STATENS HAVERIKOMMISSION

BOARD OF ACCIDENT INVESTIGATION
SWEDEN

AIRCRAFT ACCIDENT REPORT

N98610 (USA-REG)

CESSNA 340A

HISINGEN, GOTHENBURG

JANUARY 3, 1981

ACCIDENT REPORT N98610 1/81

DECEMBER 1981

Address
Kungsgatan 38

Telephone
+ 46 8 143860

Telex
12841 HAVKOM S

INVESTIGATION REPORT

CONCERNING ACCIDENT AT HISINGEN, GOTHENBURG

JANUARY 3, 1981

AIRCRAFT	CESSNA 340A
REGISTRATION	N98610 (USA)
OWNER	DAY DREAM FLIGHT INC P.O. BOX 52, C/O C.E. JACOBSSON WESTPORT, CONNECTICUT 06880, USA
CREW	ONE - DEAD
PASSENGERS	THREE - ONE DEAD AND TWO SERIOUSLY INJURED
ACCIDENT SITE	LAT 57^0 43, 6′ N LONG 11^{0}51, 1′ E
ACCIDENT TIME	16.32*)

*) GMT, UNLESS OTHERWISE STATED.
LOCAL TIME IS DESIGNATED LT (LT = GMT + 1).

TRANSLATED FROM SWEDISH.

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INTRODUCTION

An USA-registered aircraft, a Cessna 340A, with four persons on board, crashed on January 3, 1981, at Hisingen, Gothenburg, during approach to Säve Airport. In the accident two persons were killed and two were seriously injured.

The Board of Accident Investigation where informed about the accident by Cefyl (Search and Rescue Central) the same day at 1800 hrs.

The Board - Göran Steen, Chairman, and Aage Roed, Chief Investigator - started the investigation on January 4, 1981.

The following experts have assisted the Board:

Mr Bengt Bellander
Mr Åke Christianson
Mr Ahti Hietala
Mr Helmer Larsson
Mr P O Olsson

The Board has been in session:

1981-01-04--05	in Gothenburg	(Steen, Christianson and Laurell)
1981-01-07	-"-	(-"- -"-)
1981-01-21	-"-	(-"- -"-)
1981-12-07	in Stockholm	(Steen, Roed and experts)

The investigation has been followed by relatives of the deceased and representatives for the Board of Civil Aviation, the Swedish Traffic Controllers Association and the Swedish AOPA.

1 FACTUAL INFORMATION

1.1 History of Flight

On January 3, 1981, at 1157 N 98610, a twin engine aircraft type Cessna 340 A, took off from Geneva Airport (LSGG), Switzerland, for a flight to Gothenburg, Säve Airport (ESGP). The flight was a return flight after one week skiing holiday in France. On board were the pilot and three passengers.

Before take-off in Geneva the aircraft was refuelled with 592 litres Avgas 100 LL and was then fully tanked. The pilot checked the fuelling. After refuelling 150 kg of baggage was loaded in the baggage compartment and on the floor in the passenger compartment between the seat-rows. The pilot obtained weather information for the flight and filed an ATC flight plan.

In addition to filing the ATC flight plan the pilot made recordings on én route flight plan. These recordings were limited to writing the actual time of passing the navigation fixes shown in the ATC flight plan along the route to Tirstrup (TU), which was reached at 1559. Thereafter nothing was recorded except for the approach clearance to Säve and a note of the air pressure (QNH). No fuel, load or C. of G. calculations were recorded.

According to the ATC-flight plan the take-off was planned to 1100 with a flight route via airway Green 5 to Hamburg, LR1 to Alsie, thereafter to ODIN (navigation point 6 NM ENE Odense), further on to the beacon TU (outer marker at Tirstrup Airport) and finally to Säve with Jönköping (ESSJ) as alternate, flight level 160 (16 000 ft), cruising speed 210 knots, estimated flight time to the destination 4 hours with fuel for 6 hours.

The pilot requested taxi clearance at 1132 and started taxying at 1135. Take-off time was 1158, almost an hour after the planned time for take-off. The aircraft engines had then been running for approximately 30 minutes.

The weather during the flight was characterized by large temperature contrasts. A pronounced cold front was stretching from East Germany above Frankfurt to the English Channel. In connection with the front there was a strong jet stream at high altitude. Wind and temperature at FL 160 were Geneva - Hamburg 290° 65 knots - 20° C, Hamburg - Gothenburg 300° 20 knots - 28° C.

During the flight some deviations from the flight plan were made. At 1311 the pilot requested clearance to climb from FL 160 to FL 180. He received his clearance but did not accept this until it was repeated approximately one minute later. He then announced that he had had an interruption in the reception.

The strong westerly wind made the aircraft drift 7 NM to the right of the air-way between Würtsburg and Fulda. ATC informed the pilot at 1338 whereafter N98610 corrected the course.

At 1414 N98610 requested clearance to climb to FL 200. This was granted. FL 200 was reached at 1418.40. Shortly before 1500 hours, the pilot told the passengers that the engines would soon cough a little, because he had then used the fuel in one set of tanks. One of the surviving passengers noticed that the time was approximately 1500, when the engine coughed.

The outer marker at Tirstrup was passed at 1559. Thereafter the flight continued to Backa VOR. At 1606 the pilot contacted Gothenburg Control and was cleared to Säve via Backa at FL 130.

At 1610 N98610 received the actual weather for Säve: wind 050°/ 12 knots, visibility 10 km, 6/8 1300 ft and QNH 982. Shortly thereafter clearance was given to descend to 3000 ft.

At 1614 ATC asked: "Could you make it 015° for vectoring straight in NDB runway 01?"

At 1627 the pilot reported that he was established and was then "cleared straight in approach" and "ten miles to go". Shortly thereafter (1628.30) the radar flight controller made the following call: "November six one zero confirm established". The radar flight controller observed that N98610 was well to the left of the track. He did not receive any answer to his calls and contacted Säve tower at 1628.56 to inquire if N98610 had changed to the tower frequency. At 1630.17, after approximately 1,5 minutes, N98610 answered "affirmative established". Shortly thereafter the radar flight controller inquired: "Do you have the field in sight?" to which he received a negative answer. The radar flight controller then informed the pilot (at 1630.27) that he was well left of track and four miles from touch-down. "Well ..... left?" the pilot asked surprised, and the radar flight controller confirmed.

At 1631.16 the flight controller announced "November six one zero you are still well left of track. Turn right heading zero four zero". A sketch of the aircraft's flight path is shown in Fig 1.

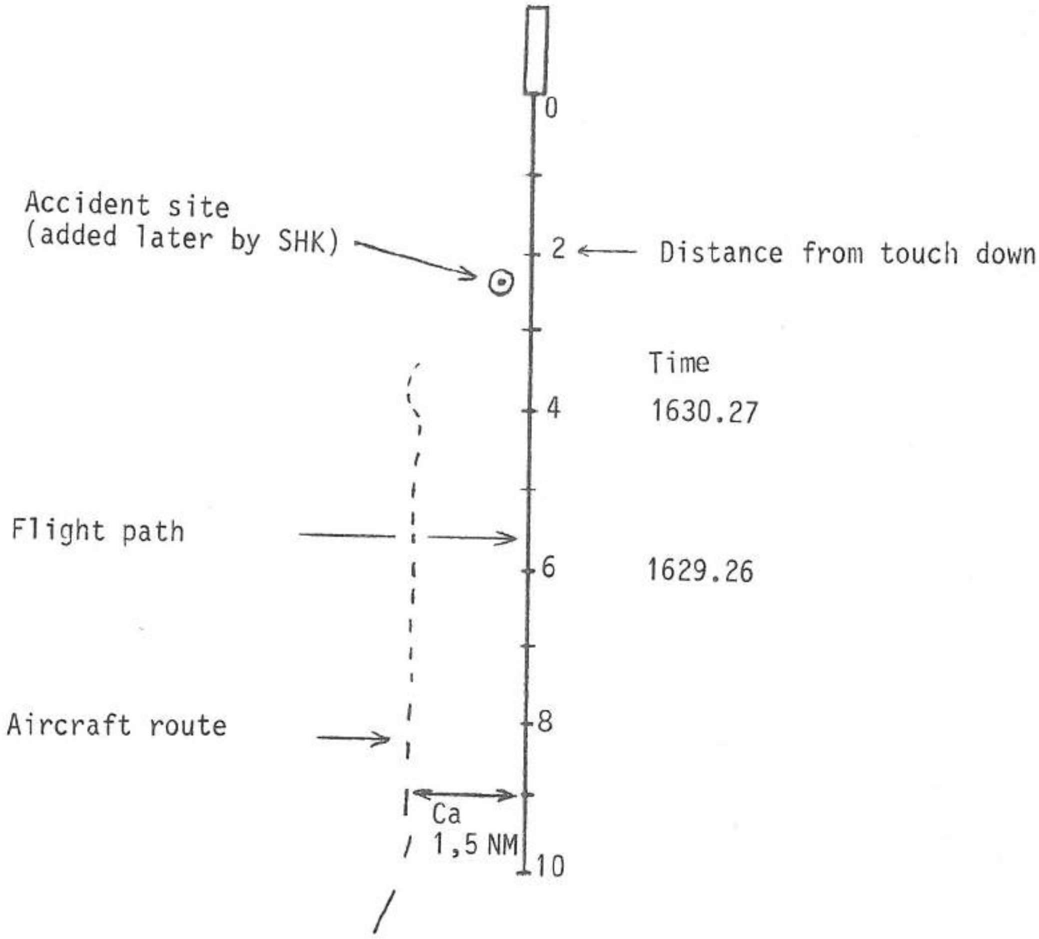

Fig 1. Flight path of N98610 drawn from memory by radar flight controller.

At 1631.24 the following comments were registered on the ACC-tape from Gothenburg Control "He is at ...... down to 300 ft" and about 3 seconds later at 1631.27 "two hundred feet".*)

At 1631.29 the radar flight controller called N98610 without getting an answer. Shortly thereafter the ACC-personnel commented "he is flying into the ground close by".

At 1631.40 the pilot reported: "Turning right." At 1631.44 the radar flight controller asked: "November, you have the field in sight?" and shortly thereafter, at 1631.49 he called out "November six one zero make a pull-up".

At 1631.54 alarm was heard from the aircraft´s ELT (emergency locator transmitter), which is automatically activated at impact.

At 1632.40 the SOS Alarm Center in Gothenburg was notified.

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*) This was observed on the secondary radar (QNH).

At 1726 the aircraft was found crashed in rolling terrain close to the Volvo head office, see Fig 2. Doctors established that the pilot and one passenger were dead. Two seriously injured persons were immediately taken to the hospital. The impact site is located approximately 800 m to the west of the approach path to runway 01, Säve, and approximately 4,6 km from the runway end.

The radar flight controller noticed that the aircraft was flying very much slower than the in the flight plan given speed during the approach to Säve. He estimated the speed to be 140-150 knots instead of 210.

During the approach two warning lights were lit. In response to a question from one of the passengers asking what that was,the pilot answered: "It´s the fuel." Both the surviving passengers and witnesses on the ground observed that the aircraft flew slowly at low altitude above the Volvo area shortly before the accident.

Fig 2. Accident site 57° 43,6' N 11° 51,1 E.

1.2 Injuries to Persons

	Crew	Passengers	Others
Fatal	1	1	-
Seriously injured	-	2	-
Slightly injured	-	-	-

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Small damage to trees in forest.

1.5 Crew Information

The pilot was 47 years old. He had a Swedish A+I-licence no 3301265538 valid until 1981-11-30. The pilot also had an equivalent American licence.

At the time of the accident the pilot had a total flying time of 2 700 hours. His flying time during the last 30 days was 13 hours and 40 minutes. He had not been flying the last seven days. The pilot had received the aircraft, that had the accident, during the summer of 1980 and he had on this a total flying time of 89 hours. He had previously owned a Cessna 310.

The latest PFT with N98610 was made 1980-10-09. After this PFT the check pilot wrote: "In general the instrument flight standard was somewhat low but acceptable." In 1976-07-27 the pilot had an accident with a sea plane. The aircraft tipped over during taxying in a strong wind. The pilot was given a warning.

Instructurs have pointed out that the pilot in a stress situation showed sign of low simultan-capacity.

1.6 Aircraft Information

The aircraft, a Cessna 340A, was manufactured 1976 by Cessna Aircraft Company,Wichita,Kansas,USA, series no 340A 0056.It was powere by two Continental TSIO-520-N engines.The aircraft was operated by Lars T Clase, address,according to the register of the Board of Civil Aviation, c/o Clase AB, Ruskvädersgatan 8, 417 34 Gothenburg. In the American "Application for Airworthiness Certificate", dated 1980-06-26, the address of the owner is given as 4865 10th Street, Vero Beach, Florida 32960,USA. According to a telex from the Federal Aviation Administration in USA,dated 1981-07-31,the registered owner of the aircraft is Day Dream Flight Incorporated, P.O. Box 52, c/o C E Jacobsson, Westport, Connecticut 06880, USA. According to information from the American Federal Aviation Administration, International Field Office 51 in Frankfurt, Germany, the aircraft was registered N98610 1976-05-04 and then received an American "Standard Airworthiness Certificate".This is valid as long as the airplane is maintained according to the regulations as long as the certificate is not recalled for other reasons.

At the first registration in 1976 the aircraft was new. The manufacturer was registered as the owner. The aircraft was flown to Europe and was taken over 1976-05-22 by Maskinfabriken Gerni A/S,Helsted, Randers, Denmark, with the registration OY-BUP. The aircraft had at that time a flight time of 29 hours and 10 minutes.

In 1979 the aircraft was transferred to Irish registration with the registration EI-BGM, and in 1980 it was transferred to the previous American registration.

At the accident the aircraft had a total flying time of 1 231 hours. Investigation of the maintenance documents shows that the Irish registration was painted on the aircraft 1979-04-05 and the American 1980-05-12.

The aircraft was not operated between 1980-01-30 and 1980-05-13. During this period a number of maintenance checks were made. Among others Cessna Progressive Care no 3 and 4 were completed. This comprises detail inspection of the aircraft fuselage below the cabin floor, landing gear, engines and the propellers and routine inspection of the fuselage above the floor, the wings and the tail section.

Progressive Care no 1, which includes detail inspection of the aircraft fuselage above the cabin floor and the tail section and routine inspection of the fuselage below the cabin floor, the engines, propellers, wings and the landing gear, was made 1979-07-18 when the aircraft had 1 043 hours and 40 minutes of flight time. Progressive Care no 2 was completed on 1979-09-29 when the airplane had flown 1 102 hours and 30 minutes. This includes detail inspection of the engines and the wings and routine inspection of the propellers, the fuselage, tail section and landing gear. The journal from the period when the aircraft was not used, 1980-01-30 to 1980-05-13, contained several notes showing that various minor engine faults had been corrected and that cylinder leakage tests and engine check runs after maintenance had been made.

During the period from 1980-05-13 to the time of the accident an ELT was installed by SABENA in Brussels, several minor repairs and flight safety checks, according to Cessna service letters,were made.The 100-hours overhaul of the engines was started in October by changing the spark plugs, the oil filters, the oil and checking the magnets. The left engine compressor was replaced. Furthermore, the left locker tank was checked for leakage. This was done 1980-12-19.

In the maintenance log the following remark had been written after the check: "Checked, no leakage, normal overflow through the ventilation tube."

The aircraft was equipped with a pressure cabin. Maximum permitted altitude without oxygen is 23 500 ft. No fault in the cabin pressure system has been reported.

The aircraft had a maximum tank volume for this type, see Fig 3, which means that it had two main tanks (wing tip tanks) each holding 51 gallons, whereof 50 are said to be usable, two auxillary tanks in each wing outside the nacelles, each pair holding 32 gallons, whereof 31,5 are said to be usable and in the nacelles

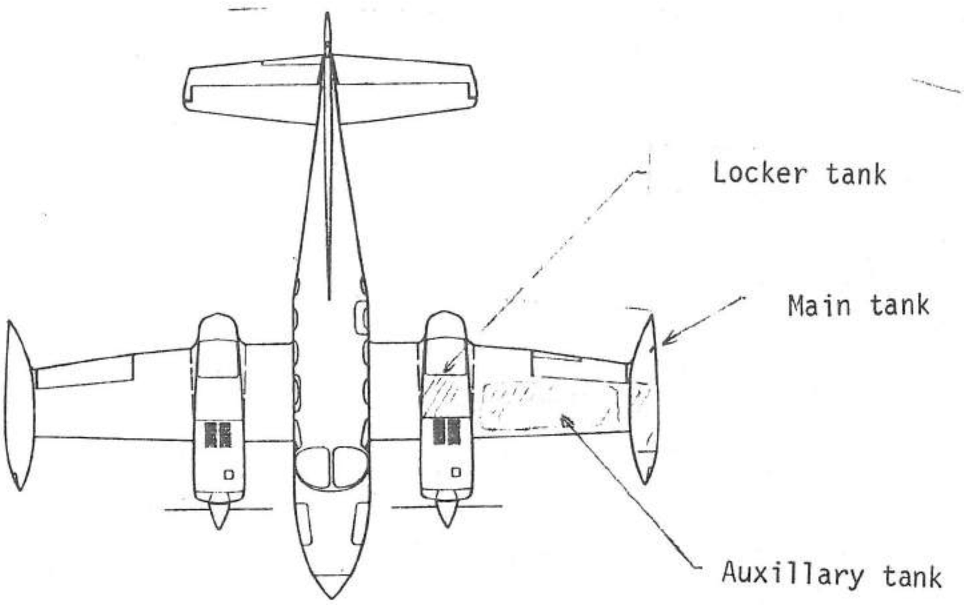


Fig 3. The aircraft fuel tanks.

two locker tanks, each holding 20,5 gallons, whereof 20 gallons are said to be usable, thus the total usable fuel quantity was 203 gallons, i.e. 768 litres. In order to utilize this fuel it is necessary to use the main tank fuel first until space is available for the locker tank fuel in the main tanks. The fuel in the nacelles is transferred to the main tanks and if the transfer starts too early, fuel will be dumped overboard through the main tank ventilation lines when the tanks are full. A minimum of 20 gallons per main tank must, according to Pilot's Operating Handbook,pages 4-8, be used before transfer is started.

The fuel in the auxillary tanks is fed directly to the engines. But, excess fuel from these tanks to the engines is fed via a return line to the main tanks. If the main tanks are full when the auxillary tanks are used even this excess fuel will be dumped overboard.

The fuel consumption of the aircraft at FL 150 and 200, according to the Flight Manual is shown below, Fig 4. To this approximately 31 pounds must be added for engine start, taxying and acceleration to take-off speed.

ALTITUDE	RPM	MP	-45°C (-48°F) PERCENT BHP	KTAS	TOTAL LB/HR	-25°C (STD TEMP) (-12°F) PERCENT BHP	KTAS	TOTAL LB/HR	-5°C (24°F) PERCENT BHP	KTAS	TOTAL LB/HR
20,000 FEET	2450	31.5	79.5	213	215	74.8	213	204	70.2	211	192
	2450	30.0	75.5	209	205	71.1	208	194	66.7	206	182
	2450	28.0	69.9	202	191	65.8	200	180	61.7	197	170
	2450	26.0	63.9	193	175	60.2	191	166	56.4	188	157
	2450	24.0	57.6	183	160	54.3	180	152	50.9	175	144
	2300	34.0	79.8	214	216	75.2	213	204	70.5	211	192
	2300	32.0	75.2	208	204	70.8	208	193	66.4	205	182
	2300	30.0	70.2	202	192	66.1	201	181	62.0	198	171
	2300	28.0	65.2	195	179	61.4	193	169	57.6	190	160
	2300	26.0	59.6	186	165	56.1	184	157	52.6	180	148
	2300	24.0	53.7	176	151	50.5	172	143	47.4	165	135
	2200	34.0	74.8	208	204	70.5	207	192	66.1	205	181
	2200	32.0	70.5	203	192	66.4	201	182	62.3	198	172
	2200	30.0	65.9	196	180	62.1	194	171	58.2	191	162
	2200	28.0	60.9	189	168	57.4	186	160	53.8	182	151
	2200	26.0	55.6	180	156	52.4	177	148	49.1	170	140
	2200	24.0	50.3	170	143	47.4	164	135	44.5	154	128
	2100	31.5	64.2	194	176	60.5	192	167	56.7	188	158
	2100	30.0	60.9	189	168	57.4	186	160	53.8	182	151
	2100	28.0	56.3	181	157	53.0	178	149	49.7	172	141
	2100	26.0	51.3	172	145	48.3	167	138	45.3	157	130
	2100	24.0	46.4	160	133	43.7	152	126	40.9	129	118
			-35°C (-30°F)			-15°C (STD TEMP) (6°F)			5°C (42°F)		
15,000 FEET	2450	31.5	79.5	203	215	74.8	203	204	70.2	202	192
	2450	30.0	75.5	199	205	71.1	199	194	66.7	197	182
	2450	28.0	69.9	193	191	65.8	192	180	61.7	190	170
	2450	26.0	63.9	185	175	60.2	184	166	56.4	181	157
	2450	24.0	57.6	176	160	54.3	174	152	50.9	171	144
	2300	34.0	79.8	204	216	75.2	203	204	70.5	202	192
	2300	32.0	75.2	199	204	70.8	198	193	66.4	197	182
	2300	30.0	70.2	193	192	66.1	192	181	62.0	190	171
	2300	28.0	65.2	187	179	61.4	186	169	57.6	183	160
	2300	26.0	59.6	179	165	56.1	177	157	52.6	174	148
	2300	24.0	53.7	170	151	50.5	167	143	47.4	163	135
	2200	34.0	74.8	198	204	70.5	198	192	66.1	196	181
	2200	32.0	70.5	194	192	66.4	193	182	62.3	190	172
	2200	30.0	65.9	188	180	62.1	187	171	58.2	184	162
	2200	28.0	60.9	181	168	57.4	179	160	53.8	176	151
	2200	26.0	55.6	173	156	52.4	171	148	49.1	167	140
	2200	24.0	50.3	164	143	47.4	161	135	44.5	154	128
	2100	31.5	64.2	186	176	60.5	184	167	56.7	181	158
	2100	30.0	60.9	181	168	57.4	179	160	53.8	176	151
	2100	28.0	56.3	174	157	53.0	172	149	49.7	168	141
	2100	26.0	51.3	166	145	48.3	163	138	45.3	157	130
	2100	24.0	46.4	156	133	43.7	151	126	40.9	142	118

<u>Fig 4.</u> Fuel consumption (TSIO-520-N).

<u>Remark</u>

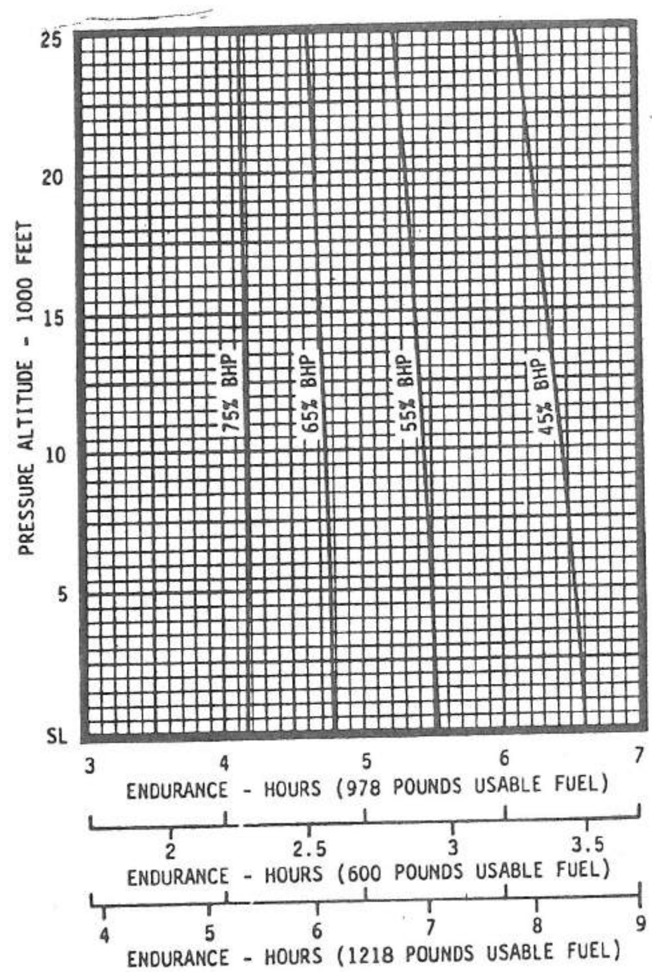
W = 5 990 pounds
Lean mixture.

Increase speed by 5 KTAS for each 500 pounds below 5 990 pounds. (20,000 feet)

Increase speed by 4 KTAS for each 500 pounds below 5 990 pounds. (15,000 feet)

Furthermore, fuel for holding due to delayed taxying and take-off clearance and fuel for the cabin-heater must be added. Increased fuel consumption for climb is balanced by decreased consumption at descent for landing.

The maximum endurance taking into consideration fuel for take-off, climb, descent and 45 minutes holding is shown in Fig 5.



CONDITIONS:
1. Starting Weight - 5990 Pounds.
2. Cruise Climb to Desired Altitude.
3. Recommended Lean Fuel Flow.
4. Standard Day.

NOTE:
1. Endurance computations include fuel required for start, taxi, takeoff, cruise climb to altitude, cruise, descent and 45 minutes holding fuel at 45% power.
2. The endurance shown is the sum of the times to climb, cruise and descend.

Fig 5. Endurance at maximum take-off weight.

Fuel consumption for holding is about 130 pounds/hour.

Fig 6 shows the fuel consumption in pounds/hour as a function of engine power at ground level for a Continental TSIO-520-N-engine. The figure illustrates how the fuel consumption at different power settings is affected by the fuel/air mixture (rich = rich mixture and lean = lean mixture).

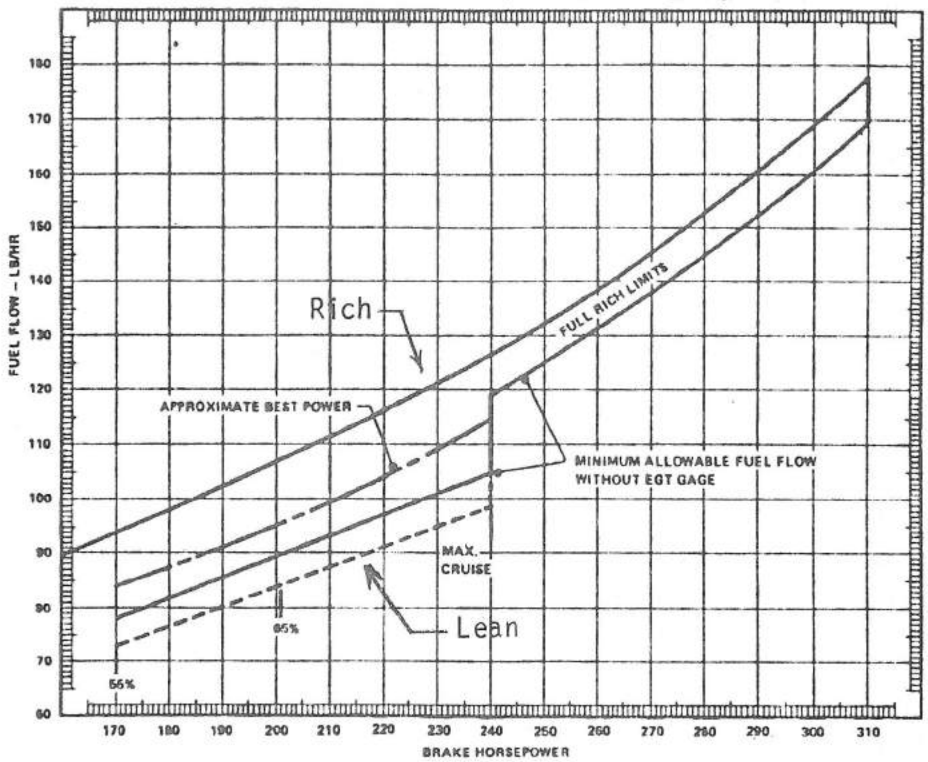


Fig 6. Fuel consumption as a function of engine power at ground level for TSIO-520-N. Observe the effect of fuel/air mixture on consumption.

The maximum take-off weight of the aircraft is 5 990 pounds. The empty weight of the crashed aircraft was 4 200 pounds.*) According to information from the Swiss authorities the aircraft was fully tanked in Geneva. It then had a fuel load of 1 236 pounds of which 1 211 were usable (based on specific weight 0,717). The baggage weighed 330 pounds (150 kg) and the passengers together approximately 600 pounds (270 kg). Thus the aircraft have had a take-off weight of approximately 6 360 pounds, which means that it had an overload of 350 pounds (approximately 175 kg).

During the flight the aircraft had a medium C.of G. position.

1.7 Weather Information

As mentioned in 1.1 the weather along the route was characterized by 290° winds, i.e. mainly crosswinds of 65 knots during the flight Geneva - Hamburg and 20 knots between Hamburg and Gothenburg.

The weather prognosis for Landvetter/Gothenburg for the time 09-18 hours was:

Wind 050°/15 knots, visibility 2 500 m, snow, vertical visibility 800 ft, GRADU 10-13 visibility 10 km 5/8 3 000 ft.

The prognosis for Jönköping 09-18 hours was:

Wind 070°/10 knots, visibility 8 000 m, snow, 3/8 500 ft
30 % PROB 09-18 visibility 2 000 m 7/8 300 ft.

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*) Estimated from the equipment list.

For Säve no prognosis was given for the actual time. At 1710 the pilot received the following prognosis for Säve: Wind 050°/12 knots, visibility 10 km, 6/8 1 300 ft temp - 1° , dew point - 3° QNH 982.

Surviving passengers reported that the pilot used the deicing system during the flight and that the visibility during the approach to Säve was good.

1.8 Aids to Navigation

The navigation equipment for approach to and landing at runway 01 Säve performed normally during the approach of N98610.

1.9 Radio Communications

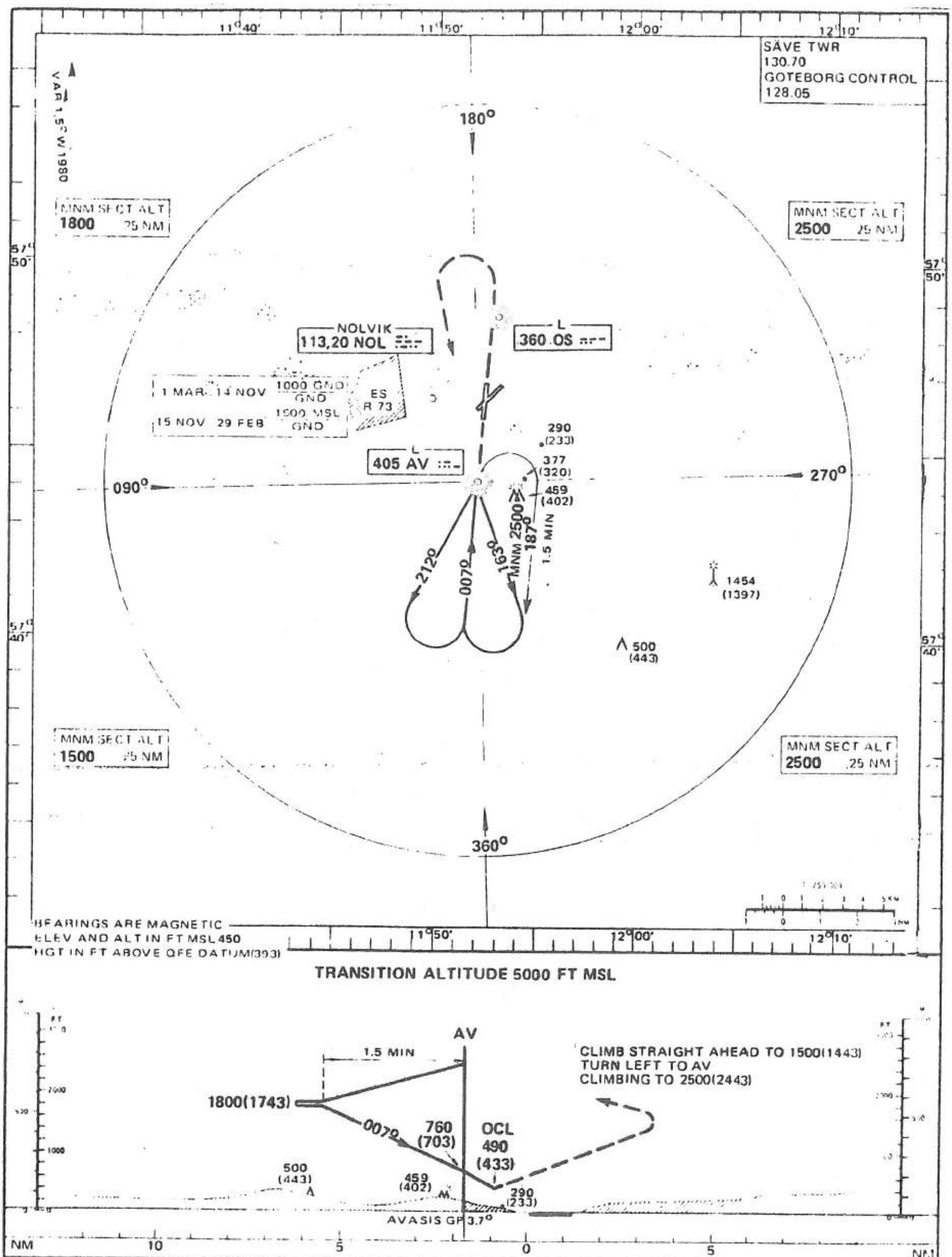
Transcripts of the radio communication between the aircraft and Gothenburg ACC indicate that no technical fault in the equipment affected the communication.

1.10 Airport Information

Gothenburg/Säve Airport is a former military airbase, which is used for general aviation traffic. Runway 01/19 is asphalt covered, 1 565 m long and 45 m wide. The approach equipment to runway 01 are an AVASIS with 3,7° glide-slope and an NDB-beacon (405 AV) located approximately 1,7 NM from the runway end. The airport is situated in forest, covered with low hills terrain. In the area there are a number of illuminated roads and road crossings. According to the flight controllers at Säve the high intensity runway lights are flashed when required even in clear weather in order to help the crew of approaching aircraft to distinguish the runway from the illuminated roads. Runway 01 has no approach lights. The airport coordinates are lat 57° 46' N, long 11° 52' E. The altitude above sea level is approximately 20 m (66 ft). VOR-beacon Nolvik is located approximately 2,6 km west of runway 01, see Fig 7.

1.11 Flight Recorders

None. Not required.



CEILING AND VISIBILITY MINIMA			OCL CIRCLING		TIME TO THR 01 FROM AV IN MIN AND SEC. DISTANCE 1.70 NM							
TAKE OFF	DAY	NIGHT	2 NM	3 NM	90 KT	100 KT	110 KT	120 KT	130 KT	140 KT	150 KT	160 KT
LANDING	•		677(620)	759(702)	1:08	1:01	0:56	0:51	0:47	0:44	0:41	0:38

Fig 7. The approach to Säve.

1.12 Accident Site and Aircraft Wreckage

1.12.1 Accident Site

The aircraft crashed on a forest covered rocky hillside ca 30 m (approximately 100 ft) above sea level. The flight direction into the forest was approximately 45^o. Marks on trees indicate a shallow flight path and show that the aircraft must have had a bank angle of approximately 90^o to the right when it flew into the trees. At the collision with the ground the aircraft had rolled another $30-40^o$ to the right. It flipped over and came to rest on its belly with the tail in the flight direction, see Fig 8.

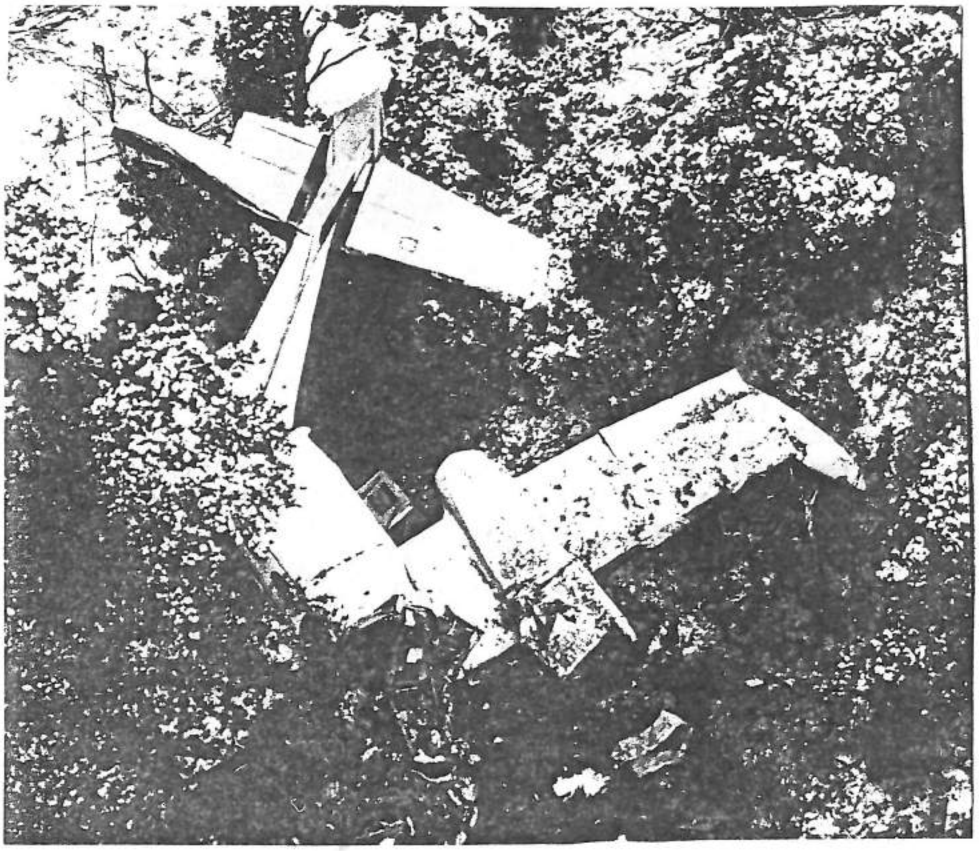


Fig 8. Aircraft wreckage.

The distance between the undamaged trees, where the aircraft's bank angle, due to limited space, must have been approximately 90^o and the point of impact was slightly more than 15 m. Thus, the aircraft had rolled at least 30^o in 15 m. This corresponds to 30^o in 0,2-0,3 seconds at the estimated impact speed.

On its way through the trees the left propeller cut off a pine tree approximately 25 cm thick, see Fig 9. There were no signs of the right propeller cutting trees or thick branches.

Fig 9. Cut-off pine tree.

1.12.2 Aircraft Wreckage

The wreckage was concentrated to the impact site with parts scattered maximum 18 m from the point of impact. There were no signs of any part leaving the aircraft while it was in the air. The landing gear was retracted. The wing flaps were retracted. The left aileron was locked in a position with maximum deflection upwards without having been damaged by contact with trees or the ground.

The aircraft fuselage was crushed from the nose to the wing leading edge. The fuselage was broken immediately behind the rear cabin bulkhead, see Fig 8.

The right wing with wingtip tank had been crushed in collision with trees. According to the rescue crew there was a smell of fuel when the aircraft was found. On the ground there were no signs indicating that a large quantity of fuel had leaked out.

The locker tank in the nacelle was undamaged. It was empty and was tilted forward so that any remaining fuel could not leak through broken fuel lines. The left wing was relatively undamaged. The nacelle and wing tanks were undamaged but empty. Tests were made to see if fuel could have leaked out after the accident. That was not the case since the fuel lines were intact and the wing was resting in a nose-down position placing the outlets of the lines in a higher position than the lowest point of the tanks.

The left main tank had broken loose but as it was not leaking and was resting with the broken fuel-line pointing upwards no fuel could leak out. It contained approximately 11 litres of fuel. Laboratory tests showed that this fuel met the standard requirements. Approximately 1 dl water was found in the bottom of the tank. Approximately 2 cc water was found in the left fuel selector valve.

Investigation of the fuel meters in the main tanks showed that these were not equipped with any warning device for low fuel quantity. In the panel on the left side of the pilot there where, however, two warning lamps with the words "Low fuel". These lamps warn against low fuel quantity in the locker tanks. The wing locker tank fuel transfer pumps are lubricated by the fuel and must not be used after the tanks are empty. Laboratory tests of the filaments of the warning-lamp bulbs showed that the lamps in all probability were lit when the accident occurred. The investigation of the position of the fuel tank selectors gave no usable information. The position of the selectors had been affected by the load on the wires to the cocks in the wings when the aircraft floor was damaged.

All fuel pumps have been investigated. Apart from the left auxillary tank in line fuel pump all worked. The left auxillary tank in line fuel pump had worn-down coals and had failed before the collision with the ground. This pump does not block the fuel line and does not prevent the engine-powered pumps from drawing fuel from the tanks.

Investigation of the left propeller showed that all blade ends had scratch marks from rotation. The blades were bent backwards after collision with the bed-rock. Investigation of the propeller to engine shaft boltholes showed that the holes in the propeller were deformed at the edges in the direction of rotation. Thus, the engine gave power when the airplane hit the ground. A piece of an engine cowling, that was found in the tree cut by a propeller, came from the left engine. The left engine shaft could be turned without any signs of bindings.

The right engine propeller had broken into three parts when the engine collided with the bed-rock. The blades did not show any signs of rapid rotation at impact.

The propeller spinner slip rings had been forced against the engine. Scratch marks on the sliprings showed that the propeller had rotated approximately 8° after the engine hit the rock. One of the propeller blades was almost undamaged. One blade had been bent backwards after collision with trees and the third blade was bent backward and had scratch marks along the upper blade surface from the blade root to blade tip after collision with the bed-rock. The propeller shaft was straight and the propeller fastening bolts were easy to remove. The propeller was not feathered at impact, the feather control arm at the engine was found in a position half way between the stops. There were no signs of the right engine producing power at impact.

Since it was not possible to turn the engine shaft, the engine was opened for a check. There were no signs of engine damages, that could have been caused prior to impact.

The binding was a result of accident damages (bent shaft). The engine appeared to be as good as new. The valves were in good condition. The spark plugs seemed to be new and showed no signs of too rich or too lean fuel-air mixture. Cylinders, pistons and piston rings were clean without sign of wear or corrosion.

In the wreckage was found a new pressure switch of the type used to switch the fuel pump from low to high RPM in case of fuel pressure decrease. The switch was intended for the left engine, which had a switch that was actuated at too low pressure.

The aircraft altimeter was set at 983 mb, see Fig 10.

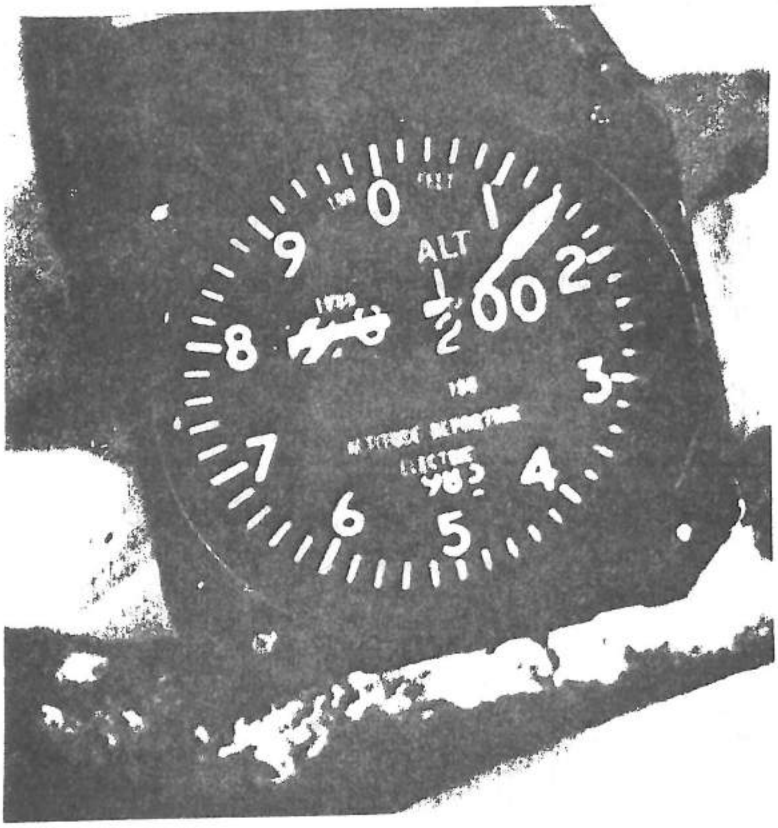


Fig 10. Altimeter. The altitude of the impact site corresponds roughly to the position of the needles.

VOR 1 was probably set at 113,2 Nolvik and VOR 2 at 112,7 Backa according to an investigation made by Swedair at Bromma. HSI VOR 1 was set at 15°. The only ADF in the aircraft was switched off. The receiver has the same knob for volume control and on/off control. The frequency setting could not be determined due to impact damage.

Accident damages made it impossible to determine with any accuracy the position of controls and switches and the readings of different instruments. However, it was observed that the engine instruments for the left engine showed considerable higher values than the instruments for the right engine. Fuel quantity and fuel flow instrument gave no useful information due to the roll attitude of the aircraft prior to impact.

The following switch positions may be due to accident damages, but are in spite of this pointed out here:

- o Auxillary pumps - both in position "low".
- o Autopilot - "off".

The control system has been investigated in the parts of fuselage, wings and tail, which were not totally destroyed. No signs of pre-impact faults have been found.

1.13 Medical Information

The pilot had the required medical check-ups for obtaining and maintaining his licence, the latest on 1980-11-11.

Nothing abnormal was found in these check-ups. The pilot was in good health. The autopsy did not show anything that could have influenced the capacity of the pilot during the last flight.

1.14 Fire

There was no fire.

1.15 Survivability

The pilot and the passenger in the right front seat died at impact. As shown in Fig 11 the aircraft was crushed in this area.

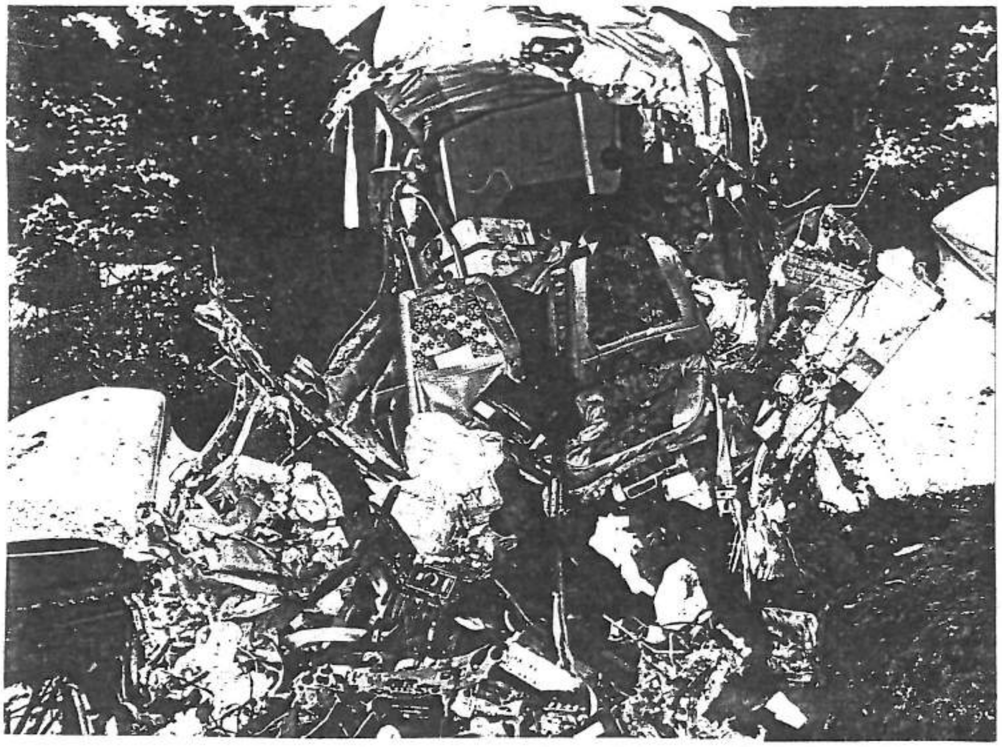


Fig 11. Damages to the aircraft fuselage.

There was no possibilities for survival in the front seats.

Immediately behind the first seat-row the survivability increased considerably. In this area the fuselage was relatively undamaged and the seats were still attached to the floor. The surviving passengers were seated in the third seat-row and used seatbelts without shoulderstraps. The passengers in this area may have been injured by heavy baggage laying on the floor.

At impact the emergency location transmitter was activated. Alarm was thereafter quickly transmitted from the ACC. The police received the alarm at 1640. The aircraft was found 1726. Through the assistance of the ATC the rescue crews were directed to the right area. When the aircraft was found there were two ambulances with doctors at the site. The survivors could quickly be transported from the accident site to the ambulances and on to the hospital.

1.16 Tests and Research

1.16.1 Approach to Säve above the Accident Site

The Board made, together with the police, on 1981-01-05 a helicopter flight in the accident area. Tests were made at the equivalent time and at a comparable weather situation to the one existing at the time of the accident. The purpose was to get a visual impression of the road lights and other lights in the approach direction. The Volvo factory area was not illuminated in the normal way due to a temporary close-down, the first in seven years.

The test showed that the pilot in an early stage of the approach could have mistaken an illuminated railroad track at Volvo to the west of and parallel to runway 01, Säve, for the runway, especially since no high intensity light were lit at Säve*).

1.17 Other Information

1.17.1 Fuel Consumption

The fuel consumption of the crashed aircraft was discussed with a pilot, who had been flying the aircraft for approximately 1 000 hours. According to him the fuel consumption was approximately 172 pounds/hour (approximately 110 litres/hour) at FL 250 at TAS (true air speed) 205 knots. At FL 100 the consumption was the same, but TAS was then 180 knots. This pilot planned with 200 pounds/hour (128 litres/hour). The fuel consumption at 30 minutes holding on the ground he estimated to be maximum 20 litres. This agrees with a ground test made later with a Cessna 340 at idle, 13-1400 RPM, plus engine run-up for magneto-checks.

1.17.2 Fuel Consumption According to Fuel Receipts

The Board of Accident Investigation has checked all available fuel receipts (credit and cash) and has by comparing with the flight time in the log-book determined the following mean consumption:

o	1980-07-20--10-04	mean consumption	143 litres/hour
o	1980-11-22--1981-01-03	-"-	161 -"-

The period 1980-10-05--11-21 has not been included since the fuel consumption in this period was difficult to check due to engine maintenance work (see 1.6). Observe that the mean consumption was roughly 12 % higher during the months following October than during the preceding months.

During the flight from Säve to Geneva one week prior to the accident the fuel consumption was 154 litres/hour.

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*) High intensity lights were not required during the visibility conditions at the time of the accident.

1.17.3 Fuel Consumption of Similar Cessna 340/2, Series No 613, SE-IVB

The pilot on this aircraft quotes a consumption of 136,7 litres/hour during 100 hours of flight at 65 % power.[1] This consumption includes all fuel tanked. The consumption at cruise altitude is 181 lb/h, i.e.115 litres/hour.

1.17.4 Fuel Consumption of Cabin Heater

The cabin heater consumes approximately 4 litres/hour. The fuel is taken from the left main tank.

1.17.5 The Pilot´s Én-Route Flight Plan

The pilot´s én route flight plan was found in the wreckage together with about 20 old flight plans. In these flight plans only the navigation fixes were recorded, except for a few cases when even the flight leg distances had been written.

1.17.6 Control Problems in Case of Single Engine Failure

As an example of problems involved with single engine failure at low speeds the following extract from the Pilot´s Operating Handbook regarding instruction for engine failure flight training is given.

WARNING

The propeller on the inoperative engine must be feathered, landing gear retracted and wing flaps up or continued flight may be impossible.

Single-engine procedures should be practiced in anticipation of an emergency. This practice should be conducted at a safe altitude, with full power operation on both engines, and should be started at a safe speed of at least 105 KIAS.*) As recovery ability is gained with practice, the starting speed may be lowered in small increments until the feel of the airplane in emergency conditions is well known. It should be noted that as the speed is reduced, directional control becomes more difficult. Emphasis should be placed on stopping the initial large yaw angles by the IMMEDIATE application of rudder supplemented by banking slightly away from the yaw. Practice should be continued until: (1) an instinctive corrective reaction is developed and the corrective procedure is automatic and, (2) airspeed, altitude, and heading can be maintained easily while the airplane is being prepared for a climb.

*) Minimum control speed V_{MC_A} = 82 KIAS.

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1) Equal to 154 litres/hour at 75 % power.

In order to illustrate the problem further the following extract regarding a light twin engine aircraft has been taken from the Canadian Department of Transportation, Aviation Safety Letter No 6/81 (certification procedures for these aircraft are the same and the statement below, therefore, concerns all light twin engine aircraft):

Here is how V_{MC_A} (minimum air control speed) will be affected. In certification, aircraft are tested for V_{MC_A} with a maximum (exact) of 5° of bank and the heading held constant by full rudder deflection. In one aircraft, a V_{MC_A} of 91 kts was established but the test pilot lost control at 115 kts when he tried it with wings level and the ball centered.

1.17.7 Air Traffic Service (ATS)

The last leg of N98610's flight to Säve was controlled by pos R1 and the Gothenburg ACC. The control was radar assisted. The intension was to guide the aircraft by radar for a direct approach to the NDB for runway 01.

R1 was responsible for the flight since two sections were at the moment controlled by one controller due to low traffic intensity.

Required coordination with Säve TWR was made at a distance of 13 NM. According to local requirements the 12 NM distance shall be reported.

At a distance of 10 NM the pilot reported that he was established on the NDB and was then cleared for a straight in NDB approach without any requirement to report altitudes.

Since the pilot reported that he was established and accepted the clearance for a straight in NDB approach the responsibility for terrain clearance and navigation was transferred from the controller to the pilot. According to the local requirements the radio communication shall be transferred to Säve TWR at latest at a distance of 5 NM, which was not done due to the temporary break in radio contact and the observed diversion from the approach path.

2 ANALYSIS

2.1 Sequence of Events Leading to Accident

The investigation of the accident site shows that the aircraft at the time of the collision with the ground had a rolling motion to the right. The rolling motion was rapid. The aircraft rolled at least 30^{o} in 0,2-0,3 seconds.

Witness marks on trees and the ground show that the left engine was running with high power while the right was running with low or no power. Investigation of the left propeller showed that the blade tips had scratch marks from rotation and that the propeller bolts had made the bolt holes oval in shape. The right propeller had no scratch marks that indicated rapid rotation at the time of impact. This shows that only the left engine gave power. Investigation of the right engine showed no sign of mechanical failure. Neither left nor right engine spark plugs showed any signs of too rich or too lean fuel-/air mixture.

All fuel pumps, except the left auxillary tank pumps, functioned. The left pump failure did not stop the fuel flow from the left auxillary tanks.

At impact the right wing with the main tank and the wing tanks was crushed. The right locker tank was undamaged. It was empty. The left wing tank system was undamaged, apart from the main tank, which had broken off the wing. However, the broken fuel line pointed upwards. No fuel could have spilled. The locker tank was empty, the auxillary tanks in the wing contained approximately 0,5 litre of fuel and the main tank contained approximately 11 litres.

With a slightly excessive bank angle in a turn with low fuel quantity in the main tanks the fuel will flow away from the fuel sump in the main tank which is lowest (i.e. the right tank in a right turn). Then the pump will draw air and the inner engine in the turn stops. Thus, no fault in the fuel system is needed for the engine to stop in a turn with a low fuel quantity.

According to the transcript from Gothenburg Control the aircraft had an altitude of approximately 200 ft (QNH) 27 seconds before the accident.

Low flight altitude was also confirmed by witnesses who saw the aircraft shortly before the collision with the hill. These witnesses also observed that the speed of the aircraft was low. An estimate of the speed during the approach can be made through analysis of the times and distances on the transcript from Gothenburg Control. Fig 12 shows these times and distances. Since the distances are not accurate the speed estimates are approximate.

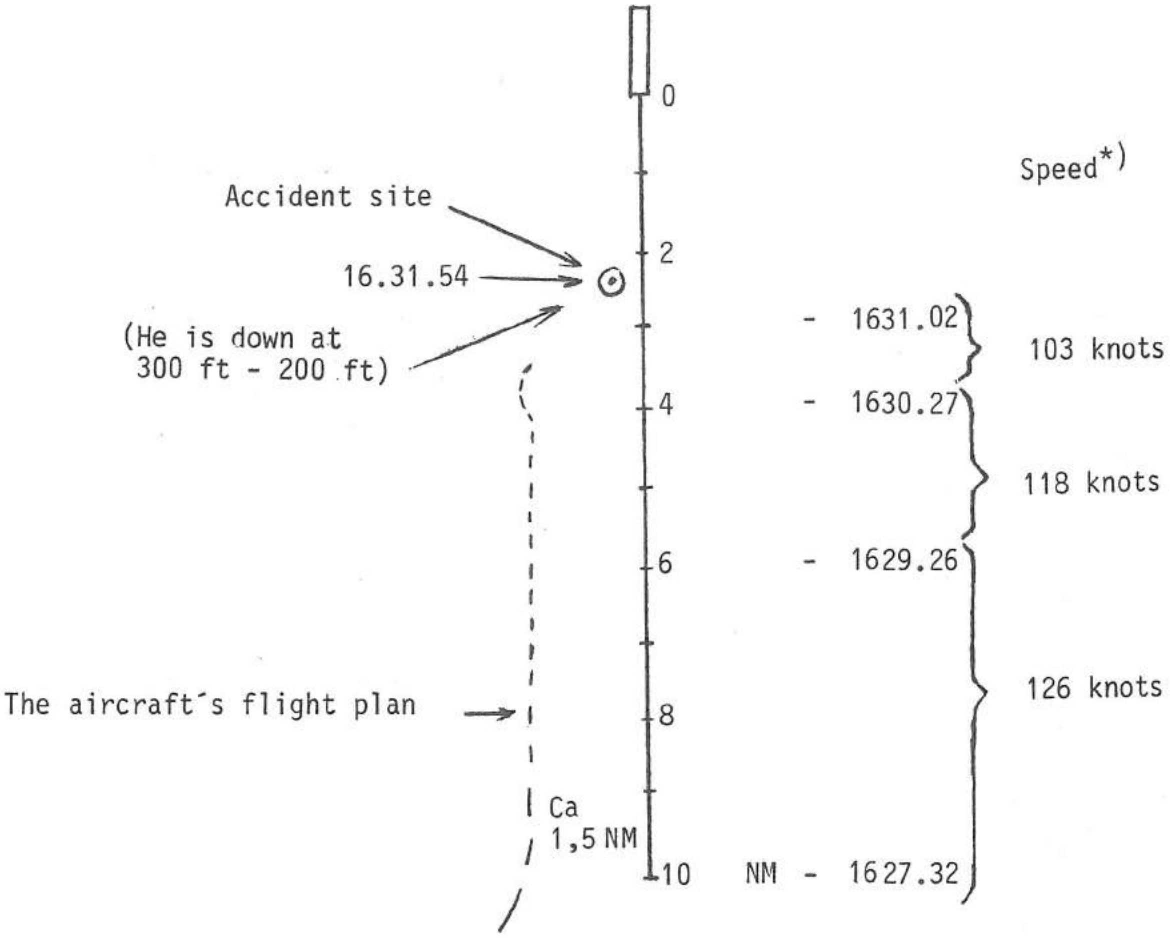

Fig 12. Estimated speeds according to transcript.

However, they show that the speed during the last 3-4 min before the accident has been low, which agrees with the witness observations. It has, however, probably been considerably higher than V_{MC_A} (= 82 knots). It is also evident that the speed was low 2-3 minutes before it was noticed that the aircraft altitude had decreased to 300 ft.

The pilot was informed that he was well to the left of the track and had been asked to turn right to 040° . Approximately 14 seconds before the collision with the ground the pilot said: "Turning right."

It is very probable that the pilot has been aware of the critical fuel situation. This is verified by the fact that two lamps warning for the empty locker tanks were lit during the approach. The pilot had evidently tried to transfer fuel from these tanks in a late phase of the flight.

Based on the above the following probable explanation of the collision with the ground can be given:

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*) Ground speed. TAS was approximately 6 knots higher due to head wind.

During low speed flight at low altitude the pilot has followed the controller´s directive to turn right to 040° in order to correct his approach to Säve. The combination of low fuel quantity and un-coordinated turn has made the fuel in the right main tank flow away from the fuel line. The right pump drew air and the engine stopped. Engine failure at the inner engine (right engine in a right turn) at low speed has given the aircraft a yaw/roll-motion which the pilot has not been able to stop before the aircraft collided with the ground.

It is known that light twin-engine aircraft of the size considered in this case are difficult to control in roll at low speeds if one engine fails and the other is running at high power. The pilot must immediately identify the problem and quickly kick rudder in order to prevent the yawing motion whereafter a rapid aileron deflection to counter the roll must be made and the stopped engine propeller must be feathered.

If the pilot reacts primarely with an aileron deflection the yaw will rapidly increase to such a magnitude that the rolling motion can not be stopped even with maximum aileron deflection. This also happens at speeds that exceed "minimum control speed" with 20-30 knots if the aircraft is not banked 5° towards the running engine. In the actual case the aircraft was probably banked towards the right when the engine stopped.

If the propeller of the stopped engine is not feathered the performance of the aircraft will be reduced so much that altitude can not be maintained without speed-loss.The performance-loss increases in turns due to increased induced drag. The speed-loss will further reduce the possibility to counter the yaw/roll motion due to engine failure.

According to the Pilot´s Operating Handbook training for single engine failure should be carried to the point where the pilot quickly can react in an emergency situation. The training should be done at a safe altitude and should start at a speed that exceeds the minimum control speed with at least 20 knots with a gradual speed decrease until an instinctive corrective reaction is learned and the corrective procedure is automatic.

The pilot´s possibility to identify the problem rapidly in a stress situation during darkness and make the necessary adjustments in time to prevent an uncontrollable roll and loss of altitude has probably been nonexistent.

The engine failure may have taken place earlier than in the right turn. However, the following speaks against this:

o No technical fault has been found in the investigation of the right engine.

o The fuel quantity in the right main tank was probably larger than in the left, because fuel to the cabin heater is taken from the left tank. The fuel consumption is approximately 18 litres in 4,5 hours. With 11 + 18 = 29 litres in the right tank it is not very probable that the right engine stopped due to fuel exhaustion on approach, when the left engine did not.*)

o There has been no attempt to feather the propeller. If the engine stopped during the approach, there should have been sufficient time for feathering.

o Surviving passengers have not observed anything unusual (as for example a yawing motion) during the approach, apart from the fact that the pilot decreased altitude and started to fly along the ground at low altitude.

o The probability is greater that the pilot lost roll control due to a sudden engine failure in a right turn than that he without feathering the propeller made a right turn towards a stopped engine.

Failure of the right engine explains the accident. But it does not explain the low fuel volume or the low altitude shortly before the accident. This is discussed in 2.2 and 2.3.

2.2 The Fuel Consumption

According to a Danish pilot, who had approximately 1 000 hours experience of the crashed aircraft, the fuel consumption was approximately 110 litres/hour at FL 250 at TAS 205 knots and FL 100 at TAS 180 knots. However, the pilot used to calculate with a consumption of 128 litres/hour. The lowest consumption agrees with the value in the manual for corresponding speeds at approximately 65 % engine power. It can only be obtained by very carefully leaning.The value is valid for flights in standard atmosphere and does not take into consideration fuel for taxying, climb, descent, cabin heater, ice, turbulence and non-standard temperature.

The pilot on a Cessna similar to the crashed aircraft reports a fuel consumption of 115 litres/hour in cruise with 65 % power and a mean consumption of approximately 137 litres/hour, when considering all fuel used during a normal flight. This is equal to a consumption of 130 respective 153 litres/hour at 75 % power.

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*) The exact amount of fuel in the right tank can not be estimated as the right engine fuel consumption may have been different from the left engine consumption.

According to estimates based on available fuel receipts the pilot of the crashed aircraft had a mean fuel consumption of 143 litres/hour during the time 1980-07-20--10-04 and a mean consumption of 161 litres during the time 1980-11-22--1981-01-03. During the flight to Geneva a week before the accident the aircraft had a mean consumption of 154 litres/hour. *) Thus it seems that the pilot in all his flights has had a high fuel consumption. During the fall he complained of a leakage from the left locker tank. In a maintenance check 1980-12-19 no faults were found. In the maintenance document is written "general overflow through the vent pipe" (i.e.ventilation pipe).

According to Fig 5, an increase of power from 65 % to 75 % decreases the maximum endurance of the aircraft approximately 12 %, i.e.the fuel consumption increases 12 %. Fig 6 shows that the consumption at 65-75 % power may increase more than 25 % if the mixture is changed from the leanest to the richest. According to Fig 5, the mean fuel consumption is approximately 120 litres/hour with the leanest mixture. This includes fuel for take-off, climb, flight at constant altitude and approach for landing. At 75 % the diagram shows approximately 134 litres/hour. The calculation is valid for heights between FL 100 and 200.

If one increases the values according to the handbook with 25 % (an increase from lean to rich mixture) the consumption will be 150 litres/hour at 65 % power and 167 litres/hour at 75 % power. A comparison between the pilot´s flight time and flight route shows that he usually used 75 % engine power. These mean consumption values were thus within what is possible for the aircraft. In this connection it should be observed that it is not advisable to use the absolutely leanest fuel/air-mixture due to the high engine temperatures which then may be obtained.

The flight, that led to the accident lasted 4 hours and 34 minutes. Remaining fuel quantity in the left main tank was 11 litres. From the left tank fuel for the cabin heater is taken. During the flight approximately 18 litres of fuel may have been used for this purpose. Thus the right tank should have contained 11 + 18 = 29 litres, i.e. total remaining fuel quantity could have been approximately 40 litres. If one assumes that approximately 15 litres extra fuel (in addition to what is used at a normal take-off) was used during the holding time for take-off at Geneva Airport, the mean consumption during the flight has been approximately 156 litres/hour. This includes fuel for take-off, climb, level flight and approach to Säve.

A detailed analysis of the flight based on ATC transcripts and meteorological data indicates that the pilot during the first hour has been flying at high speed, approximately 210 knots (TAS), using approximately 80 % engine power. Thereafter the speed has been greatly reduced during approximately 2,5 hours to approximately 178 knots (TAS) using slightly above 53 % engine power. During the flight to the north above Denmark the speed has been increased again to approximately 209 knots whereafter it finally

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*) These consumption calculations can be influenced by a number of factors and are therefore only approximate.

during the flight to Backa, has decreased to approximately 180 knots and further down to 130 knots during the approach to Säve. The mean consumption during this flight has, according to the manual, been approximately 120 litres/hour at perfect leaning (including fuel for take-off and landing).

The above reported speeds are uncertain. The flight speed has probably been influenced by unknown wind velocity and direction variations. Deviations of 20 knots have been registered during flight with DME-equipped aircraft. For this reason the consumption based on mean speed during the flight has also been calculated.

The flight route from Geneva to the accident site is approximately 810 NM and the aircraft's mean ground speed was thus approximately 180 knots. Corrected for the reported wind within the altitude range FL 160-200 corresponds to a power setting close to 65 % at the actual temperature. Thus the pilot has not used 75 % power during the complete flight. According to the manual this also gives a mean consumption of approximately 120 litres/hour.

When the fuel consumption for a given distance at a given flight time despite the low engine power which has been calculated has been high, this can be due to the following factors:

Factors	Increased consumption
o The aircraft had an overload of approximately 175 kg	2 litres/hour
o Cabin-heater	4 -"-
o Insufficient leaning According to pilots with experience it can be difficult to lean correctly with available instrumentation. A consumption increase of 15 % of the more than 25 % possible has been assumed.	18 -"-
o Turbulence and icing The effect of icing may be large. The aircraft's deicing system was used during the flight. Approximately 4 % fuel consumption increase has been estimated.	5 -"-
o The reported head-wind may have been 10 knots too low The exact wind is impossible to know. At FL 300 there was jet-stream with wind velocities of 100-150 knots.	8 -"-
o Inaccurate course due to wind The aircraft was off course above Germany.	1 -"-
Total	38 litres/hour

The above illustrates how the fuel consumption may be influenced by a series of negative factors, which together may explain why the consumption may be considerably higher than the leanest value written in the manual.

Approximately at 1500 hours, when the aircraft passed Hamburg, the pilot reported that the engines would cough when the fuel in the auxillary tanks had been used. The flight had then lasted approximately three hours. According to the manual the aircraft must be flown until the fuel quantity in the main tanks is 180 pounds/tank (totally 230 litres) before fuel is drawn from the auxillary tanks. The fuel in the locker tanks shall then have been transferred to the main tanks. In order to meet this requirement approximately 300 litres of fuel must have been used which, during the actual flight, should have taken a little more than 1½ hours. In order to use the fuel in the auxillary tanks a flight time of approximately one hour and 50 minutes is required. Together this gives a flight time of approximately 3½ hours. This could indicate that the pilot has started the transfer of the locker tank fuel and the use of the auxillary fuel too early and that he thereby may have dumped some of this fuel overboard through the main tank ventilation pipes. Faulty fuel transfer can contribute to the explanation of a high fuel comsumption. Such an explanation is credible since the spark plugs did not show any signs of rich fuel/air mixture.

The fact that no aircraft malfunction was reported, except for the complaint of the fuel leakage from the left locker tank, and that the fuel consumption of the aircraft increased when it changed to a new owner and was taken over by a pilot with less experience than the taxi-pilot, who had been flying it during the previous time, indicates that the difference in fuel consumption was due to different handling of the aircraft and not a result of technical problems. It is not probable that a technical problem on both sides at the same time can explain a high fuel consumption from both left and right tank system. The fact that the locker tanks and the left wing tanks were empty and that only a small quantity of fuel was left in the left main tank also points to the fact that the fuel system has been working. It should, therefore, be possible to exclude technical failures.

The aircraft performed well except from the high fuel consumption. The pilot had slightly more than half a year experience of the high fuel consumption and should, if he had taken this into consideration and had made a careful check of the consumption during the flight, have been aware of the risk and have made a refuelling stop. Instead of doing this the pilot chose to continue to the destination. At the time of the accident the aircraft probably had approximately 40 litres of fuel left.*) Five litres had been sufficient to complete the flight. At touchdown there should then have been fuel for more than 15 minutes holding. There was, however, not sufficient fuel for a flight to the alternate airport in Jönköping.

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*) Please observe that 40 litres, ≈10,6 US gallons, is a much higher fuel quantity than the two gallons, which are given as minimum usable fuel in the pilot's handbook.

Lack of fuel due to insufficient planning and fuel consumption check is a common accident cause. According to Safety Information (SB 81-86/3346) from the National Transportation Safety Board, USA, this was the cause to 7 % of all "general aviation" accidents in USA during the year 1978.

The analysis shows that the lack of fuel was not the direct cause of the accident. The aircraft could have reached the destination if the pilot had made a correct approach and avoided a right turn at low altitude.

For long distance flights it is, however, apparent that it is necessary - not at least in view of the actual accident - to introduce routines requiring that the pilot in his flight plan must calculate the fuel consumption for each flight leg and for the route reserve before the flight. This subdivision of the fuel consumption should make it easier to follow up the consumption during the flight and when necessary decide to land for refuelling.

2.3 The Approach to Säve

The pilot had probably set his navigation receivers for VOR-1 at Nolvik and VOR-2 at Backa. This is normal during flight to the approach path. The ADF was switched off. The pilot may have done this inadvertently after having checked the NDB-beacon station signal. The same knob is used as volume control and on/off switch. The ADF-needle would then point in the direction of flight and wrongly indicate that the aircraft was on the right course. It is possible that this explains why the track of the aircraft during the approach was well to the left of the proper approach track.

During two minutes, from distance 10 NM to 5 NM from touch down the pilot did not answer calls from the controller. This may be a result of stress. His attempt to transfer fuel from the locker tanks at a late stage of the flight indicates that he was consious of the low remaining fuel quantity. The low speed during the approach may also indicate that the pilot had an impression of a critical fuel situation.

When the pilot again contacted the controller he was told that he was left of the track. He was asked if he had the runway in sight and was informed that he was four miles from touchdown. The pilot reported that he did not see the runway and asked surprised "well - left" to the information that he was to the left of the track. Slightly more than half a minute later (38 seconds before the accident) the controller informed N98610 that the aircraft was left of track and ordered the pilot to turn right to 040°. The aircraft, which then was approximately 3 NM from the runway and should have had an altitude of approximately 860 feet, had at this time descended to approximately 200 ft and was flying at low altitude along the ground in approximately 10 seconds before it started the right turn. It is not likely that the descent was made in order to maintain RPM on the right engine because this had stopped and that the pilot voluntarily made a right turn towards a stopped engine. It is more likely that the pilot in a stress situation where he knew that he had little fuel left and also was informed that he was on a wrong track and was a short distance from the field without being able to see it, decreased the altitude in order to establish his position or that he was misled by the railroad track at Volvo. It might also be that he during a short period of time had considered landing at Torslanda (ref the flight controller´s comment "he is going toward Torslanda"). The true reason for the descent can not be determined.

2.4 Possibility to Turn without Risk of Accident with Small Quantity of Fuel Left

The minimum usable fuel quantity in the main tanks quoted by the manufacturer is two gallons i.e. approximately 3,8 litres per tank. In the actual case there was probably a great deal more left in the right tank when the right engine stopped.

As pointed out earlier,it is difficult to make perfect coordinated turn, i.e.without any tendency to side-slip, so that the fuel will not sometime during the turn be subjected to side forces. Side forces may make the fuel in the lowest located tank flow away from the fuel sump in the turn. Then the fuel pump will draw air and the engine stops. In the actual case it is very probable that the pilot flew on external references (due to the low flight altitude) in darkness and was probably stressed and tired. The risk for an uncoordinated turn would then increase very much. The accident shows that there can be serious risk for engine stop in a turn even if the remaining fuel quantity is considerable larger than the minimum usable quantity quoted in the pilot´s handbook.

Earlier it has also been pointed out that the lowest speed where the aircraft can be controlled in case of single engine failure increases rapidly if the aircraft is not banked approximately 5^o away from the stopped engine. In the actual case the aircraft had a bank angle considerably larger than 5^o in the wrong direction when the engine stopped. The possibility in this case to prevent a rolling motion towards the stopped engine must have been very small even if the speed exceeded V_{MC_A} with only 20-30 knots.

Together this shows that there is a great risk for loss of engine power followed by uncontrollable roll with the actual aircraft type in a turn with low fuel quantity even if the remaining fuel quantity is larger than the "Minimum usable fuel volume" and even if the speed exceeds "Minimum Control Speed". This is a problem for most light twin engine aircraft.

3 CONCLUSIONS

3.1 Findings

- o The pilot had a valid licence for the flight.
- o The investigation has not shown that there has been any technical failure of the aircraft or its equipment, which could have caused the accident.
- o The aircraft had an overload of approximately 175 kg at take-off.
- o No fuel, weight- or C. of G. calculations had been made.
- o A carefully prepared flight plan had not been made before the flight.
- o The pilot had not made any notes in the flight plan regarding the fuel consumption during the flight.
- o With the actual fuel consumption in mind the pilot should have made a refuelling stop.
- o The only ADF had been switched off by the pilot, probably by mistake.
- o During the approach to Säve the pilot had first descended through 3 000 ft, thereafter through the minimum outer marker altitude, 760 ft, and had continued along the ground at low speed.
- o The aircraft had a rolling motion to the right, when it on its back (approximately 120^{o}- 130^{o} bank angle) hit the ground.
- o The right engine gave no power at impact.
- o The left engine was probably running with high power.
- o The aircraft speed was probably higher than V_{MC_A}.
- o Approximately 11 litres of fuel remained in the left main tank at impact. The auxillary tanks were empty. The right main tank was destroyed.
- o The fuel supply to the right engine stopped in a right turn with low remaining fuel quantity.
- o The remaining fuel quantity was probably larger than the minimum usable quantity quoted by the manufacturer.
- o Following the alarm a rapid and effective search- and rescue activity was initiated.

3.2 Probable Cause

During approach for landing at low altitude the right engine of the aircraft stopped in a right turn due to fuel starvation. The stopped engine gave the aircraft a rolling motion to the right, which the pilot was not able to control.

Contributing factors to the accident have been:

- o Lack of flight plan preparation before the flight and fuel consumption check during the flight whereby the need to make a refuelling stop was missed.
- o ADF switched off during NDB-approach, which made the pilot follow the wrong track and placed him in a situation where he in order to correct his position made a steep turn at low altitude with a low fuel-quantity.
- o Low speed during the flight at low altitude.
- o Engine power loss in turns possible with the actual aircraft type even if the remaining fuel quantity well exceeds V_{MC_A} the minimum usable fuel volume.
- o The aircraft is probably not controllable when the inner engine in a turn stops even if the speed exceeds V_{MC_A} with 20-30 knots.

4 RECOMMENDATIONS

1. The Board of Civil Aviation should work for improved flight manual instructions for light twin engine aircraft concerning the following problems:
   - o The effect of different factors such as leaning, wind, turbulence and icing on the fuel consumption.
   - o Risk for loss of engine power in uncoordinated turns with low fuel quantity.
   - o The effect of bank angle on V_{MC_A}.
2. The Board of Civil Aviation should recommend introduction of separate on/off and volume control knobs for the ADF so that a volume decrease can not result in an unintentional switch-off.
3. Pilots should be required to write detailed flight plans for long distance flights including calculations of the fuel for each flight leg. This should be clearly shown in the standard flight plan form (see BCL-D 3-2-17, app 3).

   The Board of Civil Aviation should consider suitable means of control so that the requirements in the flight plan are observed.

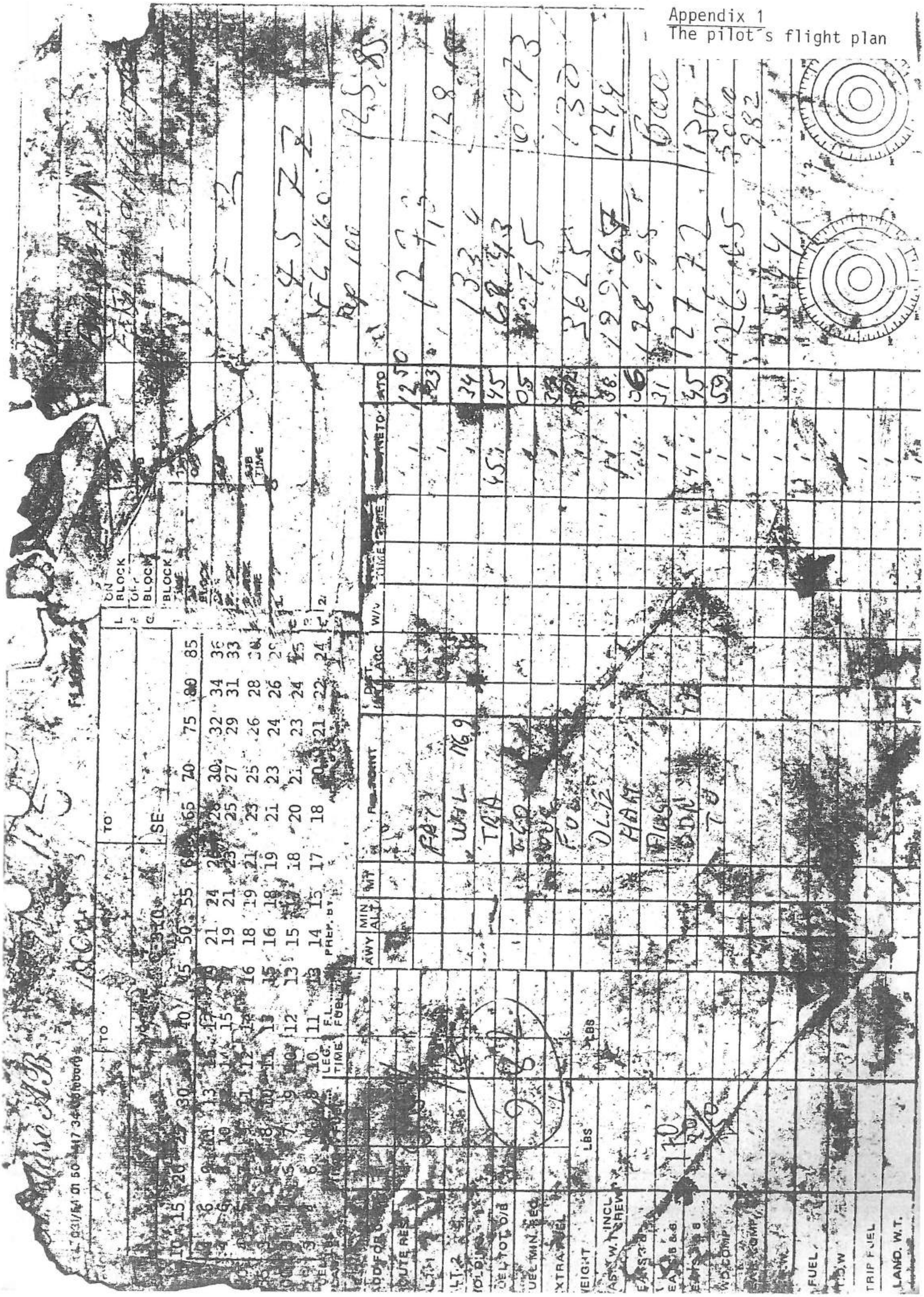
5 OTHER

The Board has noticed the flight controller´s request to the pilot "Could you make it 015^{o} for vectoring straight in NDB runway 01". Since no plate for direct NDB approach to runway 01 is available it would have been advisable to give the pilot altitude information during the approach. However, by accepting the vectoring the pilot did not, according to the present regulations, receive this type of information.

Göran Steen Åge Röed

A P P E N D I X E S

Appendix 1
The pilot's flight plan



Appendix 2
Flight plan based on analysis of ATC transcripts

CA Clase AB

TEL. 031/54 01 50 · 417 34 Göteborg

FLIGHT PLAN

WARN. ALT. 1.	WARN. ALT. 2.

FROM Geneve	TO SAVE	TO	
DATE 810103	A/C TYPE C-~~310~~ 340	~~SE~~ N 98610	

LEG. 1	ON BLOCK	O/G	
	OFF BLOCK	A/B	
	BLOCK TIME	A/B TIME	
LEG. 2	ON BLOCK	O/G	
	OFF BLOCK	A/B	
	BLOCK TIME	A/B TIME	
CREW	1. L. Clase		
	2.		

s/d	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
140	4	6	9	11	13	15	17	19	21	24	26	28	30	32	34	36
155	4	6	8	10	12	14	15	17	19	21	23	25	27	29	31	33
170	4	5	7	9	11	12	14	16	18	19	21	23	25	26	28	30
185	3	5	6	8	10	11	13	15	16	18	19	21	23	24	26	28
200	3	4	6	7	9	10	12	13	15	17	18	20	21	23	24	25
215	3	4	6	7	8	10	11	13	14	15	17	18	20	21	22	24

PREP. BY   APPR. BY OFF GENEVE

FUEL PLAN LBS	LEG. 1 TIME	F.L. ..... FUEL	LEG. 2 TIME	F.L. ..... FUEL
DEST	948	605		75%
ADD FOR CLIMB	—			
ROUTE RES.	80	51		
ALT. 1	80	51		
ALT. 2				
HOLDING	85	54		
FUEL TOT. O/B	1200	770		
FUEL MIN. REQ.	1193	765		
EXTRA FUEL	7	5		

WEIGHT	LBS	LBS
BASIC W.T INCL CREW		
SEATS 3 & 4		
SEATS 5 & 6		
SEATS 7 & 8		
FWD COMP		
REAR. COMP.		
Z.F.W.		
FUEL		
T.O.W.		
TRIP FUEL		
LAND. W.		

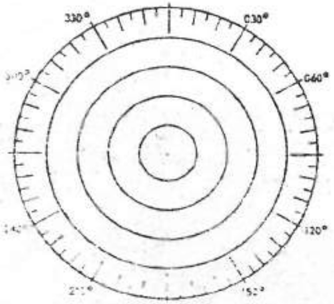
AWY	MIN ALT.	MT	Rep. POINT	DIST. INT	DIST. ACC	W/V	INT. TIME	ACC. TIME	ETO/RETO	ATO
			SIP F2	66	66		24		/	
			WIL	37	103		11		/	
			TRA	37	140		11		/	
			TGO	65	205		20		/	
			WUR	86	291		32		/	
			FUL	54	345		19		/	
			PLE	100	445		36		/	
			HAM	87	532		31		/	
			ALS	75	607		27		/	
			ODN	46	653		14		/	
			TW	43	696		13		/	
			FOR	(160)			(18)		/	
			BAK	85	781		28		/	
			AV	11	792		4		/	
			Ø →	15	807		6		/	
			06 SAVE				4:54			

Bilaga 1

Exempel på DRIFTFÄRDPLAN

Reg	Typ	Från	Max TOW	ETD	Off block	Befälhavare
Rapportpunkter (Benamn / Frekv Ident)	Datum	Till	Akt TOW	ATD	On block	Anmärkningar

Benamn	Frekv Ident	MT	AWY/ Marsch	Min Alt	FL Alt	Distans Int	Distans Acc	Tid Int	Tid Acc	ETO/RETC	ATO	Diff	CLR FL	
Från										/				
										/				
										/				
										/				
										/				
										/				
										/				
										/				
										/				
										/				
										/				
Till										/			QNH	Progn / Akt / TRL



Hast	Destination		Alternativ 1		Alt 2
Medel-TT					
W/V					
WC					
TAS	Stig	Marsch	Stig	Marsch	Marsch
GS					

BRÄNSLEPLAN	Tid	Bränsle
To Destination		
(+Alt 1: ________)		
(+Alt 2: ________)		
+ Routeres %		
+ Holding		
= Min bränsle		
+ Extra bränsle		
= Total bränsle/ Aktionstid		

Väderminima: