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Swiss Accident Investigation Board SAIB

Aviation Division

Final Report No. 2146 by the Swiss Accident Investigation Board SAIB

concerning the accident involving the Cirrus SR22 aircraft, registration N467BD

on 22 October 2008

Zurich Airport

Aéropole 1, Route de Morens, 1530 Payerne
Tel. +41 26 662 33 00, Fax +41 26 662 33 01
info@sust.admin.ch
www.saib.admin.ch

Ursachen

Der Unfall ist darauf zurückzuführen, dass der Pilot während einer eng und in geringer Höhe über Grund geflogenen Kurve die Kontrolle über das Flugzeug verlor und dieses in der Folge auf dem Boden aufprallte.

Die folgenden Faktoren haben Voraussetzungen für den Unfall geschaffen oder dessen Entstehung begünstigt:

- Der Umgang des Piloten mit dem Ausfall eines teilredundanten Systems, der die Auswirkungen der Panne nicht verminderte, sondern verschärfte.
- Ein unzutreffendes Bewusstsein über die tatsächliche Situation, welches den Piloten zu einer zu optimistischen Angabe über seine Lage an die Flugverkehrsleitung veranlasste und ihn davon abhielt, eine Notlage zu erklären.
- Eine unzweckmässige Nutzung der vorhandenen Navigationshilfsmittel.
- Der Pilot führte für den Ausweichflugplatz Zürich keine Anflugkarten mit sich.
- Ein unzureichendes Verständnis innerhalb der Flugverkehrsleitung über die Bedeutung von Störungen und Notlagen bei durch einen einzelnen Piloten geflogenen einmotorigen Kleinflugzeugen in anspruchsvollen Wetterbedingungen.
- Die verhältnismässig lange Dauer zwischen dem Auftreten der Störung und dem Beginn des Anfluges.
- Der Entscheid des Piloten, der Flugverkehrsleitung eine hohe Anfluggeschwindigkeit anzubieten.
- Der Entscheid des Piloten, mit dem Flugzeug aus einer für eine Landung ungünstigen Ausgangslage in Instrumentenwetterbedingungen nach Sicht ein anspruchsvolles Manöver durchzuführen.
- Eine hohe Flugmasse.

General information on this report

This report contains the Swiss Accident Investigation Board's (SAIB) conclusions on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Art 3.1 of the 10th edition, applicable from 18th November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent 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, follow the coordinated universal time (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is:
LT = CEST = UTC + 2 hours.

Contents

Final Report

Synopsis

Owner	Aircraft Guaranty Management LLC Trustee, 515 N Sam Houston PKWY E STE 305, Houston, TX 77060-4023, Texas (USA)
Operator	Private
Manufacturer	Cirrus D Corporation, 4515 Taylor Circle, Duluth, MN 55811, Minnesota (USA)
Aircraft type	Cirrus SR22
Country of registration	United States of America
Registration	N467BD
Location	Zurich airport, in the vicinity of the threshold of runway 14
Date and time	22 October 2008, 13:58 UTC

Investigation

The accident occurred at 13:58 UTC. The investigation was opened on 22 October 2008 at approximately 16:00 UTC in cooperation with the Zurich cantonal police.

The present final report is published by the Swiss Accident Investigation Board (SAIB).

Summary

Owing to a technical problem in the onboard electrical system, the pilot decided when south of Zurich to abort the flight with three passengers on board from Geneva to Berlin-Schönhagen and to land at Zurich airport. After an instrument approach on runway 14 associated with navigation problems, the pilot attempted, by means of visual flight navigation, to bring N467BD into a position from which a landing on runway 14 would have been possible. In the course of this manoeuvre, shortly before the beginning of runway 14, N467BD collided with the ground from a right turn. The pilot and the male passenger in the front right seat were fatally injured in the crash. The female passenger in the rear right seat died a few days after the accident from her injuries. The male passenger in the rear left seat was seriously injured. The aircraft was destroyed during the accident. Fire did not break out.

Causes

The accident is attributable to the fact that the pilot lost control of the aircraft during a tight turn flown at a low height above ground and then collided with the terrain.

The following factors created conditions for the accident or favoured its occurrence:

- The way the pilot dealt with the failure of a partially redundant system, which did not mitigate the effects of the malfunction but exacerbated them.
- An inapplicable awareness of the actual situation, which prompted the pilot to give an over-optimistic assessment of his situation to air traffic control and prevent him from declaring emergency.
- Inappropriate use of the available navigation aids.

- The pilot was not in possession of any approach charts for the alternate aerodrome, Zurich.
- An inadequate understanding within air traffic control of the significance of faults and emergencies on single-engine light aircraft flown by a single pilot in challenging weather conditions.
- The relatively long period between the occurrence of the fault and the start of the approach.
- The pilot's decision to offer the air traffic control a high approach speed.
- The pilot's decision to carry out a demanding manoeuvre with the aircraft visually, in instrument weather conditions, from an initial position unfavourable for a landing.
- A high flight mass.

In the context of the investigation, no safety recommendations were issued. This accident, together with other accidents, has led to greater clarification of the dangers which result from the non-deployment of ballistic rescue systems in the course of the accident. The results of these investigations, along with corresponding safety recommendations, were published in an additional report.

1 Factual information

1.1 Pre-history and history of the flight

1.1.1 General

The recordings of the radiotelephony and telephone communications, the radar data, the recordings of the primary flight display (PFD) and the multifunction flight display (MFD), as well as the statements of the surviving passenger, the air traffic control officers involved and eye-witnesses were used for the following description of the pre-history and history of the flight.

The flight was conducted in accordance with instrument flight rules (IFR). The north side of the Alps remained under largely complete cloud cover for the entire day. Almost the entire flight took place in cloud.

To assist in the understanding of the interrelationships in the description of the history of the flight, a brief description of the aircraft and air traffic control is given first.

1.1.2 Brief description of the aircraft

The Cirrus SR22 is a single-engine aircraft, fitted with a 310 HP Teledyne Continental engine, of composite monocoque construction, low-wing design, with fixed landing gear. Two screens by the manufacturer Avidyne were installed in N467BD to display the relevant flight and engine parameters. It was therefore equipped with a glass cockpit.

The primary flight display (PFD, cf. Annex 3) directly in front of the pilot is used to display the primary flight and navigational instruments, among other things:

- Electronic attitude direction indicator (EADI)
- Airspeed indicator (ASI)
- Altitude indicator (AI)
- Vertical speed indicator (VSI)
- Electronic horizontal situation indicator (EHSI)
- Horizontal deviation indicator (HDI)
- Vertical deviation indicator (VDI)

The multifunction flight display (MFD, cf. Annexes 4 and 5) directly to the right next to the PFD is used to display additional flight, navigation or engine parameters and includes, among other things, the following display options:

- MAP page (display of a simplified map with relief and bodies of water, airspace structures and navigation aids, information about static discharges and the position and altitude of other aircraft)
- ENGINE page (display of a number of engine parameters plus parameters of the electrical system)
- CHECKLIST pages (display of checklists, in particular the emergency procedures)
- CMax chart page (display of terrain maps plus arrival and departure charts for instrument flights, based on a Jeppesen database)

In addition to these digital displays, conventional instruments are installed as a back-up for the most important flight instruments. On the right next to the MFD there are also conventional, electromechanical engine instruments.

In the centre console, for navigation and communication, two Garmin GNS 430 units (COM/NAV/GPS #1 and #2), the intercom system, the autopilot and the transponder were installed. By coupling the PFD to a GNS 430 and the autopilot it was possible to carry out fully automated instrument approaches along an instrument landing system (ILS).

The aircraft had two largely separate electrical systems (cf. Annex 7): the main distribution bus, supplied by Alternator 1 or Battery 1, and the essential distribution bus, supplied by Alternator 2 or Battery 2. A diode which connects the two buses allows the essential distribution bus to be supplied by the main distribution bus, but not vice versa.

1.1.3 Brief description of air traffic control

Some of the air traffic control units involved in the flight of N467BD were stationed in the Zurich terminal control centre at Zurich Airport:

- Departure (DEP) – responsible for departures
- Coordinator Approach (CAP) – responsible for coordinating approaches
- Approach East (APE) – responsible for approaches from the north and east
- Final (FIN) – responsible for final approaches

Others were situated in the control tower:

- Daily Operation Manager (DOM) – directs the operation of aerodrome control, ground, clearance delivery and approach.
- Aerodrome Control (ADC) – responsible for take-offs and landings
- Ground (GRO) – responsible for movements on the ground

In air traffic control, in approach control the following workstations were occupied: Coordinator Approach (CAP), Departure (DEP), Approach West (APW), Approach East (APE) and Final (FIN). In the control tower, the following workstations were occupied: Daily Operation Manager (DOM), Aerodrome Control (ADC), Ground (GRO) and Clearance Delivery (CLD).

In contrast to the tower, the workstations in the terminal control centre have no visual contact to the outside and the corresponding air traffic control officers are dependent on screens and television monitors for weather information.

The traffic volume was high with normal complexity owing to the peak in approaches.

1.1.4 Pre-history

The pilot was the director and co-owner of a company which employed several hundred people in Poland and which had its headquarters in Geneva. He used aircraft N467BD, a Cirrus SR22, mainly for business travel.

Prior to the acquisition of the aircraft involved in the accident, the pilot had already operated a different Cirrus SR22 and replaced it with N467BD in March 2008. The first aircraft was still fitted with conventional flight instruments.

On Monday, 20 October 2008, the pilot flew with two employees of his company from an airfield in the vicinity of the town of Zielona Gora in western Poland to Geneva to visit the headquarters of the company. On this flight, according to the MFD recordings, the onboard electrical system functioned normally.

The return flight via Berlin-Schönhagen was planned for Wednesday 22 October 2008. On this flight, an additional company employee, who had flown to Geneva on a scheduled flight the day before, was on board. This passenger was the only occupant of the aircraft to survive the accident. He had flown with the pilot for several hundred hours on the first SR22 which the pilot operated and subsequently on the aircraft involved in the accident. He occupied the rear left seat on the flight involved in the accident. On the basis of his flying experience as an interested passenger, he was subsequently able to provide sound information on the history of the flight involved in the accident. He did not possess a pilot's licence.

The papers found in the aircraft do not permit any conclusions to be drawn concerning the preparation of the flight.

The pilot submitted an ATC flight plan by fax for a "Y" flight (first part of the flight under instrument flight rules, second part under visual flight rules) to Berlin-Schönhagen, where customs and immigration formalities were to be completed. Among other things, the ATC flight plan included the following information:

- Estimated off-block time: 12:00 UTC
- Cruising speed: 160 kt
- Cruising altitude: flight level (FL) 140
- Route: instrument flight as far as waypoint MILGU, then visual flight to Berlin-Schönhagen
- Flight duration: 3:00 hours
- Alternate airport: Berlin-Schönefeld
- Maximum endurance: 5:30 hours
- Number of persons on board: 4

The pilot prepared the aircraft alone. He had it refuelled with 184 litres of AVGAS and then taxied from the grass parking lot on which the aircraft had been parked for two nights to the General Aviation Terminal. There the three passengers boarded the aircraft.

1.1.5 History of the flight

At 12:34:47 UTC the pilot received from Geneva GND clearance to start the engine, as well as clearance for the part of the flight which was planned to take place under instrument flight rules. The clearance included standard instrument departure KONIL 4C and the planned flight path. The onward flight path after KONIL, according to the flight plan, was to be along airways N871 and N851 over Bern and south of Zurich airport, to the north-east (cf. Annex 1). Clearance was given as far as waypoint MILGU, which lies approximately 40 NM south of the planned destination aerodrome of Berlin-Schönhagen.

At 12:44:40 UTC, N467BD received clearance from Geneva TWR to take off from runway 23. During the climb the pilot was informed that an aircraft flying ahead of him had reported slight icing at 7000 ft. The pilot of N467BD requested and received clearance for a cruising level of FL 80.

The passenger in the rear left seat fell asleep shortly after take-off but woke up briefly several times during the flight. He noticed that the flight level was FL 80 and the outside temperature was 6 degrees Celsius and that they were not therefore flying in icing conditions.

According to the MFD recordings (cf. Annex 6) N467BD experienced an initial failure of alternator 1 at 13:01:24 UTC. At that time N467BD was north of

Lausanne; since take-off from Geneva, rather more than 16 minutes had elapsed. The voltage at the main distribution bus fell sharply from 28.2 volts to 24.9 volts and during the subsequent ~40 seconds continued to fall uniformly to 24.2 volts, but then increased sharply back to 28 volts. During the next approximately 15 minutes, the voltage remained at this normal value but at 13:16:54 UTC fell to 24.5 volts for one scan point[1]. At this time, N467BD was south of Burgdorf. Immediately after this drop, within the timeframe from 13:17:00 UTC to 13:17:06 UTC, the voltage again increased to 28.8 volts, and then at 13:17:12 UTC dropped sharply again to approximately 24 volts. Subsequently the voltage at the main distribution bus fell to 23.6 volts for approximately 4 minutes. During this period, as well during the subsequent flight up to the end of the recording by the MFD, the normal voltage for an intact Alternator 2 of approximately 28.7 volts applied at the essential distribution bus (cf. Annex 6).

In the meantime, N467BD was being guided via the Fribourg (FRI) and Willisau (WIL) VHF omnidirectional radio beacons (VOR) and was navigating on this route with the GNS No. 1 along the GPS waypoints FRI and WIL. The autopilot was engaged in GPS roll steering (GPSS) mode and ALT hold mode. At 13:20:31 UTC the pilot reported on the Zurich departure frequency. The DEP air traffic control officer instructed the pilot to leave WIL beacon on a heading of 075 degrees and to maintain his altitude of FL 80.

At 13:21:18 UTC the voltage at the main distribution bus of N467BD increased back up to approximately 28 volts, before dropping again at 13:23:24 UTC. At 13:25:00 UTC, the voltage was 24.4 volts and it then fell constantly for the next approximately 20 minutes by around 0.1 volts per minute (cf. Annex 6).

At 13:33:03 UTC the pilot reported his intention to divert to Zurich. The aircraft was at this time approximately 10 NM south-east of Zurich airport. When the DEP air traffic control officer asked him for the reasons for this change in his flight plan, the pilot informed him that alternator 1 had failed. In response to the DEP air traffic control officer's enquiry, the pilot confirmed his initial information and added that he could continue to fly for no longer than 45 minutes: *"Ah, we've got a failure of alternator one ah we can't fly for longer than ah forty five minutes Bravo Delta."* The DEP air traffic control officer confirmed that he had understood this and added: *"But confirm normal operation for the approach in Zurich?"* to which the pilot replied *"Affirmative, Bravo Delta."*

As the reason for the diversion, the DEP air traffic control officer understood *"altimeter one failure"* instead of *"alternator one failure"*. As he himself had no flying experience, it was not clear to him whether this malfunction would affect the continuation of the flight. On the basis of the *"normal operation"* confirmation from the pilot, he assumed a normal approach in which the pilot required no special support. He did not consider the period of 45 minutes to be a limiting factor, because he assumed that the approach of N467BD would in any case be handled within a shorter period of time.

The DEP air traffic control officer then informed the Coordinator Approach (CAP) air traffic control officer about the alternate landing of N467BD in Zurich due to an *"altimeter one failure"*, and also mentioned the maximum possible flight duration of 45 minutes, as well as *"normal operation".* He then coordinated with the Zurich Arrival Approach East (APE) air traffic control officer the conditions for the transfer of N467BD to his frequency. In this context, he also informed him that the aircraft was diverting to Zurich because of an *"altimeter one failure"* and had re-

[1] Recording takes place at intervals of 6 seconds.

ported *"normal operation"*. It was no longer possible to determine whether the period of 45 minutes was mentioned.

At 13:35:03 UTC the CAP air traffic control officer instructed the FDO/TS (flight data operator and trouble shooter) unit by telephone to amend the flight plan of N467BD for the diverted landing in Zurich. The electronic flight strip in the TACO (tower and approach coordination) system was then shown on all screens in approach control and in the control tower as an inbound flight.

At 13:35:19 UTC the CAP air traffic control officer informed the Daily Operation Manager (DOM) by telephone about transit flight N467BD, which was diverting to Zurich owing to *"failure altimeter one"* and could fly for no longer than 45 minutes.

According to the DOM air traffic control officer's statement, she understood the information regarding N467BD to mean that the aircraft was diverting to Zurich because of the failure of an alternator and that a maximum flight time of 45 minutes was available for this. The DOM air traffic control officer then asked the air traffic control officers present in the control tower whether there were aircraft with multiple alternators; this was answered in the affirmative. The DEP air traffic control officer, the CAP air traffic control officer and the DOM air traffic control officer were all assuming at this time that the 45 minutes mentioned by the pilot could be scheduled without operational constraints and were available as the latest landing time. According to her own statement, the DOM air traffic control officer then consulted the section on electrical failure in the emergency manual provided. Further precautions were not taken, since the pilot had reported "normal operation".

At 13:35:19 UTC the DEP air traffic control officer gave the pilot the instruction to turn onto a heading of 330 degrees and to maintain FL 80. The current weather data "Golf" from the Automatic Terminal Information Service (ATIS) was then communicated to him. *"Golf is current, visibility five kilometres with clouds few three hundred feet, scattered seven hundred feet, broken one thousand four hundred feet, QNH one zero two one."* The pilot confirmed reception of this information.

At 13:36:49 UTC the DEP air traffic control officer instructed the pilot to maintain the heading and to contact Zurich Arrival. At 13:37:09 UTC contact was made with the Approach East (APE) air traffic control officer, who was responsible for planning the approach sequence and for control of aircraft until transfer to the Final (FIN) air traffic control officer. The APE air traffic control officer instructed the pilot to continue to fly heading 330 degrees and told him that he could expect vectors to the runway 14 instrument landing system (ILS).

On the basis of the confirmation of *"normal operation"* by the pilot, N467BD did not have any higher priority for the APE air traffic control officer. He planned to allow the aircraft to fly on an extended flight path, in order not to interrupt the approach sequence of jet aircraft with this relatively slow aircraft.

At 13:38:48 UTC the CAP air traffic control officer contacted the Ground (GRO) air traffic control officer to coordinate the approach sequence. To enable the planned take-off of an aircraft from runway 16, it was necessary to schedule a gap of 10 NM in the approach sequence. The CAP air traffic control officer asked the GRO air traffic control officer whether he would accept the approach of N467BD in this gap, which the latter, however, rejected because of the bad weather. The CAP air traffic control officer replied that the gap was therefore scheduled after a Turkish Airlines aircraft. N467BD was to follow it.

Immediately after this coordination, the DOM air traffic control officer requested the CAP air traffic control officer not to delay the approach of N467BD unduly and to allow it to approach immediately. The CAP air traffic control officer replied that

N467BD had reported "normal operation" and only *"an altimeter..."*. At this point, the DOM air traffic control officer interrupted the CAP air traffic control officer and said: *"Jo, isch gliich, denn tuet er glich nüme glich lade."* [Yes, whatever, nevertheless it's not charging to the same extent]. The DOM air traffic control officer assumed from the start that N467BD's problem was an *"alternator one failure"* and insisted on an approach of the aircraft without further delay. According to her statement, flights with an abnormality were always a kind of priority for her. The CAP air traffic control officer then confirmed that the approach of N467BD was scheduled after the Turkish Airlines aircraft. The DOM air traffic control officer subsequently twice stated during this telephone coordination that N467BD should not be delayed.

In the meantime, at 13:39:22 UTC the APE air traffic control officer instructed N467BD to descend to 6000 ft QNH, with a QNH of 1021. In the following 10 minutes or so, he guided N467BD with various heading instructions in the direction of the runway 14 approach centre line (cf. Annexes 2 and 11). At 13:40:16 UTC he informed the pilot that he was number seven for the approach. Approximately a minute later, the APE air traffic control officer asked the pilot about the maximum possible speed which he would be able to fly on the ILS. The pilot answered as follows: *"a hundred and sixty we can keep on final Bravo Delta."*

In the same timeframe, on the basis of the discussion with the DOM air traffic control officer, the CAP air traffic control officer made an approach to the APE air traffic control officer about prioritising N467BD in the approach sequence, if possible. The APE air traffic control officer felt somewhat agitated, according to his own statement, because he did not understand why this relatively slow aircraft should be inserted as a priority into the flow of traffic. The CAP air traffic control officer gave no justification for this and subsequently exerted no further influence, since she assumed that the APE air traffic control officer undoubtedly already had a concept about how he would handle the upcoming approaches, including N467BD.

Also within this timeframe, the passenger in the rear left seat woke up because he perceived the change in air pressure during the descent. Because the pilot had selected the intercom mode[2] so that at least the passengers in the rear seats were not connected, the passenger did not have an opportunity to ask the pilot what was happening at that point. Initially he was of the opinion that the Berlin approach charts were displayed on the MFD, but then he realised that they were the Zurich charts. He concluded from this that something was happening which was not in accordance with the original plans.

At a point in time in this phase which can no longer be accurately reconstructed, the APE air traffic control officer changed the approach sequence and shifted the planned gap of 10 NM two positions back in the sequence. N467BD was still expected to follow after this gap.

At 13:46:00 UTC the voltage at the main distribution bus had dropped to 22.3 volts. A few seconds later, the MFD recording indicates a voltage surge to approximately 26 volts, but then it immediately fell back to the initial value. From this point on, the voltage fell distinctly more rapidly (cf. Annex 6).

According to the recorded data from the PFD memory, from the time of the instruction given by the DEP air traffic control officer to *"proceed Willisau and then on a heading 075"* the pilot had been flying with the aid of the autopilot's heading

[2] Onboard communication system which is used for communication between pilot and passengers and among passengers.

mode. Since passing the WIL beacon, waypoint GIPOL had been active in the Garmin 430 #1. At 13:46:18 UTC the pilot switched the source of the navigation data which was displayed on the EHSI from GPS to VLOC; the 108.3 MHz frequency was selected, which corresponded to that of the runway 14 instrument landing system. However, he did not change the desired course of 015 which had been automatically set since passing the Willisau VOR, corresponding to the heading from Willisau VOR to waypoint GIPOL. The EHSI course selector, which constitutes the landing course for navigation on the instrument landing system, was set to 015°. The inbound course of ILS 14 was 137°.

When the DOM air traffic control officer noticed that the agreed approach sequence had been changed, she asked the CAP air traffic control officer on the telephone at 13:46:46 UTC when the necessary gap of 10 NM for the scheduled departure from runway 16 was planned. After this gap, N467BD was to approach. The CAP air traffic control officer, who had initially not noticed the change in the sequence, confirmed the change and apologized, saying: *"Sorry, das isch e chli untergange."* [Sorry, that rather escaped my attention]. The DOM air traffic control officer then again expressed her concern that N467BD had not been placed earlier in the approach. The CAP air traffic control officer replied that she had relayed this. After the accident, the CAP air traffic control officer reported that she was of the opinion that she had had no possibility of enforcing a priority on APE for an approach.

At 13:48:18 UTC the pilot of N467BD was requested by the APE air traffic control officer to make contact with the Final (FIN) air traffic control officer. According to the FIN air traffic control officer's statement, at this time he had no exact knowledge of the reasons why this flight was diverting to Zurich. Since he had listened in along with the APE, he knew that there were technical problems, but not what kind of technical problems. He had been told that the pilot had reported *"normal operation"*.

At 13:49:19 UTC the FIN air traffic control officer assigned a heading of 320 degrees to N467BD, which brought the aircraft onto the downwind leg (cf. Annex 11). He made this heading change to guarantee a sufficient distance from an aircraft ahead of it in the medium weight category. At 13:49:27 UTC N467BD received clearance to descend to 5000 ft QNH and, at 13:50:00 UTC, clearance to descend to 4000 ft QNH.

During the descent, N467BD first received the instruction at 13:51:10 UTC to turn onto a heading of 230 degrees into the base leg and was then instructed at 13:52:13 UTC to turn left onto a heading of 170 degrees. The pilot received clearance for an instrument approach on runway 14 and was instructed to report when the aircraft was established on the approach centre line and the glide path.

At about this time the voltage at the main distribution bus reached 16 volts. At this voltage the MFD screen failed in test, done by the Aircraft Accident Investigation Board (SAIB) (cf. section 1.16.1.3). The passenger in the rear left seat observed how the display on the MFD began to flicker and then failed.

At 13:52:48 UTC the last dataset was recorded in the MFD memory (cf. Annex 6). The last recorded voltage at the main distribution bus was 12.1 volts.

The passenger in the rear left seat realised in this phase of the flight that the display of the lower of the two Garmin GNS 430 units (COM/NAV/GPS #2) was dark. The upper one was working normally and he could see the information *"ILS 14"* on the display. In addition, he noticed how certain engine indications were fluctuating, but had the impression that the engine was running normally. The transponder also failed, in his opinion.

At around 13:53 UTC N467BD crossed the localiser of the runway 14, at a distance of approximately 11 NM from the runway threshold and at an altitude of approximately 4300 ft QNH, still descending (cf. Annex 11). N467BD was therefore below the ILS 14 glide slope (GS), which had an approach angle of three degrees.

N467BD did not then turn onto the ILS 14 approach centre line, but continued its descent on an unchanged heading of approximately 170 degrees. At 13:53:30 UTC the FIN air traffic control officer informed the pilot of this and instructed him to turn onto heading 110 degrees, in order to establish himself on the ILS, now from the west. The pilot confirmed this with the words: *"Turn left one one zero Bravo Delta established runway one four.“*

Immediately afterwards, the FIN air traffic control officer asked the pilot whether he was able to receive the localiser signal. The pilot replied: *"I pick up the localiser signal but can't see the glide slope yet."* The FIN air traffic control officer informed the pilot that he was below the glide slope and to the right of the localiser. At this time the aircraft was flying at a distance of approximately 10 NM from the threshold of runway 14 at an altitude of approximately 4000 ft QNH.

According to the PFD recordings, the pilot flew N467BD until 13:53:51 UTC with the autopilot switched on and active ALT[3] mode and HDG mode. At 13:53:52 UTC, the autopilot was switched off. N467BD was at this time on a heading of 112°.

At 13:54:27 UTC, the pilot of N467BD reported: *"Sorry Final Bravo Delta can we make the heading for the runway we’re getting some difficulties with the power now."* The FIN air traffic control officer replied to this information: *"Understand you’re unable to pick up the localiser."* The pilot replied: *"Ah we get the localiser but I don’t think we can trust that indication."* At the request of the FIN air traffic control officer, the pilot repeated this information.

After instructions to two following aircraft, the FIN air traffic control officer asked at 13:55:05 UTC: *"And N7BD confirm you are established on the ILS?"* The pilot answered in the negative. The FIN air traffic control officer then asked about his current altitude and received the following answer from the pilot: *"3300 ft, heading one four four."* The FIN air traffic control officer again informed the pilot that he was somewhat to the right of the localiser and asked whether he was in a position to continue the approach. The pilot confirmed: *"OK we can continue on the current heading for the time being Bravo Delta."* In this phase, altitude information was no longer being displayed on the radar screen and at 13:55:27 UTC secondary radar contact was lost completely (cf. Annex 8).

At 13:55:33 UTC the FIN air traffic control officer again asked about the altitude and whether the pilot was receiving the glide slope signal. The pilot reported an altitude of 3300 ft and that he was not receiving the glide slope signal. Then, at 13:55:44 UTC, because of the loss of radar contact and the fact that the aircraft was not established on the ILS, the FIN air traffic control officer ordered the approach to be aborted: *"N7BD roger continue present heading climb to 6000 feet."* The pilot confirmed at 13:55:49 UTC: *"continue present heading and climb to 6000 feet."* According to the radio recordings he initiated a climb shortly afterwards. This can be seen from the altitude reports by the pilot, who at 13:55:13 UTC reported an altitude of 3300 ft, and at 13:56:17 UTC an altitude of 3500 ft. These values are consistent with the recorded PFD data.

[3] When the autopilot altitude (ALT) mode is selected, it keeps the aircraft at a constant pressure altitude.

The air traffic control officers in the control tower had in the meantime also selected the FIN frequency, in addition to the aerodrome control frequency, in order to monitor radio traffic with N467BD, and were observing the approach on the radar screen. In view of the unclear progress of the flight they decided not to allow any more take-offs, as they were considering the possibility that N467BD might land on a runway other than runway 14.

At 13:56:17 UTC the pilot of N467BD reported in response to the FIN air traffic control officer's question about altitude: *"3500 we're experiencing some power failure request to change to VFR. We got a visual on the ground, we can proceed this way."* The pilot answered the FIN air traffic control officer's question about whether he could see the runway as follows: *"Er negative no runway in sight we just have a visual to the ground."* At this time a primary echo appeared on the radar which was assigned to N467BD by the FIN air traffic control officer. The echo showed N467BD at a distance of just over 3 NM from the runway 14 threshold, clearly west of the extended centre line (cf. Annex 8). The FIN air traffic control officer instructed the pilot to maintain visual contact with the ground and to fly a heading of approximately 140 degrees to navigate to the airport. The pilot confirmed this.

At 13:56:48 UTC the FIN air traffic control officer informed the pilot that the airport was now in the direction between the 11 and 12 o'clock position and 2 NM away. The pilot confirmed receipt of this message and reported he was descending to 2500 ft. The FIN air traffic control officer confirmed this and once again requested the pilot to maintain visual contact with the ground.

At 13:57:21 UTC the FIN air traffic control officer informed the pilot: *"N7BD the airport just on your nose around half a mile confirm in sight?"* The pilot replied in the negative and stated he had visual contact with the ground and was on a heading of 140 degrees. At this time the primary radar showed N467BD at a position approximately 1 NM west of the threshold of runway 14 (cf. Annex 8).

At about the same time the CAP air traffic control officer, who had since come to the FIN air traffic control officer's workstation to support him, called the GRO air traffic control officer and asked if they could see N467BD. The DOM air traffic control officer took the call; in the meantime she had also left her workstation and together with the other air traffic air traffic control officers in the control tower was monitoring the approach on the radar. They also tried to establish visual contact with N467BD, but did not succeed. The DOM air traffic control officer informed the CAP air traffic control officer that they could only see a primary radar echo and did not have visual contact. The DOM air traffic control officer also reported that the weather conditions were very bad, that the high-intensity lights on all runways had been switched on and that all take-offs were being suspended. After the CAP air traffic control officer reported that N467BD had descended to 2500 ft, the DOM air traffic control officer ordered that the aircraft should not be allowed to descend further. This was too dangerous because of the restricted visibility. Later in this conversation, the DOM air traffic control officer proposed to the CAP air traffic control officer that N467BD should remain on the FIN frequency and that the landing clearance should be given by the latter, in order to avoid a further frequency change.

While this conversation was still in progress, the FIN air traffic control officer gave N467BD the following instruction at 13:57:35 UTC: *"Turn a bit to the left to around heading 110 that brings you just over the runway 16. You're approaching now the intersection between runway 16 and runway 28."* To which the pilot replied: *"Ah negative we can do the hundred and eighty and then approach runway two … one four."* The pilot answered the question as to whether he still had visual contact with the ground as follows: *"We're visual we have runway in sight Bravo*

Delta." According to the primary radar recordings, at this time the aircraft was flying parallel to runway 14 at a distance of approximately 0.8 NM and was approximately 0.5 NM from the Kloten (KLO) VOR (cf. Annex 8).

The PFD recordings are consistent with these values and in addition permit the conclusion that the aircraft was at an altitude of approximately 1700 ft QNH or approximately 300 ft above the ground. The aircraft's speed in this phase was approximately 140 knots. From this initial position, before even crossing the centre line of runway 28, the pilot initiated a left turn at a bank angle of 45 to 50 degrees.

At 13:57:55 UTC the FIN air traffic control officer then instructed N467BD to contact aerodrome control for further instructions. This instruction was not read back by the pilot. According to the FIN air traffic control officer’s statement, it was not clear to him which runway N467BD would land on and so he would no longer have been able to assist the pilot. He had therefore instructed N467BD to contact aerodrome control.

The FIN air traffic control officer's request to N467BD to switch to the aerodrome control frequency coincided roughly with the end of the coordination discussion between the CAP air traffic control officer and the DOM air traffic control officer. Consequently, the agreement to leave N467BD on the FIN frequency could no longer be implemented.

At approximately 13:58 UTC, on a heading of 327 degrees, at an altitude of just 1500 ft QNH, or approximately 100 ft above the ground and at a speed of approximately 100 knots, the pilot completed the left turn and allowed N467BD to roll further around the longitudinal axis in order to go smoothly into a right turn.

At 13:58:06 UTC the pilot reported on the aerodrome control frequency: *"N7BD we're just at the xxxx* (not comprehensible) *of threshold for runway one four."* Then N467BD was given clearance for the landing on runway 14, along with the wind information. This clearance was confirmed by the pilot at 13:58:18 UTC. At this point in time, the PFD recorded an airspeed of 95.6 KIAS, a pressure altitude of 1355 ft, corresponding to an altitude of 1579 ft QNH or approximately 150 ft above the ground, a heading of 030° and a bank angle of 52° to the right. Subsequently, in this right turn, the aircraft crossed the extended centre line of runway 14 to the east and turned back on it again. During this manoeuvre the bank angle increased within three seconds to approximately 85 degrees right, the aircraft began to rapidly lose height and finally crashed before runway 14 on a heading of approximately 170 degrees (cf. Annex 9).

From 13:58:24 UTC there was no longer any response to aerodrome control's question to the pilot, posed three times, as to whether he could see the runway. The ADC air traffic control officer then triggered the alarm.

A weather observer, who was working in the observation station west of the threshold of runway 16 and who had monitored the crash, informed aerodrome control of her observations. From this communication, it was clear where the exact site of the crash was located. Thus the fire brigade could be dispatched directly to the site of the accident and arrived there very rapidly.

At 13:59:45 UTC, approximately 27 minutes after notification of the alternate landing by the pilot, the DOM air traffic control officer informed the CAP air traffic control officer that N467BD had had an accident.

The fire brigade found a badly damaged, but not burning aircraft. The pilot and the male passenger in the front right seat were fatally injured in the crash. The two passengers in the rear seats were recovered badly injured and taken to hospital. There the passenger who had been sitting in the rear right seat died three days later.

1.2 Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	1	2	3	0
Serious	0	1	1	0
Minor	0	0	0	0
None	0	0	0	Not applicable
Total	1	3	4	0

1.3 Damage to aircraft

The aircraft was destroyed during the impact.

1.4 Other damage

There was damage to the terrain. The soil contaminated by leaking fuel had to be removed and disposed of appropriately.

1.5 Personnel information

1.5.1 Pilot

1.5.1.1 General

Person	Polish citizen, born 1970
Licence	Commercial pilot licence aeroplane – CPL(A), issued by the Federal Aviation Administration (FAA) on 8 March 2008.
Ratings	Rating for single engine land (SEL), entered on the FAA licence. Instrument rating aeroplane – IR(A), entered on the FAA licence.
Medical fitness certificate	Class 1 acc. to FAA, with the restriction "holder should wear corrective lenses", issued on 8 March 2007. Validity: 6 months (Class 1) 12 months (Class 2) 36 months (Class 3)
Last medical examination	8 March 2007
Commencement of pilot training	Before 1998 (according to logbook)
Flying experience	Total: > 800 hours of which on the accident type: > 600 hours during the last 90 days: unknown of which on the accident type: unknown

1.5.1.2 Training

It was not possible to fully reconstruct either the flying experience or the training history of the pilot because not all logbooks were available or kept up to date. According to the documents available, the pilot had commenced his flight training in his home country of Poland before 1998. The first usable logbook begins with a transfer of 54 hours 29 minutes flying experience, described as "basic training". In the years 2000 to 2004, he flew at irregular intervals on the aircraft types Antonov 2, Cessna 150, Cessna 152, Cessna 172, KO-5 Pelikan, Socata Morane and PZL 110[4]. Some of these flights are documented as training flights; however, the pilot had entered a few flights in his logbooks as pilot in command.

From 22 August 2005, the only flights entered in the pilot's logbooks are flights on aircraft registered in the United States of America.

On 22 August 2005 on the Portland Troutdale airfield in America the pilot took over his first Cirrus SR22, registered as N789RK. In the following four days up to 26 August 2005 he flew N789RK, together with a pilot employed for this ferry flight to Europe, from Portland Troutdale to Zielona Gora in Poland, with a total of nine intermediate landings, including Goose Bay, Narsarsuaq and Poznan. The total flight time for this ferry flight was 35 hours 45 minutes, which the pilot entered in his logbook in the column "dual or co-pilot", sub-column "dual". The day after arriving in Zielona Gora, the pilot completed a local flight from Zielona Gora of 2 hours 50 minutes duration, with 8 landings, together with the ferry flight pilot. The ferry flight pilot signed these flights in the pilot's logbook in the "Remarks and endorsements" column, but did neither add his name nor his licence number, as is normal and prescribed for entries by flying instructors licensed by the FAA, the United States civil aviation authority. It was not possible to determine whether this ferry flight pilot was authorised to provide flight training.

On 28 August 2005, i.e. on the day after this local flight with the ferry flight pilot, the pilot completed his first solo flight, which he listed in the "Pilot in command time" column in his logbook.

From the pilot's logbooks no actual training on the Cirrus SR22 could be reconstructed. The high performance airplane endorsement necessary for flights on aircraft with an engine in excess of 200 HP could not be found in the pilot's logbooks for the time of the first flight as pilot in command on his first type SR22 aircraft, registered as N789RK. After the ferry flight from America, in the course of 2005 the pilot completed a further 22 hours 55 minutes flying time on N789RK, all during visual flights within Poland. As of the end of 2005, the pilot ended his entries in the Polish logbook. At this time he had total flying experience of 169 hours 10 minutes, 131 hours 33 minutes of which as dual and 37 hours 37 minutes as pilot in command. Of these, 22 hours and 55 minutes were entered in the logbook as pilot-in-command on N789RK.

On 28 December 2005 the pilot opened a new logbook in accordance with the FAA directives and simultaneously began instrument flight training from North Las Vegas Airport (USA). By 27 March 2006 the pilot had completed instrument flight training according to the FAA requirements on two different SR22 aircraft. On 27 March 2006, after a training flight time of 57 hours 30 minutes, the pilot passed the flight examination to obtain an FAA instrument flight rating.

From 12 April 2006 the pilot made a number of instrument flights from Zielona Gora to destinations throughout Europe on N789RK. On 27 April 2006 he flew

[4] PZL-110: licensed Polish construction of the Socata Morane

from Zielona Gora to Geneva for the first time. Later in 2006, the pilot completed 188 hours and 18 minutes of flying time on N789RK and flew a total of 11 times to Geneva. On 24 August 2006 a flight instructor signed the high performance endorsement for him. How the entry of this endorsement came about and whether the perfectly legible date of this endorsement might possibly have been incorrectly entered, with the "24.08.2006" instead of "24.03.2006", could not be determined. On 24 March 2006 the pilot was at Calipatria airfield in California for the purpose of instrument flight training. On 24 August 2006, however, the pilot was not in training, but was flying regularly in his aircraft from Zielona Gora in Poland. On 24 March 2006 the pilot had 109 hours flying experience on SR22 aircraft; on 24 August 2006 he had 230.8 hours of flying experience on the SR22.

In 2007, the pilot completed 177 hours and 42 minutes on N789RK and in the process flew twice to Geneva airport.

In 2008 the pilot flew another 5 hours 18 minutes on N789RK; the last entry in his logbook dates from 27 February 2008. From 2 March 2008 he completed commercial pilot training in accordance with the FAA requirements. This training took place on the aircraft subsequently involved in the accident, N467BD, from North Las Vegas airport and was concluded on 8 March 2008 by the examination. From 8 March 2008 up to the accident flight on 22 October 2008, no further entries were made in the pilot's logbook.

An attempt was made, using the entries of flight instructors who had signed certain entries in the pilot's logbook and provided the licence number, to reconstruct the content of training. Various questions, such as for example whether the pilot had received full training on the technically complex electrical system of the SR22 and whether as part of his training flights he had made flights at a critically low airspeed (stall exercises), could not be answered.

1.5.2 Passengers

Seat front right	Polish citizen, born in 1969, no flying experience.
Seat rear right	Polish citizen, born 1975, no flying experience.
Seat rear left	Polish citizen, born in 1966, several hundred hours of experience as a passenger on the pilot's two Cirrus SR22 aircraft.

1.5.3 Air traffic control personnel

1.5.3.1 Air traffic control officer ADC trainee

Function	Aerodrome Control (ADC)
Person	Swiss citizen, born 1982
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 5 October 2006
Relevant ratings	ADI, valid till 19 October 2009

1.5.3.2 Air traffic control officer ADC coach

Function	Aerodrome Control (ADC)
Person	Swiss citizen, born 1973

Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 11 October 1996
Relevant ratings	ADI, valid till 1 May 2009 OJTI, valid till 1 May 2009

1.5.3.3 Air traffic control officer DEP

Function	Departure Control (DEP)
Person	Swiss citizen, born 1979
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 27 September 2005
Relevant ratings	APS, valid till 29 May 2009

1.5.3.4 Air traffic control officer CAP

Function	Coordinator Approach (CAP)
Person	Swiss citizen, born 1969
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 14 November 1997
Relevant ratings	APS, valid till 13 March 2009

1.5.3.5 Air traffic control officer FIN

Function	Final Approach (FIN)
Person	Swiss citizen, born 1974
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 27 September 2005
Relevant ratings	APS, valid till 23 September 2009

1.5.3.6 Air traffic control officer APE

Function	Approach East (APE)
Person	Swiss citizen, born 1969
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 2 November 1995
Relevant ratings	APS, valid till 28 February 2009

1.5.3.7 Air traffic control officer DOM

Function	Daily Operation Manager (DOM)
Person	Swiss citizen, born 1962
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 21 October 1985
Relevant ratings	ADI, valid till 21 October 2009 SPVR, valid till 21 October 2009

1.5.3.8 Air traffic control officer GRO

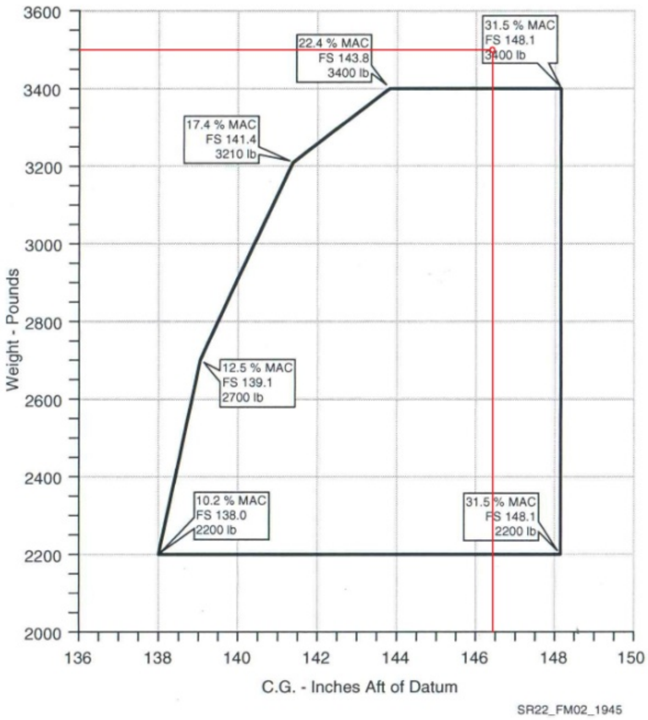
Function	Ground Control (GRO)
Person	Swiss citizen, born 1974
Licence	Air traffic control officer licence based on European Community Directive 2006/23, first issued by the Federal Office of Civil Aviation (FOCA) on 14 November 1997
Relevant ratings	ADI, valid till 21 October 2009

All air traffic control employees were in possession of a valid medical fitness certificate.

1.6 Aircraft information

Registration	N467BD
Aircraft type	Cirrus SR22
Characteristics	Single engine piston aircraft, constructed as a cantilever low-wing composite aircraft with fixed landing gear in nosewheel configuration.
Manufacturer	Cirrus Design Corporation, 4515 Taylor Circle, Duluth, MN 55811, Minnesota (USA)
Year of manufacture	2004
Serial number	1161
Owner	Aircraft Guaranty Management LLC Trustee, 515 N SAM Houston PKWS E STE 305, Houston, TX 77060-4023, Texas (USA)
Operator	Private
Engine	Teledyne Continental IO-550N, horizontally opposed, direct drive, 6 cylinder, power 310 HP S/N 917328
Propeller	Hartzell PHC-J3YF-1RF/F7693DFB, three-blade variable pitch propeller S/N FP3232B
Avionics	Avidyne FlightMax Entegra Primary Flight Display (PFD)

	Avidyne EX5000C Multifunction Flight Display (MFD)
	2 Garmin GNS 430 (COM/NAV/GPS)
	S-Tec System 55 X Autopilot
	Garmin GTX 327 Transponder
Operating hours airframe	Total hours 386.1 hours since the last 100-hour check 78.4 hours
Engine operating hours	Total hours 386.1 hours since the last 100-hour check 78.4 hours
Propeller operating hours	Total hours 386.1 hours since the last 100-hour check 78.4 hours
Max. permitted take-off mass	3400 lb / 1542 kg
Mass and centre of gravity	An estimate indicates that the aircraft's mass at the time of the accident was approximately 3500 lb / 1587 kg and that the centre of gravity was approximately 146.46 inches aft of datum.



For this estimate it was assumed that the aircraft had been fully refuelled in Geneva before take-off. In addition, a fuel consumption of 20 USG up to the time of the accident was estimated, as was the mass of the baggage at 20 kg and that of the surviving passenger at 70 kg.

Maintenance	The last 100-hour check took place on 11 July 2008 at 307.7 hours.
Technical limitations	According to the surviving passenger's statements, the aircraft had previously had problems with an alternator.

Fuel grade	AVGAS 100LL
Fuel	According to the flight plan, the endurance for the flight involved in the accident was 5:30 hours. For this, the aircraft had to be fully refuelled, corresponding to 81 USG. Up to the time of the accident, the flight had lasted approximately 1:13 hours.
Registration certificate	Issued by the FAA on 17 March 2008.
Airworthiness certificate	Issued by the FAA on 4 November 2004.
Certification	VFR/IFR day/night

1.7 Meteorological information

1.7.1 General

The information in sections 1.7.2 to 1.7.7 was provided by MeteoSwiss and translated from German.

1.7.2 General meteorological situation

Switzerland was in the area affected by a trough whose axis extended from the Baltic over France and as far as Portugal. The corresponding cold front had already crossed the Swiss Plateau on the north side of the Alps in the morning. Behind it, in the lower strata, considerably cooler air was flowing in on northerly winds.

1.7.3 Weather at the time and location of the accident

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

Cloud	1-2/8 at 1700 ft AMSL, 3-4/8 at 2100 ft AMSL, 5-7/8 at 2800 ft AMSL
Weather	Light drizzle
Visibility	3000 m
Temperature/dewpoint	8 °C / 7 °C
Atmospheric pressure	QNH LSZH 1021 hPa, LSGG 1021 hPa
Hazards	Moderate wind from the north-west at the level of the main cloud base

Instrument meteorological conditions (IMC) therefore applied.

1.7.4 Astronomical information

Position of the sun	Azimuth: 224°	Elevation: 20°
Lighting conditions	Daylight	

1.7.5 Aerodrome meteorological report

In the period from 13:50 up to the time of the accident at approx. 13:58 UTC, the following aerodrome meteorological aviation routine weather report (METAR) was valid:

LSZH 221350Z 31008KT 3000 –DZ FEW003 SCT007 BKN014 08/07 Q1021 NOSIG

In clear text, this means:

On 22 October, shortly before the 13:50 UTC issue time of the aerodrome weather report, the following weather conditions were observed at Zurich airport:

Wind	from 310° at 8 kt
Meteorological visibility	3000 m
Precipitation	Light drizzle
Cloud	1-2/8 at 300 ft AAL 3-4/8 at 700 ft AAL 5-7/8 with cloud base at 1400 ft AAL
Temperature	8 °C
Dewpoint	7 °C
Atmospheric pressure	1021 hPa, pressure reduced to sea level, calculated using the values of the ICAO standard atmosphere
Land weather forecast	No significant changes expected in the two hours following the weather observation.

1.7.6 Forecast

At the time of the accident, the following terminal aerodrome forecast (TAF) applied:

LSZH 220900Z 221019 32007KT 6000 RA FEW005 SCT010 BKN013 TEMPO 1019 2500 BKN008 T09/12Z T08/15Z=

In clear text, this means:

On 22 October, the following weather conditions were forecast for Zurich airport between 10:00 UTC and 19:00 UTC:

Wind	from 320° at 7 kt
Meteorological visibility	6000 m
Precipitation	Rain
Cloud	1-2/8 at 500 ft AAL 3-4/8 at 1000 ft AAL 5-7/8 with cloud base at 1300 ft AAL
Conditional forecast	Between 10:00 UTC and 19:00 UTC it is to be expected at times that visibility will be 2500 m and the cloud cover 5-7/8 with a cloud base at 800 ft AAL. The duration of this change will probably be less than one hour in each case and in total less than 4:30 hours.

1.7.7 Aviation weather warning

In the period from 11:20 UTC to 14:00 UTC the following airman‘s meteorological information (AIRMET) was valid:

LSAS AIRMET 6 VALID 221120 / 221400 LSZH-

LSAS SWITZERLAND FIR MOD ICE W AND N PART OF SWITZERLAND ABV FL065 STNR NC=

In clear text, this means:

Region of validity	Flight information region (FIR) and upper flight information region (UIR) in Switzerland
Weather phenomena	Moderate icing
Area information	Western and northern part of Switzerland at altitudes above FL065, stationary
Changes in intensity	No change

1.7.8 Weather according to eye witness report

The weather observer who was working on the day of the accident in the observation station to the west of the threshold of runway 16 and who observed the accident described the weather situation as follows [translated from German]: "The weather was bad all day, i.e. low visibility values (2.5 – 3 km visibility), low cloud base, north-westerly wind (approx. 8-9 knots) and drizzle."

1.8 Aids to navigation

1.8.1 Ground-based

Runway 14 at Zurich airport had a category IIIB instrument landing system. The localiser provided an approach line with a course of 137 degrees and the glide slope had an angle of three degrees. The instrument landing system was used on a frequency of 108.3 MHz.

At Zurich airport, the Kloten (KLO) VOR was located further to the south-west of the intersection of runways 10/28 and 16/34.

All components were fully functional at the time of the accident.

1.8.2 Onboard

The primary flight display (PFD) installed in N467BD displays on a screen built into the instrument panel directly in front of the pilot all the information which is required for the direct control of the aircraft. The display of lateral navigation takes the form of a compass rose with an overlaid navigation display, termed the EHSI (Electronic Horizontal Situation Indicator).

By means of a link with the Garmin GNS 430, the information necessary for navigation can be displayed on the PFD's EHSI, using GPS, ILS or VOR data. To do this, it is necessary to couple the PFD to the desired navigation function of the upper or lower GNS 430 by selecting VLOC1, VLOC2, GPS1 or GPS2. In the case of VLOC navigation it is necessary to select the desired frequency and course on the respective GNS 430. The PFD automatically detects whether the received signal corresponds to an ILS or a VOR and accordingly displays the information required for navigation. In the case of an ILS, the PFD automatically displays the horizontal deviation indicator (HDI), as well as the vertical deviation indicator (VDI), which display the relative position of the aircraft in relation to the localiser or the glide slope.

By means of coupling with the autopilot it is also possible to make fully automated ILS approaches.

According to the PFD recordings, after 13:46:18 UTC the source of information which was displayed on the horizontal situation indicator (HSI) was "ILS" with the frequency of 108.3 MHz selected. 14.63° was recorded as the desired course. The inbound course of ILS 14 was 137° at the time of the accident. With a selected inbound course of 14.63°, the HSI display indicated a confusing picture, and the autopilot was not able to follow the localiser signal in approach mode.

If the destination airport is selected correctly in the Garmin 430, it is possible, using the procedure (PROC) function, to select a menu with all available approaches for the destination aerodrome. The selection of an instrument approach, for example, then results in the frequency of the instrument landing system being set automatically in the "stand-by" frequency selection window. If during the approach the pilot is vectored by air traffic control onto the instrument landing system, he selects under "PROC" the "activate-vectors-to-final" function, which means that the ILS frequency is selected in the "use" window of the NAV receiver and the "desired course" is set to the ILS inbound course stored in the GNS430 database. This did not happen in the course of the approach by N467BD. The pilot had selected the ILS 14 frequency but had not set the inbound course of 137° nor arranged for it to be set automatically by the "activate-vectors-to-final" function of the GNS 430.

1.9 Communication

The radio communications between the pilot and the air traffic control units contacted during the flight took place without technical difficulties up to the time of accident.

All the air traffic control officers questioned stated that the pilot had at all times made a calm and professional impression. The recordings of the radio communications confirm this impression.

1.10 Aerodrome information

1.10.1 General

Zurich airport is located in north-east Switzerland. In 2008 it handled a traffic volume of approximately 275 000 landings and departures.

The runways have the following dimensions:

Runway	Dimensions	Elevation of runway thresholds
16/34	3700 x 60 m	1390/1388 ft AMSL
14/32	3300 x 60 m	1402/1402 ft AMSL
10/28	2500 x 60 m	1391/1416 ft AMSL

At the time of the accident a runway length of 3300 m was available for a landing on runway 14.

The reference elevation of the airport is 1416 ft AMSL and the reference temperature is 24.0 °C.

1.10.2 Runway equipment

Zurich Airport is characterised by a system of three runways; two of these runways (16/34 and 10/28) cross at the airport reference point. Runways 16 and 14 are each equipped with a category IIIB instrument landing system (ILS). Runway 34 has a category I ILS and runway 28 has an uncategorised ILS, which features increased weather minimums compared to category I. These runways are therefore all suitable for precision approaches.

At the time of the accident the approach sectors of runways 14, 16, 28 and 34 were equipped with a minimum safe altitude warning system (MSAW). This system triggers a visual and audible alarm in air traffic control if aircraft in the corresponding approach sector descend below defined minimum heights. In the present case, the necessary parameters for an alarm were never met.

The high-intensity lights of runways 10, 14 and 16 were switched on at the time of the accident.

1.10.3 Rescue and fire-fighting services

At the time of the accident Zurich airport was equipped with Category 9 fire-fighting resources. The airport's professional fire brigade is on permanent stand-by during flight operations.

After an alarm was triggered by the ADC air traffic control officer, the fire brigade was dispatched towards the start of runway 14, since the exact location was initially unclear. After the message was received from the weather observer, the fire brigade could be directed to the site of the accident. The first rescue vehicle arrived at the accident site less than three minutes after the alarm was triggered.

1.11 Flight recorders

1.11.1 General

A flight recorder was neither prescribed nor installed.

The primary flight display (PFD) and the multifunction display (MFD) flight each had a non-volatile memory, which could be read out after the accident despite the high degree of destruction of the equipment.

1.11.2 PFD recordings

In the PFD memory more than 100 parameters on the flight status and the settings of the navigation system were stored and could be read out.

1.11.3 MFD recordings

The following 15 parameters were recorded and stored in the MFD memory and could be read out:

- Exhaust gas temperature (EGT) all 6 cylinders
- Cylinder head temperature (CHT) all 6 cylinders
- Manifold pressure (MP)
- Revolutions per minute (RPM)
- Fuel flow (FF)
- Fuel status, i.e. consumption since engine stated
- Power in %
- Oil temperature
- Oil pressure
- Ground speed
- Position according to GPS
- Outside air temperature (OAT)
- Current for Battery 1, Alternator 1 and Alternator 2
- Voltage at the main distribution bus
- Voltage at the essential distribution bus

Some of those values were not correctly stored and could not be used for the investigation, for example the values for the current for Battery 1, Alternator 1 and Alternator 2. The electrical voltages important for the reconstruction of the status of the on-board electrical system at the main and essential distribution bus were recorded in full for the duration of the accident flight up to the failure of the MFD (cf. Annex 6).

1.11.4 PFD characteristics

Type	Avidyne FlightMax Entegra
Manufacturer	Avidyne Corporation, 55 Old Bedford Road, Lincoln, MA 01773, Massachusetts (USA)
Part number	700-00008-000
Serial number	21317414
Recording medium	Non volatile memory EPROM
Duration of recording	approx. 100 flying hours

1.11.5 MFD characteristics

Type	Avidyne EX5000C
Manufacturer	Avidyne Corporation, 55 Old Bedford Road, Lincoln, MA 01773, Massachusetts (USA)
Part number	700-00004-008
Serial number	23596394
Recording medium	Non volatile memory EPROM
Duration of recording	approx. 100 flying hours

1.12 Wreckage and impact information

1.12.1 Wreckage

The aircraft was destroyed on impact. The engine lay some metres away from the main wreckage. The three-blade propeller together with the spinner lay separately, a few metres away, near the engine. The deformation of the propeller blades permits the conclusion that the engine was providing power at the time of the accident.

A visual inspection of the controls produced no evidence of pre-existing defects.

The flaps were retracted.

The abdominal and shoulder belts were being worn and withstood the deceleration forces. The front right seat was torn from its fixing with the passenger sitting in it and lay next to the wreckage. The seats under the cushions of the rear seats were very compressed.

1.12.2 Impact

The impact occurred at a bank angle of approximately 80° to the right and at a high rate of descent. The distance from the first trace of the impact to the final position of the wreck was approximately 15 metres.

1.12.3 Site of the accident

At the site of the accident, notes by the pilot were found relating to the flight on 20 October as well as the flight involved in the accident. These notes were the pilot's records concerning ATC clearances and cleared flight levels.

An updated Jeppesen Volume 1, from which the Emergency section was missing, was also found at the site of the accident. Filed in it was, among other things, a general map of Zurich.

The Jeppesen Europe low altitude enroute chart E(LO) 3/4 was found separately. No approach charts for Zurich airport were found.

A Quick Reference Checklist for the Cirrus SR22, which contained abbreviated checklists, was also found. The part "Emergency Checklists", among other things, contained in section 1.16.1.2, the prescribed procedure for action after a failure of alternator 1. A schematic of the electrical system was included on the last page.

Accident location	Geissbühl, Oberglatt/ZH municipality
Swiss coordinates	682 526 / 259 816
Latitude	N 47° 29' 01"
Longitude	E 008° 32' 02"
Elevation	429 m AMSL 1407 ft AMSL
Location	approx. 110 m before the start of runway 14 at Zurich airport, on the runway centre line
Map of Switzerland	Sheet no. 1071, sheet name Bülach, Scale 1:25,000

1.13 Medical and pathological information

The bodies of the pilot and the passenger who was sitting in the front right seat underwent an autopsy. No indications were found which indicated a limitation of the pilot's capability to fly.

No evidence of alcohol or other effects on the central nervous system due to other substances was found.

The pilot and the passenger sitting in the front right seat died from the severe injuries suffered in the crash. The female passenger sitting in the rear right seat died three days after the accident of multiple organ failure due to the multiple trauma suffered in the crash. The passenger who was sitting in the rear left seat mainly suffered injuries to the musculo-skeletal system and was able to provide useful information about the history of the flight involved in the accident one day after the accident.

1.14 Fire

Fire did not break out.

1.15 Survival aspects

1.15.1 General

The high deceleration forces which occurred on impact were survivable only by chance.

The two passengers in the front seats were fatally injured in the crash. The pilot was trapped in his seat as a result of the significant deformation of the airframe in the forward section. The front right passenger seat was torn from the airframe by the impact and was found with the passenger still strapped to the seat next to the main wreckage.

For the passengers in the rear seats, slightly lower deceleration occurred on impact, due to the energy dissipation as a result of the deformation of the front part of the airframe; this is why they both survived the immediate accident. The highly compressed floors of the rear seats indicate that the seats absorbed part of the vertical deceleration forces through deformation.

1.15.2 Cirrus Airframe Parachute System

The aircraft was equipped with a ballistic rescue system (BRS) cf. Section 1.16.4, known as the Cirrus Airframe Parachute System (CAPS). The CAPS was not deployed on the flight involved in the accident.

1.15.3 Emergency transmitter

The aircraft was equipped with an emergency locator beacon aircraft (ELBA). The device was activated by the accident.

1.16 Tests and research

1.16.1 Electrical system of N467BD

1.16.1.1 General

The Cirrus SR22 aircraft has an electrical system consisting of two alternators and two batteries (cf. Annex 7).

The main system consists of Battery 1, a 24-volt lead-acid battery consisting of 12 cells, with a capacity of 10 ampere hours, and Alternator 1, which can provide a current of up to 60 amps. The output voltage of Alternator 1 is regulated at 28 volts. Battery 1 supplies the main distribution bus and is charged by alternator 1 when the engine is running. Main bus 1, main bus 2 and two non-essential buses are supplied via the main distribution bus, which in turn provide electricity to the following consumers (the list is not exhaustive):

- MFD
- Garmin GNS 430 #2 (COM 2/NAV 2/GPS 2)
- Transponder
- Garmin 340 audio panel, containing the intercom
- Landing flaps
- Electric trim
- External lights
- Pitot heater
- Engine instruments

The second system consists of Battery 2, consisting of two 12-volt lead-acid batteries wired in series, with a respective capacity of 7 ampere hours, and Alternator 2, which can deliver a maximum of 20 amps. The output voltage of Alternator 2 is regulated at 28.75 volts. Battery 2 supplies the essential distribution bus and is charged by Alternator 2 when the engine speed exceeds approx. 1700 rpm. The two essential buses are supplied from the essential distribution bus; these provide the electrical supply to the following consumers:

- PFD
- Garmin GNS 430 #1 (COM 1/NAV 1/GPS 1)
- Autopilot
- Annunciator lights
- Stall warning

The main distribution bus and essential distribution bus are connected to each other via a diode. The diode allows the supply of the essential distribution bus by the main distribution bus, but not vice versa.

In normal operation with two functioning alternators, Alternator 1 supplies the main distribution bus and Alternator 2 supplies the essential distribution bus. Since regulation of the output voltage of the alternators on the essential distribution bus ensures a slightly higher voltage than on the main distribution bus, supply of the essential distribution bus by the main distribution bus via the diode does not take place.

If Alternator 2 fails, the essential distribution bus is supplied via the diode from the main distribution bus and therefore from Alternator 1.

If Alternator 1 fails, the main distribution bus is supplied only from Battery 1, because the diode prevents supply via the essential distribution bus. The essential distribution bus continues to be supplied from Alternator 2. Therefore the electrical consumers connected to the essential distribution bus remain fully available in the case of a failure of Alternator 1 and a possible discharged Battery 1.

1.16.1.2 Procedure in the event of failure of Alternator 1

According to the airplane flight manual (AFM), Section 3 – Emergency Procedures, the procedure in the event of a failure of Alternator 1 is as follows:

“ALT 1 Light Steady

Steady illumination indicates a failure of ALT 1. Attempt to bring alternator back on line. If alternator cannot be brought back, reduce loads and use Main Bus or Non-Essential loads only as necessary for flight conditions.

1. *ALT 1 Master Switch …………………………………………… OFF*
2. *Alternator 1 Circuit Breaker ……………. CHECK and RESET*
3. *ALT 1 Master Switch …………………………………………… ON*

If alternator does not reset:

4. *Reduce loads on Main Bus 1, Main Bus 2, and the Non-Essential Buses.*

   Monitor voltage.
5. *ALT 1 Master Switch ……………………………………………OFF*
6. *Land as soon as practical"*

The AFM contains no explicit time indication for the period during which the supply of the main distribution bus via Battery 1 is assured in the event of a failed Alternator 1.

The AFM mentions *"land as soon as practical"*, which in clear text means the following, according to title 14 of the Code of Federal Regulations (CFR):*"The landing site and duration of flight are at the discretion of the pilot. Extended flight beyond the nearest approved landing area is not recommended."*

1.16.1.3 Tests by the SAIB

Tests carried out by the SAIB with an aircraft of identical construction indicated that the discharge current of Battery 1 after failure of Alternator 1 with the loads normally connected during an instrument flight is approximately 19 amps. By switching off consumers which are not essential for flight such as Pitot heating, external lights and the Garmin GNS 430 #2, the discharge current could be reduced to approx. 7 amps.

If after the failure of Alternator 1 consumers which are not urgently required are switched off within a reasonable time, a fully charged Battery 1 with a capacity of 10 ampere hours will be fully discharged after approximately one hour. If other consumers such as wing de-icing or pitot heating are switched on, the time before the critical battery voltage at which the minimum voltage required for the operation of the various devices supplied by the main distribution bus is reached, becomes significantly shorter.

The tests indicated that the time which elapses between the failure of Alternator 1 and the reduction of electrical consumers by the pilot has a significant influence on the time for which Battery 1 can supply the main distribution bus.

According to the MFD recording, at the time of the final failure of Alternator 1 at 13:24 UTC the voltage dropped to a value of 24.7 volts within one minute. Twenty-eight minutes later, by which time N467BD was under radar vectors on the left-hand base leg on the runway 14 instrument landing system, the voltage at the main distribution bus reached 16 volts.

By means of experiments with an aircraft of identical construction and on the test bench, the SAIB reconstructed the sequence of the failing equipment as the voltage dropped at the main distribution bus. The reconstruction resulted in the following sequence:

Voltage at the main distribution bus	Operation of the relevant units MFD, GNS 430 #2 and transponder supplied by the main distribution bus
24 volts	all units function normally
16.1 volts	MFD display flickers
16.0 volts	MFD display fails
12.1 volts	MFD data recording ends
10 volts	COM2 (part of GNS 430 #2) still transmits normally, display normal
	Transponder: transmission power 200 watts (nominal)
9.1 volts	Transponder fails
8 volts	COM2 still transmits normally, display black

5.9 volts	In the master control unit the relay which establishes contact between Battery 1 and the main distribution bus opens

1.16.1.4 Alternators

Alternator 1 on N467BD was removed after the accident and tested for functionality. The alternator was defective. A broken connection in the rotor winding was found during the examination.

Alternator 2 was also tested for functionality. Despite the high degree of destruction suffered in the accident, the alternator was still working.

1.16.2 CMax Approach Charts function

In addition to many other options, if correspondingly equipped the MFD allows the display of approach and departure charts for instrument flights (cf. Annex 5). This optional CMax approach charts function is based on a Jeppesen database, which must be updated periodically. N467BD was equipped with this function.

For approach charts which are to scale, the aircraft symbol is overlaid on the chart display according to the GPS position; this is useful for situational awareness.

Excerpt from the AFM concerning CMax approach charts function:

"Section 2 – Limitations

Do not use the CMax Approach Charts function for navigation of the aircraft. The CMax Approach Charts function is intended to serve as a situational awareness tool only. The electronic approach charts must not be used as the primary set of on-board approach charts.

Section 7 – Systems description

The optional CMax Approach Charts function allows the pilot to view terminal procedure chart data on the EX5000C MFD. If the chart is geo-referenced, an ownship symbol and flight plan legs can be overlaid on the chart to further enhance the pilot's situational awareness. Most approach charts and airport diagrams are georeferenced; most arrival, departure, and miscellaneous charts are not. The CMax installation is entirely software dependant. No additional hardware is required."

1.16.3 Stall characteristics and stall speeds

In Section 4 – Normal Procedures, the AFM describes the stall characteristics of the aircraft as follows:

"SR22 stall characteristics are conventional. Power-off stalls may be accompanied by a slight nose bobbing if full aft stick is held. Power-on stalls are marked by a high sink rate at full aft stick."

The AFM also includes the warning:

"Extreme care must be taken to avoid uncoordinated, accelerated or abused control inputs when close to the stall, especially when close to the ground."

In section 5 – Performance Data, the AFM lists the stall speeds for power-off and maximum permissible take-off mass as a function of the position of the centre of gravity, the flap setting and the bank angle (cf. Annex 10). The AFM contains no corresponding table for power-on.

1.16.4 Ballistic rescue system

1.16.4.1 General

The aircraft was equipped with a CAPS (Cirrus Airframe Parachute System). The pilot can deploy this system by means of a lever which is attached to the canopy. A solid-fuel rocket then ejects a parachute through part of the surface designed for this purpose on the top of the fuselage behind the passenger cabin. This parachute is attached to the structure of the aircraft by three straps and begins to open approximately two seconds after ejection. The round-canopy parachute has a surface area of 223 m^2 and a diameter of 17 metres. The maximum airspeed specified by the manufacturer for releasing the CAPS is 133 KIAS. The aircraft's rate of descent under a fully deployed CAPS chute is approximately 1700 ft/min. More than a dozen cases are known in which the CAPS was deployed and all the occupants survived the landing uninjured or with slight injuries.

According to the manufacturer's information, the following scenarios may require deployment:

- Mid-air collision
- Structural failure
- Loss of control
- Landing in inhospitable terrain
- Pilot incapacitation

The CAPS was not triggered on the flight involved in the accident

1.16.4.2 Additional clarifications

Shortly after the report of the accident the SAIB employee on duty realised that the aircraft involved in the accident was equipped with a ballistic rescue system (BRS). A consultation with the rescue service indicated that this rescue system had very probably not been triggered, neither during the flight nor by the impact. The rescue service personnel were not aware at this time of the dangers which an armed rescue system might involve, and were encouraged not to try to deactivate the system and not to move the wreck. Since there was no specialist available in Europe who could have expertly disarmed the system, the aircraft manufacturer immediately dispatched an expert who arrived in Zurich the following day. In the meantime, on its own initiative the airport fire brigade had recovered the wreck with the system still armed. The recovery of the wreck, which was lying in the final approach area of runway 14, took place at the airport's own risk and with the objective of enabling runway 14 to be brought back into service as soon as possible. Subsequently, the expert from the aircraft manufacturer disarmed and dismantled the pyrotechnic components of the BRS from the recovered wreck.

Figure 1: Main wreckage at the accident site

This type of rescue system is a fairly new development. Given the quantity produced, it is to be expected that such equipment will be increasingly used in modern aircraft. Experience in dealing with this system after the accident indicated that rescue personnel and police are not sufficiently aware of the associated dangers. In an effort to identify these dangers and to be able to make recommendations for dealing with such a system safely, the Swiss Accident Investigation Board decided to undertake additional clarifications. Since the manufacturer has only issued instructions for dealing with the system after an accident, without addressing the aspects of a possible fire scenario, extensive clarifications were made in cooperation with a government explosives laboratory; these have been published in a separate report together with further details and recommendations.

1.17 Organisational and management information

None.

1.18 Additional information

None.

1.19 Useful or effective investigation techniques

None.

2 Analysis

2.1 Technical aspects

Apart from the failure of Alternator 1, there are no indications of any pre-existing technical defects which might have caused or influenced the accident.

2.2 Human and operational aspects

2.2.1 Electrical system and pilot behaviour

The MFD recordings (cf. Annex 6) prove that Alternator 1 failed at 13:01:24 UTC, 13:16:54 UTC and 13:17:12 UTC, but came back on line within a relatively short time. Whether this happened independently or as the result of a reset as described in the emergency checklist could not be determined. At 13:23:24 UTC Alternator 1 failed again and apparently could no longer be brought back on line. The pilot then decided on an alternate landing in Zurich and informed air traffic control of this at 13:33:03 UTC. This decision was appropriate for the situation.

Concerning the consequences of the failure of Alternator 1, the pilot stated the following on the radio:

"Ah we've got a failure of alternator one ah we can't fly for longer than ah forty five minutes Bravo Delta."

The relatively long period of just under ten minutes between repeated failure of Alternator 1 and the pilot's report that he would be making an alternative landing in Zurich can possibly be explained by the fact that the pilot was trying to bring Alternator 1 back on line by a reset and that he had learned in the previous failure that this could take several minutes.

At this time, there were two scenarios for the continuation of the flight:

1. The available electrical energy in Battery 1 is sufficient to supply the main distribution bus and thus all consumers with sufficient voltage until landing. The period of availability of the system can be extended by switching off non-essential electrical consumers on the main distribution bus.
2. The available electrical energy in battery 1 is not sufficient to supply the main distribution bus and thus all consumers with sufficient voltage until landing. After the definitive failure of Alternator 1 the pilot would have to expect this scenario.

The facts that the pilot specified a maximum flight time of 45 minutes and confirmed *"normal operation"* for the approach permit the conclusion that he was assuming scenario 1 and wanted to avoid scenario 2 by limiting the duration of the flight. The statement *"we can't fly for longer than forty five minutes"* was incorrect in that it would still have been possible to fly N467BD after the full discharge of Battery 1, as far as the electrical system was concerned, for an unlimited time with the equipment supplied by the essential distribution bus and Alternator 2 respectively.

The AFM contained no explicit time with regard to the period during which Battery 1 can supply the main distribution bus after a failure of Alternator 1, and merely recommended *"land as soon as practical"*. This was reasonable, because the corresponding length of time depends on various factors, for example the state of charge and the temperature of Battery 1 at the time of failure, the time up to the reduction of electrical consumers on the main distribution bus and the extent of this reduction.

In view of the fact that the passenger in the rear left seat observed how the MFD screen and later the Garmin GNS 430 #2 failed, it must be assumed that no significant reduction of electrical consumers on the main distribution bus had taken place. This is confirmed by the SAIB tests described in section 1.16.1.3 and the actual time of just under 30 minutes between the definitive failure of Alternator 1 and the drop to a voltage of 16 volts at the main distribution bus and of the resulting failure of system components.

The reason why no significant reduction of electrical consumers on the main distribution bus was carried out could lie in the training of the pilot. The information on the procedure to be applied was available to the pilot both on the corresponding MFD page and in the quick reference checklist. The quick reference checklist also included a schematic diagram of the electrical system, which could fully prepare the pilot for the consequences of the occurrence of scenario 2. Whether the pilot had this detailed knowledge of the system is questionable on the basis of the facts as well as his statement "*We can't fly for longer than forty five minutes"*.

In any case specifying a maximum flight time of 45 minutes proved to be too optimistic. At 13:51:54 UTC, approximately 28 minutes after the definitive failure of Alternator 1, the voltage at the main distribution bus dropped to a value of 16.1 volts, at which the MFD display failed in the SAIB test. At this time, N467BD was on the left-hand base leg of the instrument landing system for runway 14, shortly before turning onto the centre line of the final approach. From this point on, due to the failure of the MFD and hence of the CMax, the pilot no longer had any documentation of the approach, i.e. he was lacking key data such as the approach minimums and the description of the go-around procedure.

Unbeknown to the pilot and without relevance to the history of the flight, the voltage at the main distribution bus at 13:52:48 UTC reached the last recorded value of 12.1 volts, at which the recording function of the MFD also failed. At this time, N467BD was on the final intercept heading of 170 degrees and should have followed the localiser of the runway 14 instrument landing system. In this flight phase, the voltage at the main distribution should bus may have dropped to a range below 10 volts, due to the power consumption of the devices which were still working – the GNS 430 #2, the transponder and the Garmin 340 Audiopanel, and the pitot heating which may still have been switched on; at this point these units also failed. In the test set-up, the relay which connects Battery 1 to the main distribution bus opened at a voltage of 5.9 volts. However, this value is not relevant, because all of the consumers supplied by the main distribution bus ceased performing their functions even at higher voltages. The pilot was therefore faced with the following situation:

The following systems supplied from the main distribution bus were failing or had already just failed (cf. Appendix 7, a non-exhaustive list):

- MFD
- Garmin GNS 430 #2 (COM 2/NAV 2/GPS 2)
- Transponder
- Garmin 340 audiopanel with intercom
- Flaps
- Electrical trim, in which context it should be noted that no manual trim is available on the SR22 aircraft,
- Pitot heating

The following continued to be functional (cf. Annex 7):

- PFD
- Garmin GNS 430 #1 (COM 1/NAV 1/GPS 1)

- Autopilot (still able to drive the trim motors)
- Annunciators
- Stall warning

At 13:54:27 UTC the pilot reported: *"Sorry Final Bravo Delta can we make the heading for the runway we're getting some difficulties with the power now."* Given thorough training, which would have included the SR22's electrical redundancy aspects, in this flight phase the pilot would probably have been prepared for the cascade of failures of the various units and functions supplied from the main distribution bus. His statements to air traffic control in connection with the expected development of the consequences of the causal technical problem, the loss of Alternator 1, indicate an inadequate level of education and training.

After the total loss of all of the units and functions supplied from the main distribution bus, for a pilot trained in instrument flight and in the use of the aircraft's equipment, a category I approach would have been possible without limitations, or by coupling with the autopilot even fully automatic.

2.2.2 Navigation and pilot behaviour

From the analysis of the data recorded in the PFD it is apparent that the pilot was controlling the aircraft with the autopilot in heading mode from the first heading instruction given by the DEP air traffic control officer in the vicinity of Willisau VOR at 13:20:38 UTC, but at this time made no entries in the Garmin GNS 430 #1 in preparation for the approach on the alternate airport. He left waypoint GIPOL set in the GNS 430#1 as the active waypoint. After he had made the decision on the alternative landing in Zurich and at 13:33:03 UTC informed air traffic control, programming of the GNS 430 #1 with regard to an instrument approach on runway 14 would have been appropriate. Entering the 4-letter code "LSZH" of the alternate aerodrome, selecting runway 14 instrument approach and activating the function "activate-vectors-to-final" would have meant that the unit would have automatically selected the ILS frequency and the inbound course. Depending on the setting of the GNS 430, the unit would then also have independently selected the source of the navigation data provided to the EHSI from "GPS" to "VLOC". The reason why the pilot, despite his great experience with this equipment, did not make use of these features may lie in the fact that he could not make the change to the new destination aerodrome LSZH and thus had no access, via the "PROC" function, to the menu with the choice of approaches for Zurich airport.

Up to the crossing of the localiser approach line at approximately 13:53 UTC – i.e. shortly after the MFD probably failed – no navigation difficulties were apparent; the pilot had flown N467BD as far as the Willisau VOR in autopilot – GPS NAV mode and from the Willisau VOR onwards in autopilot – HDG mode.

Then N467BD crossed the approach baseline of ILS 14, without turning onto it and was informed of this by the FIN air traffic control officers at 13:53:30 UTC. The pilot then corrected the heading and flew from 13:53:50 to 13:54:02 UTC on a heading of 110 degrees, before gradually turning back onto a heading which positioned N467BD, at a distance of between 0.5 and 1 NM west of the approach line and approximately parallel to it (cf. Annex 11). The pilot initially reported that he was receiving the localiser but not the glide slope signal. Shortly afterwards, he then stated that he could not trust the display with reference to the localiser and requested the heading to runway 14. This statement by the pilot is understandable, because the PFD recordings show that throughout the approach he had always set course 015 in the EHSI, which led to a confusing picture.

At no time did the pilot confirm reception of the glide slope signal.

Since all ground-based installations were functioning normally, the reasons for these problems must be sought on the aircraft or in the operation of its equipment.

Despite the drop in voltage at the main distribution bus to below 10 volts and the consequent failure of various systems, thanks to the architecture of the SR22's electrical system with the PFD, the Garmin GNS 430 #1 and the autopilot, a fully functional system was available for navigation on an ILS.

The PFD recordings also show that the pilot crossed the approach centre line of the localiser with the autopilot in the ALT – HDG mode. According to the PFD recordings the pilot never armed the approach mode. This failure is occasionally observed if pilots in this phase of flight are under a high workload. This applied to the pilot of the N467BD because some equipment has failed.

It can be assumed that the pilot had entered the flight route from the departure aerodrome of Geneva as far as the planned destination aerodrome, Berlin-Schönhagen, in the Garmin GNS 430 navigation system. Since the Jeppesen Europe low altitude enroute chart E(LO) 3/4 was found separately after the accident, it can be assumed that he was following the flight path on this chart. After the decision to divert to Zurich, he had to prepare for an ILS 14 approach. On the MFD, he had access to all approach charts for Zurich airport, which allowed for detailed preparation. The pilot only had access to charts in the MFD; he was not in possession of any approach charts on paper or on another device. In the Jeppesen Volume 1 found at the crash site, a general map of Zurich would have been to hand. However this was found filed in the ring binder, so it can be assumed that the pilot had not used this map. In order to access the menu with the approaches to Zurich airport, in the Garmin 430 he had to change the destination airport to LSZH. Only with destination LSZH preselected in the Garmin 430 could he access the menu with the approaches to Zurich airport via the PROC (procedures) function.

Since alternate landings are generally rare events for pilots, problems occur occasionally in connection with the operation of the Garmin GNS 430 when the destination must be changed. Most pilots intuitively put the alternate aerodrome either after an enroute waypoint or at the end of the current flight plan. However, this does not mean that access is provided via the "PROC" function to the menu with the stored approach procedures. There are various methods which can be selected so that the pilot can gain access to the alternate aerodrome approaches via the PROC button or the "MENU" – "Select approach?" function. The procedure described by the manufacturer GARMIN for the GNS 430 in the Pilot's Guide & Reference handbook is as follows: activate the direct-to function, then enter the 4-letter code of the new destination and confirm with "ENT". Another method is to enter the 4-letter code of the new destination as the last waypoint in the flight plan and then, via "PROC", "Select Approach?" and pressing the MENU button twice, access the "Select Destination Apt?" function. Whether the pilot was acquainted with one of these procedures is not known, but seems doubtful given his training.

The PFD recordings indicate that the pilot had entered the frequency of the runway 14 instrument landing system in the GNS 430 #1 at 13:46:18 UTC, i.e. approximately 6 minutes before receiving the heading instruction to converge on the approach centre line. As the PFD recordings show, in the GNS 430 #1 up to this time the active waypoint was GIPOL and the active leg was "WIL – GIPOL". At no time did the pilot set the ILS14 inbound course of 137°; the course 015 automatically selected by the GNS 430, which corresponds to the course from beacon WIL to waypoint GIPOL and which was the last automatic waypoint switching, that occurred passing the Willisau VOR. This meant that the display on the EHSI was confusing for the pilot. The reason why he did not notice this setting, which was 122° out, probably lay in the stress which the pilot was under at this time.

To ensure that the displays of the instrument landing system were shown on the PFD, the pilot had to switch the source of the navigation data from GPS to VLOC. Without this switchover, no glide slope display appears on the PFD. According to the PFD recordings, at 13:46:18 UTC, i.e. approximately six minutes before the heading instruction to intersect the approach base line, the pilot had selected the source "VLOC" as navigation source for the EHSI and so had carried out this switchover. This is very late in terms of the flight progress; N467BD had already been under radar vectors since the Willisau VOR and the settings required for the approach could have been entered well before this. In terms of the approach, however, this switchover was nevertheless carried out sufficiently early.

The fact that the pilot, in the course of the approach, constantly flew 0.5-1 NM to the west of the localiser centre line and responded to the corresponding question from the FIN air traffic control officer "Ah we get the localiser but I don't think we can trust that indication" could indicate that he was confused by the picture presented to him on the EHSI as a result of the inbound course 015.

From the point on where the MFD and with it the CMax was lost the pilot had no longer any documentation of the approach in written form with the description of the lateral and vertical flight path as well as the vertical constraints. Important data as for example approach minima and description of the missed approach procedure were missing to him. However, he would have had access to a moving map, NAV page 1 via the GNS430 # 1, showing the lateral flight path but without the vertical limitations of the missed approach flight path. From this point, the failure to set the ILS inbound course could have been remedied only if the pilot had memorised this value from the preparation of the approach or had requested it from air traffic control, because he had at his disposal neither printed approach charts nor the approach charts displayed on the failed MFD, nor even the option of displaying this information, e.g. on a personal digital assistant (PDA).

The pilot, who was relatively accustomed to instrument flight, was very probably acquainted with the frequently used "activate vectors-to final" function. However, he had definitely not used this function, even though N467BD had been under vectors for a fairly long time and was thereby being guided onto the instrument landing system. If he had applied this function, then the GNS 430 would automatically have selected the ILS inbound course of 137 degrees. The fact that he had not applied this function can only be explained by the fact that he had not entered the ILS 14 approach into the GNS 430. The latter in turn may have been the result of rarely inputting an alternate aerodrome. These shortcomings of the pilot regarding the operation of the device are very probably due to incomplete training.

The loss of all chart information could also have been a reason why the pilot did not comply with the FIN air traffic control officer's instruction to go around and attempted, despite instrument weather conditions, to reach the runway in visual flight, by maintaining visual contact with the ground.

The fact that the pilot had no approach charts on paper and relied exclusively on the MFD CMax approach charts function might have had an effect on all subsequent decisions by the pilot after the failure of the MFD.

The speed of approximately 160 kt not adapted to the approach phase might have additionally made the situation more difficult. According to the manufacturer a typical approach speed is in the range of 90 to 110 kt. The speed of 160 kt, offered to the air traffic control by the pilot, would have been demanding to the latter already under normal conditions. Under the prevailing meteorological conditions and in relation to the loss of some equipment this high approach speed was a striking additional stress factor.

According to primary radar recordings, in the final approach phase N467BD was slightly north of runway 10 and west of runway 16. Air traffic control had turned the high-intensity lighting to full brightness on all three runways. At 13:57:53 UTC, the pilot reported *"we have runway in sight",* though it is not clear which of the three runways he was referring to. Although he probably had visual contact with all three runways, he decided on a 180 degree turn to get back onto the final approach for runway 14.

In the last part of the approach, carried out under visual conditions, the pilot had no landing flaps available, as their electrically operated servomotor is supplied from the main distribution bus (cf. Annex 7). The stall speed was therefore significantly higher than that for a configuration normal for a final approach with flaps fully extended (cf. Annex 10). In addition, exceeding the maximum allowable take-off mass aggravated this problem.

The PFD recordings indicate that the last right turn was flown at a bank angle of approximately 40-60° and an airspeed of approximately 100 kt. It may therefore have fallen below the stall speed. In the last three seconds before impact with the ground, the bank angle attained values in excess of 80°, but this may have been a consequence of stalling which had already occurred and the accompanying loss of control.

2.2.3 Training of the pilot

The reconstruction of the pilot's training history permits the conclusion that he had never undergone comprehensive conversion to the SR22 aircraft. The complexity of the redundant design of the electrical system, however, requires thorough training, as well as regular repetition of what has been learned. This suggests that the pilot was not fully acquainted with all the technical possibilities which were available to him on his aircraft.

2.2.4 Air traffic control and pilot behaviour

On the basis of the expected high volume of approach traffic, the DEP air traffic control officer decided, as was usual in such cases, to deviate from the standard WIL VOR – GIPOL – TRA VOR route and allow this transit flight to fly at FL 80 south of the approach sectors through TMA Zurich. This decision was appropriate and corresponded to normal practice.

South of KLO VOR, the pilot reported the failure of *"alternator one"* and opted for a technical alternative landing in Zurich. However, the DEP air traffic control officer understood this as a failure of *"altimeter one"* and relayed this to the CAP air traffic control officer. The pilot then reported that he could fly for a further 45 minutes. To the air traffic control officer’s enquiry as to whether he would be able to make the approach under *"normal operation"*, the pilot replied with *"affirmative"*. The confusion of *"altimeter"* and *"alternator"* had no effect on the DEP air traffic control officer's assessment that this was not an emergency situation. As a result of the confirmation of *"normal operation"* by the pilot, ATC assumed a normal technical alternative landing.

It remains inexplicable why the DOM air traffic control officer always assumed an *"alternator one"* failure, whilst the CAP air traffic control officer had reported a failure of *"altimeter one"*. No corresponding coordination discussions were found in the recordings. For the DOM air traffic control officer this was an approach with technical problems to which special attention should be paid. A corresponding wish on the part of the DOM air traffic control officer was relayed from the CAP air traffic control officer to the APE air traffic control officer.

The APE air traffic control officer decided, on the basis of the traffic situation and the facts known to him concerning the current situation of N467BD, neither to prioritise it nor to delay it. This was a comprehensible decision at this time given the confirmation by the pilot of *"normal operation"*.

The pilot subsequently switched to the frequency of the FIN air traffic control officer, who at this time did not have any accurate knowledge of the reasons why N467BD was diverting to Zurich. After the approach clearance was given, the pilot crossed the approach line for runway 14 and, despite a course correction by the FIN air traffic control officer, remained on a parallel course west of ILS 14. These were the first indications of any navigation problems for the FIN air traffic control officer. Shortly afterwards, at a distance of approximately 8 NM from the touchdown point, the pilot reported for the first time *"difficulties with the power now"*, upon which the FIN air traffic control officer asked the pilot several times whether he could receive the ILS signals and at what height he was flying.

Since the pilot reported that he was not receiving any reliable ILS indications and no longer had any radar contact either, the FIN air traffic control officer decided to abort the approach of N467BD and gave him the following instruction: *"November seven Bravo Delta, roger, continue present heading, climb to six thousand feet."* Under these circumstances it was appropriate, in order to ensure terrain clearance, to abort the approach and to arrange a go-around manoeuvre. After the pilot first confirmed this instruction, he reported shortly afterwards: *"(…) we're experiencing some power failure, request to change to VFR. We got a visual on the ground, we can proceed this way."*

This statement by the pilot contradicted the missed approach confirmed shortly before and placed the air traffic control officers involved, in approach and tower, in a new situation.

Owing to the uncertain situation in the approach observed by the ADC and GRO air traffic control officers, it was decided to keep the aircraft which were due to take off in the near future on the ground. The high-intensity lighting of runways 14, 16 and 10 was switched on with the intention of enabling the pilot to make a landing on the first runway to come into view. Although this was not explicitly communicated to the pilot, these measures were safety-conscious.

The proposal by the DOM air traffic control officer to the CAP air traffic control officer to leave N467BD on the FIN frequency until landing was appropriate given the circumstances, but took place at the same time as the instruction from the FIN air traffic control officer to N467BD to switch to the aerodrome control centre frequency. From his point of view this was appropriate to the situation, because it was not clear, given the position of the aircraft, on which runway N467BD would land. In this connection it must be mentioned that this coordination is not to be found on any skyguide recording. However, it is confirmed by the independent testimony of the DOM, ADC, GRO and CAP air traffic control officers that it did take place.

Communication within the approach control centre, as well as between the CAP air traffic control officer and the DOM air traffic control officer did not take place optimally and was characterized by a number of misunderstandings. It is incomprehensible why not all coordination discussions were recorded by skyguide.

2.2.5 Basic considerations concerning a technical alternative landing

The air traffic control officers in the approach control centre decided on the basis of the information available to them not to assign a higher priority to the approach of N467BD. The reason for this was that the pilot had confirmed *"normal operation"* and in addition was using the radio calmly and professionally, the high volume of airliner traffic on runway 14 and the 45 minutes reported by the pilot which were still available to him for the approach. These considerations were logical given the information at that time.

Neither the pilot nor the air traffic control officers in the approach control were sufficiently aware when planning the approach of the significance of the relatively bad weather. In such weather conditions in particular, it is dangerous to try to wish to exploit time limits or general conditions. Instead, safety-conscious planning should include sufficient time reserves for unforeseen events such as a possible essential go-around and a repeated approach procedure.

An unplanned technical alternative landing with a low cloud base is generally a major challenge for the pilot of a single-engine aircraft.

With a view to the prevention of future accidents it would make sense if air traffic control officers' knowledge of the significance of technical failures in a single-engine light aircraft flown by a single pilot in demanding weather conditions and an approach on an unfamiliar aerodrome could be improved. Even though no general rule can be established, in such cases, regardless of the pilots' demands, the simplest possible approach on the shortest route and with a high priority should be considered.

In the present case it is striking that an air traffic control officer had intuitively realised the danger of the situation and had therefore urged her colleagues to provide the quickest possible approach. With regard to the information actually available, her colleagues decided, however, to handle the aircraft according to the sequence of priorities of the operating procedures and to prioritise faster aircraft. From the experience of numerous accidents in which a lack of cooperation of individual crew members was a causal factor, in the early 'eighties of the last century so-called crew resource management (CRM) was developed as training for flight crews and was subsequently incorporated as a component of the training or further training of commercial pilots. CRM is designed to increase awareness of the fact that, in addition to technical skills, the interpersonal domain is a key factor for a safe flight. It is a generally recognised fundamental principle of CRM that in case of doubt the crew member with a higher safety-conscious attitude should prevail. Air traffic control – at least in Switzerland – is traditionally not designed to the same extent for cooperation within a group. The individual air traffic control officer enjoys a wider autonomy in his actions and decisions than a member of the flight crew of a commercial aircraft. Even if this principle is not fundamentally called into question here, the present accident does strongly indicate that even within air traffic control, further efforts are necessary to improve cooperation and promote more safety-conscious decision-making.

On the other hand, in the training of pilots of aircraft operated by a single pilot, it should be stressed that technical problems should not be played down. A pilot of such an aircraft should develop an awareness that he is placed in a very demanding situation with a technical problem, depending on the weather conditions, and that it may be in the interests of safety to send an urgent or emergency message at an early stage. In the present case this would certainly have led to a reduction in the time up to the approach and might have defused the situation.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The aircraft was licensed for VFR/IFR transport.
- Apart from the failed Alternator 1, the investigation did not reveal any indications of pre-existing technical defects which might have influenced the accident.
- The last 100-hour check was conducted on 11 July 2008 at 307.7 operating hours.
- The last condition check by the FAA took place on 21 June 2008.
- There is no evidence of any technical limitations on the ground-based navigation systems.

3.1.2 Crew

- The pilot was in possession of the necessary licences for the flight.
- Evidence of full training of the pilot for operation of the SR22 aircraft could not be found.
- There are no indications of the pilot suffering any health problems during the flight involved in the accident.

3.1.3 Air traffic control

- The air traffic control officers involved were in possession of the necessary licences.

3.1.4 History of the flight

- N467BD took off at 12:45 UTC from runway 23 in Geneva with four people on board, with destination Berlin-Schönhagen.
- The aircraft climbed to FL 80 and was routed via the FRI and WIL VOR.
- After three brief outages, Alternator 1 finally failed at approximately 13:25 UTC.
- At 13:33:03 UTC the pilot reported to the DEP air traffic control officer the failure of Alternator 1 and the alternative landing in Zurich, as well as specifying a maximum flight time of 45 minutes.
- When asked by the DEP air traffic control officer, the pilot confirmed "normal operation".
- Subsequently, N467BD was transferred to the APE air traffic control officer and routed into the vicinity of ILS 14 via various heading changes.
- N467BD was transferred to the FIN air traffic control officer at approximately 13:48:30 UTC.
- At 13:51:30 UTC the pilot answered to the respective question from the air traffic control that he could maintain an approach speed of 160 kt.
- At 13:51:54 UTC the voltage at the main distribution bus dropped to 16 volts, at which point the MFD screen may have failed and from which time the pilot no longer had approach charts available for Zurich airport.

- At 13:52:48 UTC the MFD recorded a voltage of 12.1 volts at the main distribution bus and then made no further recordings.
- At approximately 13:53 UTC N467BD crossed the approach centre line of runway 14 and then continued flying on an unchanged heading of approximately 170 degrees.
- At 13:53:43 the pilot reported: *"I pick up the localiser signal but can't see the glide slope yet."*
- At 13:54:27 the pilot reported: *"Sorry Final Bravo Delta can we make the heading for the runway we're getting some difficulties with the power now."*
- Subsequently the FIN air traffic control officer asked the pilot several times whether he was able to receive the localiser signal or the glide slope. The pilot replied in the negative.
- In the meantime, N467BD was flying on a heading roughly parallel to the centre line of runway 14.
- At 13:55:27 UTC the secondary radar echo of N467BD disappeared from the radar screen.
- At 13:55:44 UTC, the FIN air traffic control officer requested: *"Continue present heading and climb to six thousand feet Bravo Delta."* This was confirmed by the pilot.
- At 13:56:17 UTC the pilot reported in response to the FIN air traffic control officer's question about his altitude: *"3500 we're experiencing some power failure request to change to VFR. We got a visual on the ground, we can proceed this way."*
- To the enquiry by the FIN air traffic control officer as to whether he could see the runway, the pilot answered: *"Ah negative no runway in sight we just have a visual to the ground."*
- Around 13:56:27 UTC a primary radar echo of N467BD appeared on the radar screen.
- At 13:56:31 UTC the FIN air traffic control officer requested the pilot to maintain visual contact with the ground and to fly a heading of approximately 140 degrees.
- Subsequently, the FIN air traffic control officer provided the pilot with several indications of the relative positions of the airport and the aircraft.
- At 13:56:58 UTC the pilot reported that he was descending to 2500 ft.
- At 13:57:35 UTC the FIN air traffic control officer gave the following instruction: *"Turn a bit to the left to around heading 110 that brings you just over the runway 16. You're approaching now the intersection between runway 16 and runway 28."* The pilot then replied: *"Ah negative we can do the hundred and eighty and then approach runway two … one four."*
- To the question as to whether he had still visual contact with the ground, the pilot answered: *"We're visual we have runway in sight Bravo Delta."*
- The FIN air traffic control officer then transferred N467BD to the aerodrome control centre.
- At 13:58:06 UTC the pilot reported on the aerodrome control frequency *"N7BD we're just at the xxxx* (not comprehensible) *of threshold for runway 14."*

- The ADC air traffic control officer then gave the landing clearance for runway 14, which was read back by the pilot.
- A few seconds later the aircraft crashed to the ground from a tight right-hand turn.
- According to the PFD recordings, the last turn was flown at a bank angle of 40 to 80° and at a speed of approximately 100 knots.

3.1.5 General conditions

- The flight took place as part of the pilots' business activity and was conducted under instrument flight rules.
- The AFM gave no explicit indication of the time during which Battery 1 can ensure the supply to the main distribution bus after a failure of Alternator 1.
- The AFM specified that in the event of a failure of Alternator 1, non-essential electrical consumers on the main distribution bus should be switched off.
- There is no evidence that a reduction of electrical consumers on the main distribution bus had taken place.
- The AFM prohibited the use of the CMax Approach Charts function as a primary means of navigation.
- No charts for the approach in Zurich could be found.
- The DEP air traffic control officer understood *"altimeter one failure"* to be the reason for the alternate landing and relayed this to the CAP air traffic control officer and the APE air traffic control officer.
- The DOM air traffic control officer understood *"alternator one failure"* to be the reason for the alternate landing, although she was informed by the CAP air traffic control officer of an *"altimeter one failure"*.
- All the air traffic control officers in the control tower (DOM, GRO and ADC) assumed an *"alternator one failure"* and *"normal operation"*.
- Of the air traffic control officers in approach control, DEP, APE and CAP always assumed an "altimeter one failure", whilst FIN had no information regarding the nature of N467BD's technical difficulties. All assumed *"normal operation"*.
- The DOM air traffic control officer insisted several times to the CAP air traffic control officer that the approach of N467BD should not be delayed.
- The CAP air traffic control officer relayed this to the APE air traffic control officer.
- No high priority was assigned to N467BD.
- According to the PFD recordings, an ILS inbound course of 015°, instead of 137°, was set on the EHSI throughout the entire approach
- An estimate indicates that the mass of the aircraft at the time of the accident was approximately 45 kg or just under 3% above the limit allowed in accordance with the AFM.
- The aircraft was equipped with a CAPS, which was not deployed.
- The north side of the Alps remained under largely complete cloud cover for the entire day. Almost the entire flight took place in cloud.
- Instrument weather conditions prevailed at Zurich airport.

3.2 Causes

The accident is attributable to the fact that the pilot lost control of the aircraft during a tight turn flown at a low height above the ground and then collided with the terrain.

The following factors created conditions for the accident or favoured its occurrence:

- The way the pilot dealt with the failure of a partially redundant system, which did not mitigate the effects of the malfunction but exacerbated them.
- An unfounded awareness of the actual situation, which prompted the pilot to give an over-optimistic assessment of his situation to air traffic control and prevent him from declaring emergency.
- Inappropriate use of the available navigation aids.
- The pilot was not in possession of any approach charts for the alternate aerodrome, Zurich.
- An inadequate understanding within air traffic control of the significance of faults and emergencies on single-engine light aircraft flown by a single pilot in challenging weather conditions.
- The relatively long period between the occurrence of the fault and the start of the approach.
- The pilot's decision to offer the air traffic control a high approach speed.
- The pilot's decision to carry out a demanding manoeuvre with the aircraft visually, in instrument weather conditions, from an initial position unfavourable for a landing.
- A high flight mass.

Payerne, 2 July 2012 Swiss Accident Investigation Board

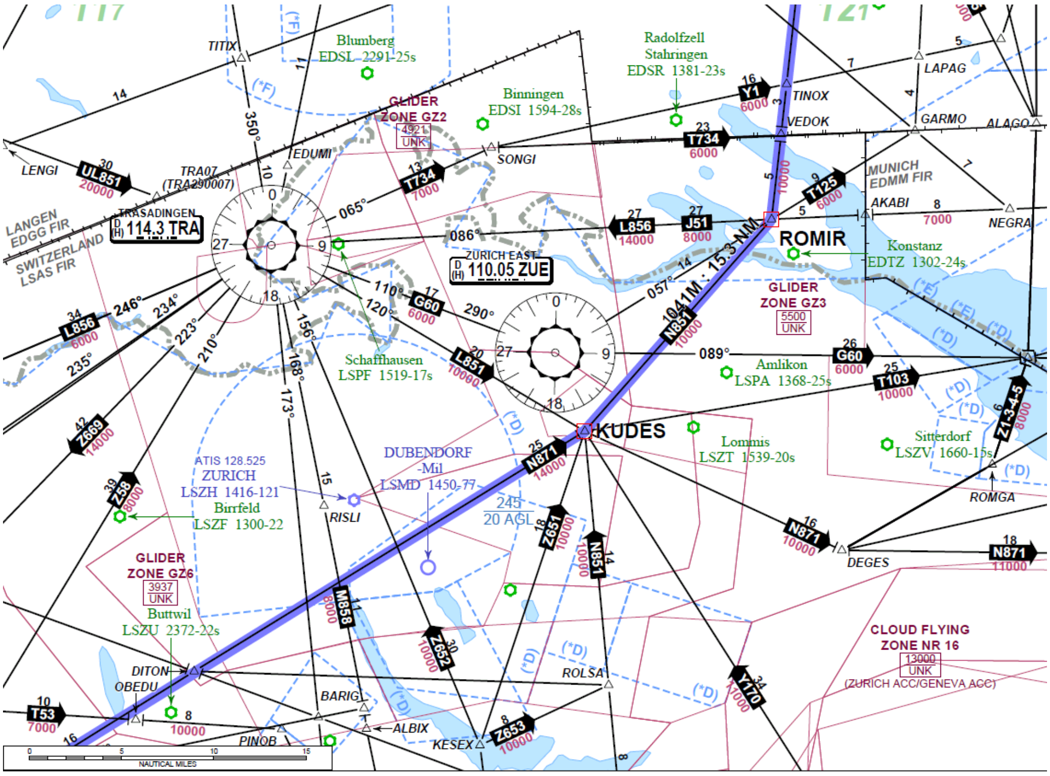
This final report was approved by the management of the Swiss Accident Investigation Board SAIB (Art. 3 para. 4g of the Ordinance on the Organisation of the Swiss Accident Investigation Board of 23 March 2011).

Berne, 9 August 2012

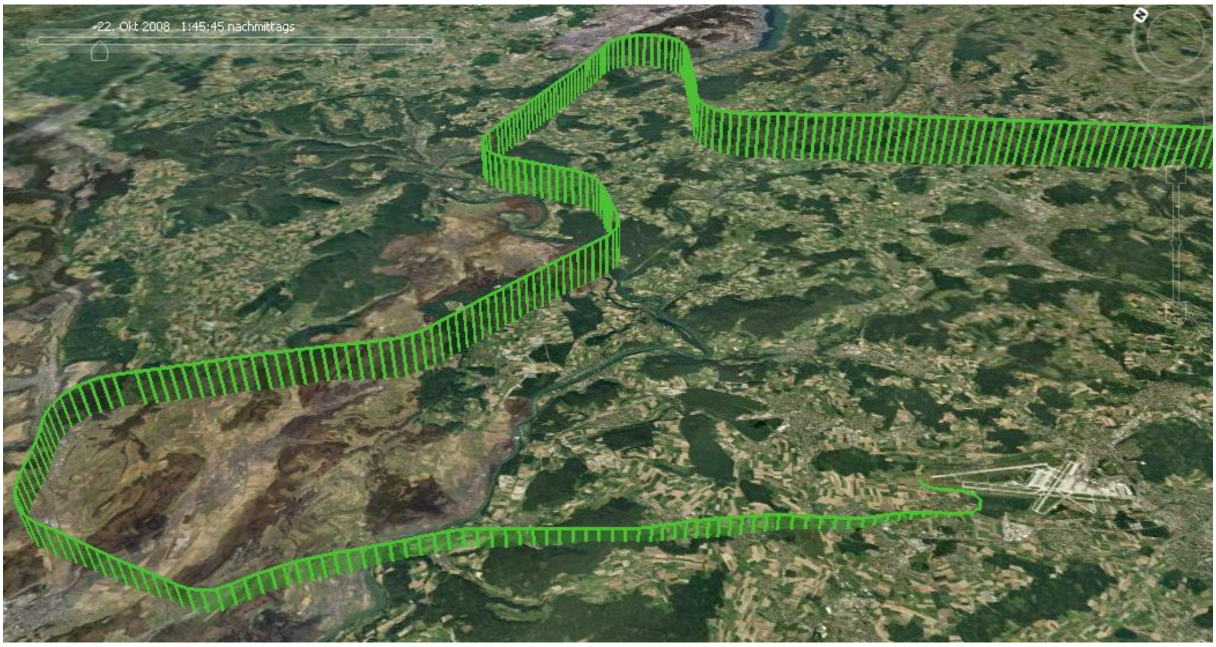
Annexes

Annex 1

Planned flight path south of Zurich airport according to flight plan



Annex 2: Flight path according to the PFD recording



Annex 3

Primary Flight Display (PFD) Avidyne FlightMax Entegra

Annex 4

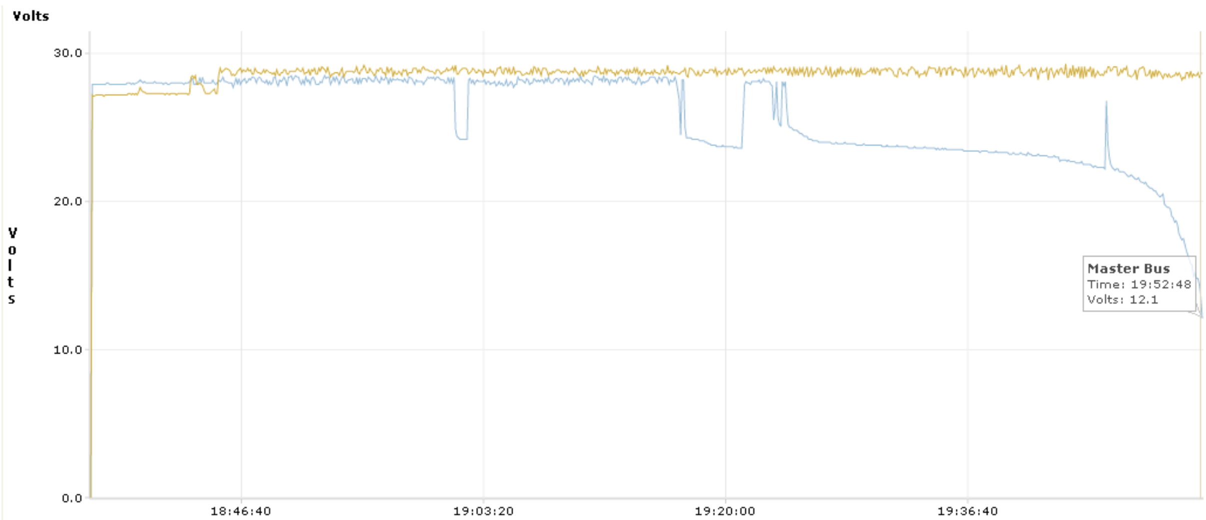
Multifunction Flight Display (MFD) Avidyne EX5000C

Annex 5

MFD in CMax Approach Charts Mode

Annex 6

Recording of the voltage at the essential distribution bus (brown, upper) and the main distribution bus (blue, lower, labelled "Master Bus") by the MFD. The times at the bottom of the graph correspond to UTC +6 h. In the box: the last recording was at 13:52:48 UTC, voltage 12.1 volts.

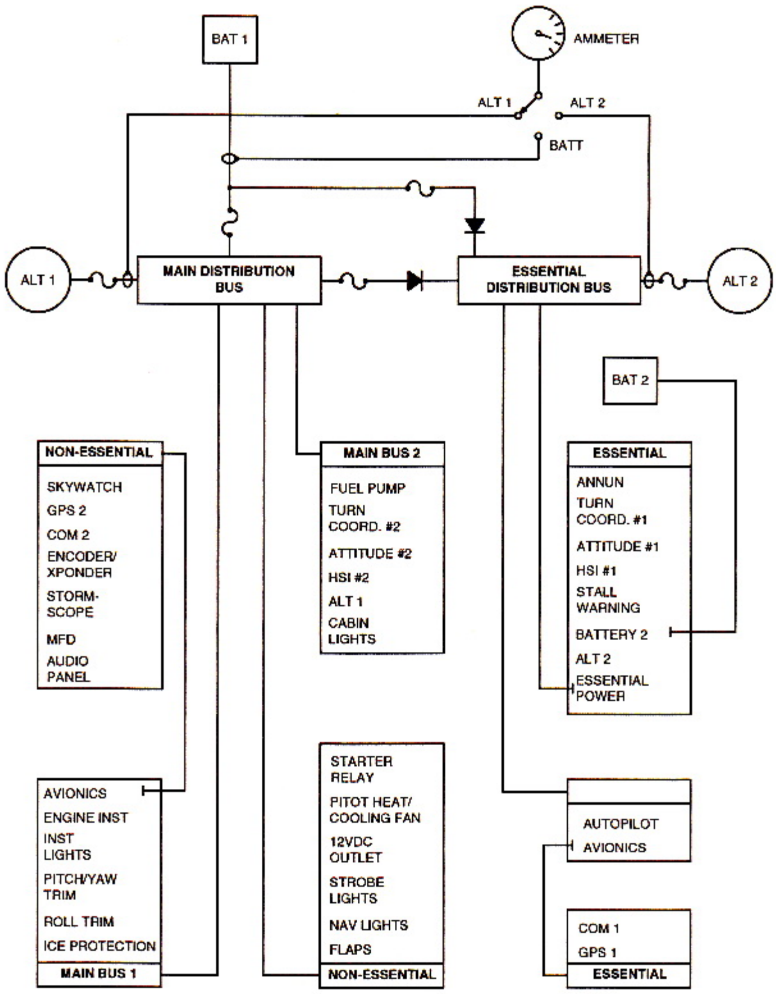


Annex 7

Schematic of the electrical system according to the AFM

Section 3
Emergency Procedures

Cirrus Design
SR22



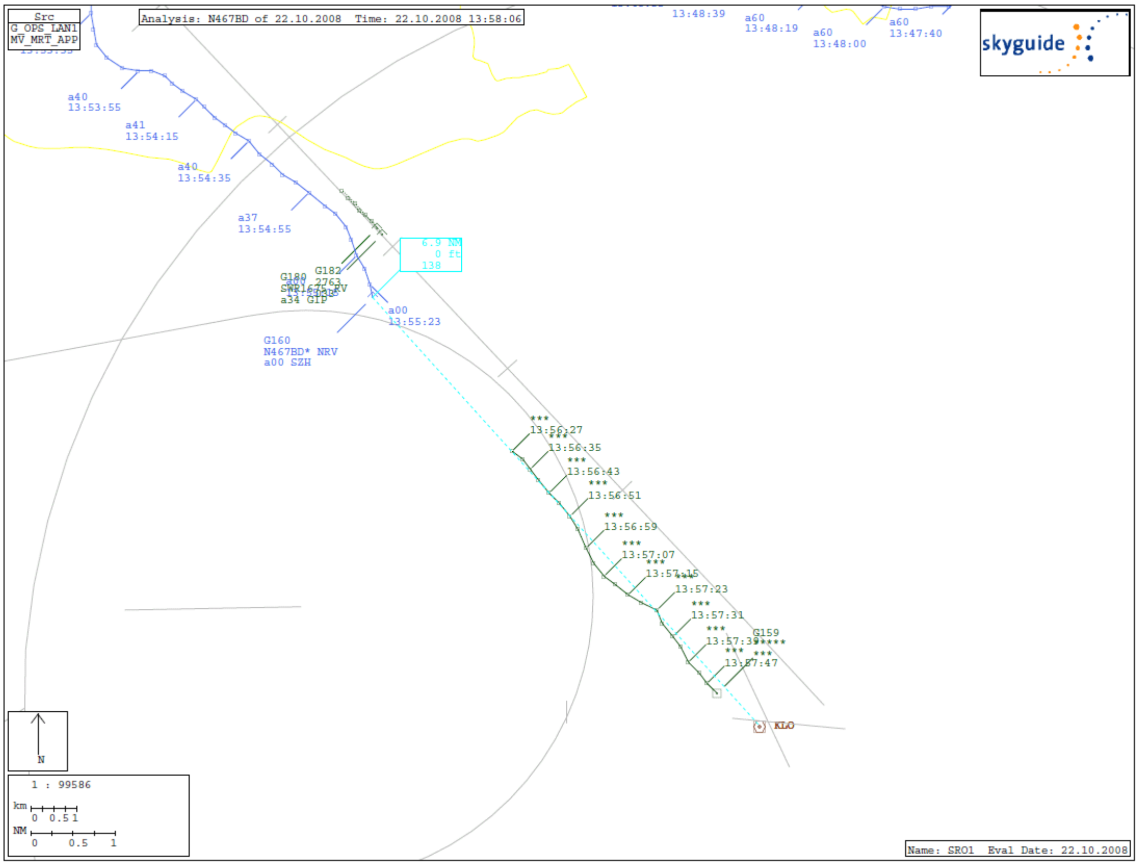
SR22_FM03_1453A

Figure 3-2
Electrical Power Distribution (Simplified)

3-26 **P/N 13772-001**
Revision A1

Annex 8

Flight path before and after the failure of the transponder according to the recording by sky-guide



Annex 9

Flight path in the final phase of the flight according to the PFD

Annex 10

Overview of stall speeds according to the AFM

Stall Speeds

Conditions:

- Weight .... 3400 LB
- C.G. .... Noted
- Power.. Idle
- Bank Angle .... Noted

Example:

Flaps .... Up (0%)
Bank Angle.................................... 15°
C.G.. Forward

Stall Speed.......... 71 KIAS | 70 KCAS

• Note •

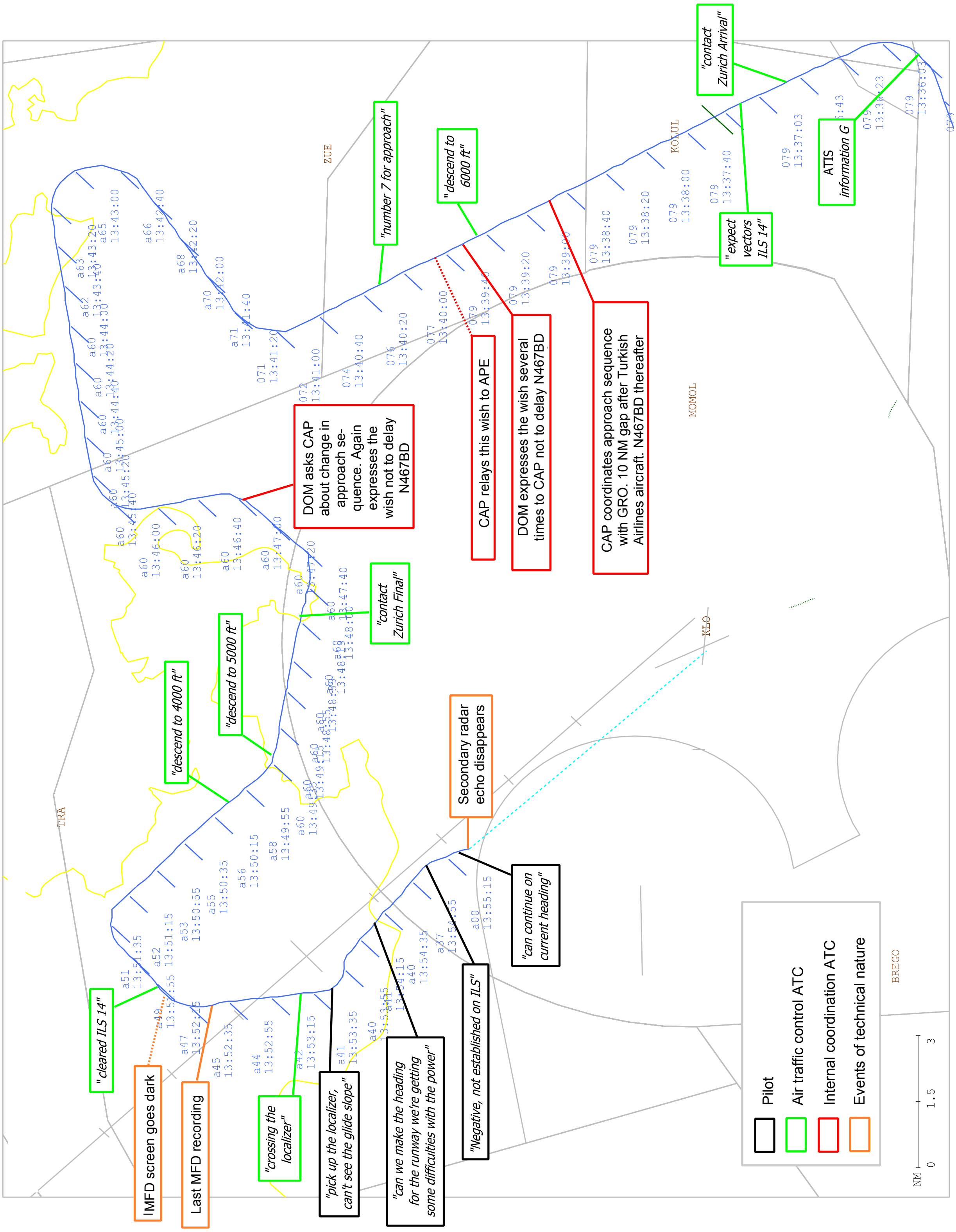
- Altitude loss during wings level stall may be 250 feet or more.
- KIAS values may not be accurate at stall.

Weight LB	Bank Angle Deg	STALL SPEEDS Flaps 0%Full Up KIAS	KCAS	Flaps 50% KIAS	KCAS	Flaps 100%Full Down KIAS	KCAS
3400 Most FWD C.G.	0	70	69	67	64	59	59
	15	71	70	68	65	62	60
	30	75	74	72	69	66	64
	45	84	82	80	76	73	70
	60	99	97	95	90	87	84
3400 Most AFT C.G.	0	68	67	66	62	61	59
	15	69	68	67	63	62	60
	30	73	72	71	67	65	63
	45	81	79	78	74	72	70
	60	96	94	93	88	86	83

Figure 5-7

Annex 11

Overview of the chronology of important events I



Annex 12

Overview of the chronology of important events II