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Report RL 2000:40e

Aircraft accident to SE-GDN 8 kilometers northwest of Sundsvall/ Härnösand airport, Y county, Sweden on the 9th of December 1999

Case L-107/99

SHK investigates accidents and incidents with regard to safety. The sole objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

The report is also available on our web site: www.havkom.se

Translated by Dennis L. Anderson

From the original Swedish at the request of the Board of Accident Investigation.
In case of discrepancies between the English and the Swedish texts, the Swedish text is to be considered the authoritative version.

F20 Rapport L_eng

2000-11-15 L-107/99

Swedish Civil Aviation Administration

601 79 NORRKÖPING

Report RL 2000: 40e

The Board of Accident Investigation (Statens haverikommission, SHK) has investigated an aircraft accident that occurred on the 9th of December 1999, 8 kilometers northwest of Sundsvall/Härnösand airport, Y county, Sweden involving an aircraft with registration SE-GDN.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a final report on the investigation.

S-E Sigfridsson

Monica J. Wismar Henrik Elinder

F20 Rapport L_eng

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APPENDICES ***(no appendices in internet version)***

ABBREVIATIONS

ACU	Annunciator Control Unit
ADF	Automatic Direction-Finding equipment
ARCC	Aeronautical Rescue Control Center
BFU	Dept. of Aircraft Accident Investigation (Germany)
°C	Degrees Celsius
COM	Communication
DME	Distance Measuring
EKG	Electrocardiography
FL	Flight Level
FLUX	Magnetic Flux
Ft	feet
GP	Glide Path
GPS	Global Positioning System
GS	Ground Speed
h	Hour
HDG	Heading
hPa	Hectopascal
HSI	Horizontal Situation Indicator
IAL-chart	Instrument Approach and landing chart
IAS	Indicated Air Speed
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IOR	Recording and Registration
kt	Knot
lbs	Pounds
LLZ	Localizer
LFI	Civil Aviation Administration Inspection Dept.
LFV	Civil Aviation Administration
m	Meters
METAR	Regular meteorological aviation weather reports
MHz	Megahertz (cps)
MKR	Marker Radio Beacon
mm	Millimeters
mph	Miles Per Hour
MUST	Military Intelligence & Security Service (Swedish)
NAV	Navigation/Navigator
NDB	Non Directional radio Beacon
NM	Nautical Mile
QNH	Atmospheric pressure at Mean Sea Level
s	Seconds
SMHI	Institute of Meteorology & Hydrology (Swedish)
SSR	Secondary Surveillance Radar
SBY	Standby
TWR	Aerodrome control tower
V	Volt
VMC	Visual Meteorological Conditions
VHF	Very High Frequency
VOR	VHF Omnidirectional Radiorange

Report RL 2000:40e

L-107/99
Report finalised 2000-11-15

Aircraft: registration, type	**SE-GDN, Piper PA-31**
Class/airworthiness	Normal, valid certificate of airworthiness
Owner/Operator	Twin Air HB, box 6078, 400 60 Gothenburg
Date and time	1999-12-09, 12:04.30 hours in daylight *Note*: All times in the report are given in Swedish normal time (SNT) = UTC + 1 hour
Place of occurrence	Approximately 8 kilometers northwest of Sundsvall/Härnösand airport, Y county, Sweden (pos. 6233N 1719E, approximately 200 meters above sea level)
Type of flight	Private
Weather	METAR Sundsvall at 11:50 hours: wind 120°/11 kts., visibility 500 meters in snowfall, runway visual range (rwy 16) 1000 meters, vertical visibility 300 feet, temperature/dewpoint -2/-2°C, QNH 986 hPa.
Persons on board: crew	1
passengers	7
Injuries to persons	All onboard fatally injured
Damage to aircraft	Destroyed
Other damage	Damage to trees
Pilot in command:	
age, certificate	57 years old, Private pilot's license with instrument rating
total flying time	729 hours, of which 98 hours on type
flying hours previous 90 days	5 hours, all on the type
number of landings previous 90 days	6

The Board of Accident Investigation (SHK) was notified on the 9th of December 1999 that an aircraft with registration SE-GDN had an accident at 12:04.30 hrs on that day.

The accident has been investigated by SHK represented by Sven-Erik Sigfridsson, Chairman; Monica J. Wismar, Chief investigator flight operations, and Henrik Elinder, Chief technical investigator aviation.

The Board was assisted by Billy Nilsson as operative expert, Dan Åkerman and Jan-Inge Henriksson as technical experts, Georg Kramer as technical expert instrumentation, Matts Aldman as medical expert and Gunnar Jarsjö as meteorological expert.

The investigation was followed by Max Danielsson, Swedish Civil Aviation Administration.

Summary

The pilot had, on the morning the day prior to the accident, together with seven passengers, flown from Gothenburg to Sundsvall via Östersund.

During the afternoon everyone had participated in a working meeting and had dined together in the evening. The day of the accident they had a working meeting that concluded at 10:30 a.m. The group arrived at the airport around 11:15 a.m. The weather situation was difficult with snowfall and gusty winds. The passengers remained inside the flight planning room in the terminal building while the pilot ordered fuelling and went out to prepare the aircraft for the flight. Departure was planned to take place at 11:30 a.m. and the flight was estimated to take 2 hours and 20 minutes.

After having boarded his passengers and taxied out to the take off position, the pilot reported ready for take off at 12:00.08 p.m.

The pilot was instructed to contact Sundsvall control on frequency 135.02 MHz when airborne and was then given clearance for take off. The pilot read back these clearances and thereafter took off.

Approximately two minutes after take off the tower controller observed on his radar screen that the aircraft echo from SE-GDN was not following the cleared flight route but instead had turned to the north. He contacted the aircraft and asked the pilot if he was experiencing problems. The pilot then stated that he did have a problem and in response to the tower controller's inquiry as to his intentions the pilot answered "Climbing" two times and thereafter "-I have a problem with the eeee... äääee.. with the compass at, at this moment, so could you, could you give me a ... di, direction at this moment." The air traffic controller then answered "Ja, you are climbing towards the north-west now, turn left about 90 degrees and climb as soon as possible, you meeting terrain." Subsequently the tower controller was unable to attain any further radio contact with the aircraft.

At time 12:04.27 radio signals from an emergency locator transmitter were perceived in the area and the air traffic controller triggered the alarm button to the SOS center and alerted the air rescue services at ARCC.

ARCC alerted a search and rescue helicopter that was stationed at Sundsvall/Härnösand airport. At 12.30 hours the aircraft was located in the forest on the southern slope of a mountain known as Kvickberget. The helicopter lowered rescue personnel on the winch who ascertained that none of the persons on board had survived.

No failures on the aircraft, the engines, or instrumentation have been ascertained.

The pilot was not qualified to fly during darkness.

The medical investigation has shown that the pilot had two disorders, each one of which was disqualifying for a pilot's license.

The accident was caused by the pilot losing control of the aircraft during flight in IMC. Contributory factors were, that

-the weather situation was difficult,
-the pilot's time to prepare for the flight was insufficient,
-the navigation system was in all probability misaligned,
-the pilot distrusted the flight instruments,
-the aircraft was overloaded and tail-heavy,
-the pilot probably felt pressured into carrying out the flight and that
-the pilot's medical condition may have reduced his capacity.

Recommendations

The Swedish Civil Aviation Administration is recommended

-to carefully consider the possibilities to find methods to ensure the qualifications of those with a private pilot's license (A), who fly with passengers in their vocational activities *(RL2000:40 R1)* and

-to the extent it is possible, to inform business executives of the differences in qualifications between private and commercial pilots. *(RL2000:40 R2)*

1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Events prior to the flight

On Wednesday the 8th of December 1999 at 08:32 hrs. the pilot took off with the aircraft from Gothenburg/Landvetter airport for an IFR flight to Sundsvall/Härnösand airport via Östersund/Frösön F4 airport. Present onboard were seven passengers, all employed by a company in Gothenburg. The flight proceeded via the reporting point of MEGEN (6001N 1424E) and they landed at 10:45 hrs. in Östersund. After a short groundstop to deplane one of the passengers, they took off 13 minutes later to continue the flight to Sundsvall.

It was beautiful weather in Sundsvall. The wind was 320 degrees at 12 knots and the temperature –12°C. The pilot performed a visual approach to runway 34 and landed at 11:33 hrs. After the landing he parked the airplane for the night on spot 25 on the southern tarmac, designated "Apron S" (ref. 1.10). According to what he stated later that evening, he placed covers on the aircraft wings and stabilizer and connected electricity for heating in the cabin and engines before he, along with his passengers, departed for the city of Sundsvall.

In Sundsvall they had lunch and had a business meeting with a subcontractor, which was concluded at approximately 16:00 hrs, at which time they were driven to the hotel. Around 19:00 hrs. the party dined at a restaurant together with a few of the employees from the subcontractor. The consumption of alcoholic beverages was sparse and none of the persons that SHK has talked with observed the pilot consume anything other than non-alcoholic beverage. Dinner concluded around 23:30, after which the party returned to the hotel.

The following morning it was snowing. The group was picked-up around 08:00 hrs. and initially made a short visit at a factory. Thereafter they were driven to the subcontractor's office where they had a short coffee break and then continued their business meeting. During the trip to the office the pilot called the airport and ordered weather information that was faxed to the office. On questions to the pilot concerning flying in the bad weather, his response was that it was no problem. If he had felt doubtful in that respect, he would cancel the flight. However, due to the weather situation the pilot decided not to perform the return flight to Gothenburg via Östersund. The passenger that was there had to get to Sundsvall with other means of transport and join the group at the airport.

1.1.2 Preparations before the flight

The business meeting was concluded at time 10:30 hrs. A taxi had been booked for that time. Due to the taxi being somewhat late the group arrived at the airport around 11:15. The passengers remained in the flight planning room in the terminal building while the pilot ordered fueling and went out to prepare the aircraft for the flight. He had filed a flight plan by telephone earlier in the day. Departure was planned for 11:30 hrs. and the flight time was estimated to be 2 hours and 20 minutes.

When the fueling order came, the fueling personnel were busy re-fueling another aircraft with type JET A-1 fuel. The tanker truck with AVGAS 100LL fuel had not been in use earlier that day. Prior to re-fueling with this truck it was drained and prepared for re-fueling. When the fueling personnel arrived at the aircraft the pilot was already in the aircraft warming-up the engines. He cut the engines and requested to have "full wings". A total of 396 liters of fuel were uploaded in the aircraft's four fuel tanks. The fueling personnel noted that the aircraft wings were free from ice and snow.

The pilot contacted the air traffic controller in the tower at 11:41.38 and requested clearance to taxi, which was granted, to the flight planning office next to Apron M, in order to pick up his passengers. At 11:49.24 hrs. the pilot again contacted the tower controller and requested clearance to start-up the engines and at the same time reported that he had received the weather information. Four minutes later he requested taxi instructions and was cleared to taxi to holding position "Charlie" on the taxiway (ref. 1.10). After further instructions from the air traffic controller the pilot taxied to the specified position and held there for a departing SAS (Scandinavian Airlines) aircraft. The air traffic controller thought that the aircraft appeared to be free from snow when it was parked on Apron M, but that a thin layer of snow had accumulated when it taxied out for take off.

The Commander of the departing SAS aircraft has recounted that both the approach and the departure from Sundsvall that day were difficult due to poor visibility, heavy snowfall and gusty winds. During taxi on the runway snowdrifts had occurred that created strands of blowing snow. He estimated the visibility to be 600-700 meters. During take off he was "fully occupied maneuvering the 58 ton heavy MD 80 in the wind gusts".

1.1.3 The Flight

When the SAS aircraft had departed the pilot received clearance to taxi out to the take off position on runway 16. At the same time he received air traffic control clearance to Gothenburg/Landvetter via reporting point MEGEN at flight level 120 (approximately 3 660 meters), and the transponder code of 6377. He was also requested to report when the aircraft had reached the take off position, as the air traffic controller could not see the aircraft in the snowfall. At 12:00.18 hrs. the pilot reported that he had lined up into take off position. The controller then reported that the wind was 120 degrees at 17 knots, that the pilot was to make a right turn after take off and that he was cleared for takeoff. When the aircraft was airborne the pilot was to contact Sundsvall Control on frequency 135.02 MHz. The pilot read back these instructions and thereafter took off. The tower controller visually observed the aircraft a short moment during the take off as it passed abeam the control tower, then it disappeared again out of his sight due to the snowfall.

A witness, who is a former pilot himself and was on the northern part of Alnön (an island), about 5 km south of the airport, heard the aircraft take off. After take off he heard that the engine rpm decreased somewhat and thereafter heard the characteristic sound that can arise on a multi-engine aircraft when the engines are not totally synchronized with the adjustment of the throttles and propeller levers. The sound of the engines became normal after a while. When the sound faded out is was perceived as normal for a twin engine aircraft.

Witnesses who were situated along the flight path of the aircraft heard it and a few observed the aircraft during a short moment through the heavy snowfall. Several felt that the aircraft was flying low but that the sound of the engines was normal. One witness observed that the landing gear was retracted. In the vicinity of Kvickberget northwest of the airport a few witnesses heard that the engine rpm increased sharply. After that it was silent.

Approximately two minutes after take off the tower controller observed that the echo from aircraft SE-GDN on his radarscope was not following the route cleared but had turned to the north. He made an inquiry with the air traffic controller at Sundsvall Control and received word that the same had not yet been contacted by the aircraft. The tower controller then contacted the aircraft on tower frequency and asked the pilot if he was experiencing problems. The pilot responded that he did have problems and in response to the controller's inquiry about his intentions, the pilot answered "Climbing" twice and thereafter "-I have a problem with the eeee ... uuumm .. with the compass at, at this moment, so could you, could you give me a ... di, direction at this moment." The tower controller then answered "Ja, you are climbing towards the north-west now, turn left about 90 degrees and climb as soon as possible, you meeting terrain." Subsequently the tower controller was unable to attain any further radio contact with the aircraft.

1.1.4 Rescue operations

At time 12:04.27 radio signals from an emergency locator transmitter were perceived in the area and the air traffic controller triggered the alarm button to the SOS center and alerted the air rescue services at ARCC. It was agreed upon to apply the yellow checklist, which meant assumed crash with unknown crash site. The airport was closed.

The SOS center alerted according to the alert plan for an assumed crash. A suitable breakpoint (where the ground rescue party has to depart from the surface road structure) was chosen in connection with the area where the aircraft disappeared.

ARCC alerted a search and rescue helicopter that was stationed at Sundsvall/Härnösand airport. The crew of the search and rescue helicopter received the alarm at 12:10 hrs. and was airborne with the helicopter at 12:24. Six minutes later the aircraft was located in the forest on the southern slope of a mountain known as Kvickberget. The helicopter lowered rescue personnel on the winch who ascertained that none of the persons on board had survived. They were only able however to find five persons and searched through an area around the downed aircraft without results.

Police, ambulances and fire vehicles reached the breakpoint between 12:21 and 12:27 hrs. The SOS center received the exact position of the accident site at 12:35 hrs. and the breakpoint was moved to a road intersection about 4 km from there. The forest road towards the accident site was unplowed and two tracked vehicles had to begin the trip while snow plows cleared the forest road so that ambulances and fire vehicles could make their way. The last portion from the forest road up to the aircraft was approximately 300 meters long and consisted of a ravine and difficult terrain. Medical and fire personnel had to make there way on foot this last portion and reached the accident site at 13:30 hrs. They verified that none of the persons onboard had survived and found that there was an imminent risk of fire because of the large quantity of aviation gas that had been spread at the site. Hand-held fire extinguishers and police search and rescue dogs were requisitioned to the site. At 14:36 hrs. it was reported to SOS that additionally three people had been found in the aircraft. At 19:40 hrs. the last of the victims were transported from the accident site.

A crisis group was established at Sundsvall/Härnösand airport. About 40 persons participated in the rescue operations at the site, which was concluded at 23:39 hrs. Despite the difficult terrain, which limited the availability of equipment, the general consensus was that the search and rescue action had worked well.

The accident occurred at location: 6233N 1719E; approximately 200 m above sea level.

1.2 Injuries to persons

	Crew	*Passengers*	*Others*	*Total*
Fatal	1	7	–	8
Serious	–	–	–	–
Minor	–	–	–	–
None	–	–	–	–
Total	1	7	–	8

1.3 Damage to aircraft

Destroyed.

1.4 Other damage

Damage to trees.

1.5 Personnel information

1.5.1 The pilot's experience

The pilot was 57 years old and had a valid private pilot's licence with medical limitations (ref. 1.13) that meant he was only authorised to fly within Scandinavia and only during daylight. For flights outside Scandinavia he was obliged to request special permission for the respective country.

Flying hours previous	*24 hours*	*90 days*	*12 Months*	*Total*
All types	-	5	71	729
This type	-	5	71	98

Number of landings this type previous 90 days: 6.
Flight training on type concluded on 11 August 1998.
Latest periodic flight training (PFT) was carried out on the 15th of October 1999 on the Piper PA-31.

The pilot started his pilot training in 1984 and received a private pilot license the 2nd of January 1985. He began instrument flight training in October of 1987 and he received his instrument rating in the spring of 1988. During night flight and when flying outside of Scandinavia a safety pilot with an instrument rating was required to accompany him. During the spring of 1988 until 1999 the pilot logged a total of 37 hours of night flight. At the time of the accident he had accumulated a total of 425 hours of instrument flying time.

The pilot underwent multi-engine training in 1989 in a Piper PA-34. At the time of the accident he had accumulated a total of 390 hours of multi-engine time.

During the period of the 30th of March 1994 until the 31st of October 1995 the pilot took a pause in his flying.

Prior to the flight to Östersund and Sundsvall on the 8th of December the pilot had not flown in almost two months.

1.5.2 The pilot's personality

By colleges and acquaintances that SHK has been in contact with, the pilot was considered to be a happy, outgoing and likeable person. He never found any problems more difficult than that they could be solved. He was considered to be calm and stable and seldom seen as stressed. As a consultant he was esteemed and he possessed a large network of personal contacts.

He had a great interest in flying and would gladly utilise his airplane on trips. He spoke very convincingly of the aircraft's equipment and of the time and cost advantages of travelling with your own airplane.

1.6 Aircraft information

AIRCRAFT:		
Manufacturer:	Piper Aircraft Corporation, USA	
Type:	Piper PA-31	
Serial number:	31-7300947	
Year of manufacture:	1973	
Gross weight:	Max authorised 3 053 kg, actual 3 362 kg	
Centre of gravity:	Close to or behind the aft center of gravity limit	
Total flying time:	7 266 hrs.	
Number of cycles:	Unknown	
Flying time since latest inspection:	71 hrs.	
Fuel loaded before event:	100LL	
ENGINE:		
Manufacture:	Lycoming	
Model:	TIO-540-A2C	
Number of engines:	2	
Engine	*No 1*	*No 2*
Total operating time, hrs.	1 798	1 840
Operating time since overhaul	4	483
PROPELLER:		
Manufacture:	Hartzell	
Operating time since latest overhaul		
Propeller 1:	535 hrs.	
Propeller 2:	535 hrs.	

The aircraft was equipped with a de-icing system.
The aircraft had a valid certificate of airworthiness.

The aircraft SE-GDN

1.7 Meteorological information

1.7.1 Actual weather and forecast

A warm front was moving north from Götaland (southern 1/3 of Sweden) and caused heavy snowfall in the Sundsvall area. Cumulonimbus activity can have occurred locally, which intensified the snowfall. At 11:50 hrs. Sundsvall/Härnösand airport reported; wind 120°/11 knots, visibility 500 meters in snow, runway visual range (rwy 16) 1000 meters, vertical visibility 300 feet, temperature / dewpoint –2/-2°C, QNH 986hPa.

Airfield forecast valid from 10:00 to 19:00 hrs.:
Wind 150°/14 knots, visibility 5 000 meters in light snow, clouds 3-4 octaves at 400 feet and 5-7 octaves at 1500 feet, temporarily during the entire period visibility 2 000 meters in moderate snow and clouds 5-7 octaves at 400 feet, 30% probability during the entire period of 700 meters visibility in heavy snow with vertical visibility 300 feet.

1.7.2 The weather conditions during the night prior to the flight

A strong inversion occurred in the area during the night between the 8th and the 9th of December and at 02:10 hrs. the lowest air temperature of –19 °C. was measured at ground level. Thereafter the temperature rose and at 09:50 hrs. was measured at –2 °C. The night was clear and cold with low humidity in the air. Any existing wind was estimated as north-westerly, i.e. coming from landside which meant that the prerequisites for the development of frost were small.

The nocturnal inversion was "broken up" during the morning hours but during the entire day the temperature was below 0 °C. at all altitudes. The snowfall was therefore judged to be dry.

1.7.3 Wind variations

The airport is equipped with two wind gauges, one placed on each end of the runway at a height of 10 meters over the runway surface. The winds were measured as follows:

Runway 16
11:50-12:00 hrs., 115-130°/12-18 knots with gusts from 19-23 knots
12:00-12:10 hrs., 120-130°/12-18 knots with gusts from 22-25 knots

Runway 34
11:50-12:00 hrs., 095-110°/10-18 knots with gusts from 25-26 knots
12:00-12:10 hrs., 115-120°/09-16 knots with gusts from 17-21 knots

The wind increased with altitude and was estimated to have been 120°/35 knots at 600 meters height.

1.7.4 Daylight conditions

On the 9th of December 1999 sunset was at 15:24 hrs. in Gothenburg. It's estimated to have been totally dark from approximately 16:15 hrs.

1.7.5 The weather forecast for the destination airport

The valid forecast for Gothenburg/Landvetter airport (10:00-19:00 hrs.): wind 210°/16 knots with gusts to 28 knots, visibility more than 10 kilometers, clouds 3-4 octaves at 2 000 feet, 5-7 octaves at 4 000 feet, 30% probability during the entire period of rain showers with clouds 5-7 octaves at 600 feet and 5-7 octaves of cumulonimbus at 2 000 feet.

1.8 Aids to navigation

1.8.1 General

In addition to ordinary flight instruments the aircraft was equipped for IFR flight. Included in the equipment were the following units:

#	Designation	Manufacture
1	Radio Nav receiver (VOR/ILS/LLZ)	King KN 73
1	Radio Nav receiver (VOR/ILS/LLZ/GP)	King KN 73
1	Horizontal Situation Indicator (HSI)	Edo-Aire NSD-360
1	Course Director Indicator	Bendix/King KNI 520
1	ADF receiver	Bendix/King KR 87
1	DME receiver	Bendix/King KN 65
1	GPS receiver	Garmin 155 XL

Radio Nav receiver

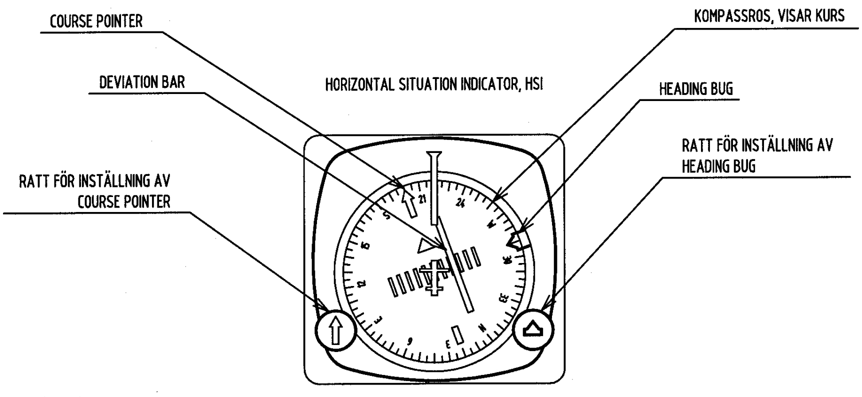
The receiver is used to receive navigation signals from VOR beacons on the ground for determination of aircraft position and also for receiving signals from the instrument landing system's (ILS) localizer and glide path transmitters placed on the approach path to the airport.

GPS receiver

The receiver is used to receive navigational signals from GPS satellites for determination of the aircraft's position and for other types of navigational data.

1.8.2 HSI

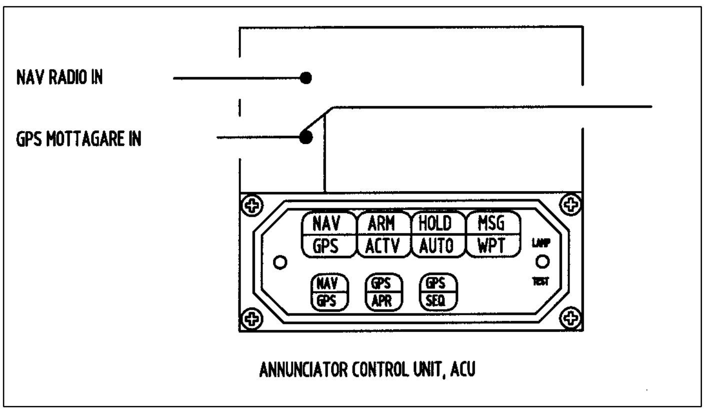
The HSI is a combination instrument. The instrument provides a clear and easy method of picturing the actual course and horizontal position in relation to selected VOR stations or selected GPS reference points. The direction of flight can be selected on the instrument through setting of a course index HEADING BUG and desired course-radial from a VOR station or GPS reference point through setting of the COURSE POINTER and DEVIATION BAR. Selection of course and radial is accomplished with help of two knobs on the bottom of the instrument's outer panel.



HSI-panel

1.8.3 ACU

The ACU can be described as a selector for which of the aircraft's two navigation systems, NAV[1] or GPS, shall be connected to the HSI and autopilot. The setting choice is accomplished by use of push-buttons on the instrument's outer panel. Indicator lights on the instrument display show which system has been chosen. In NAV-position information is acquired from the NAV-1 receiver. Additionally there is a function of the ACU that automatically switches from GPS to NAV if an ILS frequency has been chosen on NAV-1. This is to inhibit the autopilot from being coupled to the GPS when flying in ILS mode.



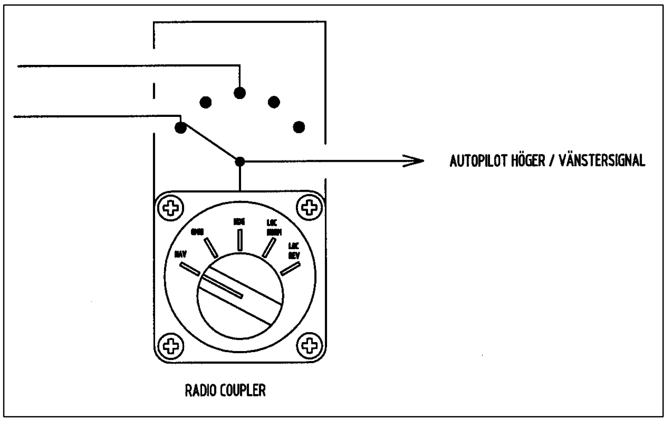
ACU-panel

[1] NAV = (ISL/VOR)

1.8.4 *Radio coupler*

The Radio coupler is a manual selector with five positions for selection of incoming signals to the autopilot. With the rotary selector in position HDG the autopilot receives signals from the HEADING BUG on the HSI and strives to turn the aircraft so that it flies the heading selected on the HEADING BUG.

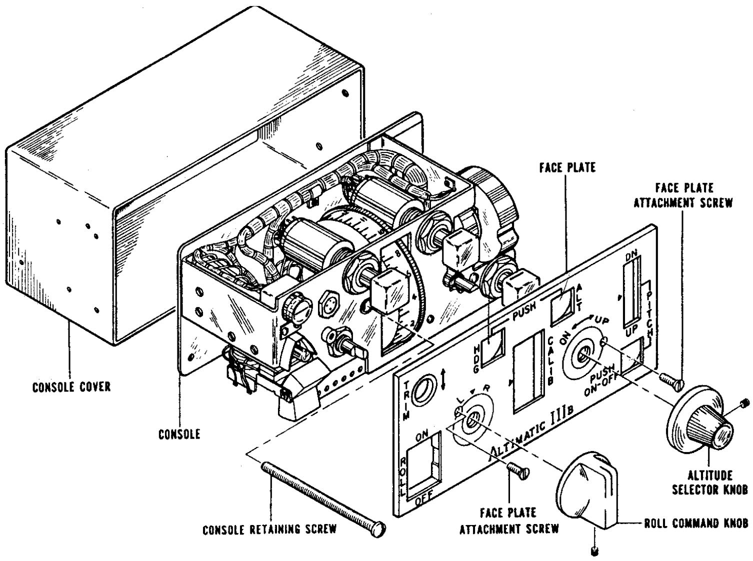
With the selector in position NAV, OMNI, LOC, LOC NORM or LOC REV, the autopilot is coupled to the NAV or GPS system via the ACU. With the Radio coupler in any of these positions the aircraft autopilot will steer the aircraft according to the settings that have been selected in the NAV or GPS systems. The different positions determine how the autopilot shall react to the signals.



Radio coupler-panel

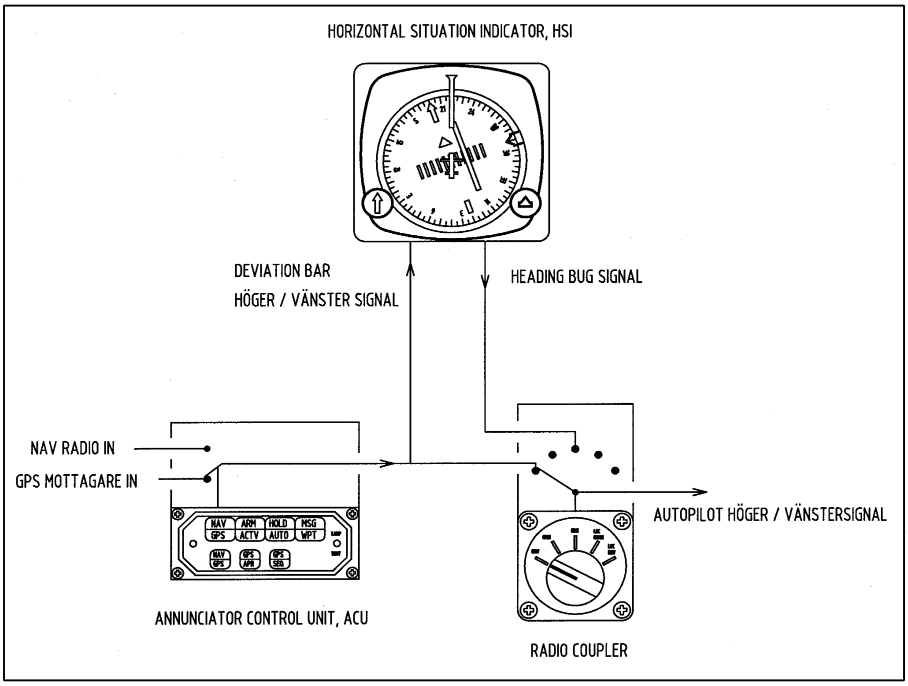
1.8.5 *Autopilot*

The aircraft was equipped with a two-axis autopilot of type Altimatic III that can control the aircraft in roll and pitch axis, and includes an altitude control function. With knobs on the autopilot control panel, the pilot can perform turns and altitude changes.



Autopilot Altimatic III

The pilot can couple the autopilot to follow the HEADING BUG on the HSI or to either of the two navigation systems, NAV or GPS. Switch-over between these alternatives takes place with the Radio coupler and the ACU according to the diagram below.



Sketch of autopilot coupling

During turns that are initiated by electrical signals from the HEADING BUG on the HSI, or from the NAV, or GPS system, the maximum bank angle is limited to 20°. This bank angle produces a turn rate of approximately three degrees per second a normal airspeeds.

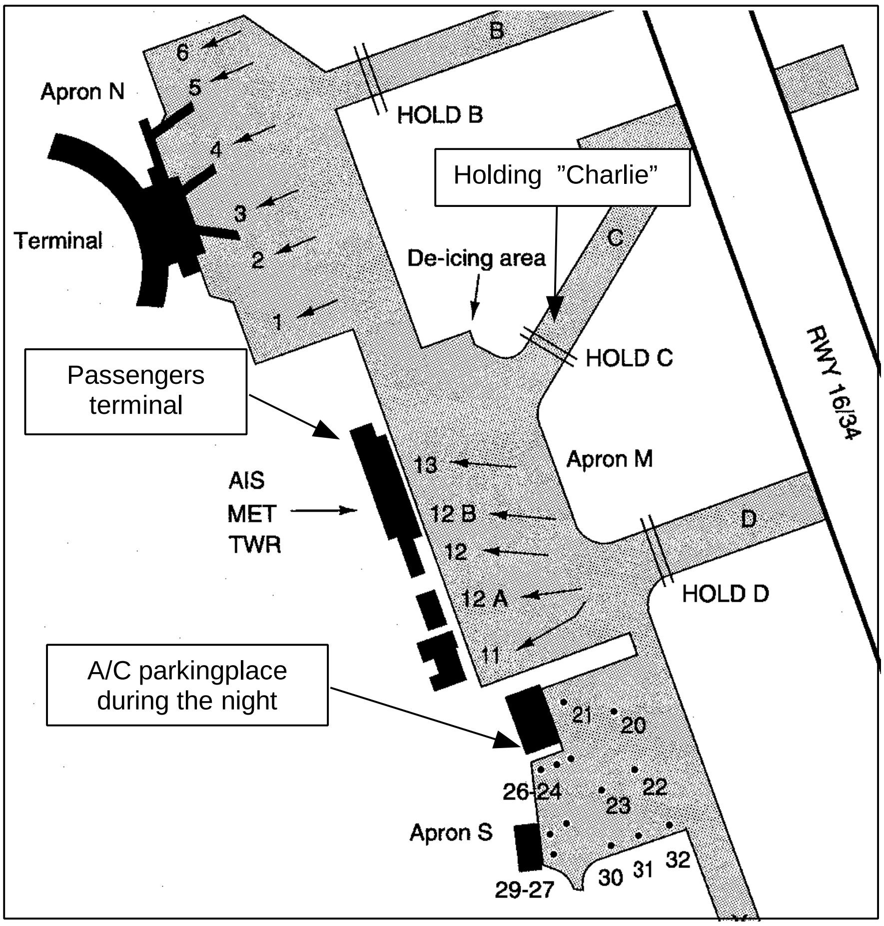
1.9 Communications

Radio communications between the pilot and the controller in the air traffic control tower at Sundsvall/Härnösand are reproduced in appendix 2. The language used in Sweden during instrument flight is English with standardised international phraseology.

It can be discerned from listening to the tape recording that the pilot talked calmly until he took off. Thereafter, when the air traffic controller inquired if he was still on the frequency, a close relative could note a change in his voice during the remaining portion of the communication. His voice seemed somewhat strained and pressured. Also, transmission took place with several pauses and the transmitter button was keyed at prolonged intervals without anything being said.

1.10 Aerodrome information

Sundsvall/Härnösand is an AIP-Sweden status airport.



Terminal area at Sundsvall/Härnösand airport

Note. During the investigation it has been stated that magnetic disturbances were found at position #13.

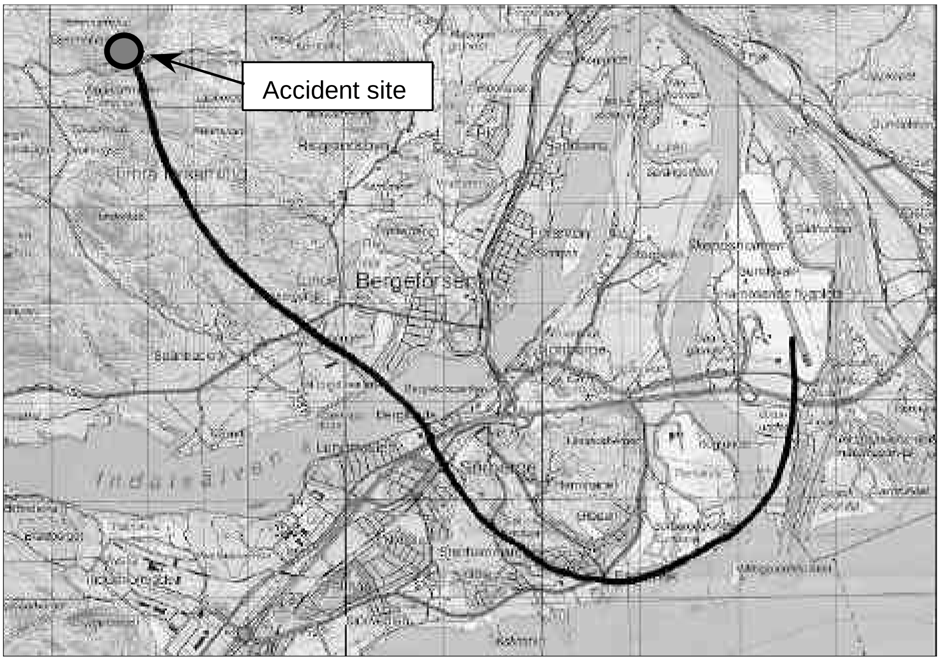
1.11 Flight recorders

There was no requirement to carry a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR) on board the aircraft and neither was fitted.

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

The accident site consists of hilly wooded terrain. The aircraft impacted in the forest with a dive angle of approximately 40 degrees and a slight bank to the left. Heading at the time of impact was about 150 degrees. The aircraft initially collided with the tops of a few pine trees prior to it's impact on a minor mountain plateau situated about 20 meters from the initial tree collision. From the mountain plateau it resumed it's airborne condition and continued to a lower plateau with rocks and low vegetation, where it, in inverted attitude, collided with a large boulder, tipped-over into a right-side-up attitude and finally came to a stop about 80 meters after the initial impact with the ground.



The flight path of the aircraft and the accident site

1.12.2 *Aircraft wreckage*

In connection with the tree collision and the ground impact on the upper mountain plateau; among other things, part of the left wing and portions of the nose section of the aircraft were torn off. Thereafter parts of the aircraft were spread along a more than 100 meter long accident lane. The bulk of the aircraft lay at the end of this lane collected within a circle with a radius of 15 meters. The final attitude of the aircraft was right-side-up with the nose in a general northerly direction. It was substantially demolished. The cabin was crushed and both wings had separated from the fuselage. The left-hand engine had been torn off the wing. The damage to the aircraft and to the impact area give the impression that subsequent to the collision with the trees and the initial ground contact the aircraft became airborne, yawed to the left and thereafter made a half-roll to the right before it impacted on the lower plateau.

1.13 Medical information

Through medical journals from a company medical clinic reception in Gothenburg in December of 1992, it is apparent that the pilot had a substantial heart murmur, a sign of turbulence in the blood flow in the heart. This had also existed the previous year. An X-ray of the heart and lungs showed a slight heart enlargement and that some growth had taken place since the year before. He was therefore referred to Mölndal Hospital for ultrasound examination. The result revealed an outflow obstruction in the left ventricle as is evident in a so-called hypertrophic cardiomyopathy. This condition constitutes a change and a thickening of the heartwall muscles, which results in the muscle walls becoming rigid and the heart not being able to be filled in a normal way. During contraction this thickening can also restrain the outflow and affect adjacent valves so that their function is impaired. Many who have this affection are free of symptoms but they are recommended not to subject themselves to heavy physical exertion. They can be subjected to sudden rhythmic alterations that either severely impair physical ability or to a direct cardiac arrest with unconsciousness within a few seconds. According to relatives of the pilot he had, on one occasion a few years ago, suffered constant heart palpitations during a 30 minutes period.

In 1994 the pilot contracted a mild form of diabetes mellitus and stopped flying on his own accord. He resumed his flying in 1995 after having learned that LFV, could, under certain circumstances, approve a private pilot's license for persons with this condition. According to LFV no information has been received by them concerning the pilot's medical condition and no dispensation has been granted by them.

Initially the pilot's diabetes required diet and exercise treatments but during 1997 he was in addition prescribed the blood sugar lowering medication, Euglucon. The physician who was treating his diabetes was aware of the pilot's heart condition and examined the heart by EKG yearly. He was however not aware that the pilot had a license.

The aviation medical examinations were conducted by another physician. This physician was aware of the pilot's diabetes and of the heart murmur. In the journals that SHK has been given access to from November of 1997 it is noted that the diabetes was only treated through diet, despite the fact that the pilot was prescribed Euglocon. In the medical examination protocol that was sent to LFV there is nothing stated about the diabetes. The substantial heart murmur is noted in the journal, but not in the protocol to LFV and the physician writes that it is examined and should be considered as totally physiological, i.e. normal. In his journal he has written that the divergent EKG was also considered normal. The latest protocol that exists at LFV is dated the 14th of October 1999 and even here nothing abnormal was reported.

The pilot had a defect in his color vision that meant it was difficult to distinguish red and green from each other or from white. With a lesser degree of this defect, weak or distant light sources are prerequisite for the confusion to arise. LFV issued a limitation to the pilot's certificate meaning that flying was not to take place during the hours of darkness.

Whether the pilot ate breakfast on the morning of the 9th of December is not known and neither if he took his Euglucon pill. An employee of the company in Sundsvall gave the group a bag of sweet-rolls to take with them on the trip and the intention was to purchase something drinkable on the way out. If the pilot had time to consume any of this is unknown. The forensic medical examinations of the persons aboard showed that only one passenger had any contents in the stomach or duodenum. The examination did not show the influence of alcohol or drugs in any of the persons.

There is a risk for a person with diabetes to develop far too low blood sugar which creates a hollow feeling in the stomach, trembling, headache and mental slowness in the worst case causing coma, if medication and diet are not attended to. Physical or mental stress together with low blood sugar; can, with the type of heart disease that the pilot had, have very well triggered a rhythmic alteration, for example auricular fibrillation, which further impairs a person's possibility to deal with a trying situation.

1.14 Fire

There was no fire.

1.15 Survival aspects

The forces of the impact were great and the cabin was totally demolished. The forensic examination of the persons aboard shows that all died instantly upon impact.

The emergency transmitter of type ACK E-01 was activated by the accident and was turned-off by the police.

1.16 Tests and research

1.16.1 The aircraft

A primary technical investigation of the aircraft was conducted at the accident site. At this time it was established that the aircraft was whole prior to the first collision with the trees. With the exception of a 1-2 mm thick and 10-20 mm wide ice strand on the leading edge of the wings, stabiliser and vertical fin, the aircraft was free of ice and frost.

The aircraft wreckage was salvaged from the accident site and transported to an unheated storage room at Sundsvall/Härnösand airport for technical investigation. The aircraft was severely demolished and broken-up by the accident and therefore a complete investigation has not been possible to accomplish.

The following inspections and notations were done:

- Damage to the landing gear, the landing gear mechanism, and landing gear doors showed that the gear was retracted at the time of the first ground contact. I connection with the subsequent airborne rotation, the right main gear was thrown out and locked in the extended position.
- Damage to the wing- flap mechanism showed that the flaps were retracted.
- The jackscrews to the rudder trim tab were in approximately neutral position.
- The fuel tank selectors were in the position for left and right inner tank.
- The crossfeed lever was in position "OFF".
- The aircraft's stall warning sensor (Lift detector) functioned.
- Pneumatic pumps with accompanying regulation systems, with the task of, among other things, providing the flight instruments with air pressure, were inspected and partially tested for function at an aviation work shop and were judged to have functioned normally at the time of the accident.

1.16.2 Engines

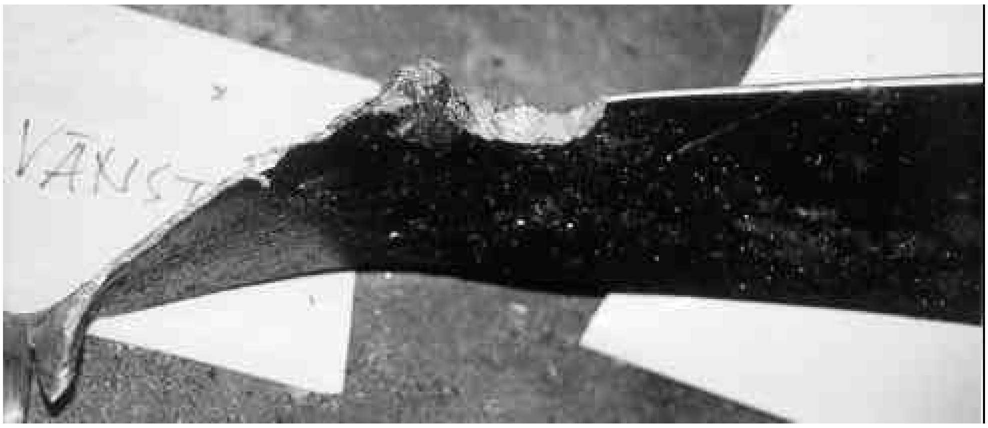
Both the aircraft engines were dismantled and inspected at an aircraft engine workshop. Where it has been possible, functional testing of affected parts has been carried out. Nothing has been revealed that would indicate that a technical failure occurred that could have prevented normal engine function on either of the engines.

1.16.3 *Propellers*

One propeller blade had separated from the left engine's propeller. All the blades were deformed and several severe impact damage zones occurred on the leading edges of the propeller.

The right-hand engine's propeller had separated from the engine. All the blades were deformed and several severe impact damage zones occurred on the leading edges of the propeller.

The propeller hubs, with adjustable pitch for the propeller blades, have been inspected at an aircraft engine workshop. Apart from the damage that has originated in connection with the accident nothing abnormal was noted. Within a tolerance of 5 mm, the propeller hub's adjusting pistons had jammed in the same position, corresponding to a propeller pitch angle of about 21°. A pitch angle of 21° corresponds to normal propeller setting for climbing or cruise flight.



Propeller blade (leading edge) from the left propeller

1.16.4 *Static and dynamic systems*

The aircraft's static and dynamic systems were partially broken but have been inspected in detail. The inspection was carried out while the temperature of the aircraft was still under the freezing point. No blockage was found in the parts that were examined and the systems were free of ice and water. One of the two pitot tubes, which are placed on the nose section of the aircraft and measure the static and dynamic pressure, was crushed but it's heating element functioned normally. The other pitot tube was destroyed and could not be functionally tested.

1.16.5 *Flight and navigation instruments*

The aircraft's instrument panel with flight and navigation instruments was heavily damaged upon impact. Many instruments were completely destroyed and some have not been found. Where it's has been possible the settings and indications of the instruments have been documented. Certain settings and indications can however have changed in conjunction with the accident and must be considered as unreliable.

The instruments that were located, and who's function was considered to have possibly been of consequence in the sequence of events, have been inspected at an instrument workshop. The following observations were made.

HSI (electrically driven)

- "flagged" as functional upon impact.
- The course scale was jammed at an indicated course of 140 degrees.
- Both the HEADING BUG and the COURSE POINTER were jammed in the position of approximately 340 degrees.
- The course transmitter KMT 112 (so-called FLUX transmitter) that gives magnetic course signals to the HSI was intact and functioned normally.
- The slaving unit KA51 that drives the HSI was in the position for "slaving" (normal).

ACU

- Filament analysis shows that the indicator lights behind the "NAV"
- (white) and the "AUTO" (green) panels were illuminated at impact. Other lights were extinguished. This corresponds to NAV mode being selected and that the aircraft should automatically fly to the next way-point. NAV mode can have been selected manually by depressing the button or automatically because of selected ILS frequency on NAV-1.

Radio coupler

- The selector knob was in position HDG.

Radio/Nav 1

- Frequency setting: COM 135.02 MHz. With regard to the VOR no whole digits could be read. The decimal digits were between 30 and 35. An analysis of the instrument's internal damage indicates that an ILS frequency was selected. The ILS frequencies were; for runway 34, 110.30 MHz and for runway 16, 108.70 MHz.

Radio/Nav 2

- Frequency setting: COM 118.10 MHz/VOR 113.95MHz
  VOR frequency Sundsvall 113.10 MHz.

Transponder I

- Display: SBY 65(7)1.

Transponder II

- Display: ON 6377 (=Assigned code from Sundsvall tower).

GPS

The GPS instrument was heavily damaged; the control display and the NavData card was missing. It's backup battery was intact and read 3.08 V. The instrument was sent to the German Dept. of Aircraft Accident Investigation (BFU) for analysis. The investigation showed that the GPS was functioning and registered positions at the time of the accident. The following data fragments could be read from it's hard memory:

- Last position N62°33.127´ E017°18.884´.
- Last altitude 724 feet.
- Bearing 112° and distance 3.98 NM (approximately 8 km) to Sundsvall/Härnösand airport.
- The co-ordinates for 33 way-points were programmed. Most of these were in the vicinity of Gothenburg/Säve airport, Gothenburg/Landvetter airport and Stockholm/Bromma airport. No way-point that can be derived from the latest flights could be identified.

Directional gyro on the right pilot position (air driven)
- The course scale was jammed at an indicated course of approximately 140 degrees.

Magnetic compass
- The instrument functioned without remarks.

Airspeed indicator on the right pilot position
- The instrument was undamaged. The pointer indicated 0 mph.

Altimeter (unknown position)
- The instrument was damaged. QNH showed 989 hPa (given setting from Sundsvall tower = 986 hPa).

Gyro horizon on the right pilot position (electrically driven)
- The instrument was damaged but was judged to have functioned normally.

Airspeed indicator, left pilot position
- The instrument was damaged. The pointer was jammed at an indication of 185 mph.

Autopilot
- The autopilot's control panel was heavily damaged and it has not been possible to determine it's status at the time of the accident with certainty.

1.16.6 Test flight

A test flight has been carried out with an aircraft fitted with the same type of navigational equipment as the aircraft involved in the accident to ascertain if an ILS signal from the airport can have been sufficiently strong to be able to send relevant information to the aircraft's NAV equipment. The test showed that such reception is not probable at the distance to the airport that the aircraft had on it's northwesterly course after take off.

1.16.7 Technical documentation

The aircraft was maintained according to applicable regulations. The latest 100 hour major inspection was signed the 9th of January 1999. The latest maintenance report (UR-B) was signed by LFI the 2nd of December 1999 in connection with the installation of a newly overhauled left engine. After this action the aircraft was flown 4 hours prior to the accident. In the technical documentation of the aircraft there is no remark or notation that is entered concerning the condition of the aircraft that could have had significance in the sequence of events.

1.17 Organisational and management information

The pilot was part-owner in the trading company Twin Air that was the owner of a twin-engine aircraft of type Piper PA-31 (the aircraft in the accident). The aircraft was used by the owners for, among other things, business trips, but was also rented-out.

1.18 Additional information

1.18.1 The pilot's relationship to the company in Gothenburg

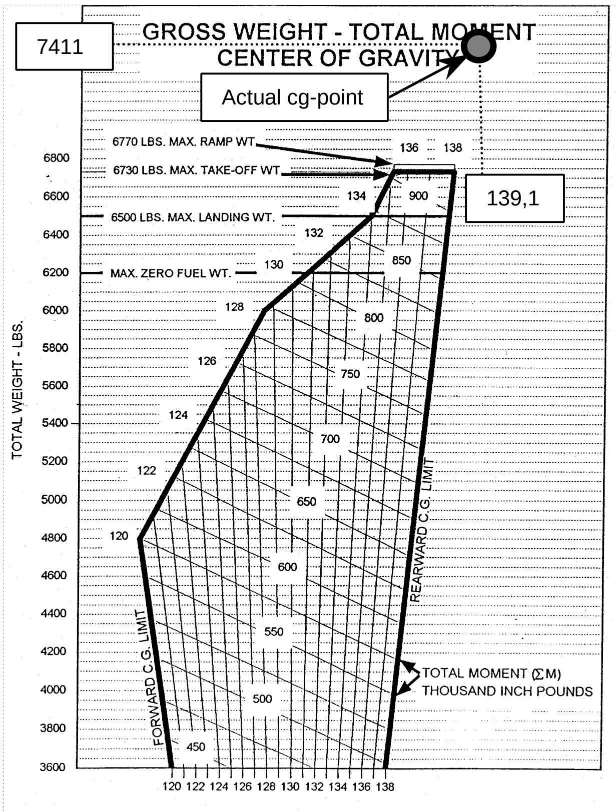
During the past few years the pilot was engaged as a consultant for the company in Gothenburg. His assignment consisted of directing larger projects and to assist in the purchasing process at the company's subcontractors. In some cases during these assignments he utilized the aircraft in connection with business trips on the company's behalf. Company employees had on several occasions traveled with him as passengers during trips to distributors in other locations. The purpose of the trip in question was to make a quarterly visit to a subcontractor in Sundsvall.

1.18.2 Weight and balance calculations

The weight and balance status of the aircraft at the time of the accident has been calculated according to appendix 3. The calculation is based on the basic empty weight of the aircraft, calculated fuel weight and estimated weights of the persons aboard. The baggage has been weighed and that weight divided equally between the aircraft's forward and aft baggage compartments. The calculation shows that the airborne weight was 7 411 lbs. (3 364 kg) and that the center of gravity point was at 139.1 inches.

Maximum allowed airborne weight for the aircraft type is 6 730 lbs. (3 053 kg) and the aft center of gravity limit is 138.0 inches.

Actual weight and center of gravity have been drawn onto the weight and balance diagram shown below.

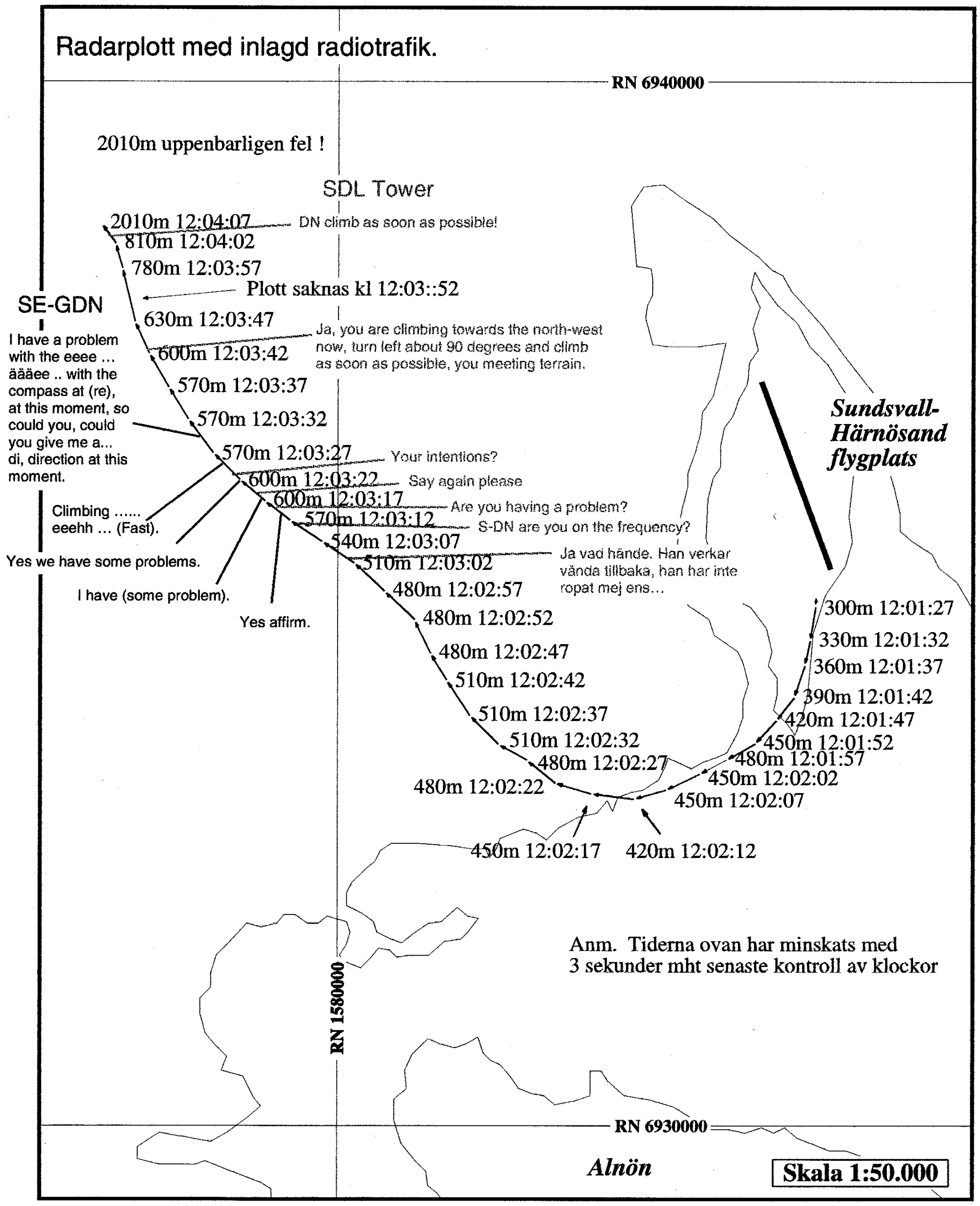


Weight- and- balance diagram

1.18.3 *Radar plot of the flight path*

Aided by information from MUST and the airport's radar system IOR, it has been possible to reconstruct the flight path and altitude of the aircraft from the time the aircraft, after take off, reached a height of 300 meters. The aircraft's altitude reporting transponder reply, with an accuracy of +/-50 feet (+/-15m), has been used as height information; without correction for atmospheric pressure deviation from so-called standard atmosphere (QNH 1013 hPa). The altitude shall in this case be reduced by 216 meters.

The flight path with time references for each radar echo has been plotted below. Radio communication between the pilot ("SE-GDN") and the air traffic controller ("Tower") has also been inserted at the actual time these occurred during the flight.

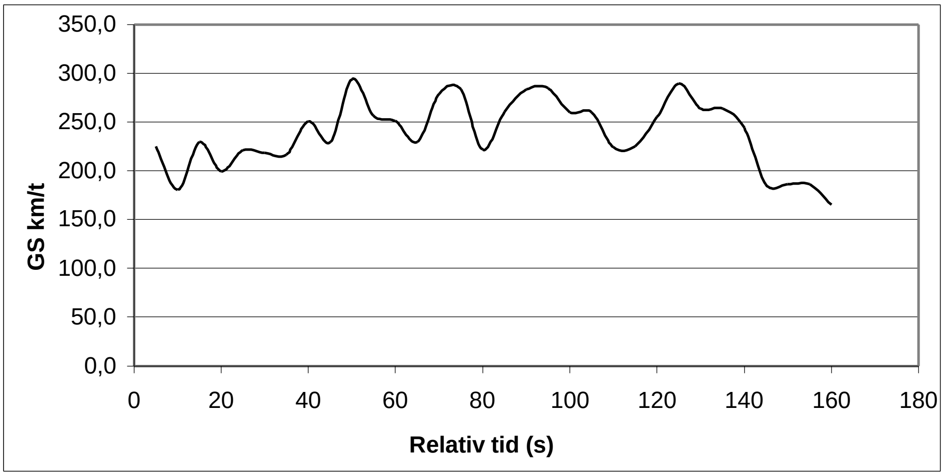


Radar plot with radio communication

1.18.4 Analysis of the radar plot

The aircraft lacked equipment for the registration of flight data. SHK has therefore attempted to get a clearer picture of the flight by performing certain calculations about the relationship between registered radar information from MUST and from IOR. During an analysis of the result however, one must be aware that the accuracy of each radar echo point is limited. The result of the calculations is shown below in the form of a diagram with the relative time from the first radar echo as the horizontal axis and the calculated variable as the vertical axis.

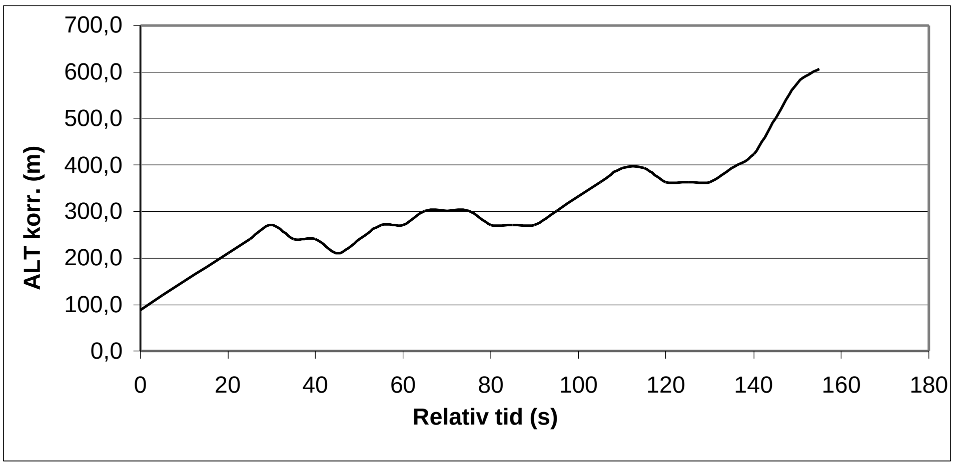
A. Calculation of GS



Calculated ground speed

B. Flight altitude above sea level

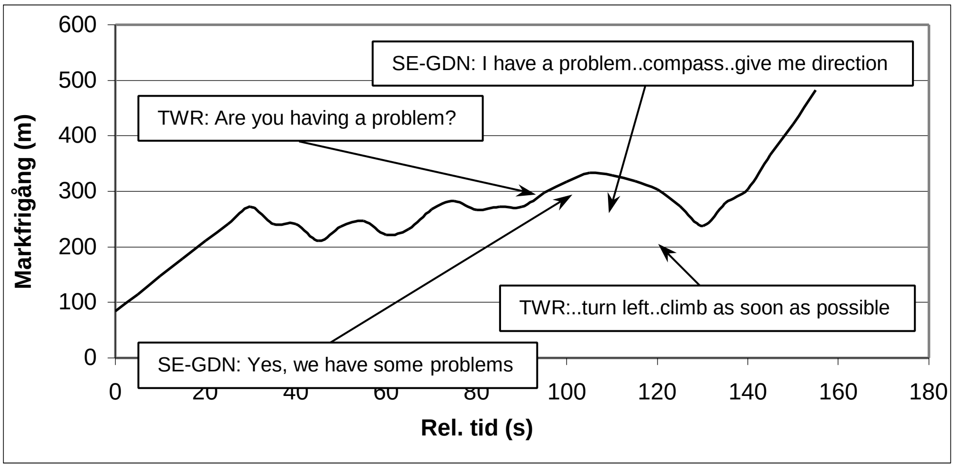
The transponder reported altitude has been corrected with reference to the actual atmospheric pressure (QNH 986 hPa).



Corrected flight altitude

C. Terrain clearance

Below, the difference between the corrected flight altitude and the height of the terrain under the flight path, the terrain clearance, is calculated and plotted. Also, at the actual times during the flight, selected radio communication between the pilot ("SE-GDN") and the air traffic controller ("TWR") has been included.

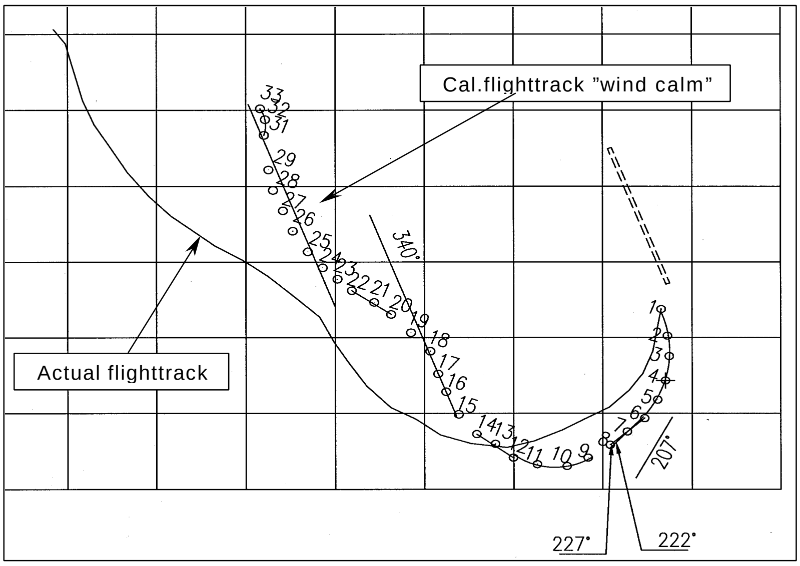


Calculated terrain clearance

D. Calculation of turning radius

The radar plot depicts the aircraft's flight path over the ground but not always how it was flown because of the effect of wind. Based on the estimated winds at different altitudes SHK has attempted to calculate how the aircraft was flown and it's actual heading at each radar echo point. The result of these calculations can be seen as the flight path that the aircraft should have depicted if the winds had been totally calm (revised flight path). Winds that have been used in the calculations are estimations and the result must therefore be regarded with some caution.

The revised flight path according to the chart below indicates that, among other things, the heading of 207 degrees towards MEGEN was passed about half a minute after the first radar echo, that the last of the right turn took place with a turning speed of about 3 degrees per second and that the approximate heading after the right turn was 340 degrees.



Calculated flight track

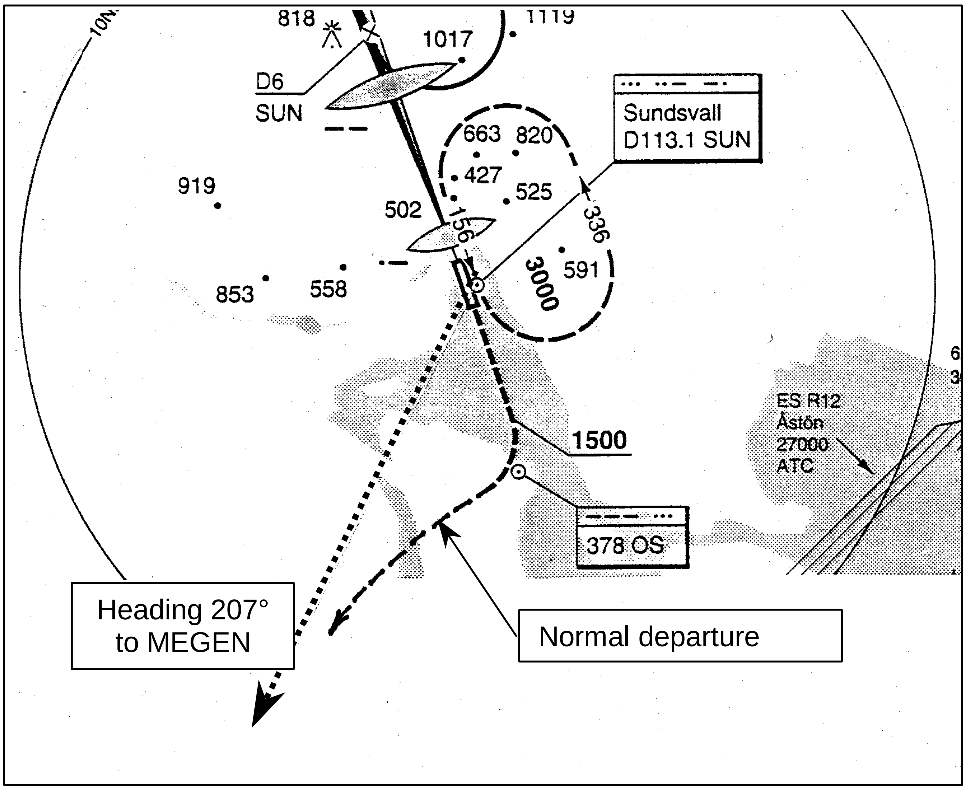
1.18.5 Navigational routines

The aircraft was equipped with two independent navigation systems, GPS and NAV. Normally both systems are pre-programmed prior to an instrument flight. Prior to flight using GPS navigation, all the waypoints for the entire flight can be pre-programmed. Concerning NAV navigation, nearby navigational beacons must be selected constantly along the route of flight. The navigational beacons must be identified by listening to their call signs in Morse code.

If an aircraft is equipped with two NAV systems it is customary prior to an IFR departure that one selects the ILS frequency of the departure airport on one system as a preparation for the eventual need to return and land immediately after take off, and the other system on the nearest VOR beacon that one intends to fly towards.

Other than programming the navigational equipment; prior to an IFR departure, procedures shall be planned taking into account, among other things, safe altitudes for terrain clearance. Furthermore procedures for rejected take off, steps in case of engine failure after take off and other possible emergency situations shall be reviewed.

During a normal IFR take off from runway 16 at Sundsvall/Härnösand airport, with clearance to turn right after take off, the aircraft should have climbed straight ahead on a heading of 158 degrees and initiated the right turn when it had reached the so-called Circling Altitude (1 120 feet/341 meters) abeam the outer marker OS.



Normal departure route

According to the evidence that SHK has acquired, the pilot usually after liftoff during an IFR departure, climbed to so-called Minimum Sector Altitude (for Sundsvall 2 800 feet/853 meters) or a minimum of 1 000 feet (305 meters) and during the climb would retract the landing gear and set the engine control levers prior to undertaking any turns. After take off he usually engaged the autopilot and navigated with the GPS engaged.

1.18.6 Distinctions between commercial and private aviation

Great demands are imposed upon airlines that pursue commercial aviation. All such activity is strictly regulated through regulations and routines. These encompass everything from technical maintenance systems to operational procedures. Special authorization, Commercial Pilot's License, is required for pilots who perform commercial flying. LFV performs regular controls of the operations in commercial aviation.

High demands are placed upon the flying personnel with respect to training and further education. Training often takes place in a flight simulator where the possibility exists to practice realistic exercises in different types of emergency situations. Periodical flight training, so-called PFT, takes place two times per year. IFR flying normally takes place with a two-pilot system, where the tasks are divided between the pilots and where the possibility exists for the pilots to support and monitor each other. Crew duty times are strictly regulated, among other things, with regard to flying time and number of flights. Included in the duty time regulations is time for both planning, the actual flying and those measures that need to be taken after the flight, plus directives on the length of the rest period required before the next flight may take place. Depending on age, commercial pilots undergo medical examinations one or two times per year. Many airlines have appointed aviation physicians that are affiliated with the company. These are very familiar with the medical status of the flying personnel.

The above system shall assure that all aviation that is carried out by approved airlines takes place with requisite flight safety.

For private flying the responsibility for flight safety, to a large extent, is transferred to the individual private pilot. In addition to prescribing certain minimum demands on private pilots regarding flying time per year and number of performed landings to be able to take passengers along, plus performing a PFT each year; it is up to the private pilot's own responsibility to maintain his operational and technical competence. The operational responsibility for planning, carrying out and terminating each flight rests solely with the pilot himself. A private pilot with an instrument rating can in many cases have formal authority to fly under the same operational conditions as within commercial aviation.

In the report (SOU 1999:42) New Aeronautical Laws of The Rights of the Air Investigation (Sweden), a certain intensification is recommended of the supervision concerning so-called corporate aviation, i.e. flying with aircraft that are owned by companies with other principle activities than flying.

1.18.7 Viewpoints concerning the search and rescue services

In connection with the rescue task, search and rescue dogs were requisitioned to the accident site at 13:52 hrs. in order to locate one passenger that at first could not be found. The said passenger was found a little later and the canine engagement was never required.

In connection with the scene investigation the day after the accident these dogs were indeed used and at that time found, among other things, remains of those onboard and their private belongings under the blanket of snow. After this occurrence it has been questioned as to why the search and rescue dogs were not requisitioned to the scene on the day of the accident, taking into consideration the size of the accident scene and the difficult weather situation that existed.

2 ANALYSIS

2.1 Conditions

2.1.1 The flight to Sundsvall

The flight to Sundsvall via Östersund appears to have taken place without problems. As it was an IFR flight and runway 34 was in use at Sundsvall, one can assume that the pilot, as preparation for an instrument landing there, selected the ILS frequency 110.30 MHz on Nav 1 and a course of 337 degrees on the COURSE POINTER in the HSI. It is also likely that that he set the HEADING BUG in the HSI to the same course during the latter portion of the approach to be able to use the autopilot in HDG mode for help in intercepting the ILS beam for landing.

When the aircraft approached Sundsvall for landing the weather was good and the pilot was cleared for a visual straight-in approach to runway 34. Therefore the pre-planned ILS procedure was never used.

After the accident both the COURSE POINTER and the HEADING BUG were jammed on a heading of 340 degrees and Nav 1 was very likely set on an ILS frequency with a decimal value of 30-35 MHz, that is to say very close to the ILS frequency for runway 34 – 110.30 MHz. This supports the hypothesis that the pilot forgot to re-set these prior to take off the next day when runway 16 was in use (ILS frequency 108.70 MHz). It cannot with certainty be ruled out that he made these changes directly prior to or during the accident flight but it is hard to understand what, in that case, would have motivated this.

2.1.2 The ground stop in Sundsvall

Representatives from the subcontractor that the persons onboard were to meet and eat lunch with were waiting in Sundsvall. Before leaving the airport the pilot had to park the aircraft for the night and among other things, install wing covers and put heating elements in the aircraft. The aircraft was not re-fueled, something that is recommended during all outdoor parking in cold weather to avoid condensation in the fuel tanks, which can be interpreted to mean that the pilot was anxious not to make the others in the party wait for him any longer than necessary. Any time for preparation for the next day's flight didn't probably exist.

One can assume that the pilot as consulting project manager thereafter had a demanding afternoon and that he was tired, when after a long day and the joint dinner, arrived at his hotel room just prior to 24:00 hrs.

2.1.3 *Preparations prior to take off*

On the day of the accident the weather was bad in Sundsvall with snowfall and high gusty winds. The party was picked-up at the hotel around 8 o'clock which means that the pilot should have got at least six hours of sleep and had time to eat breakfast. The pilot did not have authorization to fly during darkness, which means that they were forced to take off from Sundsvall before 13:00 hrs. in order to land in Gothenburg prior to nightfall. The fact that the pilot, in spite of the bad weather in Sundsvall, did not plan a visit with the meteorologist at the airport but only procured weather information by fax to the company, and in addition to this he did not have time to eat lunch, can only be interpreted to mean that the working schedule that morning was strained.

The pilot had filed a flight plan earlier by telephone with a planned departure time of 11:30 hrs. After having waited for a taxi they first arrived at the airport at 11:15 hrs. It fell to the pilot's lot to prepare the aircraft for the flight himself while his passengers waited in the terminal building. In the prevailing circumstances, with strong winds and heavy snowfall, it probably was both wet and very physically strenuous to remove and stow the wing covers and the heaters. All of the preparation work including full re-fueling of four wing tanks took less than 25 minutes, which makes it doubtful that there was time to carry out a complete daily inspection of the aircraft. It is not likely that there was any time remaining for planning of the flight itself and pre-setting of the instruments.

It is therefore very doubtful whether the pilot had time to make a correct operational flight plan, including weight and balance calculations. If that were the case he should have discovered that the weight would be more than 300 kg over the maximum allowed flying weight and that the center of gravity would end up close to or behind the aft center of gravity limit. This implies that he either neglected to perform a weight and balance calculation or that he consciously disregarded the deviation. Prior to the departure the aircraft was only next to the terminal building at position 13 a few minutes. Any possible magnetic disturbance at that position has therefore been judged as not being capable of influencing the aircraft navigation equipment.

2.2 The flight

2.2.1 *The take off*

At 11:49.24 hrs. when the pilot contacted the air traffic controller and requested clearance to start the engines for taxiing to the take off position, he had managed to taxi from the parking position to the terminal building, shut-down the engines, fetch and board seven passengers into the cabin and load their baggage into the baggage hold of the aircraft in only seven minutes time. Even this phase must have taken place in a forced manner and without time for planning of the flight.

The weather at the airport was very troublesome with strong gusty crosswind, snowfall with poor horizontal visibility and a vertical visibility of 300 feet. The pilots of the SAS aircraft that departed just prior to SE-GDN also experienced the weather as difficult. Even if the pilot of SE-GDN didn't admit this, he must have been aware that the prerequisites for the flight were not good even if the weather conditions in Gothenburg were acceptable. This can have signified yet another moment of stress for him.

The layer of snow that accumulated on the aircraft before take off can also have been a disturbing element for him. Judging by appearances, since this snow was dry, most of it blew off during take off and owing to that only affected the plane's take off performance marginally. Nor was any large amount of snow or ice found on the aircraft at the accident scene.

Shortly after the aircraft had lifted off from the runway the pilot probable lost his external references in the heavy snowfall. As is evident from the radar plot the aircraft initiated a shallow right turn even before it had passed the far threshold of the runway. According to his own routine the pilot should have allowed the aircraft to climb straight ahead to a minimum altitude of 1 000 feet and first then turned right to a heading of 207 degrees towards MEGEN. Why this did not take place is unknown. Both of the aircraft's gyrocompasses have probably functioned normally during the take off on the runway. After the accident their course indicators were jammed at 125 and 140 degrees respectively. This coincides well with the aircraft's estimated direction of impact. This in turn seems to indicate that they functioned during the whole flight. In the event of doubtfulness about the heading the pilot should have been able to use the aircraft's magnetic emergency compass which was working.

The explanation for the climb not taking place straight ahead is probably that during take off in the gusty crosswind, the pilot was so concentrated on manoeuvring the aircraft in IMC and simultaneously retracting the landing gear and setting the engine control levers that he did not have capacity left to control the heading. The early initiation to the right turn was therefore very likely initially a pure drift that he did not notice, as a consequence of the crosswind from the left.

From the evidence that SHK has acquired concerning the pilot's routines during IFR flying it is apparent that he had as a routine during climb after take off, to engage the aircraft's autiopilot and navigate with GPS. If this method was also used during the accident flight, the planned route of flight to Gothenburg should have been pre-programmed in the GPS receiver and GPS navigation should have been selected on the ACU. The GPS instrument was severely damaged during the accident and it has not been possible to verify if this route of flight was programmed. It has however been established that the GPS instrument was functional and registering position at the time of the accident. Upon impact the two lights NAV and AUTO were illuminated on the ACU. The fact that the AUTO light was illuminated indicates that an active choice was made by the pilot and probably that the intention was to navigate with GPS after take off. Practically speaking this is also the most simple method for a single pilot to plan and monitor the navigation.

It is reasonable to assume that the pilot engaged the autopilot during climb approximately when the aircraft had turned to the planned heading towards MEGEN, i.e. approximately 30 seconds after the first radar echo. The aircraft was then in a stable climb and the flight altitude was about 270 meters.

2.2.2 *The deviation from the cleared route of flight*

Up to this point it seems the pilot, despite stress and difficult weather conditions, generally has had control over the flight. But - as is evident from the radar plot and flight path calculations in 1.18 – something occurred, approximately 35 seconds after the first radar echo, that thereafter made the flight deviate from the normal in two respects. On one hand the right turn continued well past the heading to MEGEN, and on the other hand suddenly the climb transitioned to an altitude loss. Thereafter the aircraft climbed at a diminished rate and by stages.

The investigation has not been able to point to any particular explanation for this. When the air traffic controller, 105 seconds after the first radar echo, asked the pilot if he was experiencing problems the pilot answered that that was the case. He seemed disoriented and answered incoherently. Afterwards he stated that he had problems with the compass. Thereafter he left no further guidance about what the problem consisted of.

As is evident from 1.13, the pilot had more than one medical deficiency. One explanation could therefore be that he, at this time was inflicted by a serious medical problem that dramatically impaired his possibilities to control the flight. This is discussed in greater detail in 2.2.5.

In flying activities it is normally not a problem for a pilot to use the English language with standard phraseology, even if English is not the pilot's mother tongue. Difficulties can however arise in communication extrinsic to standard phraseology. This can have constituted an additional stress factor for the pilot and explain his difficulties of being informative about the problem.

As stated earlier there is nothing in the investigation that would indicate that there was any failure of the aircraft heading gyros, compass or any of the aircraft's systems. What is probable instead is that the pilot, during this phase of the flight, began to loose control. When the flight instruments showed values that did not coincide with what he expected, he did not have the capacity to analyze the situation in a logical manner, but drew the conclusion that the instruments were erroneous. This is a classical mistake that many less experienced pilots are subjected to during flight without outside visual references.

In all probability it was at the time of autopilot engagement, approximately 30 seconds after the first radar echo, that the problems began to accumulate for the pilot. After the accident it was established that the knob on the radio coupler was in position HDG and not in position NAV where it should have been during this phase of the flight. Certainly it cannot be ruled out that the knob can have changed position in conjunction with the accident or that the pilot himself changed the position of the knob with the intention of coping with his disorientation during the later phase of the flight. However, apart from the fact that the knob was relatively undamaged, several factors indicate that the autopilot was engaged at about this time and then steered according to signals from the HEADING BUG in the HSI instead of those from the GPS, which the pilot had expected.

- The right turn continued with a constant rate of turn of approximately 3 degrees/s, which coincides well with what would have been the case if the autopilot was engaged.
- The turn continued until the aircraft reached the approximate heading of 340 degrees, i.e. the heading that the HEADING BUG was on after the accident.
- Heading 340 (or 337 degrees) was probably the position of the HEADING BUG that the pilot selected prior to the landing on the day before.

It is difficult to find any other reasonable explanation for the prolonged right turn other than that the pilot engaged the autopilot, convinced that it was coupled to the GPS system but during the very strained planning of the flight forgot to switch over the Radio coupler from the HDG position to the NAV position. By not doing that, the autopilot was lead to strive after turning the aircraft to a heading of 340 degrees instead of the heading of approximately 207 degrees in the direction towards MEGEN.

The investigation of the instrument points to the fact that an ILS frequency was selected on Nav 1, which would have meant that the ACU would have automatically been coupled to the NAV system, irrespective of what the pilot had selected. The indicator light for "NAV" on the ACU panel was illuminated upon impact, which indicates that such was the case. This means that even if the knob on the Radio coupler had been set to the NAV position the autopilot would not have steered the aircraft towards the expected heading but either towards the ILS signal for runway 34 or, if the ILS signal from the airport was too weak, towards some other indeterminate heading.

One can ask oneself why the pilot did not observe a possible mistake of the type mentioned above. A single pilot has a heavy workload immediately after take off during flight in IMC. This is particularly valid if the time to prepare for the flight has been short, as in this case. Adjustment and synchronization of engines and propellers can require attentiveness. The sound of unsynchronized engines that a witness on the ground heard from the aircraft shows that it took a few seconds for the pilot to adjust them so that they were synchronized. This can also have been a contributing factor to his not discovering the erroneous setting of the autopilot and to the continuation of the right turn.

2.2.3 *Unstable climb*

As is evident from 1.18.4 the stable climb transitioned to an altitude loss approximately 35 seconds after the first radar echo. Thereafter the aircraft climbed at a diminished rate and by stages. It can also be understood from the diagrams that speed control from this point on was obviously unstable.

No technical failure has been found that can account for this. Both witness statements concerning engine sound and the technical investigations show that both engines produced normal power during the entire flight. The average rate of climb of approximately 600 feet/min from the first radar echo can be considered as reasonable taking into consideration the heavy airborne weight of the aircraft.

Contributory to the pilot's difficulty in trimming the aircraft to establish a stable climb with correct airspeed can have been the aircraft's overweight condition in combination with the fact that the center of gravity was close to or behind the aft center of gravity limit. This problem can therefore be seen as an additional factor of disturbance for him.

It is difficult to say in what order the difficulties arose, but they have certainly combined and worsened the situation for the pilot which made it all the more difficult for him to analyze the situation.

2.2.4 *The final phase*

In 1.18.4 the aircraft's calculated terrain clearance over the rising terrain during the flight and portions of the communication between the pilot and the air traffic controller is depicted. From the diagram it is evident that the altitude above the ground was barely 240 meters 130 seconds after the first radar echo. According the SHK's meteorological experts it is entirely possible that the pilot can, at that time, temporarily have seen the ground through the snowfall or seen the underlying vegetation as a darker area under the aircraft. Approximately at the same time the traffic controller instructed him to turn to the left and warned that the aircraft was flying towards rising terrain.

Confronted with the threat of hitting the ground, everything indicates that the pilot instinctively and perhaps in a state of panic pulled the control column back in order to climb. It can be understood by the diagrams in 1.18.4 that from this point in time the aircraft climbed steeply as the airspeed simultaneously decreased. At the time of the last registered radar echo the corrected altitude was approximately 600 meters and the speed had dropped to approximately 185 km/h. The aircraft's high speed and steep trajectory at the time of impact at the accident site indicates that a few seconds after the last radar echo, it was over-accelerated around the pitch axis, resulting in a stall and then dived towards the ground on a reciprocal trajectory from the earlier. As the radar replies cease from this point, the sequence of events must have been rapid and very likely surprised the pilot. Thereafter he did not succeed in regaining control of the aircraft before it collided with the ground. That the aircraft was overweight and tail-heavy can have been contributory to the rapid stall development.

2.2.5 Medical aspects

The pilot obviously perceived his heart disease to be benign in that no treatment or measures were initiated. The step to go from solely diet and exercise treatment of the diabetes to the addition of blood sugar lowering treatment was probably also not perceived by him as decisive from an aviation/medical point of view, as he did not inform the physician who issued the medical certificate for the pilot's license about this. The physician should however have reacted to the divergent EKG and ordered copies of the examination results to convince himself that the hearts murmur was benign. He should also have penetrated the blood sugar situation better, investigated laboratory results and above all written about his findings in the protocol to LFV. LFV's medical examiner has, owing to this omission, not had reason to question the pilot's continued possession of license in spite of the fact that the pilot for all practical purposes had two medical conditions, each of which was disqualifying for a private pilot's license.

As mentioned in 1.13 there is always a risk for a person with medicinally treated diabetes to develop far too low blood sugar. This implies a risk of trembling, headache and mental slowness and in the worst case unconsciousness if medication and diet are not attended to. Furthermore, physical or mental stress together with low blood sugar can, with the type of heart disease that the pilot had, very well have triggered a rhythmic alteration, for example auricular fibrillation, which impaired his possibility to deal with a trying situation.

The medical status of the pilot can consequently have had an influence on the sequence of events to a greater or lesser degree. If the pilot began to be affected by sub-normal blood sugar and/or heart rhythm alteration in connection with a heavy workload, it can have impaired his capacity for simultaneous tasks. This could mean that it became difficult for him to monitor the flight and identifying the fault, which contributed to his mistrusting of the instruments. In connection with this, the stress probably increased further which could have been contributory to his over-correction in the manoeuvring of the aircraft towards the end of the flight.

2.3 The flight concept

2.3.1 The pilot

In an aircraft fitted with modern equipment is essentially possible for a single pilot to carryout qualified IFR flights during IMC with good regularity and a good margin of safety. This assumes however that the pilot is well educated and trained for the task and has the possibility to do the required preparations for each flight.

Deviation from this means that the pilot's possibilities to analyze possible deviations or disturbances during the flight diminish. A perhaps insignificant problem can drastically increase the workload on the pilot with the risk that he makes a mistake, which can aggravate the problem.

Thereafter it is easy to make further mistakes until the pilot looses control over the situation.

Therefore especially great demands are placed upon pilots during these types of flights; he should be thoroughly rested and well prepared before each flight but above all he should be aware of his own capacity and his limits and adapt his flight thereafter. In those instances where desires or demands exist concerning punctuality, it can in many cases be difficult for a pilot to cancel or discontinue a flight with the inconveniences that this might entail. The risk that a pilot in such a situation will force himself to fly a too tough flight is obvious.

The flight in question can be considered to be a tragic case in point of just such a situation. The pilot worked as a consultant for the company where his passengers were employed. In that role he had offered his services to arrange transportation for the group to Sundsvall for a two-day meeting together with a subcontractor. His ambition was in all probability to offer an inexpensive alternate means of transportation for his customer.

The pilot therewith took upon himself the demanding task of both participating as an active member in the business meeting itself and of being solely responsible for all the necessary preparations that were required to plan and carry out the flight itself. This should have been a sufficiently demanding task even during favorable conditions.

During the previous one year period the pilot had flown 71 hours and had a total flying time of 729 hours during a time period of 15 years, which can be compared to production flight time with an airline where commercial pilots fly in the order of 300-600 hours per year.

Even if the pilot was aware of his own limits and possibly realized that due to the bad weather he should have delayed the return flight to Gothenburg, one can easily imagine that he felt a certain amount of pressure to carry through with the flight. To inform the customers that they were compelled to remain in Sundsvall for an indefinite period of time, while at the same time the SAS aircraft took off on time, would not have been easy.

2.3.2 *Distinctions in flight safety*

As stated in 1.18.6, a private pilot with an instrument rating can in many cases have the authority to fly under the same operational conditions as pilots within commercial aviation. This is something that entices many to see private air transport as an alternative to the ordinary means of transportation in connection with business trips, in order to be able to fly direct to the destination and to be able to decide departure times etc. If several persons accompany the flight it can furthermore be an economically advantageous alternative. For a private pilot this can also be a way to accrue flight time.

Even if large variations are found in the matter of flight safety in connection with private IFR aviation, there is no doubt that commercial aviation, regulated by the aviation authorities, generally offers a substantially higher level of safety than private flying. Apart from the above mentioned significant differences concerning operational and technical prerequisites for these activities, the pressure that a private pilot can sense to carry out a planned flight, similar to that which probably arose during the accident under discussion, implies a flight safety risk in and of itself. This problem has been observed in connection with investigations of similar accidents that have occurred in Sweden and abroad.

With this development as a basis and with those recommendations that The Rights of the Air Investigation has submitted concerning so-called corporate aviation, SHK considers it therefore to be of utmost importance to seek possibilities to also control the type of private flying that has the characteristics of business aviation. In the opinion of SHK, LFV should therefore seriously consider the possibilities to find methods to ensure the qualifications of those with a private pilot's license (A), who fly with passengers in their vocational activities. To the extent it is possible LFV should of course also inform business executives about the differences in qualifications between private and commercial pilots.

2.4 Search and rescue performance

The aircraft wreckage was located quickly and the search and rescue effort was carried out under difficult conditions. Otherwise the rest of the performance has not occasioned SHK to make any specific comments.

3 CONCLUSIONS

3.1 Findings

a) The pilot was qualified to perform the flight, with a "daylight only" limitation
b) The pilot had two medical conditions, each one of which was disqualifying for the possession of a Private Pilot's License, something that LFV was not aware of.
c) The aircraft had a valid certificate of airworthiness.
d) Severe weather conditions prevailed at the departure airport.
e) The pilot had limited time to prepare for the flight.
f) The aircraft was overloaded and the center of gravity was close to or behind the aft center of gravity limit.
g) The autopilot was most likely engaged after the take off.
h) The autopilot was probably coupled to the HEADING BUG on the HSI.
i) The COURSE POINTER and the HEADING BUG on the HSI were jammed on a heading of 340 degrees after the accident.
j) No technical failure has been ascertained on the aircraft, it's engines or it's instrumentation.
k) The pilot had a customer relationship to his passengers.

3.2 Causes

The accident was caused by the pilot losing control of the aircraft during flight in IMC. Contributory factors were, that
-the weather situation was difficult,
-the pilot's time to prepare for the flight was insufficient,
-the navigation system was in all probability misaligned,
-the pilot mistrusted the flight instruments,
-the aircraft was overloaded and tail-heavy
-the pilot probably felt pressured into carrying out the flight and that,
-the pilot's medical condition can have reduced his ability.

4 RECOMMENDATIONS

The Swedish Civil Aviation Administration is recommended

-to carefully consider the possibilities to find methods to ensure the qualifications of those with a private pilot's license (A), who fly with passengers in their vocational activities *(RL2000:40 R1)* and
-to the extent it is possible, to inform business executives of the differences in qualifications between private and commercial pilots. *(RL2000:40 R2)*