Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Büro für Flugunfalluntersuchungen BFU
Bureau d'enquête sur les accidents d'aviation BEAA
Ufficio d'inchiesta sugli infortuni aeronautici UIIA
Uffizi d'inquisiziun per accidents d'aviatica UIAA
Aircraft Accident Investigation Bureau AAIB

Final Report No. 1972 by the Aircraft Accident Investigation Bureau

concerning the serious incident

to the Piper PA-34-200T Seneca II aircraft, HB-LOG

on 2 March 2006

between Egelsbach EDFE (Hessen, Germany)

and Locarno LSZL (Switzerland)

Bundeshaus Nord, CH-3003 Berne

Ursachen

Der schwere Vorfall ist auf einen vollständigen Ausfall der Stromversorgung des Flugzeuges zurückzuführen.

Die folgenden Faktoren waren für den schweren Vorfall kausal:

- Mangelhafter technischer Zustand des Flugzeuges
- Die im AFM publizierten Notverfahren wurden nicht angewandt

General information on this report

This report contains the AAIB's conclusions on the circumstances and causes of the serious incident which is the subject of the investigation.

In accordance with Annex 13 of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Law, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

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

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

All times in this report unless otherwise indicated, are indicated in the standard time applicable to the area of Switzerland (local time – LT), corresponding at the time of the serious incident to Central European Time (CET). The relationship between LT, CET and coordinated universal time (UTC) is: LT = CET = UTC + 1 h.

For reasons of protection of privacy, the masculine form is used in this report for all natural persons, regardless of their gender.

Contents

Final Report

Aircraft type	Piper PA-34-200T Seneca II			HB-LOG
Operator	Akzenta Suisse SA, via Pessina 8, 6901 Lugano, Switzerland			
Owner	Akzenta Suisse SA, via Pessina 8, 6901 Lugano, Switzerland			
Pilot	German citizen, born 1951			
Licence	Private pilot's licence PPL(A), issued by the Swiss Federal Office for Civil Aviation FOCA on 29.06.2005 First issued on 23.11.1994			
Ratings	RTI (VFR/IFR), NIT(A), IR(A) Class rating: MEP(L) valid till 30.06.2006			
Medical fitness certificate	Class 2; must wear spectacles (VDL) valid till 17.01.2007			
Last medical examination	16.01.2006			
Flying hours	**total**	1931 hours	**during the last 90 days**	23 hours
	on the accident type	415 hours	**during the last 90 days**	23 hours
Location	Between Egelsbach EDFE (D) and Locarno LSZL (CH)			
Date and time	2 March 2006, between 10:05 LT and 11:37 LT			
Type of operation	IFR private			
Flight phase	Cruising			
Incident type	Breakdown of the aircraft's electrical power supply			
Injuries to persons	None			
Damage to the aircraft	Not damaged			
Third-party involvement	Deployment of the Swiss Air Force			

1 Factual Information

1.1 Pre-flight history and history of the flight

1.1.1 Pre-flight history

The twin-engined Piper PA-34-200T Seneca II aircraft, registration HB-LOG was generally parked on an uncovered stand at Lugano-Agno airport (LSZA).

After the serious incident, the pilot mentioned that on 21 February 2006 he had had a problem starting the engines in Lugano. He had been forced to use an external power source to start the engines. He was sure that he had switched off all electrical consumers after the previous flight.

On 1 March 2006, the aircraft took off at 08:59 LT from Lugano-Agno airport and landed at 10:53 LT in Egelsbach (D). This airport lies below the terminal area (TMA) of Frankfurt airport. It is not equipped with any approach navigation aids and can therefore only be approached under visual flight conditions. During the night from 1 to 2 March, the aircraft was parked in the open and the cabin area was covered with a tarpaulin. There was no precipitation during this time.

On the morning of 2 March 2006, the pilot went to Egelsbach aerodrome at 08:50 LT. The sky was overcast and it was snowing. The pilot asked for weather information in the C office and received from the duty employee the information that a temporary improvement was forecast and that the weather situation would then worsen again. The pilot submitted an ATC flight plan for a combined VFR/IFR flight (flight regulation ZULU) and according to his statement carried out a pre-flight check. Once the weather conditions had temporarely improved, he took off for the return flight to Lugano-Agno (CH).

1.1.2 History of the flight

The information from the pilot of HB-LOG, the statements of the military pilots and air traffic controllers involved and the tape transcripts were used to reconstruct the history of the flight.

The pilot was alone on board. The aircraft flight manual (AFM) with the emergency checklist and the navigation documents (Jeppesen) were on the rear seats and were difficult for the pilot to reach during the flight. There was a portable oxygen unit in the aircraft.

The take-off under visual flight rules took place at 09:48 LT. After take-off, the pilot switched off the left landing light. The strobe lights, radios, navigation equipment, transponder and the pitot and interior heating remained on. The heating for the pilot's windshield and the electric propeller de-icing were not switched on.

A few minutes after take-off, the pilot made contact with the "Langen Radar" control center on the 120.150 MHz frequency. As he was approaching the cloud base, he immediately requested clearance to switch from visual flight rules to instrument flight rules. The corresponding clearance, valid from 3400 ft AMSL, was given to him at 10:01 LT.

At 10:05 LT the pilot reported that both alternators were not working and that he was afraid that the capacity of the battery would soon be exhausted. Langen Radar asked Egelsbach aerodrome for information about the current weather

situation and reported three minutes later: *„Also Egelsbach meint, von Osten aus sei es sehr gut rein zu kommen, sie hätten 4 km Sicht und 800 ft scattered clouds“*. [So, Egelsbach thinks it will be fine to come in from the east, they have 4 km visibility and 800 ft scattered clouds]. The pilot replied that without battery his GPS would fail too and he would then no longer be able to find his way in the vicinity of Egelsbach. He would prefer to fly on to Lugano, as the weather conditions there were very good.

At 10:09 LT a change of frequency to 127.500 MHz took place. The aircraft was at FL 110 and was flying directly to waypoint NATOR. At 10:14 LT, the pilot requested clearance to climb to FL 150. Along with the clearance, the weather situation in Lugano was confirmed to him: "*At time 0850 the wind 170/4 kt, clouds and visibility ok, temperature 1, dew point minus 9, QNH 1006 and nosig on the trend"*. When passing FL 120 during the climb, the pilot began to use the oxygen unit.

At 10:22 LT, the pilot requested a further clearance to climb to FL 190. He reported that he intended to land in Locarno and asked for this message to be forwarded: "*190 HOG and another request, would you please in case I lose contact inform Locarno that I will fly to them in Locarno"*.

The pilot later justified the change in the destination aerodrome by the fact that he did not want to land without radio contact at an aerodrome with IFR and scheduled traffic.

The enquiry was confirmed as follows: "*HOG that is copied and we will relay that information, anyway just to confirm, are you on course to NATOR now"*.

At 10:27 LT, the pilot reported on the 127.050 MHz frequency as follows:

" … inbound NATOR, climbing FL 190 … so maybe our battery goes down and I cannot have contact to you then I will squawk 7 eh 7600 and I have a request could you please provide me with the frequency of Locarno in Switzerland".

At 10:35 LT, Langen Radar pointed out to him that normally, and especially in winter, he should not have made an IFR transalpine flight without taking a handheld radio with him. This was the last radiocommunication with the aircraft. At this time the aircraft was at waypoint GAGSI (approximately 50 km west of Stuttgart) at FL 192. Since the aircraft's cabin heating had also failed in the meantime, the side windows of the cockpit began to ice up.

At 10:45 LT, the Daily Ops Manager (DOM) at Zurich Area Control Centre (ACC) informed the Daily Ops Manager Air Defence and Direction Center (DOM ADDC) about the position of HB-LOG by telephone. He outlined the aircraft's situation and asked for assistance with tracking the aircraft. In his report, the DOM ADDC stated: *„Ich bestätige, die HB-LOG am Radar über NATOR* (ungefähr 60 km nördlich der Schweizergrenze) *zu sehen und melde die Radarhöhenanzeige von ca. 20 000 ft. Nach Rückfragen der Höhenanzeige beobachte ich eine weitere Sequenz und melde einen Wert zwischen 17 000 ft – 19 000 ft. Der DOM ACC gibt an, dass der Flight Plan Level für HB-LOG FL 150 ist“.* [I confirmed that I could see HB-LOG on radar above NATOR (approximately 60 km north of the Swiss border) and reported the radar altitude indication of approximately 20 000 ft. After querying the altitude indication, I observed another sequence and reported a value between 17 000 ft and 19 000 ft. The DOM ACC stated that the flight plan level for HB-LOG was FL 150].

In the meantime, the transponder mode C signal had disappeared. Calls on the 136.150 and 121.500 MHz frequencies were unsuccessful. The DOM ADDC further stated: *"Ich frage nach, ob der DOM Unterstützung durch Mil Fighters wünscht, der DOM ACC confirmed dies. Ich informiere den Chief Air Defence (CAD) und er erteilt den Auftrag zur HOT MISSION[1] ESCORT."* [I asked whether the DOM wanted support from Mil Fighters, the DOM ACC confirmed this. I informed the Chief Air Defence (CAD) and he issued the order for a HOT MISSION ESCORT].

The CAD initiated a hot mission to accompany the aircraft concerned over the Alps until it landed. Initially a patrol of two F-5 Tiger aircraft in the Thun area at FL 300 was mobilised.

At 10:56 LT, HB-LOG flew over the Swiss border and two minutes later Swiss air traffic control broadcast the following blind transmission on the GUARD 121.500 frequency: *"HB-LOG from Swiss radar, blind transmission, last observed position with radar is 10 NM NW of Kloten VOR and you will be intercepted by military aircraft in about 3 minutes"*.

Under the guidance of the ground control center, the Tigers first descended to FL 180, above the cloud ceiling, and were able to detect the Piper on their onboard radar. They finally approached HB-LOG from the rear, but because of an opposing aircraft which was approaching them at FL 180, they first had to descend to FL 170 and later to FL 130. At this altitude, the fighter aircraft were sometimes in cloud and it was not possible for the pilots to make visual contact with HB-LOG. The interception manoeuvre was aborted and the two F-5 aircraft were readied for a new attempt by moving them off to the west. This attempt now took place at a higher altitude outside the cloud and led to visual contact. The two Tigers followed HB-LOG at FL 205 virtually as far as the canton of Ticino. According to the pilots' statement they were behind the Piper Seneca throughout the whole interception manoeuvre. The pilot of the Piper Seneca never noticed the two F-5s. At 11:15 LT, the F-5 patrol broke off the interception because of an impending fuel shortage and was replaced by an F/A-18 patrol.

The pilots of the F/A-18 aircraft were informed by ground control that they would have to intercept a Piper Seneca which was descending towards Lugano after an electrical power failure. The fighter aircraft then detected HB-LOG on their onboard radar equipment and one F/A-18 closed with it, while the other remained behind the Piper Seneca as a safety element. The intercepting aircraft flew to the left of HB-LOG and performed a wing-rocking movement. At this point, the pilot of the Piper Seneca was already descending for the landing in Locarno, with landing gear down. By chance, at that moment, he made a turn, which was interpreted by the pilot of the identifying F/A-18 as a sign of cooperation. In fact, the pilot of HB-LOG had, however, not noticed the military aircraft. The military patrol were still of the opinion that the Piper Seneca would land in Lugano and reported to Lugano airport by radio that they would escort HB-LOG for the landing. At this time, the pilot of HB-LOG was making further

[1] "HOT MISSIONS" are missions against aircraft that cannot be identified by ground based means or show an uncooperative flight path. Sorties are carried out against such aircraft. Hot missions can be requested by the respective unit manager of the area control centers (ACC) ZH/GE via the EZ/LUV (headquarter air defense) as well as by the authorities mentioned in the respective decrees and regulations. For flight crews "HOT MISSIONS" have priority over all other missions. It constitutes a main task of the air force, called "air police service".

preparations for a landing in Locarno. The identifying fighter aircraft tried to shift the Piper for a landing in Lugano by showing itself above and in front of HB-LOG and lowering its landing gear. It was only now, above Lake Maggiore, that the pilot of the Piper Seneca noticed the F/A-18s for the first time. However, he was unable to interpret the fighter aircraft's behaviour correctly and descended, without taking any further notice of it, and made an uneventful landing in Locarno at 11:37 LT.

1.2 Meteorological information

1.2.1 General

The information in sections 1.2.2 to 1.2.5 was provided by MeteoSwiss.

1.2.2 General weather situation

A trough, particularly extended at high altitudes, lay over the North Sea. Along with moderate westerly winds, it brought cold and mainly in the morning very humid polar air to the north side of the Alps. The south side of the Alps had better weather, due to the protection of the Alps.

1.2.3 Aviation weather forecast and warnings

Aviation weather forecast for Switzerland, valid from 06 to 12 UTC

Under hazards, the following was stated:

Above the Jura and the Midland, moderate to strong west wind turbulence. Poor visibility in snow showers. Some Alpine crossings in cloud.

Wind and temperature, north side of the Alps:

18 000 ft 270 / 040 MS37

1.2.4 Measured and observed values

Radar image

Isolated echoes of precipitation can be detected on the north side of the Alps and in the Alps. The south side of the Alps is free from precipitation.

Satellite image

The largely compact cloud cover on the north side of the Alps as far as the Alps can be seen on the satellite image. Ticino is practically cloud-free.

1.2.5 Weather in the vicinity and during the period of the incident

On the basis of the listed information, it is possible to conclude that the weather conditions on the route from Trasadingen to Locarno were as follows.

Southern Germany

On the basis of the Stuttgart and Munich radio probes (12z), the cloud ceiling can be assumed to be approximately FL 170-180.

North side of the Alps and the Alps

Compact cloud cover lay over the eastern part of the midland; its average ceiling according to radio probes would probably have been at approximately FL-170-180.

South side of the Alps

The south side of the Alps was largely cloud-free; visibility was over 30 km.

1.2.6 Weather according to the statements of the military escorts

On the north side of the Alps, cloud cover extended up to FL 180. In Ticino the weather was good.

1.3 Aircraft information

Type	PA-34-200T Seneca II		
Characteristics	Twin-engined 6-seat low-wing aircraft with retractable landing gear and variable pitch propellers Does not have a pressurised cabin		
Year of construction Serial number	1978 34-7870415		
Operating hours on 02.03.2006	Airframe total: TSN 3738:21 hours and 4443 landings Since last 100 h check: 51:08 hours Left engine since TCM Rebuilt: 283:03 hours Right engine since TCM Rebuilt: 549:26 hours		
Engines, type	Teledyne Continental TCM, turbocharged piston engine in Boxer configuration with 6 cylinders, air-cooled		
Engine, left	TSIO-360-EB, S/N 826850-R, TCM Rebuilt 2003		
Engine, right	LTSIO-360-EB, S/N 807577-R, TCM Rebuilt 1999		
Propeller, left	Hartzell BHC-C2YF-2CKUF, S/N AN4952		
Propeller, right	Hartzell BHC-C2YF-2CLKUF, S/N AN3687		
Alternator, left	Kelly Aerospace 12V/70A, ALX9525B, S/N D020341		
Alternator, right	Electro System 12V/70A, ALX9425B, S/N 9070153		
Voltage regulator, left	Lamar, P/N B-00288-1H, S/N 80067802		
Voltage regulator, right	Lamar, P/N B-00288-1H, S/N 80067803		
Battery	Gill G 35, 12V/35 Ah, S/N G02185767		
Equipment	COM/NAV VHF	2	King KX-155
	VHF marker	1	Collins AMR-350
	SAT GPS	1	Trimble TNL 2000
	ADF	1	Collins ADF-650
	DME interrogator	1	King KN-62A
	ATC transponder mode "S"	1	King KT-73
	Emergency Equipment ELT	1	ACK E-01
	Autopilot	1	EdoAire Altimatic III C
	Engine data management	1	EDM 760 TWIN
	De-icing system		Wings and tail boots, propeller electric. D-I, pilot windshield
	Oxygen equipment		portable
Mass and centre of gravity	Max. permitted take-off mass: 1999 kg The mass and centre of gravity were within the permitted limits of the AFM		
Registration certificate	Issued by the Federal Office for Civil Aviation (FOCA) on 28.10.2005 / No. 5		

Airworthiness certificate	Issued by the FOCA on 31.05.1995 / No. 2
Certification in non-commercial use	VFR day VFR night IFR Cat I B-RNAV (RNP 5)

1.3.1 Technical investigation

At the instigation of the owner, the battery was removed and charged immediately by a maintenance company after the landing in Locarno. The battery was later checked and found to be in order.

The complete electrical system of the aircraft was checked. All current consumers were functional.

Among other things, the examination of the electrical installations found the following:

- The check on the left alternator carried out on the test bench gave no indication of any malfunction, but there was excessive axial play in the rotor. The results of the measurements met the manufacturer's requirements.
- The clutch resistance of the right alternator was outside the norm. At high loads, the clutch slipped and the alternator was unable to provide full power.
- The two voltage regulators were set to 13.8 V.
- The ring terminal to the positive pole of the battery was partially oxidised and exhibited traces of copper acetate (verdigris). In the engines' electrical cabling, the ring terminals of several live and ground cables had traces of oxidation.
- The cables to the alternator circuit blocking diodes exhibited signs of heat and oxidation. The terminals which branch off from the same connection and the cables which supply the annunciator panel were partially blackened. Both diodes were fixed to the same cooling element below the instrument panel on the right side.
- The connection at the master switch for the cable leading to the left alternator switch was broken. There were traces of oxidation and arcing inside the master switch between the contacts (cf. Annex 1 Fig. 4). The terminal was correctly screwed onto the broken part of the connection (cf. Annex 1 Fig. 2).
- The switch for the right alternator was in the OFF position. The switch for the left alternator was in the ON position. The switch field with the "master switch, alternator switch", etc. is on the left side below the cockpit windshield (cf. Annex 1 Fig. 1).
- In the fuse area on the right side of the instrument panel, the 5 amp circuit breaker for the autopilot had tripped.
- In the power distribution section of the electrical system, considerable corrosion was present on various connections.
- It could be established that water had penetrated through the front part of the fuselage and via the left cockpit windshield over a longer time period.

1.3.2 Information on the electrical system

1.3.2.1 Warning lights

The Piper PA-34-200T Seneca II includes in its basic equipment a series of warning lights which are located on the annunciator panel. Among other things, it includes the yellow “ALT” light, which appears in the event of an alternator fault. Two meters which are located in the immediate vicinity of the engine instruments and the tank indicators display the alternators’ charging current. An additional "LOW VOLT" red light, which lights up if the electrical voltage is insufficient, is affixed on the right side of the instrument panel. It was not possible to establish with certainty when this additional warning lamp had been fitted.

On the occasion of a modification to the avionics equipment, a multipurpose indicator, “engine data management, EDM-760 TWIN”, was fitted to HB-LOG on 23 February 1996. In addition to various engine parameters, among other things, the unit indicates high/low battery voltage. According to the manufacturer’s documents, the threshold voltage for the low voltage indication is set to 12 V.

1.3.2.2 Layout of some of the monitoring instruments

1 Annunciator Panel and ALT Warning Light
2 EDM 760 Instrument
3 LOW VOLT Indicator
4 Ammeter LH
5 Ammeter RH

Instrument panel of HB-LOG

According to the pilot’s statement, during the climb to FL 090 he noticed the flashing of the “low battery voltage" indication on the "EDM 760 TWIN".

1.3.2.3 Extract from the system description of the aircraft flight manual

Section 2 of the aircraft's AFM, "*AIRPLANE AND SYSTEMS"* states:

"....If both ammeters indicate a load much higher than the known consumption for more than approximately five minutes, an electrical defect other than the alternator system should be suspected because a discharged battery will reduce the alternator load as it approaches the charged conditions. .....A single alternator is capable of supporting a continued flight in case of alternator or engine failure in most conditions, however, with de-icing equipment and other high loads, care must be exercised to prevent the loads from exceeding the 65 ampere rating and subsequent depletion of the battery.

....If both alternators should fail during flight, the battery becomes the only source of electrical power; therefore, all unnecessary electrical equipment should be turned off. The length of time the battery will be able to supply power to the necessary equipment depends on the current drained by the equipment, the time it took for the pilot to notice the dual failure and to execute protective procedures, and the condition of the battery.

....During night or instrument flight, the pilot should continuously monitor the ammeters and warning light so that prompt corrective action may be initiated if an electrical malfunction occurs. Procedures for dealing with electrical malfunction are covered in detail in the Airplane Flight Manual Section."

1.3.2.4 Extract from the emergency procedures in the aircraft flight manual

Section 3 "EMERGENCY PROCEDURES" of the AFM states, among other things:

ELECTRICAL FAILURES

ALT annunciator light illuminated:

- *Ammeters ..... observe to determine inoperative alternator.*
- *If both ammeters show zero output, reduce electrical load to a minimum.*
- *Turn OFF both alternator switches; then turn them ON momentarily one at a time while observing ammeters.*
- *Determine the alternator showing LEAST (but not zero) amperes and turn its switch on.*
- *Electrical loads, re-establish up to 60 A.*
- *If one ammeter shows zero output, cycle its switch off, then on.*
- *If power is not restored check circuit breakers and reset once if required.*
- *If alternator remains inoperative, reduce electrical loads and continue flight.*

If an ALT annunciator light illuminates observe the ammeters to determine which alternator is inoperative. If both ammeters show zero output, reduce electrical loads to the minimum. Turn OFF both alternator switches and then turn them momentarily ON one at a time while observing the ammeters. The alternator showing the LEAST (but not zero) current should be turned ON. The other alternator should be left OFF. Electrical loads may be reinstated as required to a maximum of 60 amperes.

If one ammeter shows zero output, cycle its switch OFF and then ON. If this fails to restore output check the circuit breakers. The breakers may be reset once if required. If the alternator remains inoperative reduce electrical loads if necessary and continue the flight.

Corrective maintenance actions should be performed prior to further flights.

ALTERNATOR FAILURE IN ICING CONDITIONS

If an alternator fails during flight in icing conditions, an attempt should be made to reset the alternator overvoltage relay by cycling the corresponding alternator switch OFF and then ON. Check the circuit breakers and, if possible, reset any that have popped.

If these attempts to restore the alternator have failed, turn off all avionics except one NAV COM and TRANSPONDER. Turn off the electric windshield to maintain a load less than 65 amperes. If icing conditions continue terminate flight as soon as practical.

Prior to landing the electric windshield may be turned on if necessary. If the battery has been depleted the gear may require free-fall extension and the green gear lights may not illuminate.

1.3.2.5 Relevant manufacturer's instructions

For this aircraft type, Piper has published a Service Bulletin concerning "aluminum wire inspection/replacement", classified as "Piper Considers Compliance Mandatory". This is Service Bulletin Piper 836A dated 26 August 1986:

"WARNING

- *PURPOSE: Field reports have been received of corrosion resulting in overheating of the wire due to high electrical resistance. If this condition exists and is left uncorrected, excessive heat build-up could result in an electrical fire. Corrosion and resulting high resistance can also occur in the battery to ground, battery to master relay, master relay to starter solenoid, starter solenoid to starter and engine return ground cables".*
- *Compass error may exceed 10° with both alternators inoperative….."*

This manufacturer's instruction had not been carried out on HB-LOG.

1.3.3 Information on the technical documents

- From the year 2000, the maintenance company's job reports repeatedly mentioned problems with water penetration and moisture in the cabin.
- Corrosion problems had been mentioned regularly in the FOCA's test reports since 1988.
- The technical documents indicate that measures to eliminate the corrosion problems were not implemented several times.
- The onboard battery had been changed three times since September 2003. The technical documents have the following entries concerning this: on 16.09.2003 at 3475:24 operating hours, battery S/N G02094061 installed; on 03.09.2004 at 3597:00 operating hours, battery S/N G02117743 installed; and finally, on 04.03.2005, battery S/N G02185767 installed.

- No faults had been noted since the replacement of the battery on 04.03.2005 and no fault rectification was certified in relation to the electric power supply.
- In "workorder FTS01/00015" of the work report for the annual and 100 hour check on 12.03.2001 at 3298:36 operating hours, the replacement of the right ammeter was certified. In the "corrective action" column of the work report, the maintenance company stated that at the next check it would be necessary to check the "paralleling" and the right "voltage regulator". The technical documents did not note any check on "paralleling" or the "voltage regulator" since that time.
- The periodic check of the left altimeter and altitude encoder was due on 21.11.2005. According to the FOCA technical message (TM) 20.020-20, this check has to be carried out every 24 months. The last check was carried out on 21.11.2003. The check on the right-hand altimeter was due on 25.02.2006.
- Several confirmations are missing in the equipment log, such as the one concerning the check on the magnetic compass according to TM 20.040-00, the implementation of airworthiness directive (LTA) HB-2000-460R2 "mode "S" and "C" transponder system" or the one concerning the periodic altimeter check according to TM 20.020-20.
- The possible tolerances for the due dates for maintenance work according to TM 02-020-031 were exceeded. This also applies to the minimum annual maintenance according to TM 02-020-10. This fact was mentioned in the FOCA inspection report No. 004/BB/05 dated 04.03.2005.
- The validity of the GPS Trimble 2000 navigation database had expired on 16.02.2006.
- In the technical documents for the right-hand engine, a 100 hour check was certified on 31.08.2005 at 498:18 operating hours. Implementation of LTA HB-96-375 relating to "magneto impulse coupling", which is due every 500 operating hours, was not confirmed in the documents. At the time of the serious incident, the engine showed 549:26 operating hours.

1.3.4 Tests and research results

After the serious incident, as part of a test run on the ground, the damaged feed connection to the left alternator switch (field) was temporarily secured. Both engines were started and stabilised at 1200 rpm. The findings were as follows:

- With the left alternator on, the ammeter indicated only 5 amps (A), whilst the right ammeter oscillated within a range from 0 to 35 A. After some consumers were switched on, the display stabilised.
- During the same test run at a speed of 1500 rpm, the observed difference between the two ammeters was more pronounced. With some consumers switched on, the left ammeter indicated a current of 10 A and the right alternator a current of 70 A at a voltage of 14.1 volts (V).

- In a further test run at 2000 RPM, the charging indication initially appeared to be delayed. After the alternator switches were operated several times, the on-board electrical system stabilised at a voltage of 14.5 V. When the left alternator alone was switched on, with consumers it delivered a current of 70 A at a voltage of 12.4 V. With the same consumers, the right ammeter, during operation with the right alternator alone, indicated a current of 70 A at a voltage of 12.3 V. After this test, the left voltage regulator initially functioned erratically and finally failed.
- According to the battery manufacturer, the battery delivers 23 A for one hour, 40 A for 30 minutes or, for a cold start, 250 A for 60 seconds.
- After repairs to the aircraft's electrical system, a load analysis was produced with the right alternator switched on. With the aid of the discharge report, it was possible to calculate that with the consumers for the flight of 2 March 2006 switched on it would have taken approximately 25 minutes for the battery voltage to fall to 9 to 10 V. The GPS and the VHF/COM equipment fail at about this voltage.

1.4 Guidelines of the International Civil Aviaton Organisation

The following sections of the Annex 2 "Rules of the air" of the Convention on International Civil Aviation of 7 December 1944 are relevant to the serious incident:

1.4.1 Communication failure

3.6.5.2. Communication failure. (...)

3.6.5.2.1. If in visual meteorological conditions, the aircraft shall:

a) continue to fly in visual meteorological conditions; land at the nearest suitable aerodrome; and report its arrival by the most expeditious means to the appropriate air traffic control unit.

b) if considered advisable, complete an IFR flight in accordance with 3.6.5.2.2[2]

1.4.2 Interception

The ICAO Annex 2, Attachment A, "Interception[3] of civil aircraft" describes the basic interception procedures as follows:

3.3 Manoeuvres for visual identification

The following method is recommended for the manoeuvring of intercepting aircraft for the purpose of visually identifying a civil aircraft:

---

[2] Section 3.6.5.2.2 describes the criteria for the continuation of the flight according to instrument flight rules, which requires functional navigation equipment however. After the total loss of the electrical power on the aircraft this requirement was not given anymore.

[3] The term Interception means tracing a civil aircraft by a military aircraft. This term however, does not contain any information about the further proceeding after finding the aircraft in question.

Phase I

The intercepting aircraft should approach the intercepted aircraft from astern. The element leader, or the single intercepting aircraft, should normally take up a position on the left (port) side, slightly above and ahead of the intercepted aircraft, within the field of view of the pilot of the intercepted aircraft, and initially not closer to the aircraft than 300 m. Any other aircraft, preferably above and behind. After speed and position have been established, the aircraft should, if necessary, proceed with Phase II of the procedure.

Phase II

The element leader, or the single intercepting aircraft, should begin closing in gently on the intercepted aircraft, at the same level, until no closer than absolutely necessary to obtain the information needed. The element leader, or the single intercepting aircraft, should use caution to avoid startling the flight crew or the passengers of the intercepted aircraft, keeping constantly in mind the fact that manoeuvres considered normal to an intercepting aircraft may be considered hazardous to passengers and crews of civil aircraft. Any other participating aircraft should continue to stay well clear of the intercepted aircraft. Upon completion of identification, the intercepting aircraft should withdraw from the vicinity of the intercepted aircraft as outlined in Phase III.

Phase III

The element leader, or the single intercepting aircraft, should break gently away from the intercepted aircraft in a shallow dive. Any other participating aircraft should stay well clear of the intercepted aircraft and rejoin their leader.

2 Analysis

2.1 Technical aspects

The aircraft was continuously subjected to temperature fluctuations, leading to the formation of condensation inside the aircraft. Water was also found to have penetrated the front section of the fuselage. The front carpet in the aircraft and various accessories in the nose baggage section were still wet at the time of the investigation. Corrosion problems were also noted several times in the technical documents and in the FOCA inspection reports.

The poor condition of the aircraft was known to the FOCA, the maintenance company and the operator, but was not adequately corrected.

The frequent replacement of the onboard battery and the serious problems when starting the engines provided further indications of the impending fault, which finally caused the serious incident.

2.2 Human and operational aspects

After a flight time of 17 minutes, the pilot noticed the flashing “low battery voltage” message on the EDM 760 TWIN multifunction display. At the same time, he realised that the “ALT” warnings on the annunciator panel and “LOW VOLT” on the right panel were illuminated. When attempting to clarify the situation, he did not follow the instructions in the “troubleshooting chart” and the procedures in the AFM. Moreover, these documents were difficult for the pilot to access, as they were on the passenger seat behind the copilot’s seat.

Although he did not assume a total failure of the left generator, he operated the alternator switches. It can be concluded that these switches were not placed in the correct position. This applies in particular to the right alternator switch, which was found to be in the “OFF” position after the incident.

If the pilot had proceeded in accordance with the AFM emergency procedures, he would soon have realised that the right alternator was still functional. This fact would have allowed him to continue the flight with reduced power consumption and this would have prevented the serious incident.

Without the functional right alternator and initially with large consumers switched on, the remaining battery capacity would have been exhausted after a further 30 minutes.

The decision to continue the flight to Locarno in anticipation of a total electrical power failure, is understandable because, based on the weather situation, an approach under visual flight conditions was only possible on the south side of the Alps. This also complied with the proposed ICAO guidelines relative to a communication failure (see chapter 1.4.1). Nevertheless, it must be mentioned that this flight route lead through controlled airspace over a long distance which was not unproblematic. HB-LOG subsequently flew without radio contact to the south and was unable to follow the planned flight path in accordance with the IFR flight plan. Its flight path was able to be monitored only to a limited extent by using primary radar.

After entering Swiss airspace, two F-5 fighter aircraft were instructed to find HB-LOG and then to escort it south.

This patrol acquired radar contact with the Piper relatively quickly. However, it was able to establish visual contact only during a second interception attempt. The two Tigers then followed HB-LOG for a few minutes. According to the military pilots' statement, they were behind the Piper Seneca throughout the whole interception manoeuvre. According to ICAO procedures, an intercepting aircraft should fly rather higher and in front of the aircraft being intercepted, in order to enable the interceptor to be seen (see chapter 1.4.2). It must remain an open question whether in the present case the pilot of HB-LOG would have recognised the F-5 fighter aircraft in the correct interception position, since the side windows of the cockpit were iced up.

It was probably for the same reason that the pilot of the Piper Seneca did not perceive the F/A-18 fighter aircraft which replaced the F-5s. By chance, the pilot initiated a turn which was interpreted by the pilot of the identifying F/A-18 as a sign of cooperation. In fact, HB-LOG continued to descend for a landing in Locarno, without its pilot noticing the F/A-18. The military patrol were still of the opinion that the Piper Seneca would land in Lugano, because the message from the pilot of HB-LOG to the effect that he would be landing in Locarno had not been forwarded consequently by the ground control units. For this reason, the pilot of an F/A-18 informed the Lugano tower that he would escort HB-LOG when it landed. It was only over Lake Maggiore that the pilot of HB-LOG sighted the fighter aircraft for the first time, but was unable to interpret the behaviour of these aircraft correctly and landed in Locarno without taking any further notice of them.

3 Conclusions

3.1 Findings

- The pilot was in possession of the appropriate licences and ratings.
- The aircraft was rated for non-commercial transport for VFR day and night, IFR Cat I and B-RNAV (RNP 5).
- Signs of condensation water and considerable amounts of water penetration were found in the aircraft.
- The aircraft's electrical system, particularly the power distribution section, exhibited considerable corrosion.
- Several confirmations for maintenance work were missing from the technical documents. The applicable time tolerances for maintenance work to be performed and for the minimum annual servicing work were exceeded.
- The terminal on the master switch for the wire leading to the left alternator switch was broken off.
- No VHF/COM hand-held radio was carried on board.
- According to the pilot, the portable oxygen unit he had on board was used.
- Navigation manual (Jeppesen) and AFM were difficult to access during the flight.
- Seventeen minutes after take-off from Egelsbach, the pilot noticed the alternator fault.
- Some thirty minutes after the pilot had noticed the alternator fault, the onboard electrical system failed completely.
- The pilot decided not to return to Egelsbach but to continue flying south. This decision was accepted by the responsible air traffic control center.
- The pilot also informed the responsible air traffic control centers of his intention to land in Locarno instead of Lugano. This information was not forwarded consistently.
- The Swiss Air Force carried out several interception manoeuvres to escort the aircraft south. These manoeuvres allowed identification of the aircraft and verification of its altitude.
- According to his statement, the pilot of HB-LOG did not realize the intercepting manoeuvres as such.
- After landing in Locarno, the right alternator switch was found in the OFF position.
- Over Germany and over the north side of the Alps weather conditions as prevailing at the rear of a front, with occasional snow showers, were active. This made a safe approach according to visual flight rules on an aerodrome in this area practically impossible. On the south side of the Alps good visual flight conditions existed.

3.2 Causes

The serious incident is attributable to a total failure of electrical power supply to the aircraft.

The following factors were causal to the serious incident:

- the poor technical condition of the aircraft
- the emergency procedures published in the AFM were not applied.

Berne, 16 January 2008 Aircraft Accident Investigation Bureau

Annex 1

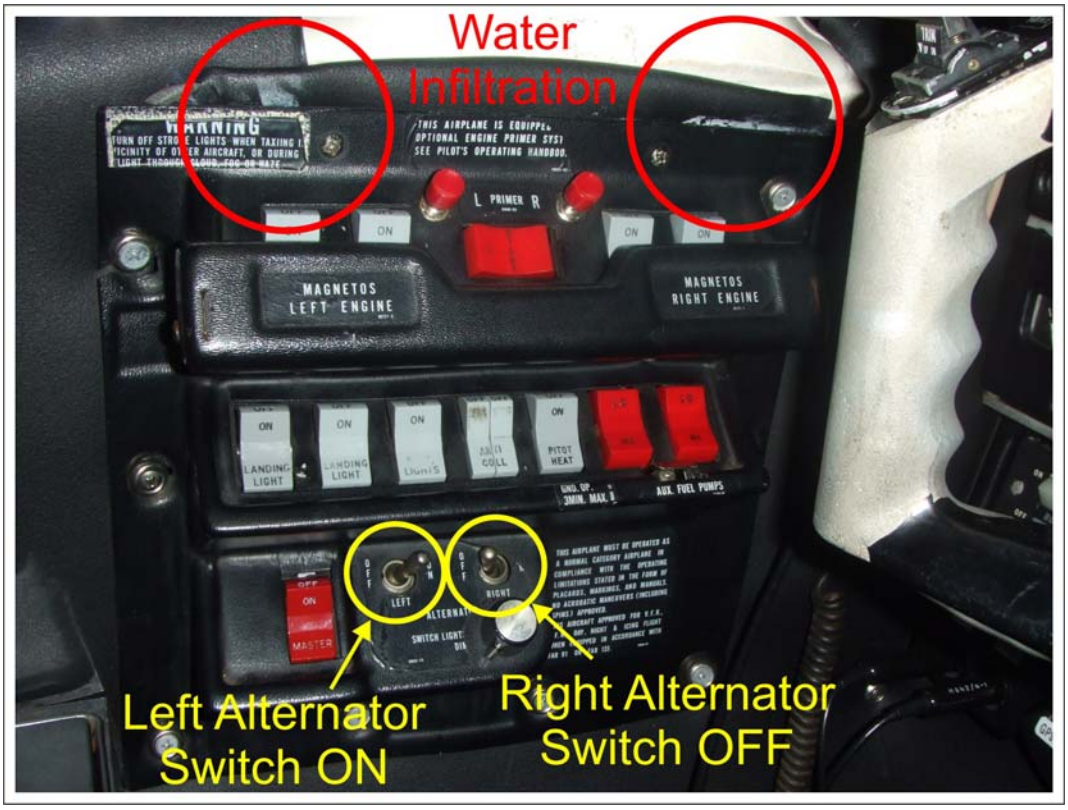

Fig. 1 Electrical switches on the left side of the cockpit of HB-LOG

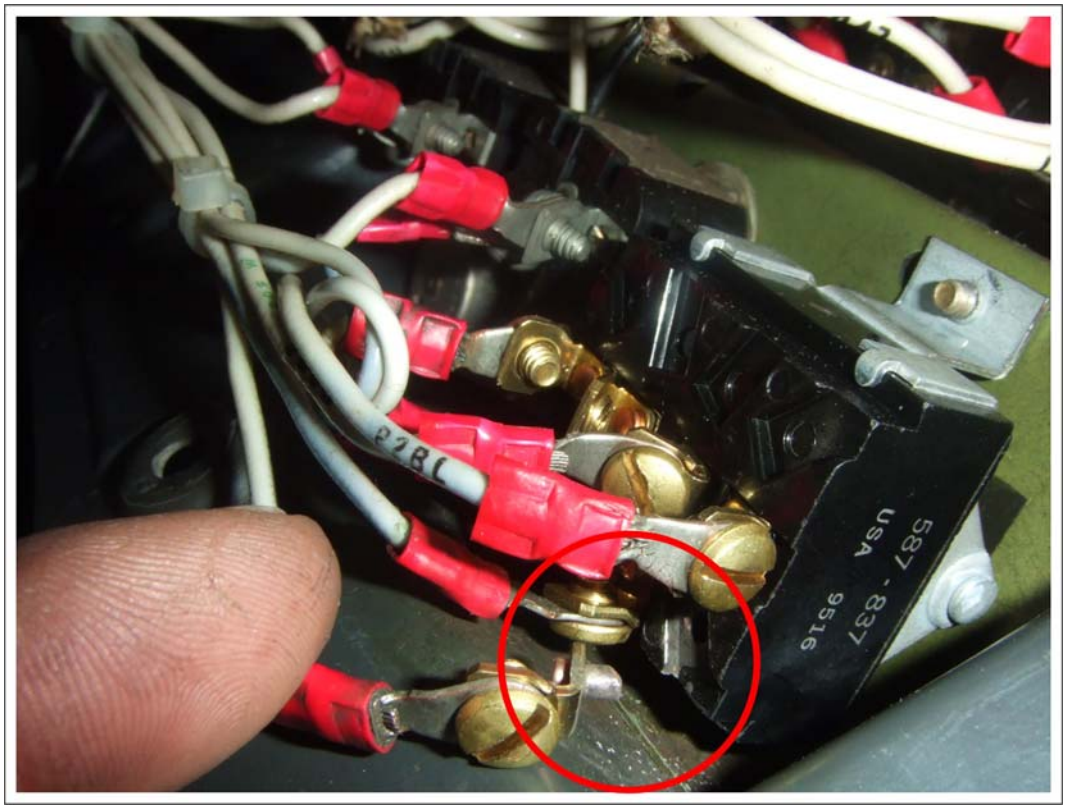

Fig. 2 Broken connection on master switch

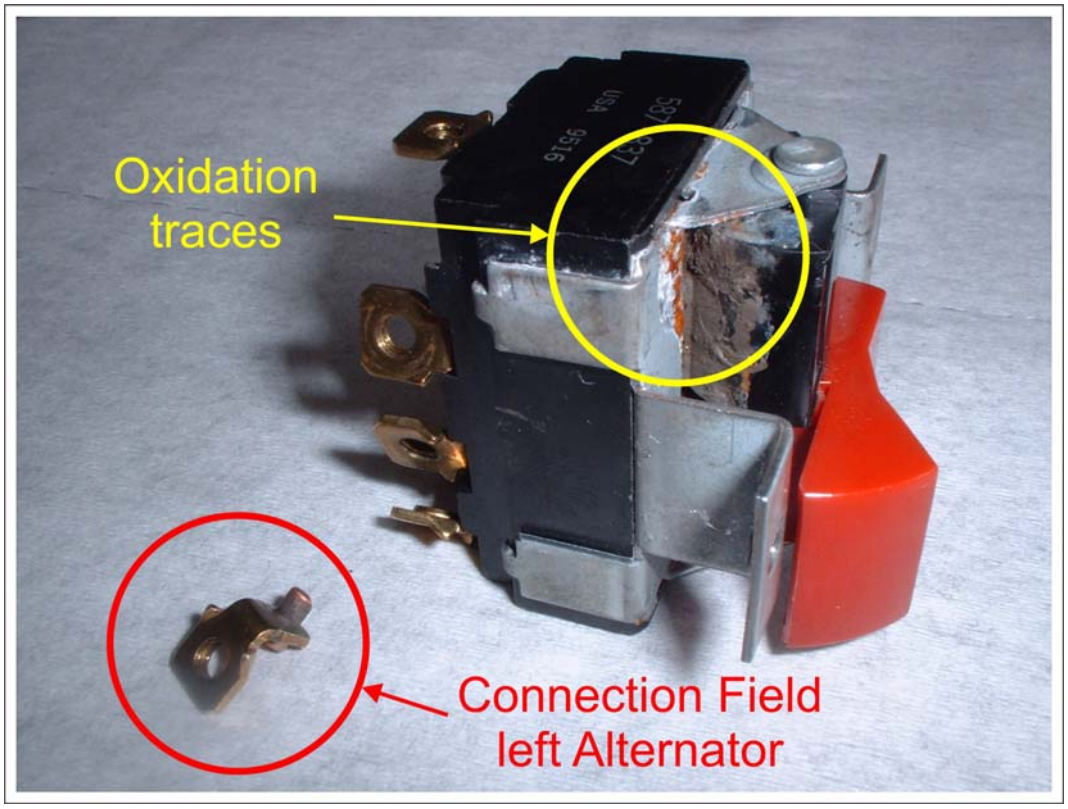

Fig. 3 External view of master switch

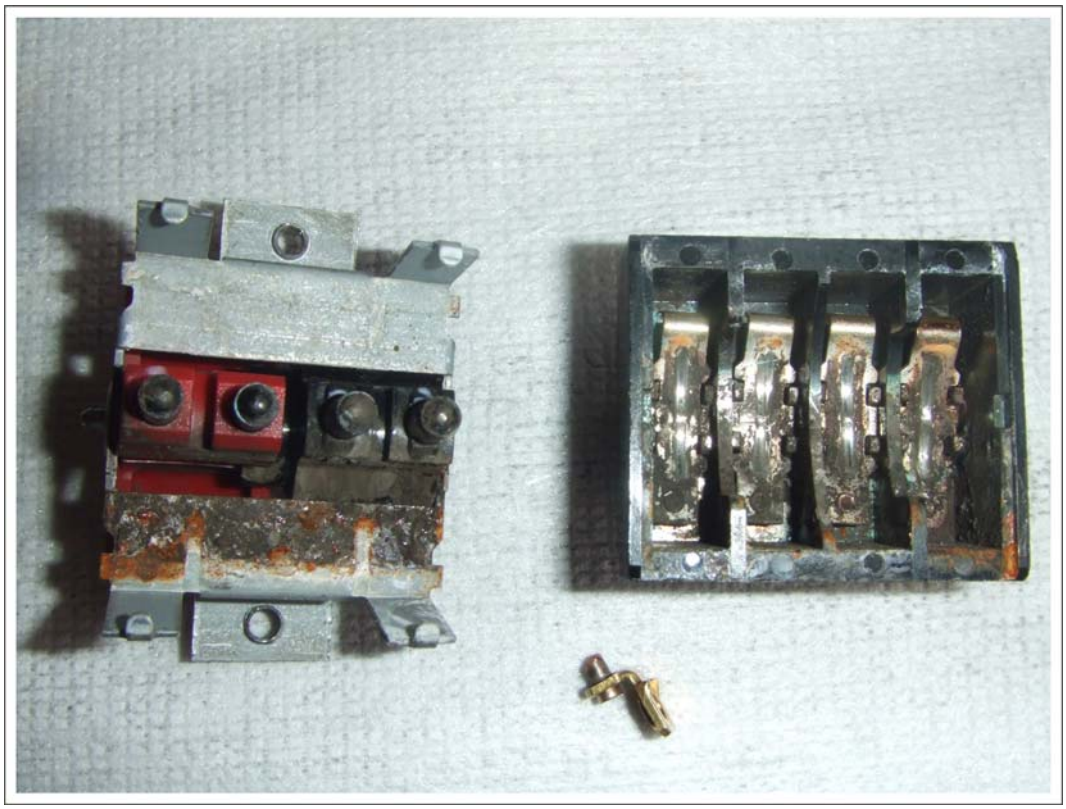

Fig. 4 Internal view of master switch