSUE 1

ITEM: **HORIZONTAL STABILIZER, PILATUS PC-12, AIRCRAFT NUMBER ZS-GAA**

1. INTRODUCTION & BACKGROUND

1.1. The remainder of the left hand elevator removed from the T-tail (Photo 1) from a crashed Pilatus PC-12, aircraft number **ZS-GAA**, was submitted to determine the possible fracture mode/s during operation and/or impact.

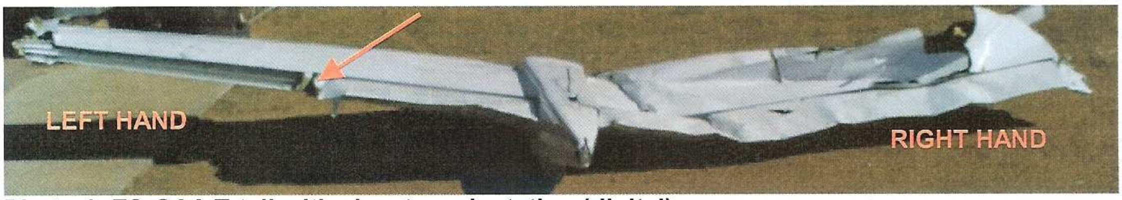


Photo 1: ZS-GAA T-tail with elevator orientation (digital)

1.2. The relevant aircraft was exposed to water impact resulting in submersion damages.

1.3. This report is divided into the following sections:

(a) INTRODUCTION	Par. 1
(b) APPLICABLE DOCUMENTS	Par. 2
(c) DEFINITIONS	Par. 3
(d) INVESTIGATOR	Par. 4
(e) APPARATUS AND METHODOLOGY	Par. 5
(f) BACKGROUND INFORMATION	Par. 6
(g) INVESTIGATION	Par. 7
(h) DISCUSSION AND CONCLUSIONS	Par. 8
(i) RECOMMENDATIONS	Par. 9
(j) DECLARATION	Par. 10

2. APPLICABLE DOCUMENTS

(a) None.

3. DEFINITIONS

(a)	OEM	Original Equipment Manufacturer
(b)	SACAA	South African Civil Aviation Authority
(c)	SEM	Scanning Electron Microscope
(d)	EDS	Energy Dispersive X-ray Analysis

4. PERSONNEL

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical

Engineering, Tech. PTA), Radiation Protection Officer (RPO) registered with the National Nuclear Regulator (NNR) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The apparatus employed for this investigation are Stereo- Light Microscopes and Digital Camera.
(b) The methodology included a visual investigation of supplied parts followed by a Stereoscopic investigation.

6. INVESTIGATION RESULTS

The on-site visual examination revealed the horizontal stabilizer assembly severed from the remainder of the T-tail on impact. The right-hand leading edge of the horizontal stabilizer revealed damages typical of a water impact (Photo 2, blue arrow). The position thereof point towards a right wing down orientation for the T-tail horizontal stabilizer on impact. However, further investigation will be necessary to determine if this impact orientation, related to the horizontal stabilizer, is reminiscent of the actual aircraft orientation on impact.

The left hand elevator failed adjacent to the mid-span bracket position (Photo 1, red arrow). The remainder could not be retrieved. Closer inspection revealed the direction of failure to be upward and inboard (Photo 3, blue arrow). The indications of buckling (Photo 3, red arrow) can be attributed to the initial (inboard and aft direction) failure of the outboard hinge (Photo 4, blue arrow). This left the lightweight elevator exposed resulting in the position of fracture at the weakest point - adjacent to the mid-span hinge. Both left and right hand outboard elevator hinge brackets revealed extensive impact damages (Photo's 4 and 5). The fracture surfaces revealed no clear indications of pre-impact crack formation or other material discrepancies (Photo 6).

The elevator control bracket fractured at the connection point (Photo's 7 and 8, blue arrows). The fracture surface revealed no clear indications of pre-impact crack formation or indications of unusual wear. The top and bottom stop positions (Photo's 8 and 9, red arrows) revealed no clear indications of excessive impact damages or wear. The elevator counter weight, still attached to the vertical section of the T-tail, proved to be in good condition with no clear indications of mechanically induced damages during operation (Photo 10, blue arrow).

Photo 2: ZS-GAA horizontal stabilizer (digital)

PILATUS PC12 ZS-GAA

COMPILED BY	Crash LAB	PAGE 3 OF 3	
COMPILED FOR: Civil Aviation Authority	INVESTIGATION REPORT: SELECTED COMPONENTS FROM PILATUS PC12 ZS-GAA	DOCUMENT NUMBER MET-009-06-11	
		DATE 2011-06-08	ISSUE 1

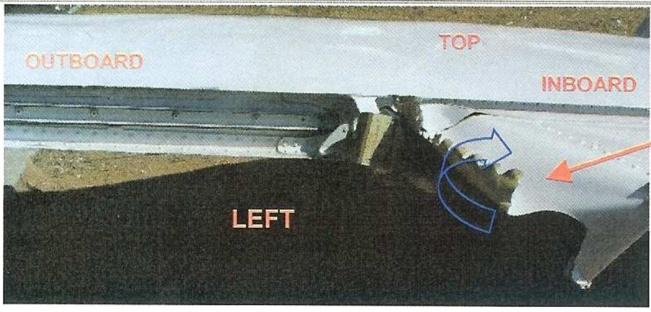


Photo 3: Left hand elevator section point of failure (digital)

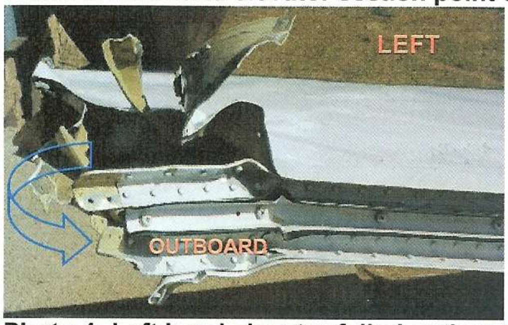


Photo 4: Left hand elevator failed outboard hinge (digital)

Photo 5: Right hand elevator damaged outboard hinge (digital)

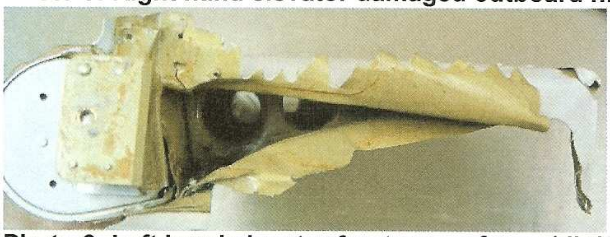


Photo 6: Left hand elevator fracture surfaces (digital)

PILATUS PC12 ZS-GAA

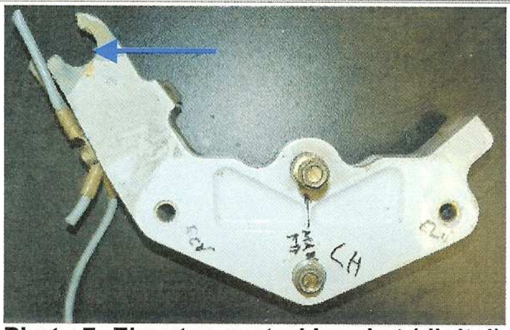


Photo 7: Elevator control bracket (digital)

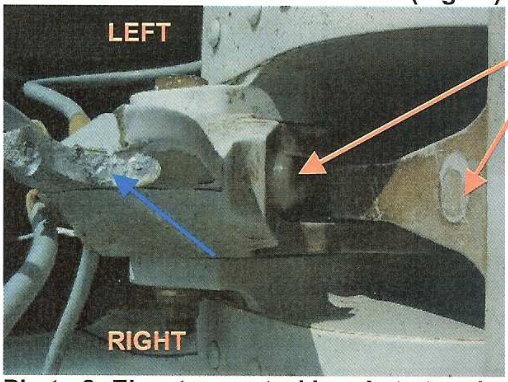


Photo 8: Elevator control bracket stop, bottom (digital)

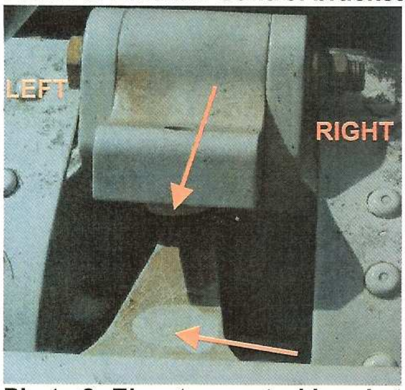


Photo 9: Elevator control bracket stop, top (digital)

Photo 10: Elevator counter weight (digital)

8. DISCUSSION AND CONCLUSIONS

Note: All conclusions are based on the investigation results obtained from the supplied parts only. Some sections of the relevant assembly could not be located at the crash site or from the third party.

8.1. The possibility of failure due to in-flight flutter of elevator was contemplated. However, the results from this investigation point towards impact rather than flutter induced failure during operation, based on the following observations:

8.1.1. In the majority of cases where flutter resulted in the failure of control surfaces during operation, the entirety of the surface will show comparable damages. In this case the right hand section of the elevator failed to reveal the same.

8.1.2. The top and bottom elevator movement stops revealed no clear evidence of excessive impact wear or damages.

8.1.3. The elevator counter weight proved to be in relative good condition with no clear indications of exposed strain typical to flutter inputs.

8.1.4. The connecting bracket fracture surface point towards failure on impact and not during operation that may have resulted in loss of elevator control and/or flutter thereof.

9. RECOMMENDATIONS

9.1. None applicable.

10. DECLARATION

9.1. All digital images has been acquired by the author and displayed in an un-tampered manner.

COMPILED BY	Crash LAB	PAGE 1 OF 1	
COMPILED FOR: Civil Aviation Authority	INV. REPORT: SELECTED COCKPIT INDICATORS, PILATUS PC12, ZS-GAA	DOCUMENT NUMBER MET-011-07-11	
		DATE 2011-07-06	ISSUE 1

ITEM: **SELECTED COCKPIT INDICATORS, PILATUS PC-12, AIRCRAFT NUMBER ZS-GAA**

1. INTRODUCTION & BACKGROUND

1.1. Selected cockpit indicators (Photo 1) from a crashed Pilatus PC-12, aircraft number **ZS-GAA**, was submitted to determine, where possible, the indications on impact.

Photo 1: Section of the supplied instrument panel (digital)

1.2. The relevant aircraft was exposed to water impact resulting in submersion damages.

1.3. This report is divided into the following sections:

2. APPLICABLE DOCUMENTS

(a) None.

3. DEFINITIONS

(a) OEM Original Equipment Manufacturer
(b) SACAA South African Civil Aviation Authority
(c) SEM Scanning Electron Microscope
(d) EDS Energy Dispersive X-ray Analysis

4. PERSONNEL

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical Engineering, Tech. PTA), Radiation Protection Officer (RPO) registered with the National Nuclear Regulator (NNR) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The apparatus employed for this investigation are Stereo- Light Microscopes and Digital Camera.

(b) The methodology included a visual investigation of supplied parts followed by a Stereoscopic investigation.

6. INVESTIGATION RESULTS

6.1.1. **Attitude Indicator (AI) P/N 504-01110-930 S/N 504011193025230.** The visual examination revealed extensive impact damages (Photo 2) on the ZS-GAA AI rendering the inner gyroscopic parts unmovable, particularly in the roll plane. The as found indication (Photo 3) corresponds with a right wing down (± 110º), nose-up (± 25º) attitude.

A serviceable attitude indicator (not the exact model) was opened (Photo 4) for reference purposes to the AI from ZS-GAA as well as a basic layout diagram (Diagram 1). X-ray photographs were taken of the ZS-GAA AI from a top- and side view perspective (Photo's 5 and 8).

The x-ray photograph of the ZS-GAA AI designating the side view (Photo 5) clearly revealed two distinct features (Photo 5, red arrows) that correspond with the attachment positions (Photo 6, red arrow) between the roll- and pitch gimbals (Diagram 1). These reference positions were exploited to determine the corresponding roll indication (Photo 9) of ± 100º right wing down.

The x-ray photograph of the ZS-GAA AI designating the top view (Photo 8) revealed two distinct screw positions (Photo 8, blue arrows) to be found on both sides of a pitch gimbal (Photo 7, blue arrow). These reference positions, combined with the perceived angle of the pitch gimbal (Photo's 7 and 8, red dashed line), were exploited to determine the corresponding pitch indication (Photo 9) of ± 40º nose-down.

Comparatively the two indications (Photo10) reveals that although the two roll indications associate favorably, the pitch indications do differ extensively. This can be attributed to the possible movement of the pitch gimbal from ZS-GAA after impact as the induced damages only arrested the larger, and outer, roll gimbal on impact.

Photo 2: ZS-GAA Attitude Indicator (digital)

Photo 3: ZS-GAA Attitude Indicator, faceplate indication, as supplied (digital)

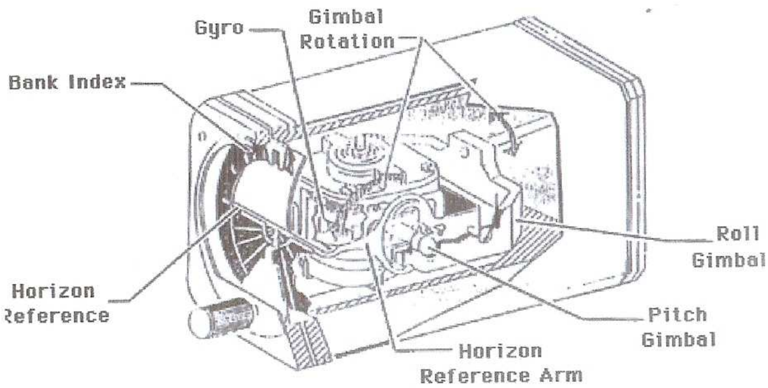


Diagram 1: Basic layout: Gyro-driven Attitude Indicator

PILATUS PC12 ZS-GAA

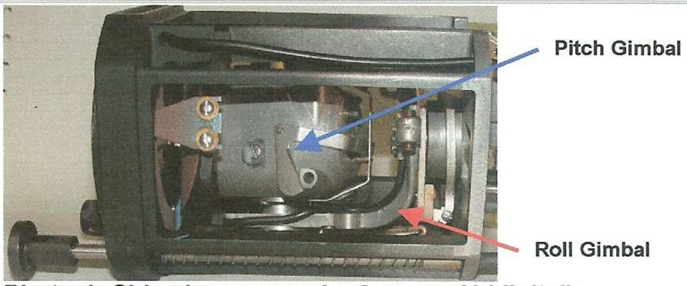


Photo 4: Side view, opened reference AI (digital)

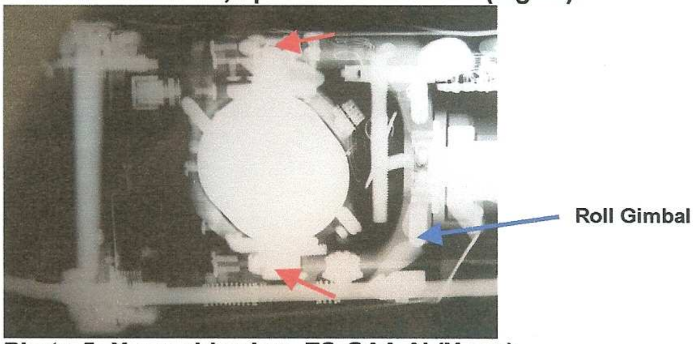


Photo 5: X-ray side view, ZS-GAA AI (X-ray)

Photo 6: Side view, reference AI (digital)

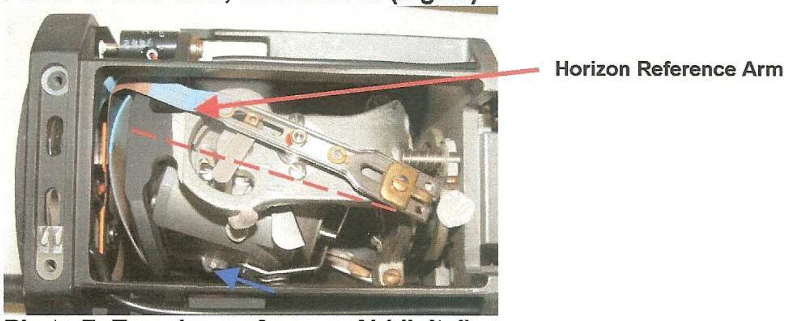


Photo 7: Top view, reference AI (digital)

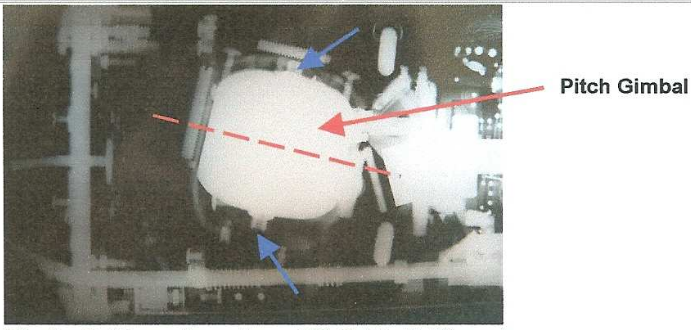


Photo 8: X-ray top view, ZS-GAA AI (X-ray)

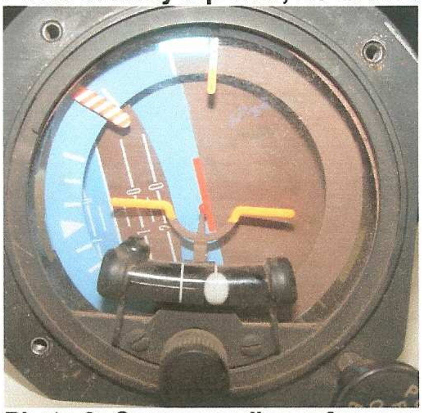


Photo 9: Corresponding reference AI indication (digital)

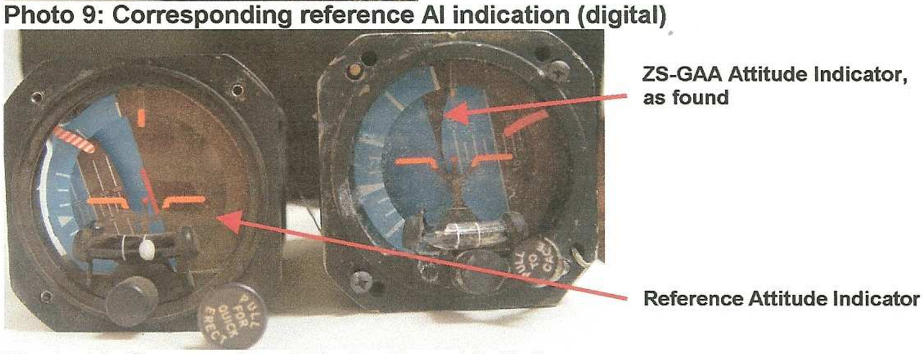


Photo 10: Comparative AI indications (digital)

6.1.2. **Direction Indicators x2 (DI) NAV 1: P/N 066-3060-01 S/N 12080, NAV2: P/N 066-3046-07 S/N -----96910.** Although the visual investigation revealed extensive impact and corrosion damages to both ZS-GAA DI's (Photo's 1 and 11), the extent of damages proved to be insufficient to arrest the inner gyroscopic parts for impact analysis purposes. However, both DI's revealed comparable readings of 115º (Photo 12) and 105º SE. This could not conclusively be confirmed as the actual direction of impact.

PILATUS PC12 ZS-GAA

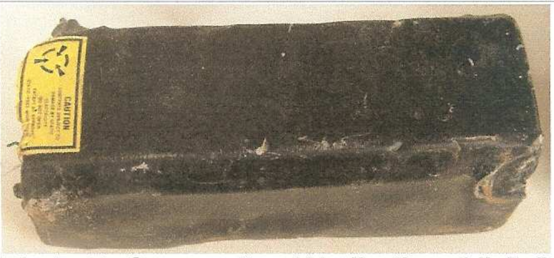


Photo 11: Comparative AI indications (digital)

Photo 12: Direction Indicator, NAV 2 (digital)

Photo 13: Direction Indicator, NAV 1 (digital)

7. DISCUSSION AND CONCLUSIONS

Note: All conclusions are based on the investigation results obtained from the supplied parts only. Results from impact investigations should preferably only be utilized to support primary evidence (fuselage, engine/s, control surfaces, etc.).

7.1. The investigation results from the Attitude Indicator (Artificial Horizon) points toward a right wing down, approaching inverted, aircraft attitude on impact. The pitch attitude could not conclusively determined from the Attitude Indicator but assumed to be nose-down at an undetermined angle.

PILATUS PC12 ZS-GAA

7.2. The instigation results from the Direction Indicators could not be confirmed by means of x-ray photography, but both indicators revealed a comparable 105º-115º reading, most probably on impact.

8. RECOMMENDATIONS

8.1. None applicable.

9. DECLARATION

9.1. All digital images has been acquired by the author and displayed in an un-tampered manner.

Spatial disorientation

The inner ear contains the balance organ, which consists of two distinct parts: the semicircular canals and the otolith organs. The semicircular canals detect angular or turning acceleration and the otolith organs detect linear acceleration. In normal conditions, with two feet flat on the ground and your head straight above your knees when moving no faster than 5km/h, the balance organ provides correct information. In other conditions, for instance while flying, the information provided by the balance organ is sometimes unreliable.

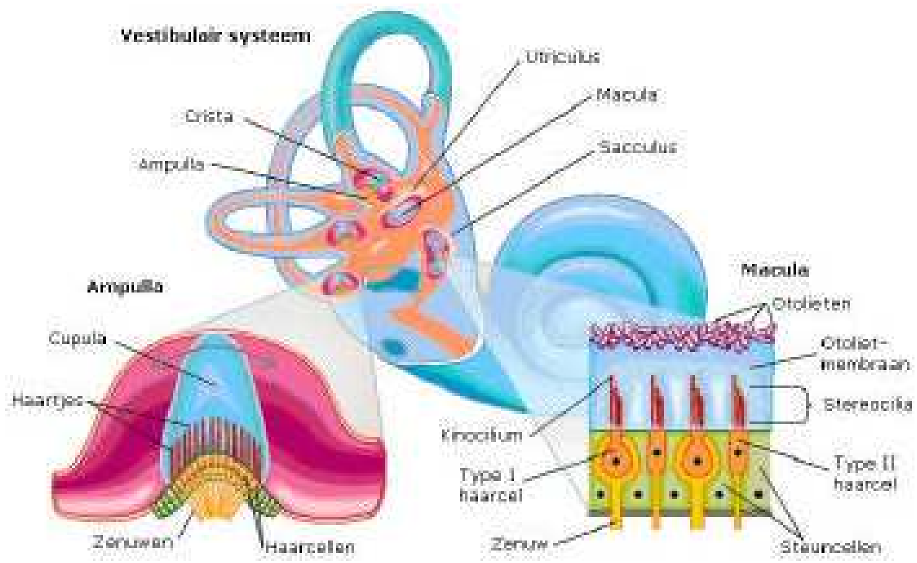


Image: The inner ear Semicircular canals

The semicircular canals consist of three hollow tubes located perpendicular to each other. The canals are interconnected and are filled with a fluid of a specific viscosity. The direction of the imaginary plane where a canal is located more or less corresponds to the three known motions of an aircraft. One canal lies in the pitch plane, another in the yaw plane and the third in the roll plane. Since measurements can be made in three canals located perpendicular to each other, provided certain conditions are met, each rotation the aircraft undergoes will be detected.

The effect is similar to the principle of making fluid rotate in a glass. When the glass is turned, the fluid will initially continue to remain stationary relative to the environment while the glass rotates. The fluid will also gradually start to rotate as a result of resistance with the glass until it rotates as fast as the glass. The semicircular canal is comparable to the glass and the fluid inside it.

Each canal contains a motion sensor with tiny hairs that are attached to the canal wall. The degree of displacement of the hairs indicates a degree of angular or rotational acceleration to the brain. Take the roll canal, for instance. If the canal is rolled anticlockwise, the fluid would seem to turn clockwise relative to the canal while it in actual fact remains stationary. The difference in movement between the canal and the fluid causes the hairs to change direction and this sends an angular acceleration signal to our brain. If a certain angular velocity is reached after a time (rotation per unit of time) at a certain point in time the fluid will turn as fast as the canal as a result of the friction between the fluid and the canal wall. The hairs will move to the centre and an angular acceleration signal will no longer be sent. If a person has no visual reference, the sensation of turning will also be removed. In other words: you will rotate at a certain speed without noticing.

If the rotational speed is subsequently reduced (negative angular acceleration), the fluid will continue to flow for a while due to its mass inertia and will want to maintain its speed while the canal rotates more slowly. The fluid is now turning in the same direction as the canal, both in anti-clock wise direction but at a different speed. The hairs are tilted in the opposite direction and consequently actually register angular acceleration and thus rotation in the opposite direction. In other words: you are still turning anticlockwise but the balance organ says that it is clockwise.

Incidentally a condition known as the threshold value is attached to registering angular acceleration. If a person rotates very slowly, i.e. when the angular acceleration is below the threshold value, nothing is registered. This creates the leans phenomenon. If no visual inputs are present, when flying through clouds or flying at night, a pilot will initially not notice that the aircraft has banked. When cross-checking the instruments the pilot will see an artificial horiz on showing that the aircraft has banked 15 degrees, for instance. In the pilot’s mind, however, the aircraft will still be flying at wings level. A logical and impulsive reaction will follow and the pilot will position the aircraft horizontally on the artificial horizon at wings level. While the roll canal does register this movement, it will be based on the incorrectly registered wings-level flight and thus registered as banking.

The pilot will now see that he is flying at wings level but feels as if he has banked. Since he knows that he can rely on his instruments, he also knows that he is flying at wings level yet in response to this illusion he will lean towards an imaginary vertical position, known as ‘leans’.

Another phenomenon that relates to the semicircular canals is called the Coriolis illusion. The registration of angular acceleration by a certain canal depends on the position of the canal in relation to the earth's surface. In other words, if you keep your head upright, the canals will correspond to the roll, pitch and yaw planes. If you tilt your head downward, for instance, the roll canal will become a yaw canal and the yaw canal will become a roll canal. If a rolling movement occurs, it will therefore be registered by the original yaw canal. It will consequently feel like a yaw movement. In aviation terms, this means that a pilot should preferably not move his head during angular acceleration. If the pilot indeed moves his head and experiences a pitch-up sensation in a horizontal turn for instance, a logical impulsive reaction will be to lower the nose of the aircraft.

The otolith organs

The otolith organs make up the other part of the balance organ. They detect linear acceleration. The otolith organs send a signal indicating linear acceleration when the accelerating force (in fact the reaction force to the latter) causes a number of crystals to move in a gelatinous layer. The otolith organs are positioned both vertically and horizontally in the balance organ.

If your head is held upright the force of gravity will pull the crystals. The crystals will not move and this therefore means that your head is in an upright position. If you tilt your head forward or backward, the force of gravity will continue to point downward and will cause the crystals in the gelatinous layer to move. The degree of movement is a measure for the position of the head relative to gravity. The position of the head is also confirmed by the activation of the groups of muscles during such head movements, such as the neck muscles. When bending forward or backward from the hips the otolith organs will move as well but other groups of muscles will be engaged.

Interaction usually occurs between the balance organ, muscular sensation and the eyes. For example, the semicircular canals also control eye movements. If a person turns around a few times and then stops, the yaw canal will continue to control the eyes for a while. These involuntary eye movements are also referred to as 'nystagmus'.

In aviation, other accelerating forces are at work in addition to the usual acceleration caused by the force of gravity. An example is acceleration during a take-off or a touch-and-go landing. An accelerating force pushes the aircraft forward. The opposite reaction force pushes you backward into the seat, causing the crystals in the otolith organs to move backward as well. The position of the crystals during acceleration is the same as when the head is tilted backward. The big difference is that no muscular activity takes place. This is therefore interpreted as a backward movement of the whole body, in other words as a high aircraft nose position. This therefore means that horizontal linear acceleration gives the illusion of a high nose position, whereas a horizontal delay which will create the illusion of a low nose position. This is referred to as the 'G excess' illusion.

A particular form of the G excess illusion and the resulting 'overbank' (too much slope) may occur if the head is held at right angles to the direction of the aircraft in a turn and the pilot looks at the centre of the turn flown. The G force that occurs in the turn will more or less follow the otolith organs and the crystals will consequently move backward. This causes a pitch-up sensation in relation to the head. Because the head is positioned at right angles to the direction of the aircraft, this sensation is interpreted as a rollout sensation (so, a pitch-up illusion for the head). Because the pilot does not want to roll out (which in reality the aircraft is not doing anyway), he is inclined to compensate for the false illusion of rollout by banking the aircraft. The pilot in fact overbanks the aircraft but fails to assume the accompanying higher nose position of the aircraft. The aerodynamic forces on the aircraft are no longer in equilibrium. The aircraft will soon point its nose downward as a result and will rapidly lose height.