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Büro für Flugunfalluntersuchungen BFU
Bureau d'enquête sur les accidents d'aviation BEAA
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Uffizi d'inquisiziun per accidents d'aviatica UIAA
Aircraft accident investigation bureau AAIB

Final Report No. 2090

by the German Federal Bureau of Aircraft Accident Investigation

concerning the accident

involving the Saab Aircraft AB/Saab 2000, registration HB-IZY

on 10 July 2002

at Werneuchen / Germany

Investigation Report

AX002-0/02
October 2010

Identification

Type of Event: Accident
Date: 10 July 2002
Location: Werneuchen
Aircraft: Civil Air Transport, Fixed Wing
Manufacturer /Type: Saab Aircraft AB / Saab 2000
Injuries to Persons: One passenger slightly injured
Material damage: Aircraft seriously damaged
Third party damage: None
Source of information: Investigation by BFU

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This investigation was conducted in accordance with the Federal German Law on Aircraft Accident Investigations and Incidents resulting in disruption to the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FIUUG*) of 26 August 1998. The sole objective of the investigation is to prevent future accidents and incidents.

The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

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Abbreviations

| | |
|------------------|--|
| AIP | Aeronautical Information Publication |
| ATIS | Automatic Terminal Information Service |
| ATPL | Airline Transport Pilot Licence |
| CAT I / II / III | Categories of the Instrument Landing System |
| CAVOK | Ceiling and Visibility o.k. |
| CMD | Commander |
| CRM | Crew Resource Management |
| CVR | Cockpit Voice Recorder |
| dBZ | Decibel Z |
| DWD | Deutscher Wetterdienst (German Meteorological Service) |
| FDR | Flight Data Recorder |
| FL | Flight Level |
| FMS | Flight Management System |
| Freq. | Frequency |
| GND | Ground |
| AGL | Above Ground Level |
| ICAO | International Civil Aviation Organization |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| kt | Knots |
| LOFT | Line Oriented Flight Training |
| METAR | Meteorological Aerodrome Report |
| MLM | Maximum Landing Mass |
| MSL | Mean Sea Level |
| MTOM | Maximum Take Off Mass |
| MWO | Meteorological Watch Office |

| | |
|-------|---|
| NDB | Non Directional Beacon |
| NfL | Nachrichten für Luftfahrer (German Language Publication for Aviation) |
| NOSIG | No Significant Change |
| OCC | Operations Control Centre |
| OM A | Operations Manual Part A |
| PF | Pilot Flying |
| PIC | Pilot In Command |
| PNF | Pilot Non Flying |
| SHP | Shaft Horse Power |
| TAF | Terminal Aerodrome Forecast |
| UTC | Universal Time Coordinated |
| VFR | Visual Flight Rules |
| VOR | Very high frequency omni directional Radio range |

Synopsis

On the evening of 10 July 2002 the German Federal Bureau of Aircraft Accident Investigation (BFU) was advised by police in Frankfurt/Oder of the emergency landing by a Civil Air Transport aircraft on Werneuchen Special Airfield.

Two BFU representatives travelled at once to the accident site. The following morning, two BFU accident investigators travelled from the Braunschweig head office to Werneuchen, to continue the investigation.

Following a flight from Basel, during a violent and turbulent thunderstorm the crew of a scheduled flight to Hamburg aborted the approach to land at their destination. The crew decided against a diversion to their declared alternate, because they would have to fly through the thunderstorm frontal system en route to Bremen. Given the continued development of the thunderstorm, the crew also decided against an approach to Hannover.

During the continued flight for a landing in Berlin-Tegel, the good weather forecast for this airport rapidly deteriorated due to the speedy formation of extreme thunderstorms, such that a safe landing at Tegel (also Tempelhof and Schönefeld Airports) would have been temporarily impossible.

With fuel running low, the aircraft was radar vectored to Werneuchen Special Airfield, where there was as yet no sign of thunderstorm activity in the vicinity.

During their approach to the former Russian military airfield, the crew did not discern that the threshold to the 2,400 metre long runway 08 had been displaced by about 900 m; which now represented the beginning of the approved runway.

After touching down on the concrete strip prior to the threshold of the runway, the aircraft ploughed through an earthen wall that had been placed across the concrete strip; all three landing gears were ripped from the aircraft.

During the final approach into an unfamiliar airfield both pilots did not recognize the wall. The original markers on the old military runway lent the impression that the full runway length was available; the white signal crosses that had subsequently been painted on the decommissioned part ahead of the now displaced threshold had become eroded and were visually insignificant.

After the decision to abandon an attempt to land at the destination airport, the subsequent development of a highly dynamic thunderstorm created a situation in which the crew found themselves finally left with no alternatives, followed by a landing on a special airfield and a total loss of the aircraft.

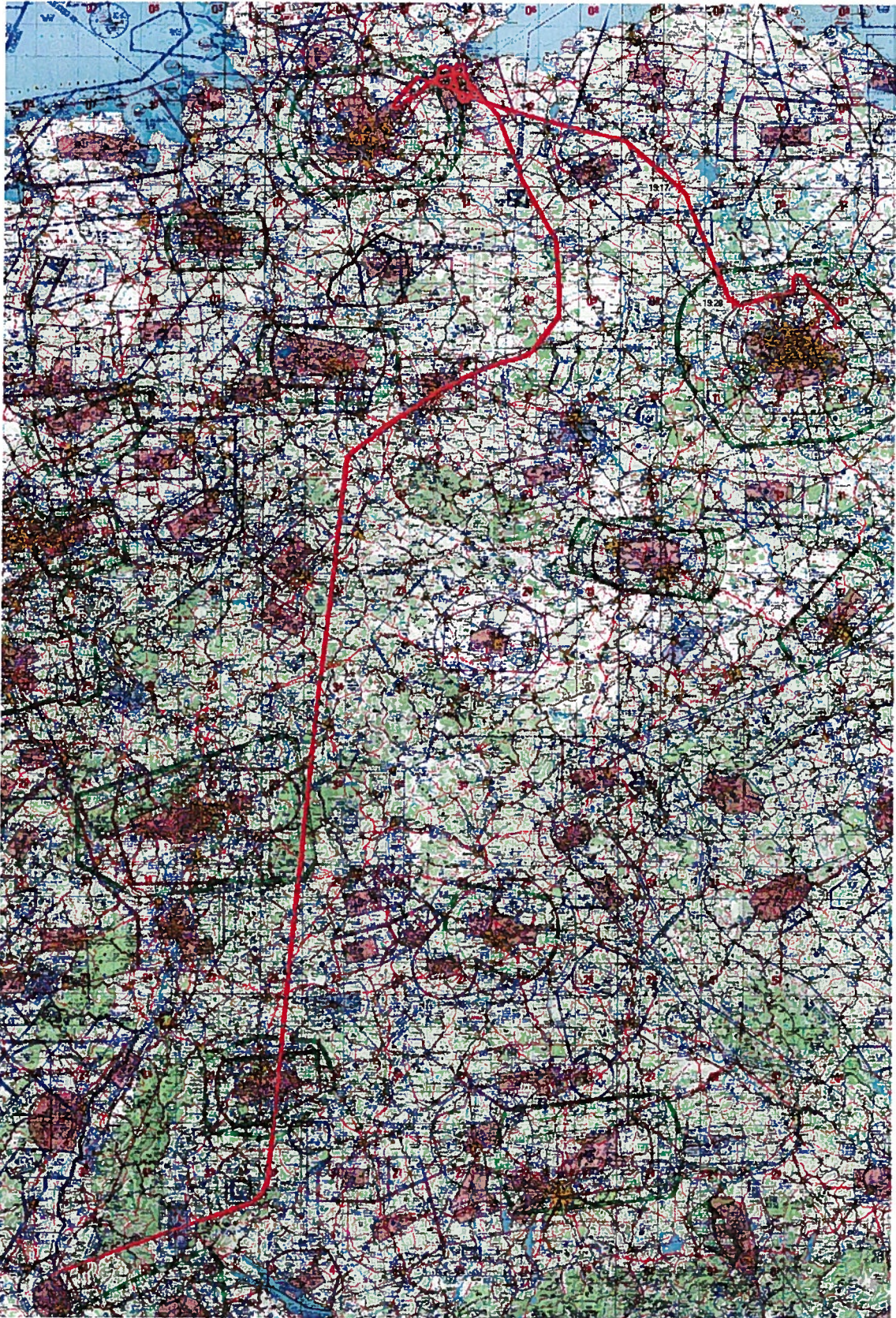
The accident was caused by the following immediate and systemic causes:

Immediate causes

- The extent and intensity of the thunderstorm frontal system, plus the speed of change in the weather system.
- Insufficient use of available resources when making decisions in flight (pro-active).
- The loss of alternative landing options, coupled with increasing time pressure (reactive).
- Aircraft touched down outside operational area of an airfield.
- Earth wall was not detected, followed by collision with the same.

Systemic Causes

- Insufficient information with respect to weather situation and development, both prior to and during the flight.
- Insufficient information about Werneuchen Special Airfield due to inadequate chart illustration, plus absence of and misunderstood communications.
- Insufficient signs and markings of operational and non-operational airfield areas.



Flight track followed by the Saab 2000

Source: BFU

1. Factual information

1.1 History of the flight

The cockpit crew went on duty at 1630 hrs¹ having been rostered for a return Basel – Brussels flight. Originally, the Hamburg flight had been scheduled with an Embraer 145, but was switched to the Saab 2000 for technical reasons. The crew was assigned to the flight Basel – Hamburg at short notice. Because of this change the crew had 15 more minutes for the pre-flight briefing.

The following weather briefing information was available to enable the crew form their judgement of the weather: METARs and TAFs for the relevant airports, upper air wind charts and the *Significant Weather Chart* valid to 2000 hrs. The crew did not have other warnings relating to significant weather phenomena or conditions.

The Pilot in Command (PIC) subsequently reported that the co-pilot had prepared the weather briefing, from which it was deduced they could expect summer thunderstorms typical of Northern Germany. This confirmed the experience of the PIC of the flights on previous days.

The TAF for Hamburg valid from 1500 hrs to 2400 hrs stated:

```
EDDH 101200Z 101322 31010KT 9999 FEW025 TEMPO 1320 29020G40KT 3000 TSRA BKN013CB  
Tempo 1922 4000 RA BKN014
```

Given a crew of four and 16 passengers, the pilots decided to take about 600 kg of fuel in addition to the calculated minima for the planned route. Based on their experience, the crew judged that "a typical summer thunderstorm lasts 20 to 30 minutes, following which the airport is generally re-opened for incoming aircraft."

The twin-engined Saab 2000 took off for Hamburg at 1809 hrs. On reaching a position about 20 nautical miles (NM) south of the Leine (DLE) VOR, the aircraft was first vectored to a heading of 060° to enable it to cross a squall line then lying over Northern Germany, at right angles and via the shortest route. The aircraft then descended under radar control from its cruise level of FL 260, via the Hehlingen VOR (HLZ), Brünkendorf VOR (BKD) and Lübeck VOR (LUB) in stages to 5,000 ft MSL. At 1936 hrs the aircraft was cleared to descend to 3,000 ft for an ILS approach to runway 23 at the destination airport.

One and a half minutes later, the crew aborted the approach to land at an altitude of about 3,300 ft, due to an encounter with severe turbulence on the forward side of a front moving northeast, with a thunder cell located above the runway threshold; the aircraft initially flew in a north-easterly direction.

In response to the air traffic controller's question as to whether they wished to wait a little, at 1941:30 hrs the crew responded: "Affirm, we have about 45 minutes fuel until we have to divert, so we just like to wait and see what happened ..." The air traffic controller then gave clearance to enter the Lübeck holding pattern at 5,000 ft MSL.

In response to the crew's enquiry about the weather at Bremen, the air traffic controller passed the following information: "Bremen weather, met report time 1720 (19:20 CET), the wind is 320/09 knots, visibility 6 km thunderstorm with rain, clouds broken 800, broken 1500 in CB the temperature is 12, dew point 11, QNH 1010 and temporary is showering rain."

The 55 NM between the two airports was straddled by a line of thunderstorms.

¹ All times local, unless otherwise stated

At 1949:06 hrs the air traffic controller advised the crew that another aircraft had just landed at Hamburg on runway 33; the wind was strong, but the landing aircraft had reported no severe turbulence. Air traffic control offered an approach to runway 33 (LOC/DME-Approach) but this was declined by the crew, which requested a diversion to Hannover.

No suggestion was made by air traffic control as to other alternative airports (e.g. Lübeck or Kiel), nor did the crew make any such request. The company's Operational Control Centre (OCC) made no attempt to contact the Saab with supporting information about the likely future progress of the thunderstorms. The crew made no contact with the OCC.

The aircraft left the Lübeck hold at 1952:38 hrs, initially on a track of 120°.

On leaving the hold the aircraft entered another ATC sector. At 1953 hrs the pilots made contact on the allocated frequency.

The written notes in the cockpit showed receipt of ATIS Information Sierra from the Hannover Airport. Air traffic control instructed the crew to head first for the Celle NDB (CEL) prior to an approach to Hannover, but the crew was unable to follow this instruction because a southerly heading to the right would have been directly into the active side of the approaching thunderstorm. The crew took up a south easterly heading and maintained an altitude of 5,000 ft.

At 2013 hrs when in the vicinity of Schwerin and in view of the situation displayed by their weather radar the crew decided upon a diversion to Berlin-Tegel. Two minutes later the Saab CVR records that the pilots monitored the ATIS- Information Delta from Tegel, which described the weather as CAVOK with the trend as NOSIG, which reaffirmed their decision. The Co-pilot copied down the ATIS recording Delta of 1950 hrs as follows: D (1750) ILS 08L TL70 040/2 CAVOK 30 17/1 30 1002 NOSIG.

At 2017:09 hrs the crew changed frequency to Berlin-Arrival. Given the general weather situation and the associated higher than usual workload, an additional air traffic controller was tasked with serving this sector.

Following the appearance of the *Low Fuel Warning*, at 2018:33 hrs the crew transmitted an urgent message reporting that they only had fuel remaining for 40 minutes, with the request for priority. The controller instructed the crew to fly direct to reporting point KONOX, 10 NM from the threshold of Berlin-Tegel Airport runway 08. Five minutes later the pilot reported: "... committed to land due to fuel ...". The crew was then instructed to fly direct to the runway *outer marker*.

At about 2025 hrs, when the aircraft was 20 NM northwest of Tegel, the line of thunderstorms had reached the central area of Berlin.

At 2028 hrs and at an altitude of about 3,500 ft and given turbulence and the presence of thunder cells in front, the crew abandoned the flight to Berlin and requested directions to another airport. Air traffic control suggested the aircraft should take up a heading of 080° to the airfield of Eberswalde-Finow (EDAV) 27 NM away, to which the crew responded: "Okay, we'll take anything at this point."

From this moment onwards, the air traffic controllers handled the situation as an emergency.

En route to Finow the Saab weather radar revealed an extended thunderstorm in the vicinity of that airfield. At 2032 hrs the pilot communicated with the air traffic controller and asked about information on EDAH (Heringsdorf) and ETNU (Neubrandenburg) which had been displayed on the onboard Flight Management System (FMS). There followed a spontaneous change of heading towards Neubrandenburg airfield 46 NM distant, but this was abandoned two minutes later because the air traffic controller reported the presence of a thunderstorm over the airfield. After having been advised by a neighbouring sector controller that the area east of Berlin was reported as 'clear' by another aircraft, at 2033 hrs the air traffic controller suggested an approach to Werneuchen 20 NM away.

The Saab 2000 took up a south easterly heading at 1,800 ft and was vectored to this special airfield.

At the same time, the supervisor for the Berlin Air Traffic Control centre tried to telephone Werneuchen Airfield. Using the mobile telephone number printed in Volume III of the German AIP VFR-Handbook as the flight operations number, he contacted the chairman of a Werneuchen flying club and advised that air traffic control wanted an aircraft to land at the airfield. At that time the club chairman was not at the airfield; he stated he had advised that the western concrete strip closest to Werneuchen was unusable for landing and a low earthen wall had been placed across the strip. The runway was about 1,500 m. This has to be considered during any landing in the direction 08. When he received the call, the club chairman was about 100 km from Werneuchen in Pritzwalk and was unable to give any information about the current wind and weather situation at the airfield. (Appendix A3 has a full transcript of the mobile phone conversation between ATC and the chairman of the flying club).

When the aircraft was about 20 NM northwest of Werneuchen, the air traffic controller advised the crew of the length and width of the runway, surface and load bearing capacity of 5.7 t. The controller had taken the information from the airfield map published in Volume III of the AIP, (Appendix A2).

On the day of the accident, there had been flight operations by three aircraft at Werneuchen from 1800 hrs to 2000 hrs. When the Saab 2000 was on approach, a number of pilots, the Flugleiter (A person required by German regulation at uncontrolled aerodromes to provide aerodrome information service to pilots) and a number of other persons were still at the airfield. They observed the approaching airliner and attempted to make radio contact.

At 2040 hrs, about 3 NM prior to reaching the airfield, the crew reported Werneuchen Airfield in sight. The crew flew a left turn to line up with the approach to runway 08. They received the following radio transmission from air traffic control: "Okay eh... (call sign)...we just eh been informed that you should use the easterly part of the runway eh so eh in you eh you are not before landing before the threshold of zero-eight – genau."

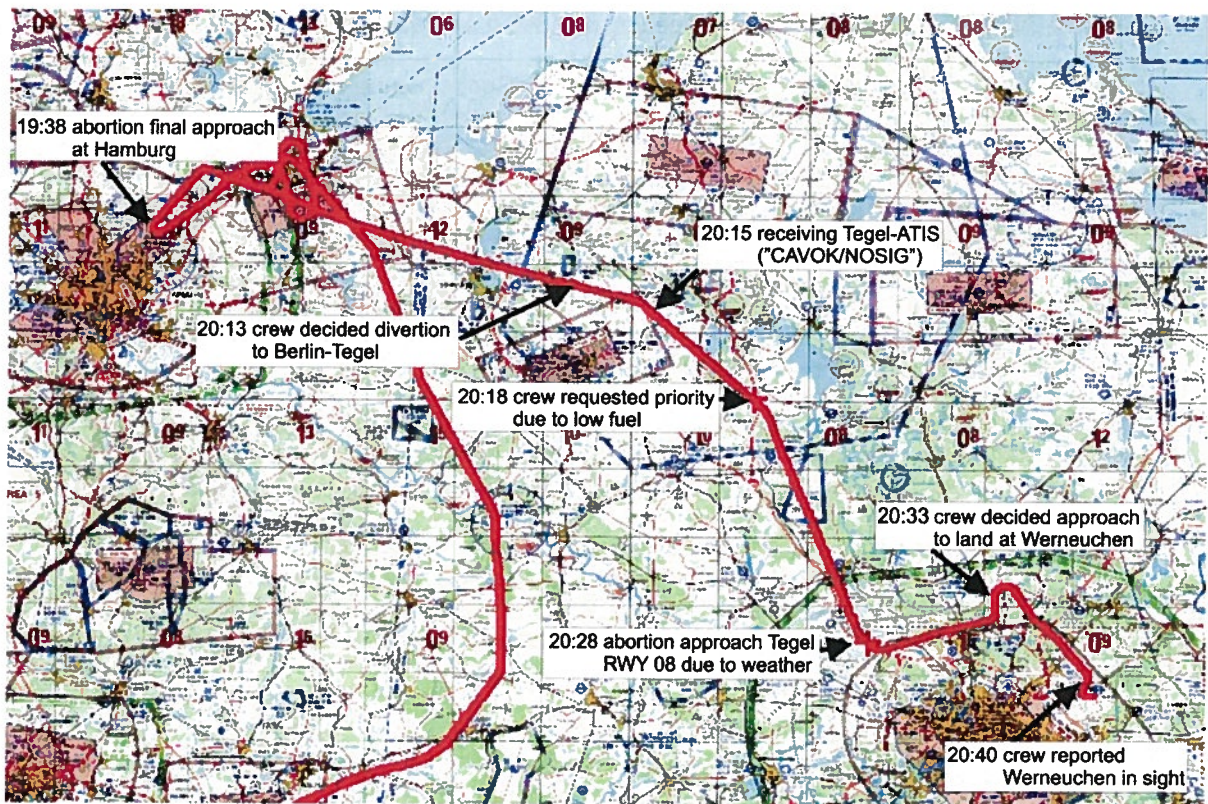
The crew responded to this radio message: "Ja we're just abeam the threshold zero-eight now making a left hand eh downwind if you agree for zero-eight."

During the final approach to land, the two pilots discussed the runway before them and the touchdown. The co-pilot, who was the pilot flying, asked: "Touch down where?" The PIC answered: "Wherever you like my friend." After passing through 500 ft AGL the PIC said: "It's longer than... longer than Bern, hä."

After passing the threshold marking, the aircraft touched down. During the landing roll the aircraft collided with a low earth wall astride the concrete strip, causing all three landing gear legs to break off. The aircraft came to rest after sliding about 350 m.

After the aircraft came to rest, the left engine fire warning light came on in the cockpit. The crew activated the fire extinguishing systems in both engines.

The Saab 2000 landed shortly before 2042 hrs. At that time the thunderstorm frontal system had not reached Werneuchen, but was in the immediate vicinity and therefore affected the normal evening daylight. During the approach the wind remained light and the conditions were VMC, while a few minutes earlier departures and arrivals had halted at the Berlin Airports of Tegel, Tempelhof and Schönefeld. About 15 minutes after the wrecked aircraft had been evacuated, a gale-force surge line passed over the airfield followed by a thunderstorm with unusually heavy precipitation, just as over the entire Berlin conurbation shortly beforehand.



1.2 Injuries to Persons

| Injured | Crew | Passengers | Total | Other |
|---------|------|------------|-------|-------|
| Fatal | | | | |
| Serious | | | | |
| Slight | | 1 | 1 | |
| None | 4 | 15 | 19 | — |
| Total | 4 | 16 | 20 | |

1.3 Damage to Aircraft

There aircraft was seriously damaged. It was subsequently written off as a total loss.

1.4 Other Damage

None

1.5 Personnel information

1.5.1 Crew

Pilot

Since 29 October 1999 the pilot in command had been in possession of a valid Air Transport Pilot's Licence (ATPL, A/FCL), as well as Synthetic Flight Instructor (SFI) and Chief Ground Instructor with Type Rating Training for the Saab 2000 operated by the company.

His total flight time was 2,600 hours. He had flown 2,350 hours on the Saab 2000 of which 1,750 hours were as co-pilot and 600 hours as PIC. In the previous 90 days he had flown 153 hours.

The BFU was provided with no evidence that the pilot had taken part in any Crew Resource Management courses.

During his periodic checks the pilot had generally received very good marks for the CRM skills demonstrated in the cockpit. The last checks were carried out as follows:

| | |
|--|---|
| Proficiency Check CAT I/II/III (annual): | 09 April 2002 |
| Line Check (annual): | 01 November 2001 |
| Proficiency and Skill Check (annual): | 30 August 2001 (The subsequent check documentation was not provided to the BFU) |

Prior to checking in at 1630 hrs, the pilot had rested for more than 18 hours.

Co-pilot

The co-pilot had been in possession of a valid Commercial Pilot's Licence (CPL, A/FCL) since 18 June 1999.

His total flight time was 1,940 hours, of which 1,732 hours were as first officer on the Saab 2000. He had flown 125 hours within the previous 90 days.

The BFU was provided with no evidence that the co-pilot had taken part in any Crew Resource Management courses.

During his periodic checks the pilot had generally received very good marks for CRM skills demonstrated in the cockpit. The last checks were carried out as follows:

| | |
|--|--|
| Proficiency Check CAT I/II/III (annual): | 25 March 2002 |
| Line Check (annual): | 18 October 2001 |
| Proficiency and Skill Check (semi-annual): | 21 September 2001 (The subsequent check documentation was not provided to the BFU) |

Prior to checking in at 1630 hrs, the pilot had rested for more than 19 hours.

Cabin Crew

There were two female cabin flight attendants on board. One was the head of cabin crew training for the company, the other a cabin crew instructor.

1.5.2 Air Traffic Controllers

1.5.2.1 Bremen Sector Control Centre

Air Traffic Controller TEH

The 34 year-old air traffic controller had worked for the Air Traffic Control service provider for eight years, and for six years had been licensed for this sector.

1.5.2.2 Berlin Sector Control Centre

Supervisor

The 42 year-old supervisor had worked for the Air Traffic Control service provider for 13 years and had been supervisor for three years.

Air Traffic Controller TR1N

The 36 year-old air traffic controller had worked for the Air Traffic Control service provider for nine years, and for eight years had been licensed for this sector.

He occupied position TR1N which had been opened in response to the weather situation and the consequential increased need for coordination.

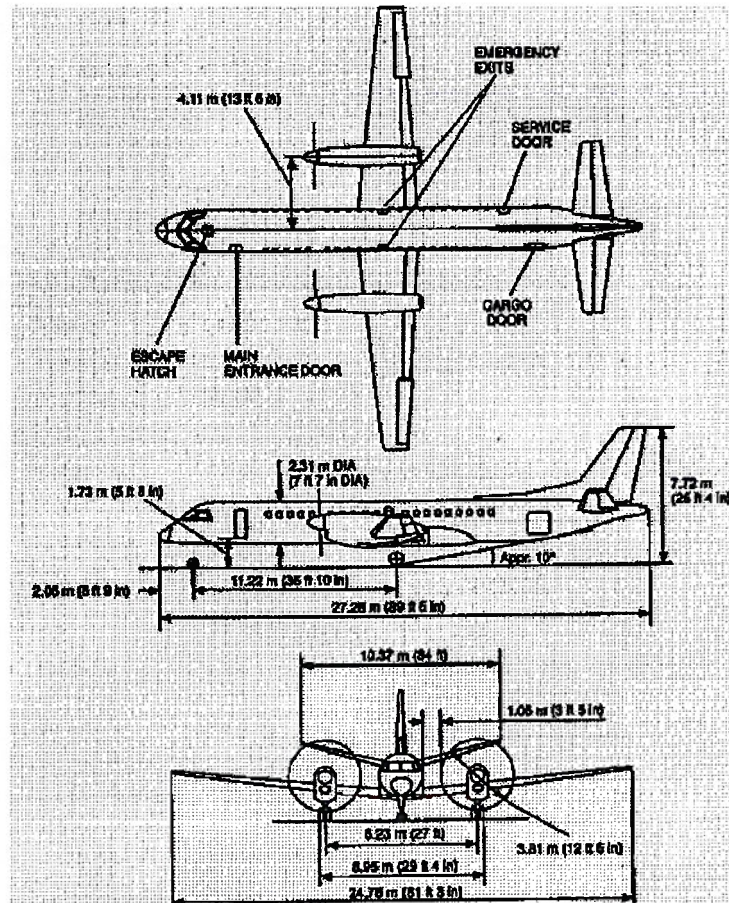
1.6 Aircraft Information

The Saab 2000 is a twin-engined turboprop aircraft manufactured by Saab Aircraft AB, Linköping, Sweden. This low-wing Civil Air Transport is registered in the weight category >20,000 kg. The aircraft is used primarily for regional scheduled services and depending upon the interior arrangements can carry up to 50 passengers.

| | |
|------------|--|
| Length: | 27.03 m |
| Height: | 7.72 m |
| Wing Span: | 2,476 m |
| MTOM: | 22,999 kg |
| MLM: | 22,000 kg |
| Engines: | 2 Allison AE 2100A, each rated at 4,152 SHP take-off power |
| Propeller: | 6-blade propeller Dowty Aerospace R381-123-F/5 |

The fuel requirement for Basel to Hamburg was calculated on the basis of a flight time of 1hr 17 min. To this quantity was added the standard reserves required, resulting in a minimum fuel quantity calculated at 2,030 kg. This quantity incorporated 350 kg as 'Final Reserve Fuel' for about 30 minutes flight time.

An additional 570 kg kerosene were taken on board as 'Extra Fuel'. At start-up the aircraft had 2,600 kg fuel on board, which was 1,650 kg below the maximum fuel tank capacity of 4,250 kg.



Three-view drawing Saab 2000

Source: Air Operator

The aircraft was registered by the Swiss Civil Aviation Authority on 26 March 1998. An appendix to the Certificate of Airworthiness gave the operating limitations as VFR / IFR Cat. IIIa / B-RNAV. The aircraft was manufactured in 1997, since then it had flown 12,303 hours / 12,069 cycles.

The Saab 2000 was mainly equipped with Collins avionics. The on-board weather radar was a Collins TWR 850 and was operational.

The weather radar has a scan angle of 7.3° and a forward angle of 120°, enabling the unit to detect echoes at chosen distances between 20 and 160 NM.

The regional service Saab 2000 aircraft was not fitted with a digital ACARS (Aircraft Communications Addressing and Reporting System) for communication between the crew and the company.

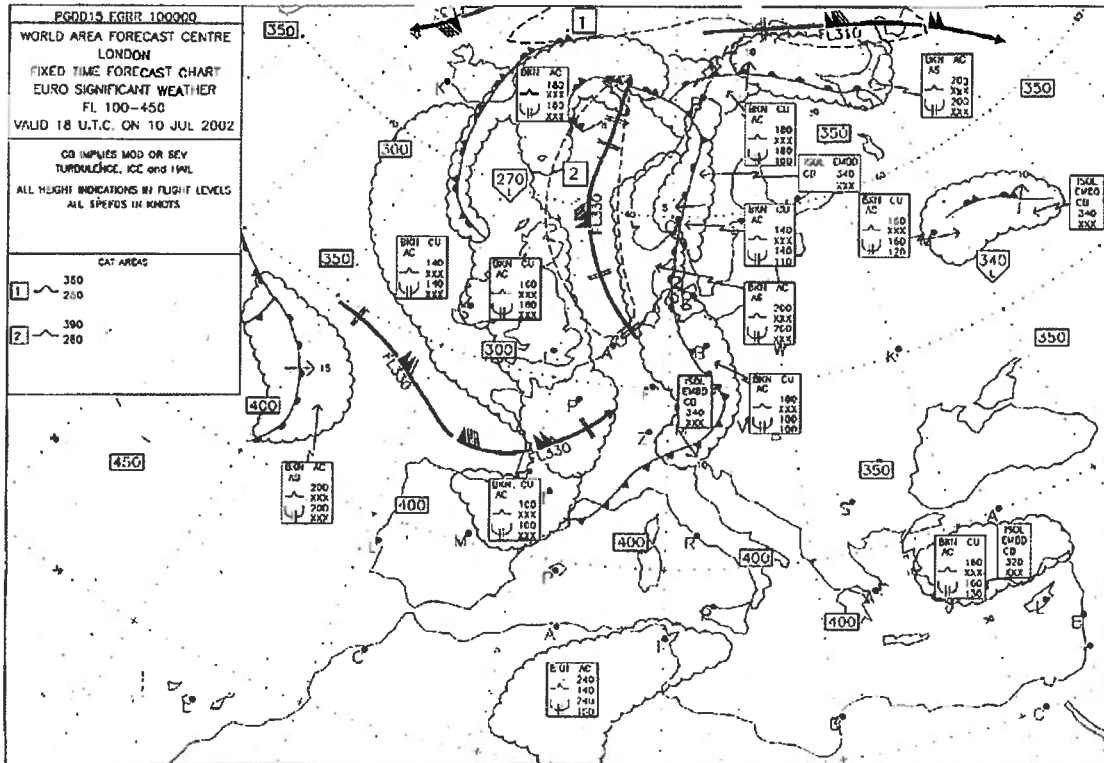
1.7 Meteorological Information

The German Meteorological Service (DWD) issued the following official weather report:

On 10 July 2002 Germany was subject to the influence of a cold front advancing east, which at about 1400 hrs extended from the North Sea to the South of France and Mediterranean Sea. During the day, the temperature on the advancing face of the front exceeded 30° C, while the air temperature behind the front declined to between 17° C and 12° C under the influence of incoming cold maritime air. The associated up-draughts were intensified by a high pressure salient swinging north east, resulting in the formation of showers and thunder cells extending very high along almost the entire frontal system. In the

vicinity of the cold front – in advance of which a convergence line had formed as the day progressed – there were areas of vigorous thunderstorms with heavy rainfall, hail and severe gusts, especially in the eastern part of Germany. At times the surface wind reached hurricane strength.

The crew evaluated the weather situation using METARs and TAFs for the relevant airports, the upper altitude wind charts plus the *Significant Weather Chart* valid to 2000 hrs.

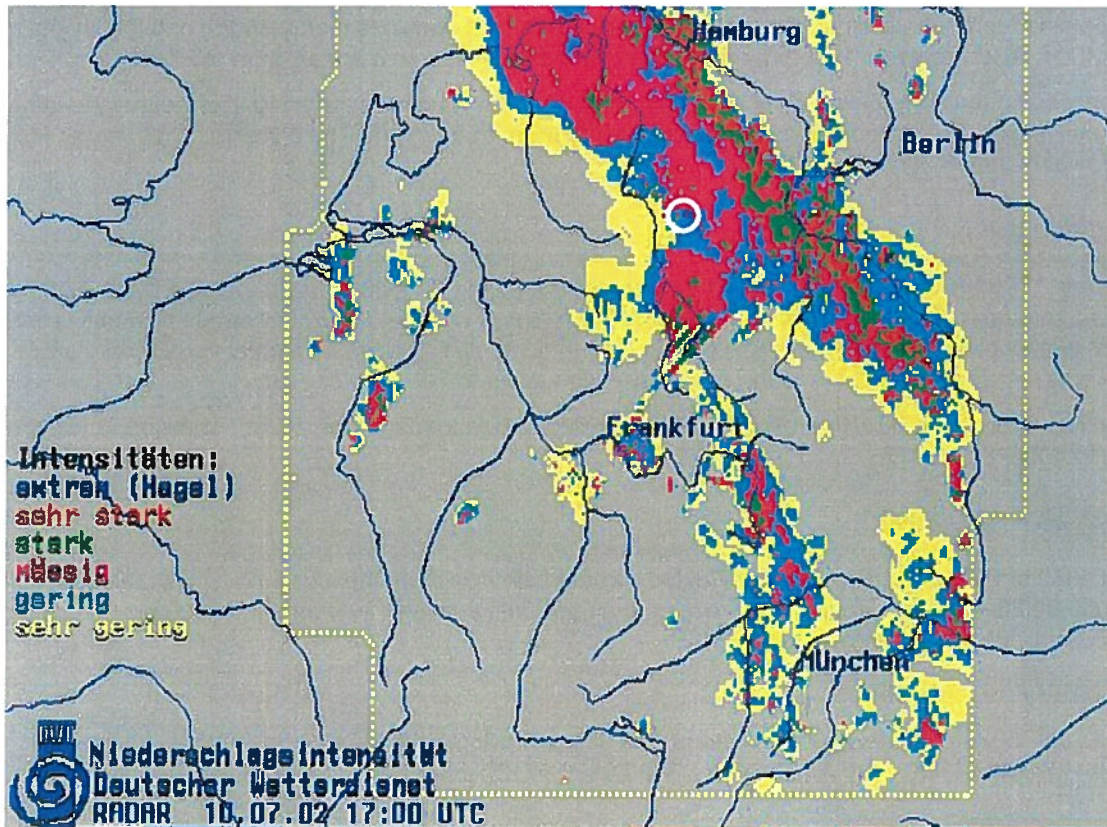


Significant Weather Chart

Source: DWD

The crew had no further warnings with respect to significant weather phenomena or conditions.

The radar image from 1900 hrs shows the position of the thunderstorm frontal system when the aircraft was radar vectored to a heading of 060° and the aircraft's position at this time.



Radar image showing intensity of precipitation and the aircraft position at 17:00 UTC (1900 hrs local)

Source: DWD

Meteorological Aerodrome Routine Report (METAR)

A METAR report summarises the flying weather conditions existing at an aerodrome. This is followed by a TREND landing weather forecast of the likely weather development, whose validity is limited to two hours. METAR reports for international airports are updated every day around the clock on the hour + 20 minutes and on the hour + 50 minutes.

Selected Special Aviation Weather Reports (SPECI)

Selected special aviation weather reports depend upon events that have been reported, which generally consist of coded current observations and values measured. The landing weather forecast is formed on the basis of the TREND forecast and SPECI observations.

1.7.1 Weather Conditions in the Bremen FIR

Hamburg Airport

The frontal precipitation arrived at Hamburg between 1830 hrs and 1900 hrs. In the subsequent period to 2030 hrs the Fuhlsbüttel weather station reported the passage of the cold front with showers, thunder and wind gusting to 39 kt. At times the horizontal surface visibility was less than 5,000 m and the cloud-base down to 500 – 700 ft AGL.

At the time the Saab aborted the approach to Hamburg, there was a thunderstorm in progress with moderate precipitation.

Bremen Airport

The Bremen weather station initially reported light rain at 1620 hrs. There was rainfall and thunder as the front passed through. At times the horizontal surface visibility was less than 2,500 m and the lowest cloud was 400 ft AGL. Between 1630 hrs and 1730 hrs wind gusts reached a maximum of 27 kt.

There was no thunderstorm activity after 1930 hrs. After the wind dropped to 10 kt or below, the rainfall was only slight. The horizontal visibility increased to more than 10 km. The 4-6 oktas cloud cover rose to a base of between 700 ft and 1,000 ft.

Hannover Airport

Between 1700 hrs and 2030 hrs the Hannover area was under the influence of the cold front. As the front passed through between 1707 hrs and 1820 hrs, the airport weather station reported showers – some of which were violent – plus thunder and gusts peaking 53 kt. At times the horizontal visibility at surface level was less than 1,000 m, and the cloud base was down to 200 – 400 ft AGL.

After 1820 hrs the visibility improved in light to moderate rain to more than 10 km. The cloud base then rose to 500 – 800 ft AGL.

Lübeck Regional Airport

Until 1950 hrs the cloud cover was 7-7 oktas cumulonimbus without thunder activity, with the base at about 5,000 ft AGL. The front did not reach the airport until between 2010 hrs and 2020 hrs. There was heavy rain with gusts reaching nearly 50 kt.

The METAR reports read:

EDHL 101750Z(19:50 Uhr) 30015KT 9999 SCT019 SCT035C BKN050 19/16 Q1005 ATIS Z=
EDHL 101820Z(20:20 Uhr) 26032G48KT 3000 9999 +TSSHRA BKN009CB 13/12 Q1007 ATIS A=

1.7.2 Weather Conditions in the Berlin FIR

Berlin-Tegele

Although the weather at 1950 hrs was still CAVOK, at about 2030 hrs thunderstorm cells in the vicinity of the cold front hit the airport. The cold front passed through between 2033 hrs and 2207 hrs, during which period there were vigorous thunderstorms with winds gusting up to 64 kt. At times the horizontal visibility at ground level was down to 3,000 m and the cloud base down to 300 – 700 ft AGL.

| | |
|------------|--|
| METAR 1750 | EDDT 04001KT CAVOK 30/17 Q1002 A2959 0998 2947 NOSIG |
| METAR 1820 | EDDT VRB01KT 9999 FEW040CB SCT120 BKN260 29/17 Q1002 A2959 0998 2947 TEMPO 27025G55KT 2000 +TSRA BKN009 BKN015CB COMMENTS: OCNL LTNG AND CB SW OF STN |
| SPECI 1826 | EDDT 20015G39KT 9999 SCT030CB SCT120 BKN260 29/17 Q1003 A2963 0999 2950 TEMPO 27025G55KT 2000 +TSRA BKN009 BKN015CB COMMENTS: OCNL LTNG AND CB SW OF STN |
| SPECI 1828 | EDDT 22036G56KT 5000 BKN023 SCT030CB BKN260 22/14 Q1005 A2968 1001 2956 TEMPO 27025G55KT 2000 +TSRA BKN009 BKN015CB COMMENTS: OCNL LTNG AND CB SW OF STN |
| SPECI 1831 | EDDT 23036G49KT 5000 BKN023 SCT030CB BKN260 25/14 Q1006 A2971 1002 2959 TEMPO 27025G55KT 2000 +TSRA BKN009 BKN015CB COMMENTS: OCNL LTNG AND CB SW OF STN |

Berlin-Tempelhof

There were still CAVOK conditions here at 1950 hrs. From 2023 hrs onwards until the end of the relevant period there were thunderstorms, some of which were violent. The gusts reached a maximum strength of 43 kt.

Berlin-Schönefeld

Likewise, CAVOK conditions continued here until 1950 hrs. The first thunder cells arrived at about 2005 hrs, followed by the passage of a cold front with violent thunderstorms like those at Tegel and Tempelhof. The gusts reached a maximum of about 56 kt.



Extract from the weather radar picture taken at 17:43 UTC (1943 hrs local), precipitation intensity (dBZ)

Source DWD

Neubrandenburg Military- / Civil Airfield

This airfield was unaffected by the cold front until the end of the period in question. Between 1700 hrs and 2030 hrs the airfield weather observer repeatedly noted the presence of thunder cells in the vicinity, which had formed on the leading edge of the front.

The front hit the airfield after 2100 hrs, with violent thunderstorms and wind gusts up to 52 kt. At times, the horizontal visibility at ground level reduced to 1,000 m with the cloud base down to 300 ft AGL.

Werneuchen Special Airfield

Prior to the arrival of the cold front, the airfield was under an east to south-east airflow with good weather and visibility 10 – 15 km. Given the approaching front, light aircraft based at the airfield terminated their local area flights with the last landings being at 2001 hrs and 2015 hrs.

During the approach and landing of the Saab 2000 at 2042 hrs the visibility was 5 – 7 km. About 20 minutes after the accident, visibility declined in heavy precipitation to 1-3 km. The passage of the front was accompanied by an immediate change in wind direction from southwest to west, with gusts exceeding 50 kt.

1.7.3 Weather Warnings

Different types of weather warnings are issued by the aeronautical meteorological service. These consist of AIRMET and SIGMET reports, plus Aerodrome Weather Warnings.

AIRMET Reports

AIRMET reports are aviation warnings advising of weather phenomena that are potentially dangerous and could affect air traffic safety. They are issued by the Meteorological Watch Office (MWO) for the respective Flight Information Region (FIR). They provide a brief description of the observed or anticipated en route weather problem, giving the times and places where it might be encountered in the FIR.

AIRMET reports are issued in accordance with the guidelines and recommendations contained in ICAO Annex 3 and ICAO European Plan EUR ANP. AIRMET reports are issued for the lower air space (up to FL100 and FL150) in the presence, or forecast, of given weather phenomena; these were not previously stated in Section I of the respective GAMET area forecast. The criteria (e.g. moderate turbulence) for issue of an AIRMET report are contained in ICAO Annex 3, Appendix 5.

In the afternoon, the following AIRMET was issued for the Bremen FIR at 12:22 UTC:

EDWW AIRMET 3 VALID 101225/101400 EDZH –
BREMEN FIR ISOL CB FCST ALL PARTS MOV NE, NC=

At 13:15 UTC and in the evening the following AIRMETs were issued for the Berlin FIR:

EDBB AIRMET 3 VALID 101400/101800 EDZB –
BERLIN FIR MOD TURB FCST EXTREME SW-PART NEAR GND, MOV NE, INTSF
BERLIN FIR MT OBSC FCST EXTREME SW-PART ABV 2000 FT MSL, MOV NE
BERLIN FIR OCNL TSGR FCST EXTREME SW-PART, TOPS FL 390, MOV NE INTSF=

EDBB AIRMET 4 VALID 101800/102200 EDZB –
BERLIN FIR MOD TURB OBS IN W-AND SW-PART NEAR GND, MOV NE, INTSF
BERLIN FIR MT OBSC OBS IN W-AND SW-PART ABV 2000 FT MSL, MOV NE
BERLIN FIR OCNL TSGR FCST IN W-AND SW-PART, TOPS FL 390, MOV NE INTSF
BERLIN FIR SFC VIS 1500-4000 M, +TS OBS IN W-AND SW-PART, MOV NE
BERLIN FIR BKN CLD 600-1000/XXX FT GND FCST IN EXTREME W-PART, MOV NE=

SIGMET Reports (Significant Meteorological Information)

SIGMET reports are aviation warnings informing of potentially dangerous weather phenomena that could affect air traffic safety. They are issued by the MWOs for their respective Flight Information Regions (FIR/UIR) or control sectors in the FIR/UIR. They provide a brief description of the observed or anticipated significant en route weather problem, giving the times and places where it might be encountered in the FIR. They are issued in accordance with the guidelines and recommendations contained in ICAO Annex 3 and ICAO European Plan EUR ANP.

The following SIGMETS were issued for the Bremen FIR from 14:56 UTC onwards:

EDWW SIGMET 1 VALID 101500/101800 EDZH -
BREMEN FIR SQL TS OBS S PART OF FIR TOPS FL 380, MOV NE, INTSF=

EDWW SIGMET 2 VALID 101830/102230 EDZH -
BREMEN FIR SQL TS OBS LINE ITZEHOE-LUECHOW-DRESDEN TOPS FL 380, MOV NE, NC=

The following SIGMET was issued for the Bremen UIR Upper Airspace from 14:57 UTC onwards:

EDYY SIGMET 1 VALID 101500/101800 EDZH -
UIR ABV BREMEN FIR SQL TS OBS S PART OF UIR TOPS FL 380, MOV NE, INTSF=

EDYY SIGMET 2 VALID 101835/102235 EDZH -
UIR ABV BREMEN FIR SQL TS OBS LINE ITZEHOE-LUECHOW-DRESDEN TOPS FL 380, MOV NE, NC=

The following SIGMET was issued for the Berlin FIR from 13:15 UTC onwards:

EDBB SIGMET 1 VALID 101400/101800 EDZB -
BERLIN FIR SQL TS HVYGR FCST EXTREME SW-PART, TOPS FL 390, MOV NE, INTSF=

EDBB SIGMET 2 VALID 101800/102200 EDZB -
BERLIN FIR SQL TS OBS HVYGR FCST ALONG THE RIVER ELBE, TOPS FL 390, MOV NE, NC=

Aerodrome Weather Warning

The Meteorological Watch Offices issue aerodrome weather warnings covering its areas of responsibility for international and regional airports. These give warnings of significant weather phenomena that may be expected at the respective airports, and are intended to enable precautions to protect aircraft parked on the ground and airport equipment. The aerodrome weather warnings should be provided to the control tower, aerodrome weather observer, the airport operating company, services operating on the airfield and air operators. They are issued in accordance with the guidelines and recommendations contained in ICAO Annex 3 and ICAO European Plan EUR ANP.

The following thunderstorm warning was issued at 1345 hrs valid for the period 12:00 UTC to 00:00 UTC the following day, for Schleswig-Holstein, Lower Saxony, Hamburg and Bremen:

Danger of thunderstorms in the afternoon and evening, some with hail and severe gusts from varying directions. With the approach of a cold front from the west, the thunderstorm activity will reduce in the evening.

The following weather thunderstorm warning was issued for the Berlin Airports at 1730 hrs, valid for the period 17:00 UTC to 20:00 UTC:

Passage of vigorous thunderstorm in conjunction with a cold front. Heavy rain expected, hail in places and from the west up to 55 knots.

A thunderstorm warning was subsequently issued for the regional airports of Schwerin-Parchim and Heringsdorf.

1.8 Aids to navigation

The crew did not have a copy of the published visual approach chart to Werneuchen Airfield.

The information relating to Werneuchen Airfield was not included in the Saab's on-board FMS data bank.

1.9 Communications

The voice communications between the Saab 2000 and the respective air traffic control stations were recorded. Transcriptions were prepared of the voice communications from the point at which the Saab was handed over to Maastricht UAC (Upper Airspace Control) until the landing in Werneuchen.

In chronological order the Saab 2000 crew was in contact as follows:

| | | | |
|---------------------------|-------------|---------------------------|------------------|
| from 18:53:17 to 19:04:13 | (10:56 min) | with Maastricht UAC | Freq. 134.71 MHz |
| from 19:04:41 to 19:23:39 | (18:58 min) | with Bremen Radar OR4 | Freq. 125.85 MHz |
| from 19:23:50 to 19:30:06 | (06:16 min) | with Bremen Radar OR3 | Freq. 124.22 MHz |
| from 19:30:11 to 19:53:32 | (23:21 min) | with Hamburg Director | Freq. 118.20 MHz |
| from 19:53:35 to 20:02:22 | (08:47 min) | with Bremen Radar OR3 | Freq. 124.22 MHz |
| from 20:02:27 to 20:16:33 | (14:06 min) | with Berlin Center NR2 | Freq. 136.05 MHz |
| from 20:17:09 to 20:41:04 | (17:36 min) | with Berlin Arrival TR1-N | Freq. 119.62 MHz |

The pilots did not have the frequency 122.6 MHz for Werneuchen Airfield. This was not passed to the crew by air traffic control during the approach.

The attempt made by the Werneuchen Flugleiter to contact the aircraft was unsuccessful.

The recording and transcription of the phone call between ATC and the chairman of the flying club were provided to the BFU for evaluation.

1.10 Aerodrome Information

1.10.1 Hamburg Airport

Hamburg International Airport (EDDH) is 53 ft MSL and located in the northern part of the city between the suburbs of Fuhlsbüttel, Schnelsen and Langenhorn.

The airport has two asphalt runways in a cruciform arrangement: Runway 33/15 is 3,666 m long and 45.8 m wide; runway 23/05 is 3,250 m long and 45.8 m wide. Runway 33 has a Non-Precision Approach (LOC-DME) instrument landing system. Each of the other three runway directions has an ILS (Precision Approach).

On the day in question, prior to the arrival of the thunderstorm the primary runway in use was runway 23. The last aircraft to land on this runway in the relevant time period was a SW II Metroliner at 1930 hrs.

After the Saab 2000 aborted its approach at 1938 hrs, runway 33 was in use. After likewise having aborted an approach to runway 23, nine minutes later a Boeing 737 landed on this runway. An Embraer 120 landed 26 minutes later at 2013 hrs.

From 2035 hrs movements continued as usual without any restrictions due to weather.

1.10.2 Werneuchen Special Airfield

Description / Operational Limitations

Werneuchen Special Airfield (EDBW) is located 1.1 NM east of the town of Werneuchen and is 263 ft MSL.

On 11 July 1997 the aerodrome was given approval by the Brandenburg planning authorities (*Brandenburgische Landesamt für Verkehr und Straßenbau*) for daylight flying in accordance with visual flight rules. Use is restricted ('*Sonderlandeplatz*', Special Airfield') in accordance with section 49 para. 2 No.2 of the German air navigation order (LuftVZO).

The planning approval gave the runway dimensions as 1,499 m long and 80 m wide.

The aerodrome was approved for the following classes of aircraft:

- a) Aircraft up to 5.7 t maximum take-off mass (MTOM)
- b) Helicopters (no weight limit)
- c) Motor gliders
- d) Ultralight aircraft

Werneuchen was used as a military aerodrome by the CIS-States until 1993. The aerodrome covered an area of about 3,300 x 2,200 m and had a concrete runway 2,400 m x 80 m oriented 083°/263°. After 1990, co-user agreements also allowed for the use of the aerodrome by civil aircraft.

The revised planning approval arrangements made in 1997 limited the use to civil aircraft and reduced the length of the runway for use to 1,499 m. Aircraft movements were limited to the eastern part of the concrete runway, though the original 2,400 m concrete runway remained in place.

As a precaution against unauthorised access, the aerodrome operator was given permission by the regional Civil Aviation Office to erect an earthen wall no more than four metres high at the western end of the ex-military airfield. In addition, a 70 cm high wall of heavy clay was placed across the entire width of the runway about 235 m west of the threshold to Runway 08 and about 770 m from the western end of the ex-military airfield.

The position and dimensions of the approved runway were published in the AIP visual approach chart and the AIP airfield maps (see Appendices 1 and 2).



Aerial view of the aerodrome west end, earth wall and wall as seen in 2000

Source: Google

That portion of runway 08 in approved use had threshold markers in the form of seven visible white stripes, each about 30 m long. Four visible stripes were located left of the runway centreline and three were right of the runway centreline. The runway threshold markings straddled an overall width of about 30 m. To the left of the four visible white stripes were a further two additional stripes; to the right of the three visible stripes were three additional parallel stripes. These additional stripes were largely eroded. The 08 runway heading designator was located behind the stripes (see diagram, section 1.16).

The white touchdown zone runway markings of the former military runway 08 were located to the west of the runway threshold markings and extended towards the end of the concrete. The markings consisted of five sequential parallel pairs of white stripes astride the runway centreline, each pair about 20 m long and 20 m apart. In addition, an aiming point marking was located about 300 m to the east of the concrete runway west end, consisting of two parallel approx. 50 m long and 10 m wide white stripes.

The disused section of the concrete runway bore two roughly nine-metre large white crosses close to the centreline (see diagram, section 1.16).

Flight Operation Requirements and Procedures

There was no formal requirement for a Special Airfield to be open to traffic. Prior to the commencement of flight operations, the rules required permission to be obtained via a telephone whose number was published. This telephone was permanently in the possession of the flying club chairman. In general, the operating plan was for weekend operations from 1000 hrs to 1800 hrs, for which the club arranged a rota of Flugleiter. For any weekday operations, a Flugleiter was arranged as required. Arrangements were not always made by club members via the aerodrome telephone, but also via a direct contact with the respective Flugleiter. For this reason, it was not always the case that the flying club chairman was informed by the Flugleiter that operations were in progress.

Official Inspections of Werneuchen Special Airfield

Since opening for civil flying in 1997, the regional Civil Aviation Authority responsible for approving and supervising operations had made a number of site inspections. In the view of the regional Civil Aviation Authority, the runway markings on the approved section were in-line with the rules and no objections were raised.

The regional Civil Aviation Authority reported it had instructed the aerodrome operator to remove markings and apply white crosses, to denote that this portion of the runway was not in use. In October 1997 the aerodrome operator had confirmed compliance with these requirements.

The 70 cm high earth wall across the concrete strip was outside the outer safety area and did not represent an obstacle for aircraft using the approved runway.

Records indicated that the last official inspection of Werneuchen Special Airfield prior to the accident had taken place on 27 June 2002. As a result of the inspection, the aerodrome operator was instructed to remove weeds growing in the runway cracks between concrete paving sections without delay.

1.11 Flight Recorders

The aircraft was fitted with flight recorder equipment manufactured by Allied Signal.

The Solid State Flight Data Recorder (SSFDR) PN 980-4700-009, SN 5117, had a recording capacity of 886 parameters.

The Solid State Cockpit Voice Recorder (SSCVR) PN 980-6020-001, SN 0901, had a recording endurance of 30 minutes.

Both units worked correctly. The recordings were available for the investigation.

1.12 Wreckage and impact information

The aircraft came to a stop on the runway centreline in a normal attitude, about 350 m behind the 70 cm high earth wall, about 60 m east of the threshold markings for the approved runway and just before the runway designator 08.

All three landing gear legs were torn off. All the propeller tips on both engines were ground down.

The Saab 2000 had 420 kg of fuel remaining in the tanks.



View of the crash site looking west.

Photo: BFU

In addition to the damage to the fuselage lower surface, the propellers and engine cowls, the fuselage showed evidence of structural deformation.

As seen from the aircraft in a westerly direction, the tyre marks ran straight along the runway until they intersected the low earth wall, which had been deposited over the concrete surface. The torn-off left main landing gear leg was found north of the concrete runway centreline about 200 m from the aircraft and about 150 m east of the earth wall.



The west side of the approximately 70 cm high earth wall with impact marks: left, that of the left main landing gear; centre, that of the nose gear; right, that of the right main landing gear.

Photos: BFU

On the western part of the concrete, about 290 m before the earth wall, tracks of all three landing gears were found leading all the way into the earth wall. The aircraft had touched down about 520 m prior to the threshold of the approved section of Runway 08.

No technical defects were found on the aircraft in the subsequent investigation.

1.13 Medical and pathological information

None

1.14 Fire

There was no fire.

1.15 Survival Aspects

The BFU took statements from ten of the 16 passengers. Prior to the landing, the passengers were instructed by the flight attendants to adopt the 'brace' position. The touchdown was described as normal. During the rollout there was a sudden 'whack' and the aircraft continued to slide on its belly. There was a shower of sparks. After the aircraft had come to a stop, the doors were opened and the flight attendants evacuated the passengers.

1.16 Tests and Research

As part of the investigation, a day later a video film was made of the accident site from a police helicopter; an approach was flown to runway 08 to document to what degree the runway markings and earth walls could be discerned from the air.



View of the airfield at a distance of about 2.6 km from the runway threshold.

Film still: Police



View of the airfield at a distance of about 1.8 km from the runway threshold.

Film still: Police



View of the new threshold to runway 08 a distance of about 1.2 km

Film still: Police



View of the runway at a distance of about 1,000 from the new runway threshold, shortly prior to over-flying the original runway threshold
 Film still: Police



View of the runway shortly prior to over-flying the aiming point markings of the original Runway 08. In the background the earth wall, after that the runway threshold markings on the approved Runway 08, and the position of the aircraft.
 Film still: Police

1.17 Organisational and management information

The aircraft was one of 80 operated by a company that was founded in 2002 following the merger between two firms for scheduled and charter operations.

1.17.1 Requirements for pre-flight preparation laid down in the Flight Operations Manual

In the Flight Operations Manual (OM A) the operator had laid down pre-flight *Flight Preparation Instructions* in section 8.1.

Chapter 7 *Interpretation of Meteorological Information* listed the requirements with respect to meteorological documentation.

7.1 Documentation

7.1.1 General

Meteorological documentation is provided for planning by giving information on the meteorological conditions forecast along the routes and at the aerodromes to be considered for the respective flight.

According to company policy the documentation may replace the meteorological briefing.

The CMD shall aim to obtain the documentation, especially TAF, METAR and Trend, based on the latest available information. Thus the flight crew shall obtain the documentation as shortly before departure as possible. In case of a delay or other exceptional circumstances, it may be advisable to obtain an update or to request new documentation.

[..]

7.1.4 Standard of meteorological documentation

Applicability

Generally, standard meteorological documentation is required for each flight or leg of flight and shall be whenever the flight crew begins flight duty.

Contents

- *Significant weather chart;*
- *relevant upper wind and temperature charts;*
- *forecasts, actual and special weather reports for the relevant aerodromes.*
The actual reports shall cover at least the first two hours of the flight;
- *SIGMET for the first two hours of the flight;*
- *AIRMET for short flights below FL 100 or FL 150 in mountainous areas.*

7.1.5 Reduced meteorological documentation

The reduced meteorological documentation serves only as an update of the standard meteorological documentation. At transit or turnaround stations a reduced documentation without SWC, wind charts and SIGMET is considered sufficient.

7.2 Application of aerodrome forecast for FLIGHTPLANNING

7.2.1 General

FLIGHTPLANNING should normally be based on the latest available TAF/METAR.

If available, the TREND forecast appended to a METAR or SPECI overrules any TAF for the period of validity of the TREND.

Note: The TREND (incl. NOSIG) never provides an RVR forecast.

New, amended or corrected TAF

Any new, amended (AMD) or corrected (COR) TAF automatically cancels any previously issued TAF of the same type (9 hr, 24 hr, 18/ 24 hr) and for the same validity period.

Chapter 8 *Determination of Fuel Quantity* described the fuel calculation standard required by the company as part of the pre-flight preparation.

8.1 General

8.1.1 Fuel Policy

[...]

Required fuel is to be considered as minimum for operation under optimum operating conditions. Company and/or extra fuel is often required to cater for changing situations and for the uncertainty in forecasting and assessing weather and runway conditions.

Fuel policy consists of stipulation of fuel requirements sufficient for the planned operation and reserves to cover deviations from planned operation.

Fuel planning is based upon the following operating conditions:

- Procedures and data contained in the operations manual or current aeroplane specific data;
- realistic aeroplane fuel consumption;
- anticipated mass;
- estimated meteorological conditions;
- ATS procedures and restrictions.

8.1.2 Standard Fuel Amount

Calculation of the fuel shall include:

- Taxi Fuel;
- trip Fuel;
- reserve Fuel consisting of:
 - Contingency Fuel;
 - alternate Fuel;
 - final Reserve Fuel;
 - additional Fuel (if required by the type of operations);
 - ETOPS Reserve Fuel (if applicable);
 - company Fuel;
 - extra Fuel (if required by the CMD).

8.2 Fuel definitions

[...]

8.2.3 Contingency fuel (COF)

Due to factors which are unforeseeable during the pre-flight planning stage, the contingency fuel should be sufficient to compensate for e.g.:

- Deviation of an individual aeroplane from the estimated fuel consumption data;
- deviation from forecast meteorological conditions;
- deviation from planned routings and/or cruising levels/altitudes.

The required minimum amount may be defined by the principles below; the higher of (a) or (b) must be selected.

Calculating principles:

- a) Lowest of:
- 5% of the planned trip fuel; or
 - 3% of the planned trip fuel provided a fuel en-route alternate is available; or
 - fuel sufficient for 20 minutes flying time based on planned trip fuel consumption.
- The required data must be validated by a fuel consumption monitoring program for the individual type of aeroplane;
- b) Fuel to fly for 5 minutes at holding speed at 1500 ft (450 m) above the destination aerodrome in standard conditions.

Note: Fuel consumption monitoring programme is not available for SB20, RJXX, E1XX and MD80.

[...]

8.2.5 Final reserve fuel (FR)

Final reserve fuel is the amount equivalent to 30 min flight time at holding speed at 1,500 ft above aerodrome elevation in standard conditions at the estimated landing mass.

1.17.2 Flight Procedures

Section 8.3 *Flight Procedures* in the OM A specified the operator's flight procedures.

Chapter 7 *Policy and Procedures for the Fuel Management* contained the instructions for fuel management during the flight.

7.3 Required fuel quantity

[...]

7.3.5 Follow-up

The fuel situation shall be continually watched by the flight crew. Changes in the operational status of the aerodrome of intended landing and of alternate aerodromes and deviations from the original flight plan (e.g., ordered by ATC) shall be taken into account.

7.3.6 Fuel checks

The CMD has to ensure that the following fuel checks are carried out and evaluated during flight at regular intervals. The results of the checks have to be recorded on the operational flight plan (OFP):

- *Comparison of actual fuel consumption with planned consumption;*
- *the remaining fuel must be sufficient to complete the flight considering the required reserves;*
- *determination of the estimated fuel remaining on arrival at destination.*

a) Fuel check periods

Fuel checks should be carried out at regular intervals:

- *Before leaving the tarmac;*
- *before take-off;*
- *over checkpoints specified in the OFP or at hourly intervals if no fuel checkpoints are specified, and*
- *upon arrival at the tarmac.*

7.3.7 Fuel below required minimum

If, as a result of an in-flight fuel check, the recorded fuel is less than required fuel, the CMD shall either consider a replanning to a new destination or to continue according § 7.5.

If the CMD becomes aware that fuel on board will drop to the final reserve before landing, he must exercise his authority to declare an emergency, thus receiving priority for approach/landing.

Chapter 8 *Replanning* contained the rules with respect to any changes in the plan made in flight.

8.1 Application

A replanning is required if either:

- *A new destination has to be selected; or*
- *a significant deviation from the planned route occurs which can not be covered with the remaining contingency fuel.*

[...]

8.4 Diversion

Diversion means continuation to any alternate aerodrome whenever it becomes impossible or inadvisable to proceed to or to land at the aerodrome of intended landing.

When a diversion will be taken into account all factors which will influence the fuel required to the diversion aerodrome must be reconsidered.

Main points are:

- *Weather en-route (wind, temperature, flight hazards);*
- *estimated flight level;*
- *approach procedure and runway in use.*

8.4.1 Policy

If a flight cannot be operated to the regular destination for any reason, a diversion must be made to the most suitable alternate aerodrome providing the best available operational and passenger handling service.

Operations control centre or the handling agent should be contacted (if possible before departure) for desired diversion priorities in the event of expected problems.

The responsibility to divert en-route rests entirely with the CMD. However, at the CMD's discretion OCC may forward recommendations and/or analyses (see also § 8 above for replanning procedures).

1.17.3 Periodic Training and Checks

The operator's Flight Operations Manual states the company's requirements with respect to: Proficiency Checks (Recurrent checking) in section 1.4; Line Checks (section 1.5); and Recurrent Training (section 1.6):

1.4.2 Simulator

All proficiency checks shall be performed in the simulator with visual attachment (at least category C).

A pilot has to demonstrate his familiarity and ability with regard to:

- *Instrument flying in general;*
- *performing different types of approach;*
- *handling of various abnormal or emergency situations;*
- *organise the cockpit work in orderly manner;*
- *technical and operational knowledge.*

Furthermore, general behaviour, attitude to work, behaviour on the flight deck, leadership, flight deck management, work of pilot non flying will be evaluated.

1.5.2 Execution

The PIC under check is the CMD.

Each pilot shall normally be given 1 line check per calendar year, alternatively, with CRM training.

[...]

1.5.3 Programme

[...]

They cover at least the following points:

- *Supervision of pre-flight and post-flight procedures;*
- *assessment of teamwork within flight personnel as well as with ground personnel;*
- *check of technical knowledge;*
- *check of operational knowledge (aeroplane performance, load sheet etc.);*
- *check of pertinent company or official regulations.*

Furthermore, general behaviour, attitude to work, behaviour on the flight deck, leadership, flight crew management, supervision of in-flight work (i.e. flying ability and quality of operation) and knowledge about the flown route and the area will be evaluated.

1.6.1 General

Recurrent training serves a dual purpose:

- 1) To cover requirements by JAR-OPS 1 and JAR-FCL 1.
- 2) To maintain the operational and technical knowledge and the flying skill (for pilots) at an adequate level.

Training and checking on the location and use of all emergency and safety equipment carried on board is of utmost importance.

Validity

| Training | Validity Period | Note |
|---|------------------------|-------------|
| Annual and semi-annual training / checking | 6 month alternatively | 1), 2) |
| Line check | 12 month | 1), 2) |
| Emergency & safety equipment training / CRM | 12 month | 1), 3) |
| Ground & refresher training | 12 month | 1), 3) |
| Dangerous goods | 2 years | 1), 3) |

Note:

- 1) New validity extends from the current expiry date. In addition and except for the annual training/checking the new validity may be extended to the end of the month of the current expiry date. If planned before -3 month new validity extends from the date of revalidation.
- 2) Planning tolerance is +0/-3 months.
- 3) Planning tolerance is +/-3 months.

[...]

1.6.5 CRM courses

- Safety awareness
- Human aspects development training, e.g.
 - Communication
 - Team-building and co-Operation
 - Situation awareness
 - Judgement and decision making
 - Workload management

1.17.4 Operations Control Centre

The operator had set down the responsibilities of the Operations Control Centre and the duties of its Flight Operations Officer in the section of OM A Chapter 4 *Operational Control and Supervision* under the sub-heading *Operational Control*.

Operations Control is part of the network management. Operations Control is responsible to manage the [...] airline system up to seven days before departure. This includes operational supervision as well as commercial interests. Operations Control is responsible to supervise and initiate appropriate actions in case of deviations on:

- Booking figures (passenger and cargo/mail);

- *weather phenomena en-route and at destinations;*
- *technical status of the fleet;*
- *equipment or facilities on aerodromes and en-route;*
- *hub performance;*
- *ATS performance;*
- *crew availability;*
- *punctuality;*
- *operation performed by other carriers on behalf of [...] (wet lease-in);*
- *political actions/curfews/strikes;*
- *incidents/accidents/hijacking of aeroplane or persons, bomb threats/black-mailing*
- *initialise meetings of the political crisis group;*
- *organise the emergency committee.*

Operations Control has the sole authority to:

- *Initiate, cancel, consolidate or advance flights;*
- *exchange aeroplane or aeroplane versions;*
- *delay flights by more than 15 minutes;*
- *decide on fuel-stops;*
- *divert or re-route flights, except for in-flight diversion which is in the responsibility of the CMD.*

Operations Control may not:

- *Issue a flight preparation.*

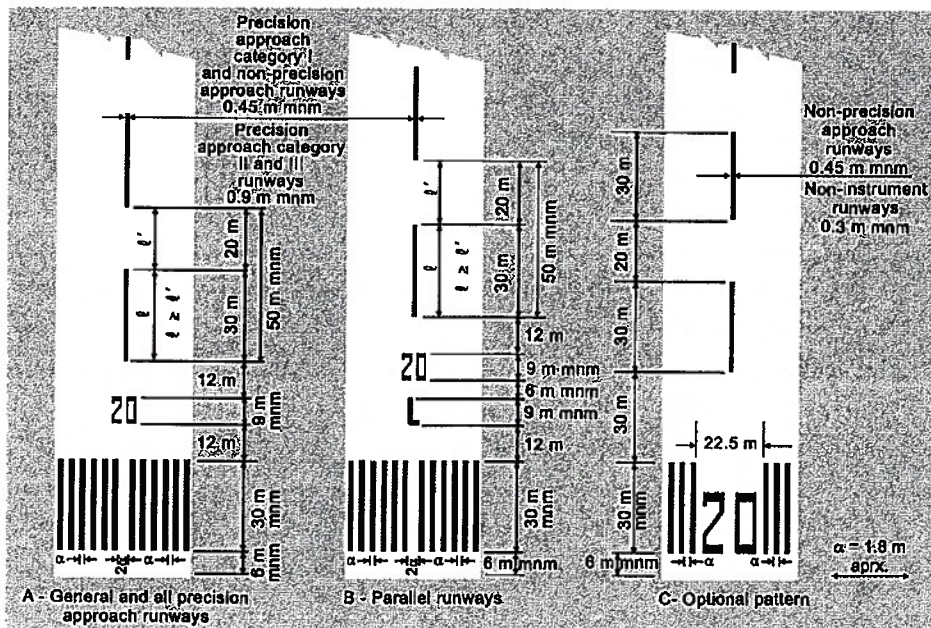
1.18 Additional Information

1.18.1 International Requirements for Aerodrome Markings

The International Civil Aviation Organisation (ICAO) set out guidelines and recommendations for the design and operation of aerodromes in Annex 14 of the Civil Aviation Agreement.

Chapter 5 *Visual Aids for Navigation* of ICAO Annex 14 contains the Standards and Recommendations for runway threshold markings. It recommends the use of marking Code Number 3 or 4 for threshold markings for hard runways 1,200 – 1,799 m in length – also if more than 1,800 m length – even if they might also be used for purposes other than international commercial traffic

With respect to the position and form of the runway threshold markings, the recommendation was that the threshold should have a symmetrical pattern of identically-sized elongated stripes (see diagram, Variant A), starting six metres from the runway threshold. The number of stripes was dependent upon the width of the runway and given as four for a runway up to 18 m wide and 16 stripes for a runway 60 m wide. In the case of a runway 45 m wide or more and not used for precision- or instrument-approaches, runway markings of Variant C were also permissible.



Runway threshold markings (Source: ICAO)

Another recommendation was that the runway threshold marking should extend to 3 m from the runway lateral edge or up to 27 m from the runway centreline.

Chapter 7 *Visual Aids for Denoting Restricted Use Areas* in ICAO Annex 14 contained the Standards and Recommendations for disused or closed surfaces.

The Standards and Recommendations stated that permanently closed parts of a runway were to be marked accordingly.

Location

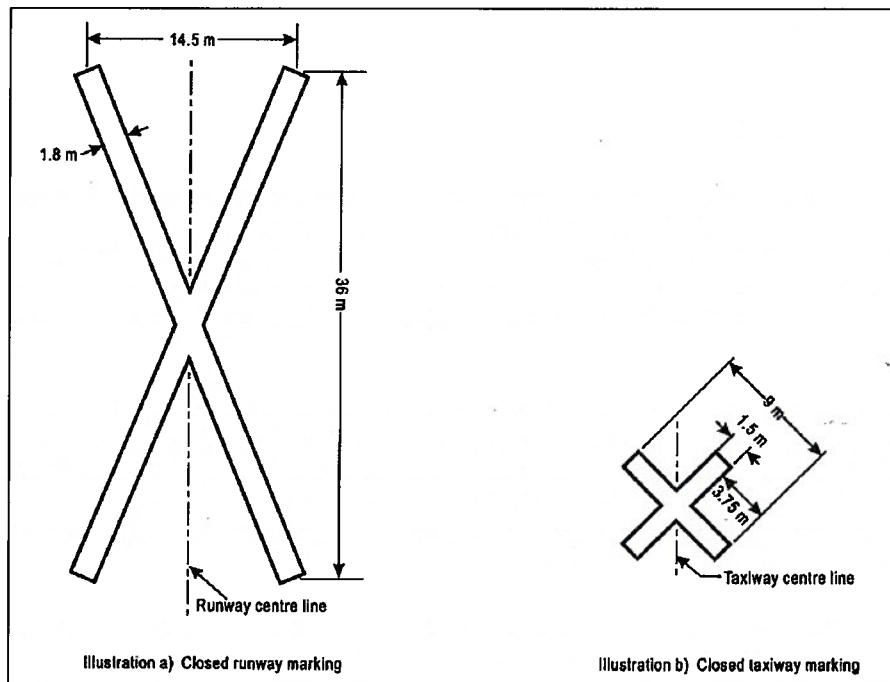
7.1.3 On a runway a closed marking shall be placed at each end of the runway, or portion thereof, declared closed, and additional markings shall be so placed that the maximum interval between markings does not exceed 300 m. On a taxiway a closed marking shall be placed at least at each end of the taxiway or portion thereof closed.

Characteristics

7.1.4 The closed marking shall be of the form and proportions as detailed in [...], Illustration a), when displayed on a runway, and shall be of the form and proportions as detailed in [...], Illustration b), when displayed on a taxiway. The marking shall be white when displayed on a runway and shall be yellow when displayed on a taxiway.

Note — When an area is temporarily closed, frangible barriers or markings utilizing materials other than paint or other suitable means may be used to identify the closed area.

7.1.5 When a runway or taxiway or portion thereof is permanently closed, all normal runway and taxiway markings shall be obliterated.



Closed runway and taxiway markings

Source: ICAO

1.18.2 National Requirements for Aerodrome Markings

The national aerodrome licence for Werneuchen specified that runways and taxiways were to be marked in accordance with the requirements set out in *Richtlinien für die Tageskennzeichnung von Landeplätzen und Segelfluggeländen* ('Guidelines for daylight markings used on aerodromes and sailplane launch sites') published on 10 May 1982 in the *Nachrichten für Luftfahrer NfL I-98/82*. This stated that hard runways 30 m or more in width should be marked with runway designators, threshold markings, start-line and runway centreline. The markings should be in accordance with the requirements stated in NfL. Deviation from these requirements were only allowed if in accordance with ICAO Annex 14.

The NfL requirements stated – amongst other things – that for runways more than 80 m wide, the threshold markings should consist of 30 elongated stripes each 20 m long and 1.2 m wide. The NfL made no requirements with respect to the marking of disused or closed runways, taxiways or surface manoeuvring areas.

At the time of the accident NfL I-98/82 was in force. It was replaced on 27 February 2003 by the requirements of NfL I-94/03 headed *Gemeinsamen Grundsätze des Bundes und der Länder über die Markierung und Befahrung von Flugplätzen mit Sichtflugverkehr* ('Joint Federal and Regional Government requirements for runway and taxiway markings and lighting of airfields used under visual flight rules'). The new NfL rules with respect to runway markings, and the markings for disused or closed areas, were changed to meet the requirements of ICAO Annex 14.

1.19 Useful or effective investigation techniques

Not applicable

2. Analysis

2.1 Weather Aspects

The weather radar image for 17:00 UTC shows that at this time a cold front had reached the River Elbe and was approaching the Berlin area from the south west. At the same time, a powerful thunderstorm cell had become established in front of the line of thunderstorms, east of the River Elbe and south of Berlin. As time progressed, a further thunderstorm cell arose in the southeast between 17:30 UTC and 17:45 UTC. The upper airflow above the leading edge of the thunderstorm line drove the cells northwards.

The routine weather reports from Berlin Tegel, Tempelhof and Schönefeld for 17:50 UTC (1950 hrs local) were still reporting CAVOK conditions for the two-hour period of validity for the TREND forecasts stating NOSIG (no significant change). The subsequent routine weather report at 18:20 UTC (2020 hrs local) and the SPECI (Aviation selected special weather) reports issued from 18:26 UTC, were included in the TREND forecast for Berlin Airports Tegel, Tempelhof and Schönefeld, advising thunder with heavy precipitation and wind gusting up to 55 kt.

The weather radar image for 17:43 UTC shows that, at about the time the METAR report was assembled, there still were actual CAVOK conditions at Berlin Tegel. However, at this time the cold front was about 30 km southwest of the airport. In the hour previous, the front had advanced more than 100 km to the northeast. The BFU is of the opinion that it is not understandable why the TREND report issued at this time still included the report NOSIG, i.e. a forecast that the situation would remain unchanged for the next two hours.

In the 30 minute time period between the two routine weather reports, weather conditions worsened considerably. The worsening weather conditions resulting from the approaching cold front were recognisable and did not occur totally unexpectedly. The BFU is of the opinion that it would have been appropriate to issue a SPECI report in the period between 17:50 UTC (1950 hrs local) and the next routine weather report at 18:20 UTC (2020 hrs local).

2.2 Flight Operations Aspects

2.2.1 Pre-flight Preparation

Given the short-notice change in their roster plan, the crew had 15 minutes more than usual for their pre-flight preparation. The crew subsequently stated that they had obtained a comprehensive briefing. The aerodrome forecasts available valid for the period 13:00-22:00 UTC (1500 - 2400 hrs local), and for the period from 16:00 UTC to 01:00 UTC on the following day for Hamburg, Bremen und Hannover Airports, forecast thunder with moderate rain, also winds gusting to between 35 kt and 45 kt.

The Euro Significant Weather Chart available to the crew showed that the route from Basel to Hamburg would be subject to the influence of an active cold front. The weather that could be expected in Northern Germany – especially at the destination Hamburg, and the diversion alternates Bremen and Hannover – was interpreted and considered at the weather briefing. The crew had no indication that they could expect unusual or extreme weather. The crew had no doubt about the safe conduct of the flight.

Given the weather forecast, the cabin crew were briefed to expect moderate turbulence during the cruise phase of the flight.

The flight crew decided to get 570 kg of additional fuel in case of any delay caused by thunderstorms. This was sufficient for an additional approximately 45 minutes flight time. The BFU holds the view that this decision is understandable given the information available to the crew.

The SIGMET warnings for the Bremen UIR and FIR issued about an hour prior to departure, did not reach the flight crew. These SIGMETs warned of the approach of a strengthening line of thunderstorms already observed in the south of the UIR and FIR, advancing northeast and extending up to FL 380. A SIGMET warning was also issued at 14:00 UTC (1600 hrs local) for the Berlin Flight Information Region to the east of the Bremen FIR; it warned of a line of approaching thunderstorms (SQL TS HVYGR FCST EXTREME SW-PART, TOPS FL 390, MOV NE, INTSF). This report did not reach the flight crew during their pre-flight preparation. The BFU is of the opinion that if they had been available, these SIGMETs would have alerted the crew that these were not isolated thunderstorm cells, but a thunderstorm front of considerable proportions. This knowledge might have had an influence on the decisions made by the crew during the flight.

2.2.2 Conduct of the Flight

The BFU holds the view that the decision made by the crew to abort the approach to Runway 23 at Hamburg on account of the strong turbulence and contact sighting of the thunder cell was understandable. The subsequent entry into the Lübeck holding pattern was intended to give them time to consider and plan their next actions.

At this time, the options included the following:

- Another approach to Hamburg
- Approach to one of the standard alternate airports
- To consult the FMS data base for another suitable alternate airport (NAV-Display)
- Make contact with the OCC and request support
- To consult air traffic control with a request for suitable alternatives

The crew decided against an approach to runway 33 in Hamburg, which had been suggested by air traffic control.

The crew asked the controller for information about the weather in Bremen. The controller passed the current weather for Bremen; this had become acceptable for an ILS approach, but was on the rear side of the storm. Probably, the crew considered that an attempt to penetrate the front was too critical. The flight crew decided to fly to their second alternate, which was Hannover, and requested the necessary clearance.

At 1952 hrs they were cleared to the Celle NDB CEL (on a southerly heading). Because they did not wish to fly into the thunderstorm, they flew parallel to the storm on a south easterly track in the hope that they would be able to fly around the storm cell to the south and then take up a heading for Hannover. After about 20 minutes, they realised that they would not be able to do so. At this time, their weather radar indicated that the Berlin area seen in their screen was as yet unaffected by the approaching front, and requested an approach to Berlin-Tegel. At this time, no further options were discussed. The controller gave clearance for the flight to Berlin-Tegel.

At 2015 hrs the crew monitored the ATIS broadcast for Berlin Tegel; this supported their decision of two minutes earlier to divert to Berlin Tegel. Information Delta timed at 1950 hrs gave the impression that the prevailing weather at the airport was very good (CAVOK). The NOSIG Trend suggested that the weather conditions were stable. The BFU holds the view that the crew's estimate was understandable.

After the air traffic controller had advised the crew to change frequency to Berlin Approach Control, the crew made contact with Berlin Arrival and soon after requested priority for a direct approach because the aircraft had a low fuel warning light. The cockpit voice recording from this phase of the flight makes it quite clear that the crew believed they had no alternative than to land at Tegel.

Shortly after, the crew abandoned this plan in the face of turbulence and a thunderstorm directly in front; the PIC spontaneously asked the air traffic controller for another airport option. The controller first suggested Finow, which the PIC readily accepted and immediately altered course to the east. A short while later, the on-board weather radar indicated the presence of a fast-developing thunderstorm cell overhead Finow.

In an effort to identify other suitable airfields, the PIC asked the air traffic controller for information about airfields with location indicators EDAH and ETNU, which he had seen on his NAV-Display. In view of the weather reported, a few minutes later the decision to divert to Neubrandenburg was discarded.

When the controller then suggested Werneuchen, the PIC agreed at once. Because of the changing weather and the necessity to alter track several times, the crew found themselves in a situation where, instead of a routine diversion to an airport, the shortage of fuel and the weather situation made a precautionary landing necessary at any airfield with a suitable runway. Although it was still unlikely that an engine would stop very soon because of lack of fuel, there was hardly any other alternative. The crew therefore accepted an airfield that was totally unknown to them, Werneuchen Special Airfield.

Three minutes prior to touchdown, the air traffic controller passed another message: "Okay eh..(callsign).. we just eh been informed that you should use the easterly part of the runway eh so eh in you eh you are not before landing before the threshold of zero-eight genau." The contents of the message were incomprehensible for the flight crew without having the possibility of checking or interpreting the approach and runway plates. The choice of the word "should", would normally be understood by the crew as a recommendation, and was therefore not perceived as a warning. The message contained none of the key vocabulary with which the crew would have been familiar, such as *closed portion, obstacle, blocked, displaced threshold*.

The PIC responded: "Ja we're just abeam the threshold zero-eight now making a left hand eh downwind if you agree for zero-eight." In this phase of the flight, the pilots were fully occupied with configuring the aircraft for approach and landing. The cockpit voice recording bore no indication of a response to the controller's advice, from which the BFU draws the inference that the crew did not understand the message.

That the crew, in spite of the fact that they were unfamiliar with the airfield which was not licensed for use by aircraft the size of a Saab 2000 and that they had no radio contact with the airfield, chose not to make a pre-landing overflight or a *midfield crossing shows the* BFU that the crew believed themselves to be in an extremely critical situation as a result of the weather and shortage of fuel. It will have to remain an open question as to whether the crew would have spotted the obstacles on runway 08 if they had made a prior overflight to inspect the runway.

Probably, if there had been radio contact between someone on the airfield and the Saab pilots – who could also communicate in German – they could have been alerted to the obstacles.

During the final stages of the approach, the view of the runway as seen by the crew was the familiar optical impression of a long runway. The CVR recorded the PIC's remark: "It's longer than... longer than Bern, hä." (Bern Airport, runway length 1,510 m). The BFU draws the inference, that the crew did not observe the threshold markings consisting of seven visible stripes denoting the 1,499 m approved runway section. Instead, their descent and approach was made with reference to the target touchdown point markings, still clearly visible, for the original 2,400 m long and 80 m wide military runway.

The low earth wall running across the concrete runway was poorly visible and not seen by the crew. In the opinion of the BFU, under the circumstances (lighting conditions, expectations, urgency of the situation) the earth wall was not recognisable as an obstacle.

The original colour markings on the old military runway were still easily visible to the crew as touchdown marker points on Runway 08. The small crosses positioned before the actual runway threshold were so badly eroded as to be meaningless and could not be interpreted as a *closed runway marking* during the approach.

Tracks on the concrete runway show that the aircraft touched down shortly after the target touchdown markers. It was not until immediately before the collision that the crew could see grass growing from the earth wall across the runway.

After the aircraft came to a stop with torn off landing gear, the two highly experienced flight attendants conducted the passenger evacuation on their own initiative while the pilots worked through the emergency procedures.

2.2.3 Flight Crew Decision Making

The BFU was provided with no evidence that the crew had taken part in any CRM courses. Participation in such courses is a requirement under air law (JAR-OPS). During the course of their experience within the company it is probable that both pilots had received training in optimising their teamwork. This type of training is usually provided as an Initial Cockpit Resource Management Training Course and in subsequent regular refresher courses.

ICAO Human Factors Digest No. 2 "Flight Crew Training: Cockpit Resource Management (CRM) and Line-Oriented Flight Training (LOFT)" contains basic CRM guidelines and its practical-methodical implementation via LOFT. LOFT simulator exercises provide the most effective feedback with respect to the CRM lessons learned and implemented.

While the CRM courses and their contents are described in the flight operations manual, the manual is silent about LOFT exercises. The BFU therefore assumes that up to the time of the accident, the flight crew had not been offered or provided with any LOFT exercises. The BFU was provided with no evidence that the crew had taken part in any specific LOFT exercises.

The contents of CRM training are assessed within regular Proficiency Check CAT I/II/III, Line Check, Proficiency and Skill Checks. During these checks, both pilots consistently received good or very good marks for their demonstrated cockpit teamwork. These assessments related primarily to adherence to standard procedures in routine flight operations, interpersonal communication in the cockpit, communications with the flight attendants and passengers, also their professional approach and calmness in tackling their tasks.

Many aspects of this assessment were reflected by the behaviour documented by the CVR during the flight in question. However, one important focal point of the analysis relates to the decision making process at the point when the crew still had many possible options for the continued flight. After the aborted approach to Hamburg and their entry into the LUB Lübeck holding pattern, the next task was to reach a decision upon how the flight should continue. If there could be no landing at the original declared destination, a diversion to a predetermined alternate airport is a standard operating procedure. Because Bremen was behind the weather front and the crew was not prepared to penetrate the front or fly around the frontal area, the decision to divert to the second alternate – Hannover, which by that time was also behind the cold front – is not understandable. This shows the BFU that the list and sequence of alternates was followed diligently instead of trying to get an idea of other options and possibilities.

While in the holding pattern it would have been advisable to take enough time to obtain a more comprehensive assessment of the overall weather situation and the airports within range. The crew was not restricted in obtaining all available information by sole use of on-board systems; they could have made use of external resources via radio communications.

The heuristic method used in aviation to resolve problems in complex situations e.g. FORDEC or DECIDE, calls for the decision to be made after all the available options and associated risks have been analysed. The advantage of this approach is that it avoids a situation arising in which – as a result of a constant reduction in the number of options – there remains at the end only one single choice.

2.2.4 Support for Crew Provided by Operations Control Centre

The company's OM A said that the OCC's responsibilities included assisting the crew by provision of pre-flight weather documentation. The documentation contents were defined and included both SIGMET and AIRMET warnings. Evaluation of the original documents and statements made by the crew, show that they were not provided with any weather warnings. Although such warnings were not provided at the original briefing, there was sufficient time between the briefing and departure from the aircraft ramp to update the weather information, including the latest warnings.

In the opinion of the BFU, the question must be asked as to whether it would have been an option for the OCC to consult with the crew and postpone departure, in view of the weather.

Another task of the OCC would have been to provide the crew with updated relevant weather information for the cruise and approach phases of the flight. The weather warnings issued during the flight were not passed to the crew. This made it difficult for them to re-plan the flight. The nature and technical implementation of these OM A objectives were not subject of this investigation.

2.3 Air Traffic Control

2.3.1 Bremen Air Traffic Control

Due to the weather conditions the sector radar controller had a higher workload than usual.

Because the pilots had not considered any airports other than the standard diversion alternates – and had therefore not put the question to the controller – the controller saw no need to suggest other airports such as Lübeck, which was immediately below.

The same holds true e.g. for the up-dated weather warnings (SIGMET/AIRMET), which were available to air traffic control and would have been provided to the crew upon request.

2.3.2 Berlin Air Traffic Control

Due to the weather there was a high workload at Berlin Air Traffic Control. The following additional sector was opened on account of the weather situation:

Air Traffic Control Sector Berlin Arrival North (TR1-N):

After the pilot's request for priority on account of diminishing fuel reserves (40 minutes remaining), the controller cleared the Saab direct to reporting point KONOX, 10 NM from the runway threshold. Five minutes later, the pilot reported he was "committed to land due to fuel"; in other words he wanted the most direct approach possible. A minute later, the pilot requested permission for direct flight to the *outer marker*. During the subsequent four minutes, communications with the pilot left the controller with the impression of growing urgency to terminate the flight.

At 2028 hrs the pilot aborted the approach to Berlin Tegel because of "moderate turbulences" and requested another airfield, at which point the controller assessed the situation as increasingly critical.

The nearest available airfield that occurred to the controller was Finow, for which he gave a heading. In response to the advice that it was an ex-military airfield, the pilot responded: "Okay, we'll take anything at this point." The controller then decided the aircraft was faced with an emergency. A few minutes later, faced with worsening weather the pilot declined Finow and asked for further suggestions. The neighbouring sector controller asked one of his aircraft for a Werneuchen weather report. The controller suggested a landing at Werneuchen, because it was still apparently clear of the front.

A map of Werneuchen Special Airfield was handed to the controller, from which he passed the runway data including length, width and weight bearing capacity to the Saab crew. Because he was unable to make a clear interpretation of the runway and taxiway layout from the map, he passed on information that was shouted to him by the supervisor who was on the telephone. The controller's choice of words: "...you should use the easterly part of the runway..." was intended to convey to the pilots the supervisor's warning that under no circumstances should the aircraft touch down before the correct runway threshold. His choice of words: "not before landing before the threshold of zero-eight" was his own attempt to make this warning more explicit. The controller did not request a confirmation from the crew.

Supervisor Berlin Tempelhof Centre:

At 2037 hrs the controller who was assisting the supervisor dialed the mobile phone number published in the official VFR Handbook AD section for Werneuchen OPS (Flight Operations). The call was answered with "Flugplatz Werneuchen" ("Werneuchen Airfield") by the chairman of the Werneuchen Flying Club.

After about 40 seconds, the supervisor took over the telephone call from his colleague, believing his interlocutor to be at the airfield and advised him of the pending landing by the Saab 2000. The club chairman advised the supervisor that "[...]" "... a five hundred metre strip is limited by an earthen wall, but everything has been correctly published" and further stated: „[...] And there is an earthen wall, so he should pay attention, that he does not attend er does not land on this five hundred meter strip – he should land on the one thousand five hundred metre strip.

The supervisor was confused, initially suspecting the existence of two runways at Werneuchen and speaking to the controller at the radar screen said: "He should not ... he should not take the short runway, there is an earth wall after five hundred metres."

At 2040 hrs the controller passed the following information to the pilots: "Okay, eh [callsign], we just eh been informed that you should use the easterly part of the runway eh so eh in you eh you are not before landing before the threshold of zero-eight - genau."

The supervisor then asked his telephone interlocutor to alarm the Werneuchen fire brigade.

It was not until the time at which the Saab 2000 was touching down that he was told and realised that his interlocutor was not anywhere near Werneuchen Airfield. This information caused him to end the telephone conversation so that he could alert the fire brigade.

About ten minutes later the supervisor again called the same mobile phone number to ask the club chairman if, now that the Saab had landed, he would drive out to the airfield; the club chairman responded it would take more than an hour and a half to reach Werneuchen Airfield.

From the tape recording of the first telephone conversation between the air traffic controllers and Werneuchen Airfield, it is clear both controllers assumed that their interlocutor – who had taken the call with the words "Werneuchen Airfield" – was actually at the airfield as they spoke. Neither the remark made to the first controller "but there is no Flugleiter there", nor the remark to the supervisor – "He shall then land in direction two six ... I am not at the site / outside at the moment, I do not know" – cast doubt for either man as to the location where they assumed their interlocutor to be; neither asked exactly where he was.

These two telephone conversations left the BFU with the impression that neither party properly understood the other. The flying club chairman does not seem to have grasped the importance of the situation, probably because he did not recognise the Saab 2000 as a civil air transport. The supervisor did not realise that, because the flying club chairman was not at the airfield, he could not provide any effective assistance.

(Appendix 3 has a full transcription of the telephone conversation)

2.4 Defences

Defences are measures to protect a system from the consequences of technical or human failure. The entire aeronautical system with its sub-sections – e.g. aircraft, air traffic control and meteorological services – is considered to be a complex socio-technical system both individually and as a whole. In the context of this accident, the BFU sees the following mechanisms as critical.

2.4.1 Weather Warnings

In aviation, SIGMET/AIRMET meteorological warnings are issued to give warning of dangers. The weather warnings relevant for this flight did not reach the crew.

2.4.2 Visual Approach Charts / Aerodrome Chart

If the user is to obtain rapid and precise situational awareness, the information on an aviation chart must be clear, understandable, comprehensive and correct.

In the opinion of the BFU, the Werneuchen Aerodrome Chart published in the Aeronautical Information Publication - *Lufffahrthandbuch (AIP) VFR* ('Air Pilot') – did not meet these criteria. The chart was incomplete and there was no systematic use of the standardised symbols required by ICAO Annex 4. The aerodrome chart made no reference to *closed runway markings* on the disused sections of the old runway. Further, the aerodrome chart bore no markings denoting the displaced threshold to runway 08.

2.4.3 Aerodrome Markings

Clear marking of flight operation areas, in particular runways, is an essential safety mechanism for the prevention of accidents. A runway must be clearly visible for pilots in the air, and distinguishable from other flight operation areas.

The markings at Werneuchen Special Airfield did not meet the requirements or recommendations of ICAO Annex 14, or the national regulations then in force.

3. Conclusions

3.1 Findings

- The crew was properly licensed and qualified to conduct the flight.
- The air traffic controllers were in possession of the licenses and ratings required for the exercise of their duties.
- On the afternoon of 10 July 2002 a cold front preceded by a convergence mass moved over Germany from west to east. The moist unstable air in advance of the cold front led to the development of squall lines.
- The weather briefing documents available to the crew prior to their flight only mentioned isolated CB. The crew did not have the then valid SIGMET reports for the Berlin FIR which is adjacent to the Bremen FIR nor did they have the then valid AIRMET reports for either FIR.
- The BFU is of the opinion that the fact that the SIGMET issued at 15:00 UTC (1700 hrs local) for the destination area (Bremen FIR) – which contained a warning of a squall line reaching FL380 – did not reach the aircraft even though it remained on the ground until 16:09 UTC (1809 hrs), indicates that the operator's Operational Control Centre provided insufficient support.
- At 1938 hrs and at a height of 3,300 MSL, the Saab 2000 crew aborted the approach to Hamburg runway 23 due to the weather.
- While in the Lübeck holding pattern the crew decided against a further approach to Hamburg. The crew then decided to divert to the alternate of Hannover without first obtaining a comprehensive weather overview of those airfields within range and as yet unaffected by the front. This decision was made without making use of the relevant information and available resources.
- According to the OM-A, the CRM training did not include LOFT.

- After leaving the Lübeck holding pattern and a 20-minute flight in a south-easterly direction in advance of the squall line, the crew decided against trying to reach Hannover by flying around the thunder cells, instead diverting to Berlin Tegel.
- This decision was made on the basis of the radar image. Two minutes later, the Tegel ATIS Delta broadcast was listened to.
- The TREND (NOSIG) given at the end of the METAR did not indicate that the existing CAVOK weather would significantly worsen by the time the aircraft arrived at Tegel.
- During the subsequent flight, at no time did the aircraft exceed 5,000 ft. However, the FDR trace indicates that this did not lead to a higher rate of fuel consumption.
- At 2019 hrs the crew requested a priority approach, because they had just observed a low fuel warning light.
- At 2020 hrs a METAR was issued with the suffix TEMPO; at 2026 hrs a SPECI was issued for Berlin Tegel.
- At 2028 hrs the crew aborted the approach on account of thunderstorms over Tegel.
- The aircraft took up a heading for the airfields at Finow and Neubrandenburg northeast of Berlin, but this was abandoned because of the weather en route and the distance.
- At 2033 hrs, air traffic control advised the crew that Werneuchen Special Airfield was reported as yet unaffected by the line of thunderstorms, whereupon the crew decided to fly there.
- Using the AIP aerodrome chart, the air traffic controller advised the crew of the length, width and nature of the runway surface.
- The aerodrome was not licensed for operation of aircraft in the category of the Saab 2000, nor was it equipped for their use. However, the runway was long enough.
- The airfield chart did not provide absolute clarity with respect to the non-usable portion of the runway.
- The aerodrome frequency was not passed to the crew, nor was it requested.
- The crew approached runway 08 directly without radio communication with the airfield and – due to the weather and shortage of fuel – without first inspecting the runway from the air.
- With respect to the displaced runway threshold, communications were unclear between Werneuchen Special Airfield and air traffic control, also between air traffic control and the Saab 2000 crew.
- The markings on the disused portion of the old full-length runway had not been removed, nor had the disused portion been marked as such.
- The touchdown zone markings on the old full-length runway were still in good condition, and misled the Saab pilots to use this as a touchdown target marker.
- The active runway markings and the disused runway surfaces were not marked in accordance with the requirements of ICAO Annex 14 or national rules.
- The last airfield inspection made by the Regional Civil Aviation Authority prior to the accident had produced no criticism with respect to the runway markings, or the disused runway.

- The approx. 70 cm high earth wall extending the full width of the runway was not visible to the flight crew during the final stages of their approach.
- After touchdown, it was not possible for the Saab to avoid a collision with the earth wall.

3.2 Causes

The aircraft accident was due to the following causes:

Immediate causes

- The extent and intensity of the thunderstorm frontal system, plus the speed of change in the weather system.
- Insufficient use of available resources when making decisions in flight (pro-active).
- The loss of alternative landing options, coupled with increasing time pressure (reactive).
- Aircraft touched down outside operational area of an airfield.
- Earth wall was not detected, followed by collision with the same.

Systematic Causes

- Insufficient information with respect to weather situation and development, both prior to and during the flight
- Insufficient information about Werneuchen Special Airfield due to inadequate chart illustration, plus absence of and misunderstood communications
- Insufficient signs and markings of operational and non-operational airport areas.

4. Safety Recommendations

None

Braunschweig, October 2010

Bundesstelle für Flugunfalluntersuchung

On behalf of

F. Kühne

Investigator-in-Charge

The following investigators contributed to this report:

J. Friedemann (Evaluation / Report generation)

G. Leibe (On-site investigation)

H. Peters (Air Traffic Control)

K. Severin (Evaluation / Report generation)

5. Appendices

Appendix 1 – Visual Approach Chart Werneuchen Special Airfield; source: AIP/VFR

Appendix 2 – Airfield Chart Werneuchen Special Airfield; source: AIP/VFR

Appendix 3 – Telephone conversation (transcription) between Berlin Air Traffic Control and Werneuchen Special Airfield.

Appendix 1 – AIP-Visual Approach Chart for Werneuchen



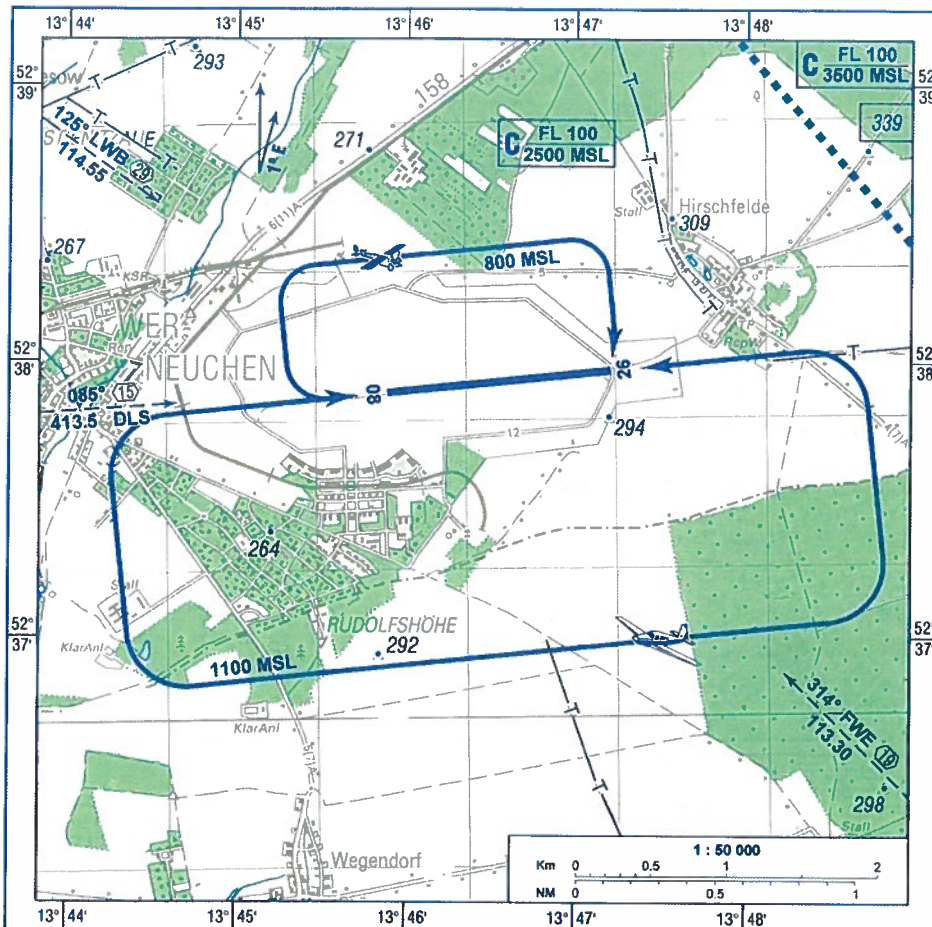
Sichtanflugkarte
Visual Approach Chart

Höhe ü. NN
ELEV 263

WERNEUCHEN
EDBW

FIS
BERLIN RADAR
121.050

WERNEUCHEN INFO
122.600 Ge (15 NM 3000 ft GND)



Berichtigung: Luftraum C.
Correction: Airspace C.

Die Orte Rudolphshöhe, Hirschfelde und Werneuchen sind lärmempfindliche Gebiete, Überflüge sind möglichst zu vermeiden.
Motorsegler dürfen nur mit laufendem Triebwerk in der Platzrunde fliegen.

The villages Rudolphshöhe, Hirschfelde and Werneuchen are noise-sensitive areas, overflights shall be avoided.
Powered gliders are only allowed to fly the traffic circuit with running engines.

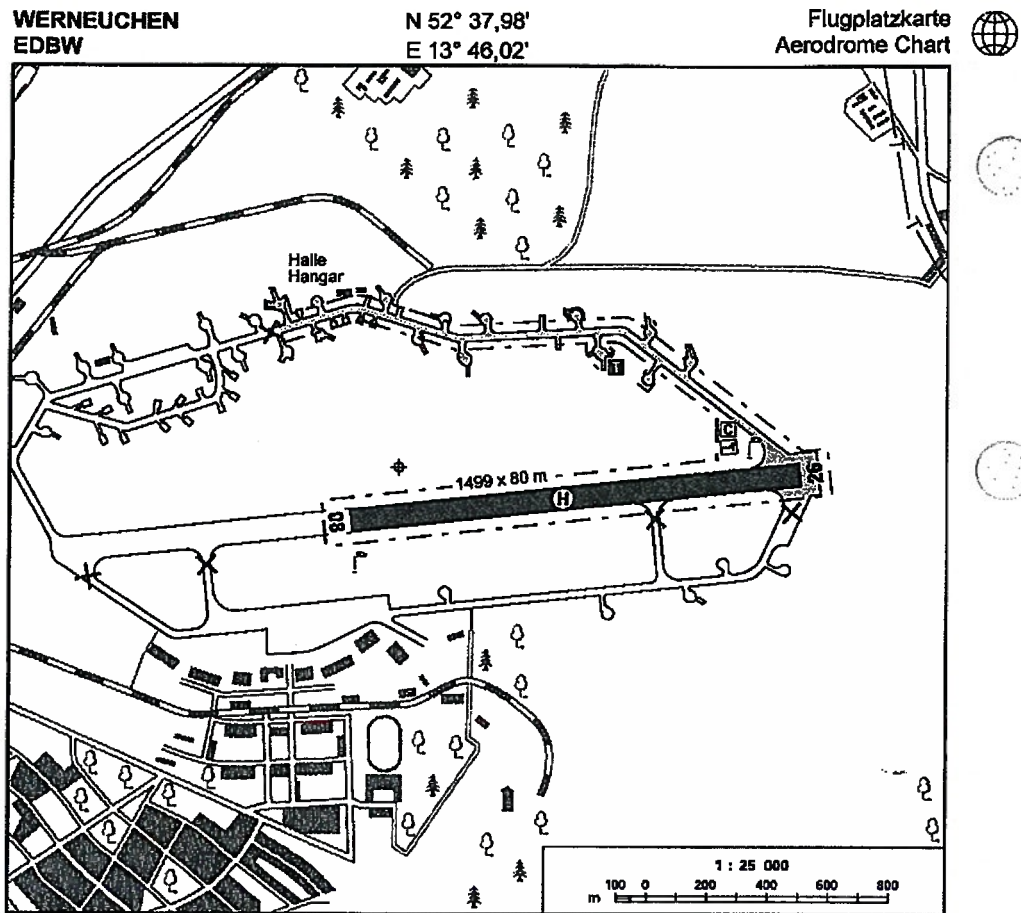
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DFS DEUTSCHE FLUGSICHERUNG GMBH

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Appendix 2 – AIP-Airfield Chart for Werneuchen



Berichtigung: Neue Karte.
Correction: New chart.

| RWY MAG | Abmessungen Dimensions | Belag Surface | Tragfähigkeit Strength | TKOF | LDG |
|------------|---------------------------|--------------------|---------------------------|--------|--------|
| 083 263 | 1499 x 80 m | Harthelag paved | 5700 kg MPW | 1499 m | 1499 m |

Appendix 3 – Telephone call (transcript) between Berlin Air Traffic Control and Werneuchen Special Airfield

| Telephone conversation (transcript) between Berlin Air Traffic Control and Werneuchen Special Airfield | | |
|--|-------------------------------|--|
| 20:37:39 | Flying Club Chairman (EDBW) | [incomprehensible] Werneuchen [incomprehensible] |
| :41 | Air Traffic Controller (ATCO) | Good day. My name is [Name], calling from Berlin Air Traffic Control |
| :44 | EDBW | Yes |
| :44 | ATCO | We will shortly have a landing with you |
| :46 | EDBW | Yes |
| :46 | ATCO | It will be a Saab two-thousand |
| :50 | EDBW | Yes |
| :50 | ATCO | [callsign] |
| :52 | EDBW | Yes |
| :52 | ATCO | Emergency due to fuel short on fuel |
| :55 | EDBW | Yes |
| :55 | ATCO | He is going to land with you, because he can no longer land in Berlin due to the weather |
| :58 | EDBW | Understood |
| :59 | ATCO | He will be there in about ... 4 minutes ... he will be with you |
| 20:38:03 | EDBW | Yes [up to here, voice over] good, but there is no Flugleiter out there, he will have to land at his own discretion, yes |
| :07 | ATCO | Understood, I will tell him |
| :09 | EDBW | An then er will he stay overnight, or [the rest is incomprehensible, voice over] |
| :12 | ATCO | Oh, that er [incomprehensible, to here voice over] but first he wants to land |

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| :14 | EDBW | Yes [voice over] |
| :14 | ATCO | Er I would pre.. er I will pass you to the supervisor, just a moment |
| :18 | EDBW | Okay |
| 20:38:19 | Supervisor (SV) | [Name], hallo |
| :22 | EDBW | Yes here is Werneuchen Airfield, [Name] |
| :24 | SV | Yes, the aircraft will soon be landing at your place |
| :26 | EDBW | Okay |
| :26 | SV | Will be landing at your place ... er ... [incomprehensible] it would be best if we stay on the phone |
| :33 | EDBW | Yes, today he will not ... certainly not take off again, no |
| :37 | SV | No no |
| :37 | EDBW | He shall then land in direction two six ... I am not at the site / outside at the moment, I do not know <i>The German word "draußen" used in the sentence can either mean at the site or outside.</i> |
| ca. :42 | SV | Yes, I can't say, I don't know, what the wind is doing at the moment |
| ca. :44 | EDBW | Yes |
| ca. :45 | SV | I do not know what the wind is doing at the moment |
| ca. :47 | EDBW | Okay, but he must make sure that, in case... |
| :49 | SV | [into the room] Fire brigade out [voice over everything] |
| :49 | EDBW | [beginning incomprehensible, voice over] are ... in direction two six, thus adjacent to Werneuchen... |
| :54 | SV | Yes |
| :55 | EDBW | ...a five hundred metre strip is limited by an earthen wall, but everything has been correctly published |
| 20:39:00 | SV | Yes |
| :01 | EDBW | And there is an earthen wall, so he should pay attention, that he does not attend er does not land on this five hundred meter strip – he should land on the one thousand five hundred metre strip |
| :10 | SV | Yes good, he'll do that anyway |

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| :11 | EDBW | Yes |
| :11 | SV | Er please we stay on the phone, we will soon need the fire brigade |
| ca. :14 | EDBW | I beg your pardon? |
| ca. :15 | SV | I need ... we will shortly need the fire brigade... I think so... |
| 20:39:17 | EDBW | Okay [voice over] |
| 20:39:17 | SV | ...for the off-field landing ... |
| :18 | EDBW | Yes |
| :19 | SV | ...and so I think er that we should stay here |
| :21 | EDBW | Okay, he can then backtrack and find himself a spot to park overnight, yes |
| :26 | SV | Yes yes, there are ... there are pa... passengers, so it is not that simple |
| :29 | EDBW | Okay |
| :30 | SV | Er thou ... you said the runway is one thousand five hundred metres long, yes |
| :33 | EDBW | Yes, is long hmm |
| :34 | SV | As published |
| :35 | EDBW | Okay |
| :37 | SV | [into the room] he should not use ... he should not use the short runway after five hundred metres there is an earthen wall |
| ca. :41 | EDBW | Yes so, he [rest incomprehensible, because voice over] |
| :43 | SV | There is one which is five hundred metres [voice over until here] and one that is one thousand five hundred ... he should not mix up the two |
| :47 | EDBW | Yes... [incomprehensible] five hundred metres are towards Werneuchen, yes |
| :52 | SV | Before Werneuchen are the five... |
| :54 | EDBW | Yes [voice over] |
| :54 | SV | ...hundred metres |
| :55 | EDBW | The five hundred metres are towards Werneuchen, the others are in the direction zero eight ... and one thousand five hundred metres ... |
| 20:40:01 | Back- | So then... the western... |

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| | ground | |
| :02 | EDBW | ER [rest incomprehensible, voice over all] |
| :02 | Back-ground | [several voices] ... the western part, is that with the earthen wall / the west / don't use that / the eastern / he should the / no no / the eastern part / the eastern part of the runway |
| 20:40:02 | SV | Correct, that we should use the eastern part of the runway no |
| :12 | EDBW | Yes, he should watch out for the threshold... |
| :14 | SV | Yes |
| 20:40:14 | EDBW | ...the thresholds are okay |
| :16 | SV | Threshold |
| :16 | EDBW | The thresholds are okay, yes |
| :18 | SV | Okay, thanks |
| :19 | Back-ground | [several voices] [beginning incomprehensible] however / landing before the threshold of zero-eight |
| :23 | SV | Exactly |
| :23 | Unknown | Exactly |
| :24 | SV | Exactly so |
| :26 | Back-ground | <i>You should use the easterly part of the runway... not... landing before the threshold of zero-eight - exactly</i> |
| :35 | Back-ground | Shall I telephone the fire brigade |
| :36 | SV | [incomprehensible] |
| :37 | Back-ground | Or will he do it |
| :38 | SV | He will do it here ... we will call the fire brigade, soon, yes... |
| :40 | EDBW | Okay [everything voice over] |
| :40 | SV | ... when we ... when ... when he has landed |
| :42 | EDWB | Okay, yes |
| :44 | SV | He is about to land |
| :45 | EDBW | Yes, okay |

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| :46 | Back-ground | Fire brigade or what where have you got there [incomprehensible] |
| :48 | SV | Have you got a telephone there |
| :50 | EDBW | No, we haven't |
| 20:40:52 | EV | Well, have you got the er ... er ... of the fire of the fire brigade there |
| :55 | EDBW | The number |
| :56 | SV | Yes |
| 20:40:56 | EDBW | The hundred twelve [standard emergency telephone number] nothing else ... hundred and twelve, I can call them, but ... er |
| 20:41:02 | SV | I'll do that from here |
| :03 | EDBW | Yes, okay |
| :04 | SV | Just a moment |
| :04 | EDBW | Hundred twelve |
| :07 | SV | Just a moment, stay on the line |
| :09 | EDBW | Yes |
| :16 | Back-ground | 'Evening... can I help you |
| :18 | SV | [into the room] Yes, can you phone [incomprehensible] phone the fire brigade [incomprehensible] Werneuchen |
| :21 | EDBW | Yes |
| :22 | SV | Fire brigade ... Werneuchen... [from here voice over] off-field landing... |
| :24 | EDBW | Hundred twelve [voice over] |
| :24 | SV | ... Saab two thousand |
| :26 | EDBW | Yes |
| :27 | SV | Okay, the fire brigade is on its way, my colleague ... |
| :29 | EDBW | What sort of [up to here voice over] what sort of aircraft will be landing there [rest incomprehensible, because voice over] |
| :30 | SV | A Saab two thousand |
| :31 | EDBW | A what |

| | | |
|---|-------------|---|
| :32 | SV | A Saab two thousand |
| :34 | EDBW | Saab two thousand, understood ... good |
| :43 | SV | The fire brigade is informed |
| 20:41:44 | EDBW | Good |
| :47 | Back-ground | [several voices] [beginning incomprehensible] everything else with [incomprehensible] and such a / [incomprehensible] I told him, that the fire brigade er somehow... |
| :51 | SV | So... okay... er what will you do now er will you go to the airfield, or what will you do |
| 20:41:59 | EDBW | No, at the moment I am er at home ... Berlin [rest incomprehensible] |
| <p>AT THIS MOMENT THE SAAB 2000 LANDS IN WERNEUCHEN</p> | | |
| 20:42:02 | SV | Pardon |
| :03 | EDBW | I am at home in Berlin |
| :04 | SV | Okay. Just a moment, I have to hang up |
| :06 | EDBW | Yes, okay |
| :07 | SV | I'll phone again. Thanks. 'Bye. |
| :08 | EDBW | Understood hmm |

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| 20:53:55 | EDBW | Werneuchen Airfield, [Name] |
| :56 | SV | [Name] from air traffic control again |
| :58 | EDBW | Yes |
| :58 | SV | Say, do you drive out to the airfield ... I just thought that you must ... certainly want to know what has happened there or not |
| 20:54:03 | EDBW | No, I have [everything voice over] |
| :03 | SV | Or don't you have to [up to here, voice over] or don't you have to do something ... will anyone drive out there |
| ca. :06 | EDBW | No, it would take me an hour and a half to get there |
| :09 | SV | Yes, I don't know, well it is not my responsibility |

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| :12 | EDBW | ER has he landed now |
| :13 | SV | I don't know |
| :15 | EDBW | Oh no oh [rest incomprehensible, voice over] |
| 20:54:15 | SV | I can't [to here, voice over] tell you, I don't know, maybe he has crashed. I can't tell you. We are all waiting, what happens here |
| :20 | EDBW | You don't say so |
| :21 | SV | Yes |
| :22 | EDBW | I can't contact anyone out there |
| 20:54:25 | SV | Nor me |
| :26 | EDBW | Yes... that is difficult... there is just only one, he is seventy eight or eighty years old but is very mobile. But he could drive out, should I ask him to do so? |
| ca. :36 | SV | Don't know, that's up to you |
| ca. :37 | EDBW | Good, I'll do it |
| :38 | SV | Yes I have told everyone. The fire brigade is on its way, th... the police et cetera et cetera... |
| :43 | EDBW | Yes |
| :43 | SV | ...so that's why [from this point, voice over] it's okay |
| :44 | EDBW | Is the weather [up to here, voice over] that bad with you? |
| :46 | SV | Pardon... yes |
| :46 | EDBW | Is the weather that bad with you |
| :48 | SV | Yes, it's bad in Berlin |
| :49 | EDBW | Oh well ... er... you cannot tell me in which direction he landed |
| :53 | SV | Surely zero eight |
| :54 | EDBW | He landed zero eight |
| :55 | SV | Yes |
| :56 | EDBW | Good, then he came right over the five hundred metre strip ... the main thing is that he spotted the threshold and he sees the threshold... |
| 20:55:01 | SV | Yes |

| | | |
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| :01 | EDBW | ...quite clearly and then he has one thousand five hundred metres available |
| 20:55:05 | SV | Yes |
| :06 | EDBW | And then he must continue to taxi in landing direction, then around to the left ... then there will be two shelters ... the taxiways ... two shelters, they are occupied ... |
| :14 | SV | Hm |
| :14 | EDBW | ...and then there is a shelter, that is open, he can put his plane in there |
| :18 | SV | Oh, I don't know that, I think he will be just happy to get down ... but... now I am waiting I just wanted to briefly inform you ... er then you will be informed also , yes |
| 20:55:26 | EDBW | Okay |
| :26 | SV | Okay, 'Bye |
| :27 | EDBW | [Beginning incomprehensible] if you would ring me back some time er er I would be er that would be good |
| :31 | SV | Okay thank you... 'Bye |
| 20:55:32 | EDBW | Yes... thanks also... 'Bye |