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# THE AIRCRAFT ACCIDENT INVESTIGATION BOARD/NORWAY

**REP.: 07/96**

# REPORT ON THE ACCIDENT TO DHC-6-300 TWIN OTTER, LN-BNM NEAR NAMSOS, NORWAY ON 27 OCTOBER 1993.

Note: This is a translation in English of the official Norwegian report dated June 1996. Any formal references required should be made to the original report in Norwegian. All the appendices are not translated.

**SUBMITTED JUNE 1996**

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**REPORT ON THE ACCIDENT TO DHC-6-300 TWIN OTTER, LN-BNM NEAR NAMSOS, NORWAY ON 27 OCTOBER 1993**

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|---|---|
| Aircraft type: | DHC-6-300 Twin Otter |
| Registration: | LN-BNM |
| Call signal: | Widerøe (WF) 744 |
| Owner: | Widerøe's Flyveselskap AS (WF)<br>Vollsveien 6<br>1324 LYSAKER<br>NORWAY |
| User: | Same as for owner |
| Crew: | 2 |
| Passengers: | 17 |
| Accident site: | Near Berg farm in Overhalla District, North Trønderlag County, 64°29'20"N, 011°42'30"E |
| Time of accident: | 19:16:48 hours, 27 October 1993 |

All times given in this report are local times, if not otherwise stated.

## NOTIFICATION

The Aircraft Accident Investigation Board, Norway (AAIB/N) was first informed by the Oslo Police Operations Department, at 19:28 hours on October 27, 1993, that an aircraft was missing on approach to Namsos. Subsequent conversations with the Aerodrome Flight Information Service unit (AFIS) at Namsos airport confirmed that the unit had received signals from an emergency locator transmitter at the time the aircraft should have landed. At 20:23 hours the Namdal police confirmed that the aircraft had crashed, and had been located on the approach path approximately 6 km east of Namsos. Initially it was reported that 19 passengers and a crew of 2 were on board, but this was subsequently corrected to 17 passengers and 2 pilots.

That same evening the AAIB/N, with a task force of 4 accident inspectors, prepared to go out to the scene of the accident and arrived there at 11.30 hours the following day.

In accordance with the ICAO Document, Annex 13, Aircraft Accident Investigation, the Canadian investigative authority - the Transportation Safety Board (TSB), representing the country of manufacture - appointed Mr Ron Coleman, Superintendent of Operations Investigations (Air) to be the accredited representative for this aircraft accident. Mr Coleman was accompanied by the following advisers:

- Mr. Jim Donnelly, Manager of Product Safety, Customer Services Department, Bombardier Regional Aircraft Division, Bombardier Inc.

- Mr. Bob Gumbinger of de Havilland Flight Operations

- Mr. Geoff Eddy of United Technologies Corporation, Pratt and Whitney Repr.

Mr. Coleman and his advisors met the AAIB/N in Namsos and made a valuable contribution to the investigation.

The Widerøe Pilots' Union assisted the AAIB/N with the interpretation of the Cockpit Voice Recorder tape.

## SUMMARY

On 27 October 1993, at 19:16:48 hours, a Twin Otter LN-BNM hit the ground and crashed while approaching runway 26 at Namsos airport. The aircraft was operating as Widerøe flight (WF) 744 from Trondheim Airport, Værnes, to Namsos, with a crew of 2 and with 17 passengers. The accident took place after dark and in overcast weather, in heavy rain showers and in a comparatively strong wind. A short time after the aircraft passed the Namsos radio beacon on an instrument approach, the copilot got the airfield in sight. The captain, who was piloting the aircraft, discontinued the instrument flying and changed to manoeuvering the aircraft by visual

references. The aircraft was set into a relatively steep descent. At 500 ft, indicated on the pressure altimeter, the captain said that he wanted to maintain that altitude, but the aircraft still continued a shallow descent. This resulted in the aircraft hitting the ground at altitude of 392 ft, approximately 6 km from the airfield. The crew and 4 of the passengers died. The other passengers escaped with varying degrees of injuries.

Subsequent investigation of the history of the flight has led to the conclusion that the aircraft was airworthy and that the crew was in control of the aircraft when it hit the ground. Descent without visual reference to the ground below was the last link in the chain of events. Other links in the chain were, among others, lack of approach planning, wrong wind corrections, lack of vigilance in relation to aircraft height above the ground and aircraft position. Also poor crew cooperation was found. The AAIB/N has, in addition, conducted a system directed, flight safety investigation, with particular reference to the air operational support functions and other important elements of management activities in the organisation of Widerøe's Flyveselskap AS (Widerøe's Airlines). This investigation has also included the Civil Aviation Administration of Norway's position with regard to regulations and company inspections. This part of the investigation has revealed weaknesses in flight safety, a potential for improvement in, for example, internal control and quality assurance, standardisation and procedures, regulations, attitude-creating flight safety work, reporting, risk analysis and management relations in general.

# 1 FACTUAL INFORMATION

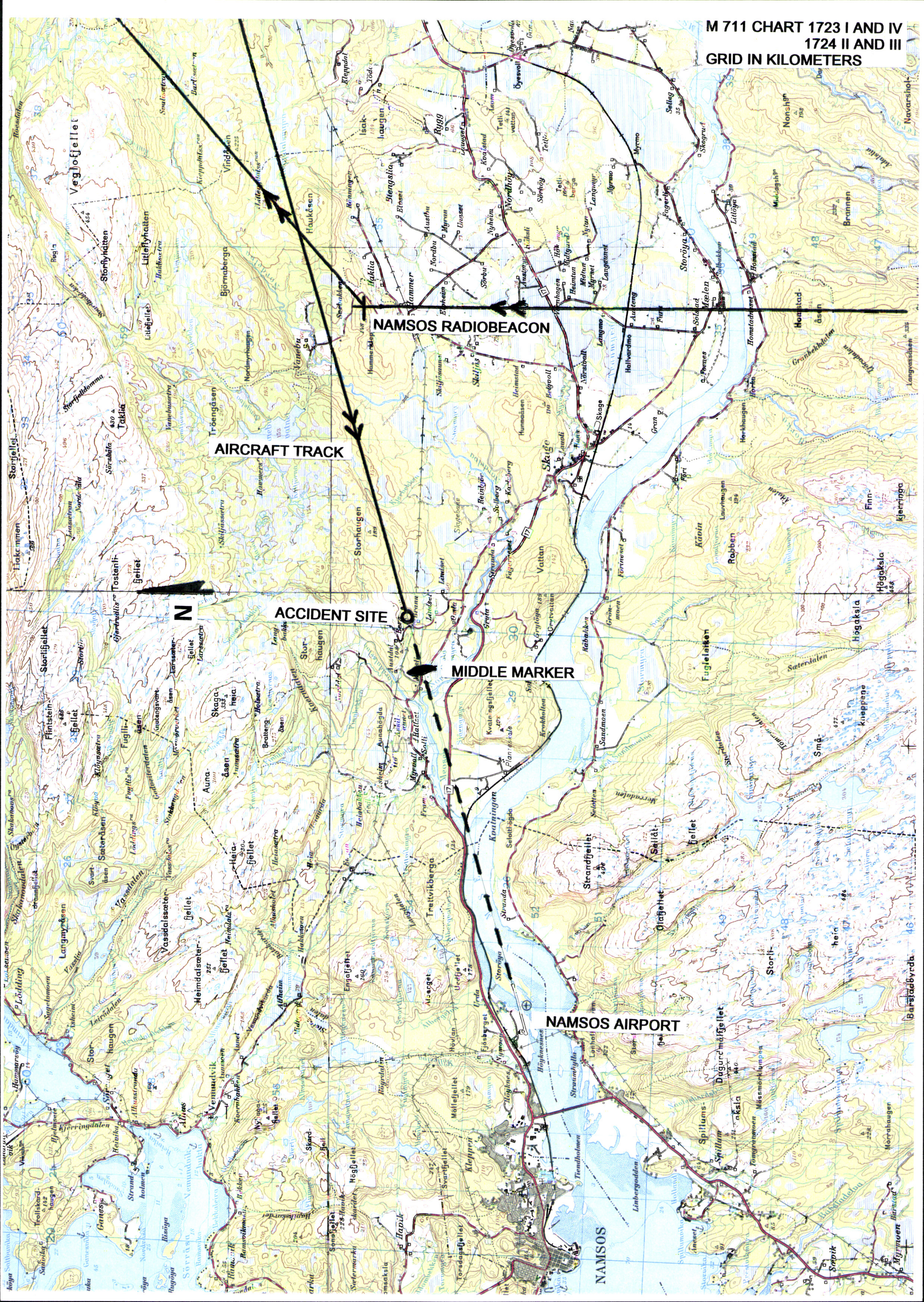
## 1.1 History of the flight

1.1.1 The crew, which comprised a Pilot-in-Command (PiC) and a co-pilot, began their turn of duty at 13:30 hours on 27 October 1993. Their flight schedule was that they would cover flights WF 711 and WF 744, i.e. the following route segments:

WF 711: Bodø - Sandnessjøen - Mosjøen - Brønnøysund - Rørvik - Trondheim, and

WF 744: Trondheim - Namsos - Rørvik, including an overnight stop.

1.1.2 After receiving weather information from the Meteorological Office, the aircraft took off from Bodø airport at 14:02 hours. Mosjøen was bypassed en route to Trondheim owing to the weather conditions there. Apart from this, the other planned intermediary stops were made. The aircraft landed at Trondheim airport Værnes at 17:52 hours.


M 711 CHART 1723 I AND IV
1724 II AND III
GRID IN KILOMETERS
NAMSOS RADIOBEACON
AIRCRAFT TRACK
N
ACCIDENT SITE
MIDDLE MARKER
NAMSOS AIRPORT
NAMSOS

1.1.3 17 passengers boarded at Trondheim and 136 kg of baggage was loaded onto the aircraft. A standard IFR flight plan for flight WF 744 was stored at the Air Traffic Control. The flight time was given as 35 minutes (40 minutes block time according to the time table). The aircraft's endurance was given as 1 hour 55 minutes, Værnes being the alternate airport.

1.1.4 WF 744 took off from Trondheim on an IFR flight plan at 18:37 hours. The aircraft climbed to a cruising altitude of 5,000 ft, which was maintained until the crew made the procedure turn, the "base turn", during the instrument approach to Namsos. The PiC flew the aircraft while the co-pilot handled radio communications and read the check list. The flight was controlled by the Værnes Approach radar until 18:53 hours. The crew was then instructed to contact Namsos AFIS (Aerodrome Flight Information Service). The position at that point in time was 29 NM from Trondheim (TRM) VOR. Thirty seconds later a satisfactory radio contact had been established with Namsos AFIS, and Namsos was at the same time informed that WF 744 was at 5,000 ft, approaching the Namsos radio beacon. AFIS replied as follows:

> "744 Roger. Wind 250 at 25 knots, max 36, 10 kilometers, rainshowers, scattered clouds 2,000, broken at 2,500, temp is +7 and the QNH 1017".

WF 744 acknowledged by repeating "1017".

1.1.5 At 18:58 hours the Pilot-in-Command asked for the descent checklist, and both pilots checked that they had set the correct QNH, 1017 hPa. The PiC's altimeter read 4,950 ft, while the co-pilot's read 4,900 ft. The Pilot-in-Command then briefed on the approach procedure to Runway 26 in detail (ref. Appendix 1):

> "Well, we will reduce altitude gradually to 4,000 ft, overhead beacon out on QDR 050. We can descend to 3,000 ft in one-and-a-half minutes. It will be a right turn in for a heading of 255 or localizer 255. Established inbound, we can go to 2,100, Namsos beacon inbound. Thereafter the minimum altitude in(bound) is 1,100 ft, with 1.2 kilometers visibility. Pull up - we'll do that over the marker - we can set it to high. The pull-up will go straight ahead via Leirvika to 4,000 ft."

1.1.6 Just after this the PiC acknowledged that he would maintain 5,000 ft until the aircraft was roughly above the radio beacon, because they had plenty of time. The co-pilot indicated that they knew there would be a headwind in the final stage of the approach procedure by saying:

> "we'll be standing still on the way in".

At 19:01 hours the Namsos AFIS updated the crew with the following:

> "744, wind 260 at 27 max 40".

This prompted the crew to say that the wind direction was fine and that the wind would be coming straight at them. The co-pilot then intimated that it might be an idea to add a little more altitude in the (base) turn and the PiC agreed. He revised his plan for the approach saying:

> "when we start the procedure turn we'll drop altitude gradually to 4,000 ft and maintain that altitude until we are established in".

He judged the wind to be so strong that it was not recommendable to descend to minimum altitudes and that it would be more appropriate to increase altitude by 1,000 ft. A short while later the receiver (Nav 1) was set to the Namsos localizer and identified, and the inbound course of $255^0$ was set in the PiC's Horizontal Situation Indicator (HSI).

1.1.7 At 19:05 hours the Pilot-in-Command asked for the Approach Checklist, and the co-pilot confirmed that the Descent Checklist had been completed. They started to go through the Approach Checklist by rechecking the altimeters. Both pilots confirmed that they had set QNH 1017 hPa, and that both altimeters now displayed identical readings, i.e. 5,000 ft. The bug in the radio altimeter was set to 200 ft, and the procedure for removing any ice on the aircraft's wings and tail surfaces was carried out, after which they reported:

> "Wings good".

When WF 744 approached Namsos radio beacon (NDB) the co-pilot also set $255^0$ on his HSI and identified the Namsos localizer on the Nav 2 receiver.

1.1.8 At 19:07:17 hours, over Namsos NDB, the PiC reported:

> "Yes, out on QDR 050" (The Q-code: magnetic bearing from the radio beacon)

and the co-pilot acknowledged this with:

> "050 for one-and-a-half minutes".

The Pilot-in-Command turned to the right and started flying QDR $050^0$, descending to an altitude of 4,000 ft. At 19:07:30 hours the co-pilot reported

"Namsos beacon outbound"

to the AFIS. At 19:08:42 hours the Pilot-in-Command commented that the co-pilot had started his stopwatch the moment they passed the radio beacon, while he had started his as soon as they were established on the new heading. 8 seconds later he wanted a confirmation that they were supposed to go so far out as they were getting a DME reading of 12-13 NM, but the co-pilot reported that the map said that it should be a 11 NM turn. At 19:09:02 the co-pilot said:

"11 miles then. We can add on a little bit."

and the Pilot-in-Command agreed, as they had plenty of time and did not have an altitude problem, either. At 19:09:13 hours the co-pilot said:

"Two minutes gone by according to my watch"

and the Pilot-in-Command answered:

"Well, let's go in, then".

1.1.9 At 19:09:17 hours the AFIS issued them with another weather report update:

"744, a heavy rain shower, but visibility seems to be good just the same".

The co-pilot acknowledged receipt of the report.

1.1.10 At 19:10:30 hours the aircraft closed in on the approach centre line and the co-pilot reported:

"Localizer alive"

and then asked the AFIS for a

"Q-D-Mike check" (Q code: magnetic course to airfield)

The AFIS responded:

"Q-D-Mike 255"

The Pilot-in-Command's reply was:

"Well, that'll be 2,100 we're descending to",

and the co-pilot commented that they were receiving Namsos radio beacon loud and clear. A minute later the Pilot-in-Command said that he had reduced speed slightly to make allowance for the turbulent flying conditions he was expecting.

1.1.11 At 19:13:41 hours the crew received new information about the wind conditions at the airfield:

"744, the wind 260 at 28 max 36".

A new check confirmed that they were on QDM 256. This was the last communication between the AFIS and WF 744. At 19:14:01 hours the co-pilot said that they were flying at 2,100 ft, and that they should fly in to 6 NM, with 1,100 ft as the next altitude. The PiC agreed. The crew then carried out the de-icing procedure once again and reported that both wings looked fine.

1.1.12 At 19:15:13 hours they passed the Namsos radio beacon inbound and the PiC said:

"Well, let's say 1,100 next time, then" (the AFIS was not informed).

The co-pilot acknowledged and asked whether he should tune Leirvika radio beacon on receiver One or Two. The Pilot-in-Command asked him to tune both receivers to this beacon. 30 seconds later the co-pilot confirmed the reception was loud and clear. While the he was doing this, he reported, at 19:15:30 hours, that he had

"field in sight, actually"

and the PiC replied:

"Yes, but that's good"

A little later he said that he did not want to set the flaps yet because of the danger of overspeeding them. Both pilots commented on how slowly they proceeded and on the low groundspeed.

1.1.13 At 19:16:35 hours the Pilot-in-Command reported:

"We're now at 500 ft"

and the co-pilot acknowledged this with a:

"Yes"

Four seconds later the Pilot-in-Command added:

"We should not go much lower."

and the co-pilot replied with a:

"No"

1.1.14 At 19:16:48 hours the aircraft hit the ridge of a hill, approximately 6 km (3,3 NM) from the airfield, and crashed. The crew and 4 of the 17 passengers died. The emergency signals emitted by the aircraft were received at the control tower and a search and rescue operation was mounted.

## 1.2 Injuries to persons

| INJURIES | CREW | PASSENGERS | OTHERS |
|---|---|---|---|
| FATAL | 2 | 4 | |
| SERIOUS | | 13 | |
| MINOR/NONE | | | |

## 1.3 Damage to aircraft

The aircraft was destroyed.

## 1.4 Other damage

Trees in the accident area were damaged.

## 1.5 Personnel information

### 1.5.1 The Pilot-in-Command

1.5.1.1 The Pilot-in-Command, male, aged 43, held a Class 2, senior commercial pilot licence for single- and multi-engine land aircraft weighing up to 5,700 kg, with type approval for a DHC-6. The licence was issued on 4 January 1993 and was valid until 20 November 1993, He underwent his last medical examination on 3 May 1993. The Pilot-in-Command had an approved and unrestricted medical certificate.

1.5.1.2 The Pilot-in-Command started his basic training at the Nedre Romerike Flying Club with a PPL licence, which he received in 1974. In 1976 he extended his certificate to include single-engine sea planes weighing up to 2,000 kg. On 16 June 1979 he received a Class 3 instructor certificate for single-engine aircraft. The Pilot-in-Command underwent training at Wing Car Air Service and Ascor Flying School.

He was employed by Widerøe Airlines on 6 November 1985. After training and an in house school examination conducted by Widerøe, he received a Class 2, senior commercial pilot, licence on 4 January 1993. He was promoted to Captain on 20 January 1993.

1.5.1.3 The Pilot-in-Command had acquired a total flight time as of 19 October 1993 of 4,835 hours, 1,998 hours of which were on Twin Otter aircraft. Periodic Flight Training (PFT) was last carried out on 21 June 1993.

| FLYING EXPERIENCE | TOTAL | ON TYPE |
|---|---|---|
| LAST 24 HOURS | 2:54 | 2:54 |
| LAST 3 DAYS | 2:54 | 2:54 |
| LAST 30 DAYS | 38:37 | 38:37 |
| LAST 90 DAYS | 99:17 | 99:17 |

1.5.1.4 The Pilot-in-Command had landed 13 times at Namsos airfield over the previous 12 months.

1.5.1.5 The Pilot-in-Command had had a 7-day rest period prior to commencing duty on 27 October. At the time of the accident he had been on duty for approximately 6 hours.

1.5.2 The co-pilot

1.5.2.1 The co-pilot, aged 34, had undergone training in the USA and had an American licence, "Airline Transport Pilot III, rating and limitation: airplane multi-engine land, commercial privileges, airplane single-engine land and sea". This licence was converted to a Norwegian Class 2, senior commercial pilot licence on 22 June 1988 and was valid for single and multi-engine land aircraft weighing up to 5,700 kg. The licence was valid to 19 January 1994. He underwent his last medical examination on 12 January 1993, which included the proviso that glasses should be used when on flight duty.

1.5.2.2 The co-pilot received his basic training in the USA. In 1981 he attended the flying school North American Institute of Aviation in Conway, South Carolina. He carried on flying in the USA, flying instruction and charter planes for Angel Aviation Inc. in Slidell, LA. In 1987 he was employed by Partnair AS, Oslo, as a co-pilot, where he flew Beech 100, Beech 200 and Convair 580 aircraft. On 3 December 1990 he was employed as a co-pilot by Widerøe Airlines to fly Twin Otter aircraft.

1.5.2.3 The co-pilot had acquired a total flight time as of 26 July 1993 of 6,354 hours, 1,365 hours of which were in Twin Otter aircraft. At the time of his employment by the company he had accumulated 3,441 hours as a Pilot-in-Command.

| FLYING EXPERIENCE | TOTAL | ON TYPE |
|---|---|---|
| LAST 24 HOURS | 2:54 | 2:54 |
| LAST 3 DAYS | 2:54 | 2:54 |
| LAST 30 DAYS | 34:50 | 34:50 |
| LAST 90 DAYS | 96:49 | 96:49 |

1.5.2.4 The co-pilot had landed 27 times at Namsos airport over the previous 12 months.

1.5.2.5 The co-pilot had had a 7-day rest period prior to commencing flight duty on 27 October. At the time of the accident he had been on duty for approximately 6 hours.

## 1.6 Aircraft information

1.6.1 Registration, certificate of airworthiness and maintenance

1.6.1.1 The aircraft was purchased as new by Widerøe Airlines in 1974 and was recorded in the Norwegian Civil Aircraft Register on 3 April of the same year as having Registration Certificate No. 1371 and Norwegian registration letters LN-BNM. Its

Certificate of Airworthiness was last renewed on 24 November 1992, and was valid until 31 December 1993. Maintenance was carried out on LN-BNM in accordance with the regulations current at the time, and the aircraft was airworthy at the time of the accident.

1.6.1.2 *Aircraft details*

| | |
|---|---|
| Manufacturer: | The de Havilland Aircraft of Canada Ltd<br>Downsview, Ontario, Canada M3K 1Y5 |
| Type: | DHC-6-300 Twin Otter |
| Serial number: | 408 |
| Year of manufacture: | 1974 |
| Total aircraft time: | 40, 453 hours |
| Engine type: | PT6A-27, Pratt & Whitney of Canada |
| Serial numbers: | Engine 1: GG: 41 783<br>PS: 41 897 |
| | Engine 2: GG: 40 619<br>PS: 40 939 |
| Engine operation hours: | Engine 1: GG: 8,163 hours<br>PS: 8,163 hours |
| | Engine 2: GG: 2,632 hours<br>PS: 4,354 hours |
| Propeller type: | HCB3TN3DY, Hartzell |
| Serial number: | Propeller 1: BU9821 C<br>Propeller 2: BU2806 C |
| Operation hours: | Propeller 1: 22,718 hours<br>Propeller 2: 39,412 hours |

### 1.6.2 Weight and balance

Calculations made by the AAIB/N show that the aircraft's weight at the time of take-off from Værnes was approximately 5,460 kg and that its centre of gravity was at station 214.80, equivalent to 34.0 % MAC. The maximum permissible weight at take-off was 5,675 kg. The rear centre of gravity limit was at station 216.32, equivalent to 36.0 % MAC, while the forward limit was at station 203.84, equivalent to 20.0 % MAC. At the time of the accident the aircraft had consumed approximately 180 kg of fuel, calculated from the time of take-off. The centre of gravity had thus shifted backwards to position 215.30, equivalent to 34.6 % MAC. In other words, both the weight and the position of the centre of gravity were within permissible limits both at the time of take-off and at the time of the accident.

Ground services at Værnes were handled by the company's agent, Scandinavian Airlines System (SAS), in accordance with set instructions and established practice. Rather than using Widerøe's simplified system to calculate weight and balance, SAS used a computer-generated load sheet, Palco, developed to comply with IATA standards. On the load sheet handed to the Pilot-in-Command prior to take-off, it was computer calculated that the passengers were seated in accordance with a standard seating distribution. As the actual passenger seating did not conform to this pattern, the Pilot-in-Command corrected the seating arrangement on the load sheet. In addition to this, the Dead Loaded Index (DLI) was corrected from 69.51 to 96.5, which was an incorrect value. This shows that the Pilot-in-Command used established practice to check the aircraft's trim in relation to the actual passenger seating. According to Widerøe's simplified system (for the 20 pax version), the seats in row 7 should be blocked when there are 17 or fewer passengers on board. This requirement does not apply when Palco is used and the current trim is checked when the actual passenger seating arrangement deviates from the normal arrangement. DLI 69.51 should, in this case, be modified using an index correction of -16 because of the 4 passengers in seat section A, an index correction of +25 because of the 5 passengers in seat section C and an index correction of +28 because of the 3 passengers in seat section D, giving a total index (mixed version) of 106.5. The Pilot-in-Command should then check that the corrected index falls between the minimum and maximum index in relation to the current take-off weight for a "mixed cargo / pax version" category aircraft. In the case in question, the take-off weight was 5,480 kg (Palco), giving a permissible index of between 75 and 106. In other words, with the correct check calculation giving index 106.5, one or more of the passengers should have been moved forward and a new check calculation made. On the trim formula WF 744 was using there was only a ring round 17 pax in the "20 pax version" column. As the "Balance calculation" column was not filled in, it is natural to assume that the Pilot-in-Command had made a mental calculation and obtained an answer of 96.5 instead of 106.5. As 96.5 falls within the min/max index the passengers were allowed to sit wherever they liked.

1.6.3 Fuel

The fuel used was Jet A-1. Analysis of samples from the system from which the aircraft was last refueled indicate normal values for all parameters.

## 1.7 Meteorological information

### 1.7.1 Meteorological information from Namsos AFIS

The crew of LN-BNM received the following meteorological information from Namsos AFIS at 17:53:47 hours UTC:

> "wind 250 at 25 knots max 36, 10 kilometers plus, rainshowers, scattered clouds 2,000 broken at 2,500, temp is plus 7 and the QNH 1017".

At 18:01:24 hours UTC:

> "744, wind now 260 at 27 max 40"

At 18:13:41 hours UTC:

> "744, wind 260 at 28 max 36"

### 1.7.2 Weather report from the Meteorological Office at Flesland

The AAIB/N received the following weather report (an aftercast) from the public meteorologist on duty at the Meteorological Office at Bergen Airport, Flesland in relation to the accident (all times in this part of the report are UTC times):

> "Weather conditions: the centre of the storm NW of Finnmark moved rapidly eastwards. The cold front between Southern Norway and Northern Sweden moved in a south-easterly direction and was followed by a marked low-pressure trough or a second cold front on its way past the area of the accident when the accident took place. The wind direction ahead of the front was 240-260 degrees, and after the front passage, 270-300 degrees. Wind speeds were high both in front of and behind the trough. Observations made at 18:00 hours by some of our synoptic stations on the coast (observations are rounded up to the nearest 5 kts, while the maximum mean is an exact figure).

| | OBS WIND | Max. mean since 12:00 |
|---|---|---|
| Sklinna: | 030/45 kt | |
| Norøyan: | 260/45 kt | 47 kt |
| Leka: | 260/35 kt | 37 kt |
| Buholmråsa: | 230/30 kt | 30 kt |
| Halten: | 250/40 kt | 45 kt |

METARs from Namsos:

| | |
|---|---|
| 16:50 UTC: | 24026G36 kt |
| 17:50 UTC: | 26026G37 kt |
| 19:09 UTC: | 27021G34 kt |
| 19:50 UTC: | 27021G34 kt |
| 20:10 UTC: | 27020G34 kt |

Prognostic values for upper wind over the area at 18:00:

| | |
|---|---|
| FL 050 | 290/50 kt |
| FL 100 | 300/60-70 kt |

Observed values for upper wind:

| | |
|---|---|
| Approx. 14:00 hrs: | Flornes East of Værnes: 4,000 ft: 270/60 kt |
| 18:57 hours: | East of Selbusjøen: FL 100: 310/85 kt (B 737) |
| | East of Værnes: FL 070: 90 kt (A Braathens flight, time uncertain) |

With regard to the last observation, the Pilot-in-Command was uncertain if the value was a true one, or whether the navigational equipment gave an incorrect value. The consultant at the Værnes indicated that 60-70 kt was a more likely value.

Radiosonde observations at 12:00 hours:

| | FL 050 | FL 100 |
|---|---|---|
| Bodø: | 270/51 kt | 270/53 kt |
| Ørland: | 270/52 kt | 290/55 kt |

Turbulence and icing:

We received no observations of turbulence at lower levels. At 16:45 hours a Cessna 310 reported moderate icing at FL 120 - FL 100 40 NM S of ENBN. This report immediately led to the issuing of an ICE MESSAGE FOR ENTR FIR.

Owing to the strong upper winds, turbulence was reported in the following IGA warnings:

| | |
|---|---|
| At 16:54 hours: | (Valid 18-03) TURB: MOD in the northerly sector<br>ICE: MOD in the northerly sector |
| At 19:33 hours: | (Valid 21-06) TURB: MOD, LOC MOD/SEV<br>FIRST HRS (northerly sector)<br>ICE: MOD (northerly sector) |

Because of the direction the wind was blowing (onshore) and the absence of reports of turbulence, I did not consider it necessary to send a SIGMET for turbulence (i.e. to warn for SEVERE TURBULENCE).

Weather, visibility and clouds

There was an area behind the first cold front where there was little shower activity and broken clouds mostly of an approx. 2,000-3,000 ft base. The visibility was more than 10 km. The cloud base was lowered slightly when the low- pressure trough moved into the area, and visibility fell to approx. 5-8 km in the rain. A number of synoptic stations in North Trønderlag reported CB-clouds, based on observations at 18:00 hours.

EST MIN QNH ASR HALTEN:

EST MIN QNH was reduced from 1011 (15-18 hours) to 1005 (18-21 hours) owing to the sharp falls in pressure in front of the low-pressure trough It turned out later that the falls in pressure in that area had stopped before the values became too low, and the value was raised again to 1007 (21:00-24:00 hours). There were sharp increases in pressure behind the low-pressure trough.

Crew briefing:

The adviser at Værnes received a telephone call from a Widerøe pilot asking him for an update on the weather at Namsos some time before the accident. It sounded as though he had already obtained weather information by some other means/from somewhere else, and now just wanted to get the latest METAR for Namsos. The adviser at Værnes thinks he then gave him the METAR for Namsos and Rørvik and the TAF for Brønnøysund. He also asked the pilot which airfield he had as an alternative, and the answer he received was Værnes. This was most probably the Pilot-in-Command or the co-pilot from the accident aircraft".

1.7.3 Weather Briefing, Meteorological Office, Bodø

The crew met up at the Meteorological Office in Bodø at approximately 13.30 hours for a briefing prior to WF 711 commencing its southbound flight. The meteorological adviser who conducted the briefing cannot remember anything special about the meeting. At that point in time there were a number of enquiries and a lot of other traffic, and the weather situation was "all right". Strong westerly winds accompanied by sleet and snow were blowing in from the ocean, and the weather was similar further south along the coast.

1.7.4 Telephone weather briefing. Meteorological Office, Værnes

One of the WF 744 crew telephoned the Meteorological Office at Værnes and was given the METAR for Namsos and Rørvik and the TAF for Brønnøysund.

1.7.5 Information on weather conditions in the accident area

According to witnesses in the accident area, it was dark and overcast at 19:00 hours, with heavy rain showers and a strong wind from the west.

1.7.6 Weather information provided by passengers

According to the passengers on board WF 744 the weather was rough all the way from Værnes. Turbulence increased in the final 15 minutes prior to the accident.

1.7.7 Meteorological information provided by a helicopter

A helicopter which took part in the salvage operation reported partial severe turbulence between Namdalseid and Namsos.

1.7.8 Information on the heavy shower over Namsos

1.7.8.1 The AFIS duty officer at Namsos has explained that a heavy shower of rain had gone past the control tower, and that the crew of LN-BNM had been informed of this at 19:09:17 hours. However, there was a good cloud base and visibility underneath. The shower lasted for more than 3 mins. and possibly as long as 10 minutes.

1.7.8.2 According to the AAIB/N's meteorological expert, the typical extention of a shower in this part of the country is between 5 and 10 km. Under the prevailing conditions, a shower would have been steered by the wind at between FL 100 and FL 50, i.e. $290^0$/60 kt, as long as it was over the sea, but from experience the shower would have slowed down over the land to a course and speed similar to the surface wind (reported at $260^0$/28-36 kt at 18:13:41 hours) i.e. westerly at approx. 30 kt. If the centre of the shower had gone past the tower at a speed of 30 kt in the space of 5 mins. it would have meant that the shower measured 4-5 km, and if it had taken 10 mins. to go past, it would have measured approx. 9 km. Large drops buffeted the tower as the shower passed. Downdrafts may have also been present with the heavy rain. In conditions like these, stratus clouds often form underneath the shower as a result of the high humidity. This locally produces a lower cloud base. The stratus will stay with the the shower.

1.7.9 Light conditions

It was dark when the accident took place.

## 1.8 Aids to navigation

1.8.1 Current navigational aids available at Namsos Airport

- Namsos NDB, NMS 329 kHz, 5.8 km east of the threshold to Runway 26
- Leirvika NDB, LVK 248.5 kHz, 7.4 NM west of the threshold to Runway 08
- Localizer NA 108.5 MHz for approach to Runway 26
- Distance Measuring Equipment (DME) paired to the same frequency as the localizer
- A middle marker beacon, MM, 2.8 NM from the threshold to Runway 26
- A PLASI (Pulse Light Approach Slope Indicator) is located on the left-hand side of the threshold of Runway 26 (MEHT 35 FT). The PLASI was set to a 5.1° slope according to NOTAM dated 27 October (found at the accident site). The accident site is outside the area in which the crew could have made use of this navigational aid. (At a distance of more than 3.8 km, for example, both the minimum altitude of 1,100 ft and the altitude of the accident site are in the red sector.)

- The approach lights to Runway 26 were originally a single row 200 metres long with low- and high-intensity lights. There was also a transverse row furthest from the runway with a flashing white light in the middle. The transverse row had previously been damaged by ice and had not been replaced prior to the accident. The lights that remained, a single row 160 m long, were operating at full strength.

1.8.2 Check flight of navigational equipment at Namsos Airport

1.8.2.1 On the night to 28 October 1993 the Norwegian Civil Aviation Administration's check aircraft, LN-FOM, was used to carry out a check flight. The recorded results from this flight showed that the navigational equipment at Namsos airport was within the ICAO's tolerance requirements.

1.8.2.2 On 4 November 1993 a further check flight was carried out in the daytime and in good weather conditions, and a video of this was also made. All navigational aids were operational during the check flight. The PLASI was visible out to Namsos NDB.

1.8.3 Navigational equipment on board

1.8.3.1 LN-BNM was equipped with the following flight instruments and navigational aids:

- 2 compass units
- 2 VHF NAVs with DME and DME HOLD functions which enable the aircraft's ground speed to be read off
- 2 marker beacon receivers
- 2 radio compasses (ADFs)
- 1 radio altimeter

1.8.3.2 There were no reports of any unusual performance of the navigational equipment on board, nor was there any indication of any malfunction taking place during the approach.

### 1.8.4 Ground Proximity Warning System (GPWS)

The aircraft was not equipped with a GPWS. This was not required.

### 1.8.5 Radar

The flight was registered by a military radar station. Plotting of recorded data indicates that WF 744 passed Namsos NDB at approx. 18:08:14 UTC at an altitude of 5,000 ft. The times logged at the radar station differ from those recorded by Værnes Approach and Namsos AFIS, being approximately one minute later. The aircraft followed the planned track outbound from the radio beacon and started to reduce altitude as planned. At the last reliable update at 18:10:38 hours UTC, the altitude recorded was 4,200 ft (Mode C). Recorded positions at 18:10:32 hours UTC and 18:10:38 hours UTC indicate that the aircraft made the right turn somewhat further out than the base turn prescribed in the approach chart. The last ascertainable position, at 18:10:38 hours UTC, was QDR 053$^0$ (from NMS NDB) at a DME distance of 13.5 NM.

## 1.9 Communications

### 1.9.1 Communications between the crew and the control and information units

All communications between the crew and the various control and information units have been made available to the AAIB/N.

### 1.9.2 Tape recorder and print-outs from ATCC and AFIS

The AAIB/N had received audio tapes and print-outs from Trondheim ATCC and Namsos AFIS. Communications between the units in question were normal.

## 1.10 Aerodrome information

Not applicable.

## 1.11 Flight recorders

Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) are not mandatory for this type of aircraft. The company has, however, invested in CVRs of its own volition for the entire company's Twin Otter fleet.

### 1.11.1 Cockpit Voice Recorder

1.11.1.1 The CVR was a Sundstrand P/N 980-6005-056, Serial No.S/N 7075, and was installed in the aircraft tail section.

1.11.1.2 The AAIB/N does not have the necessary expertise to open, play back or interpret information from flight recorders, so the AAIB/N requested the assistance of the UK Aircraft Accident Investigation Board (AAIB), based in Farnborough, England, who placed their laboratory and their experts at the disposal of the AAIB/N. Specialists are required to carry out this work, as damage inflicted as the result of an accident can lead to the deletion of information.

1.11.1.3 To ensure that the information on the voice recorder tape was correctly interpreted, the AAIB/N, in line with established practice, requested the cooperation of a representative from Widerøe's Pilot Union. The pilot who was selected met the AAIB/N's representative at Farnborough. He was well-acquainted with this type of aircraft and with the company's operations involving the aircraft type, and he knew the crew. The opening of the CVR, the playing back of the tape and the subsequent interpretation of the information on the tape, were all carried out successfully.

1.11.1.4 Information on the tape relating to flight safety, which had a bearing on the future operation of this type of aircraft, was immediately conveyed to the Norwegian Civil Aviation Administration (CAA/N).

## 1.12 Wreckage and impact information

### 1.12.1 The accident site

The accident took place at a ridge of a hill approx. 6,150 m (= 3,3 NM) from the threshold of Runway 26 at Namsos airport. The accident site was a sparsely wooded area made up of small and medium-sized trees. The first contact the aircraft had with the ground was with a tree 392 ft (119.4 m) above sea level. The terrain slopes slightly upwards and then slopes slightly downwards again to the west along the flight path towards the airfield. The ground in the opposite direction slopes down towards a shallow valley. The accident site itself, from the point where the aircraft came into contact with the tree to the point where it came to rest, extended for approx. 150 m. The elevation of the ground in the area rose from 114 m to 118 m and then decreased slightly to 108 m.

1.12.2 The track of the aircraft when it hit the forest was 261 $^0$T. The aircraft banked between $2^0$ and $4^0$ with the left wing low.. The aircraft was in almost horizontal flight, approx. $1^0$ down. It initially hit the ground very close to the extended center line on Runway 26, and then, approx. 25 m from that initial point, the aircraft's right propeller cut off a pine tree. The resultant torsional moment on the engine mounting caused the engine to break loose. The nose of the aircraft hit the ground approx. 55 m away from where the aircraft initially hit a tree, and the force of the impact caused the left engine to come partially loose, with the result that the propeller cut into the front part of the fuselage. The aircraft was then thrown clear of the ground again, and carried on going for approx. 40 m before it hit the ground again. The main site of the wreckage was approx. 150 m away from the initial point of impact.

1.12.3 The aircraft wreckage

1.12.3.1 The aircraft's damage pattern, broadly speaking, consisted of the cockpit being pushed in by the impact forces, both engines breaking loose from their wing mountings and the cabin structure giving way owing to an extensive crack which appeared right behind the trailing edge of the wings and close to the main door of the aircraft.

Relevant readings from the aircraft's instruments were as follows:

| | |
|---|---|
| Clock, left: | Smashed, stopped at 19:17 |
| Transponder: | X332 (first figure unreadable) |
| ADF 1: | 284.5 kHz |
| ADF 2: | 284.5 kHz |
| HSI, left: | HDG $303^0$, needle at $256^0$ |
| HSI, right: | HDG $282^0$, needle at $239^0$ |
| Altimeter, left: | Sub-scale 1017 hPa, 0 ft. (94 10 28, 14:28 hours, accident site) |
| Altimeter, right: | Sub-scale 1018 hPa, -1,000 ft. (94 10 28, 14:45 hours, accident site) |
| Com 1: | 117.975 MHz |
| Com 2: | 121.5 MHz |
| Nav 1: | 108.5 MHz |
| Nav 2: | 108.5 MHz |
| Radio altimeter: | 'Bug' at 200 ft, reading of 10 ft, flag displayed |

1.12.3.2 The flap selector handle was found in the $10^0$ position. The hydraulic actuator for pushing out and pulling in the wing flaps indicated that the flaps were all the way in at the time of impact. A minute before the accident the Pilot-in-Command stated that he did not want to select any flaps because he was afraid of overspeeding them.

1.12.3.3 The switches on both marker beacon receivers were in the OFF position. According to company procedure, the switches are to be set to HI when outbound and LO when inbound. According to the information from the CVR, at least one of the switches had been set to 'HI' in accordance with the Descent Check List, but was not set to LO when inbound. The passing of the marker beacon would be marked more accurately with the switch in the LO position. However, the AAIB/N has been informed that a number of pilots set the switch to HI as it can happen that the marker beacon does not register when the switch is set to LO. The possibility of the switches changing position during the accident or during the salvage operation cannot be ruled out.

## 1.13 Medical and pathological information

1.13.1 Post-mortem examination conducted on the crew

1.13.1.1 On examination of the bodies, no traces of alcohol, drugs or medication were found in either of the crew members.

Post-mortem examinations conducted on the deceased crew members and passengers revealed injuries consistent with the deceleration forces and damage incurred to the aircraft at the time of the accident.

1.13.1.2 While searching through the wreck the police found medicines belonging to the co-pilot of the aircraft, which had been prescribed to him for back pain at a consultation in November 1991 by a specialist physician in aviation medicine (the co-pilot was wearing company uniform during the visit). The use of these drugs is not compatible with the carrying out of flying duties. Both the Aviation Medical Board of Norway and the AAIB/N's medical specialists are of the opinion that the consulted physician should have chosen a different type of medication, as he had received basic training in aviation medicine through a course at the Institute of Aviation Medicine.

This visit to the doctor was not mentioned in the co-pilot's Medical Assessement Form when applying for his licence renewal. (This is a form used by the CAA/N in connection with medical examination for licence renewals.) As was mentioned, no trace of any such drugs was found when the post-mortem was conducted. However, the certifying authority - the Medical Aviation Board - were unaware that there had been any major circumstances affecting the co-pilot's state of health over the previous two years.

## 1.14 Fire

There were no signs of fire on board.

## 1.15 Survival aspects

The deceleration forces were greatest at the front of the aircraft, as the aircraft hit the ground nose first. Also, the outer part of the right wing was torn off. This led to such heavy stress on the cockpit structure and cabin structure that it partially gave way, particularly on the right-hand side. The fact that the left engine mounting could not stand up to the forces applied to it, resulted in the propeller cutting into the fuselage causing severe damage to the left-hand side of the cockpit. These factors resulted in the crew and passengers in seat rows 1 to 4 to the right suffering fatal injuries. All the passengers who sat on the left and in seat row 7, as well those who sat on the right in seat rows 5 and 6, survived the accident.

A modification made to the wings' rear mountings prevented the wings from swinging forward. This was previously a potential cause of damage in the cockpit area. Fuel released when the aircraft broke up meant that there was a risk of fire breaking out. A significant factor which reduced the risk of fire was the rainy weather and the wet ground which in a short time diluted the fuel concentration to a non-flammable level.

## 1.16 Tests and research

### 1.16.1 Inspection of the pressure altimeters

When the aircraft's pressure altimeters were found at the accident site, the left one read 0 ft and the right one -1,000 ft. They were inspected later in the laboratory at the Royal Norwegian Air Force Air Materiel Command (RNoAFAMC) at Kjeller. The conclusion of the inspection was that both altimeters were functioning and giving readings which were within the prescribed margins for error. This in spite of the fact that they had been subjected to strong forces as a result of the of the aircraft's impact with the ground.

### 1.16.2 Inspection of the radio altimeter

The radio altimeter was dismantled and sent to TSB in Canada for closer examination, the conclusion to which was that the instrument had been faulty prior to the accident. After the instrument was returned, the AAIB/N asked RNoAFAMC's instrument workshop to conduct further examinations to evaluate the conclusion. This part of the examination was conducted in the presence of representatives from the Civil Aviation Administration of Norway (CAA/N) and Widerøe Airlines. The result was that the findings which were the basis for TSB's conclusion, could be explained differently: the damage was the result of forces released by the accident itself, rather than the instrument had been faulty prior to the accident.

### 1.16.3 Inspection of the warning light, the DH (Decision Height) light

In order to clarify whether the warning light (DH light) was functional, the light bulb was inspected. This light indicates if the aircraft is flying below an altitude preset with an adjustable index on the instrument face. The filament in the bulb was whole and intact. When voltage was applied it was observed that the lamp gave off a dimmer light than a similar new lamp. The company had modified the electrical circuit by installing a dimmer switch and a resistance of 900 ohms in accordance with De Havilland Custom Avionics (CA) drawing No. 6CA4837. After the accident the dimmer switch was found in the DIM position. During the examination, the original lamp and the new lamp were charged with electric current equivalent to that for a dimmed lamp. The resistance in the original lamp was measured as being approx. 15% higher than in the new lamp, which is assumed to have been caused by the oxidation the filament had been subjected to during normal use. With a constant voltage, the reduction in the amperage will be proportional to the increase in resistance. The effect, which is generated in the filament, is proportional to the square of the amperage, and assumes the form of heat and light. If the relationship between the light and the heat is constant, the light intensity will be reduced by approx. 33 % when resistance is increased by approx. 15 %. The aforementioned oxidization process left a deposit of metal particles on the glass, resulting in reduced transparency.

The conclusion arrived at was that the radiance from the original light bulb was significantly reduced at the time of the accident.

### 1.16.4 Inspection of bulbs from the instrument panel

An inspection was also carried out on nine light bulbs from the section of the instrument panel where the radio altimeter was fitted. These light bulbs had not been smashed in the accident. The lamps had the same shape as the DH lamp, but were of a greater mechanical strength and carried a higher amperage. It must be assumed that because of their function two of these nine lamps had been switched off at the time of the accident. Both of them were whole and had undamaged filaments.

It is also assumed that the other seven bulbs, two of which were undamaged and five of which had damaged filaments, were lit at the time of the accident. Three filaments were damaged in that they were broken, so these three bulbs did not light up during the function test. The other four lamps worked normally. As there were some light bulbs, two of which had filaments that were completely intact, that survived the impact and went on shining, the AAIB/N considers it to be quite possible that a considerably smaller light bulb, such as the DH light, could have been shining and survived the impacts with its filament undamaged.

Having taken all the factors into account, the conclusion is that the radio altimeter and DH light were most probably in working order and functioning prior to the accident.

## 1.17 Organisational and management information

### 1.17.1 Introduction

The AAIB/N engaged SINTEF, the department for Safety and Reliability, to bolster the investigation work being carried out into organisations and management. Two research workers participated in the part of the investigation of the system which involved Widerøe Airlines, and have summarized their observations, evaluations and conclusions in their own report. The source material for this report came to light as a result of cooperation with the AAIB/N who has evaluated its contents and agrees with all the essential points SINTEF has made about the factors covered in the report. Important points are included in the analysis section of the AAIB/N's report.

### 1.17.2 Question bank

The Management Oversight and Risk Tree (MORT) was used as a basis for ensuring that all relevant areas were covered through questions.

### 1.17.3 Widerøe Airlines (Widerøe's Flyveselskap AS, WF)

WF is one of a group of companies within a concern, which, at the time of the accident, comprised:

- Widerøe's Flyveselskap AS (Widerøe Airlines Ltd., WF)
- Widerøe Norsk Air AS
- Widerøe Aero Trade AS

The head office of Widerøe Airlines in Oslo comprises two divisions - the Short Airfield Division and the Operations Division. The Operations Division runs the flight operative and technical side of the executive flight administration from its head office in Bodø. The Operations Division comprised a Technical Department, a Flight Operations Department, a Material Supply Department, a Training Department and an Operations Planning Department. There were, in addition, four line management functions, including a Quality Assurance Department. The Division was headed by a director. The Flight Operations Manager and the Technical Manager were thus, administratively speaking, below the Director of Operations who, in turn, reported to the Chief Executive Officer (CEO). The Flight Operations Department was divided into two main groups - a Training Group and a Control Group.

The board of directors, which consisted of 8 members, included a chairman of the board and two employees' representatives. The general, everyday management was carried out by a management group which comprised the CEO and the directors of the Short Airfield Division, the Concern Staff and the Operations Division .

At the time of the accident the aircraft fleet consisted of 10 DHC-6 Twin Otter, 5 DHC-7 and 4 DHC-8.

The company has a CAA/N Air Operator's Certificate and a licence to commercially operate VFR and IFR flights, as well as a JAR 145 maintenance approval.

1.17.3.1 *Interviews / questionnaire surveys*

A number of interviews were conducted with key staff members of the operational, technical and administrative management, as well as the chairman and some of the board members. A number of conversations with more randomly selected pilots both from the line and from the training organisation also took place. In addition to this, a number of pilots have come forward and informed the AAIB/N of their wish to give their own experiences and views on the way the company is run operationally.

In order to initiate a dialogue with those Twin Otter pilots who wanted to talk with the board, a questionnaire was sent out to 94 pilots currently employed by the company. This survey is below called Question Survey A. The answers were supposed to be anonymous, but a number of thee pilots chose to give their full names to the AAIB/N. Answers were received from 25 captains and 19 co-pilots. Quite a number of the answers that were given demonstrated that a lot of work had been put into them.

Another question survey (Question Survey B) selected 14 pilots at random, and put questions to them about the current approach procedure to Namsos.

1.17.3.2 *Documentation*

The AAIB/N has studied the following documentation in the course of their investigation:

- The Flight Operations Manual, FOM
- The Flight Training Manual DHC-6, FTM
- Guidelines for the Control Group
- Other documentation, e.g. basis for teaching about human factors
- The Quality Manual
- "Quality in Widerøe - Our Little Green One" (a pamphlet which sets out the company's quality assurance policy)
- Administrative Maintenance Manual

A short time after the accident the company hired a consulting firm to inspect and evaluate the company's documentation. The AAIB/N was briefed on the consulting work that was carried out.

1.17.4 The Civil Aviation Administration, Aeronautical Inspection Division

1.17.4.1 One of the Civil Aviation Administration's responsibilities is to formulate Civil Aviation Requirements (Bestemmelser for sivil luftfart, BSL). The Aeronautical Inspection Division is headed by a Director and organised in Flight Standards, an Operations Departement, a Licensing Departement with a Medical Section and an Airworthiness Departement with its Airworthiness, Maintenance and Planning Sections. The Aeronautical Inspection Division will perform case studies and inspections, access checks and surveys on commercial aviation. This also includes surveys of the application in civil aviation of the Health and Safety at Work Act. According to the Aeronautical Inspection Division, surveys and case studies are to be formulated and carried out, with the following aims in mind:

Access check

"that an access check shall determine whether, and ensure that, the aircraft materiel used, and businesses or individuals who wish to enjoy rights within the aviation system, accord with the regulations in force and meet the company's own requirements."

Company inspection

"that a company inspection shall determine whether aircraft material, businesses and individuals that are approved and have been given access to the system, continue to comply with the regulations in force and with the conditions that formed the basis for this approval."

"to give the businesses concerned the opportunity for improvement by correcting any discrepancies which may be ascertained".

Checks, which include those carried out on airline companies, are carried out by technical and operational inspectors who are given one or more airline companies as inspection their areas. Manuals are available which describe how the inspection work for each respective company is to be carried out.

Between 4 March 1991 and 30 November 1993 five operational, or technical and operational, inspections were carried out at WF.

Points of interest arising from the work carried out on this aircraft accident are quoted below from Report No. 91/103 Air Operational Inspection carried out at Widerøe Airlines dated 92 03 17.

Section 2.4:

"Application by the Company of the Internal Control System

The company has an internal control system which is constantly being developed and improved."

Section 2.5:

"Recorded causes and dates for taking corrective action

The company has follow-up routines and systems for taking corrective action. The Flight Operations Manual is revised as required, and 'Flight Orders' are issued as required."

The following quotation is taken from an Operational and Technical Inspection at Widerøe Airlines, Report No. 92/209 dated 92 10 27:

Paragraph 2, Conclusion:

"Widerøe Airlines has built up a structured organisation and a well-organised documentation system."

Paragraph 3, Discrepancy (C20) Observation:

"Adherence to the obligations of reporting and the handling of incidents, item C.

Instructions for working position are general.

Report routines are not satisfactorily described."

(AAIB/N comments as follows: No deadline was given to correct any discrepancy registered as an observation).

The following quotation is taken from the Operational Inspection of Widerøe Airlines, Report No. 93/157 dated 93 12 10 (conducted 93 11 29 - 93 11 30 i.e. after the accident took place):

Paragraph 3. Discrepancies and observations:

"3.1 The company's FOM, paragraph 9.1. page 7 point 17, does not appear to be adequately covered in the training syllabus (Training manual and check lists).

3.2 The technical description and operative use of PLASIs were not found in any of the company's manuals.

3.3 Back-up procedures for the unserviceability of PLASIs were missing.

Observation:

The company should propose an appropriate rewriting of Flight Order No. 55, and that the instructions for the use of radio altimeters should be re-evaluated."

1.17.4.2 *Interviews*

The AAIB/N has looked closely at conditions linked to the Operations Departement and the Maintenance Section of the Airworthiness Departement. Interviews have been carried out with those inspectors allocated to Widerøe Airlines, as well as with the Aeronautical Inspection Division's operational and technical management.

1.17.5 Internal control

1.17.5.1 In 1989 - 1990 the Norwegian Civil Aviation Administration published a brochure, "Guidelines on Internal Control". These guidelines were published in line with the

CAA/N's plan for the introduction of a general requirement for internal control in the aviation companies through the formulation of new regulations. At the time of the accident these new regulations had not been published. The guidelines state that internal control is a systematic method for ensuring that the prescribed air safety standards are met. The air safety standards are defined as a combination of the Authorities' requirements, the aviation companies own requirements and market demand.

1.17.5.2 The requirements for the internal control of the technical aspects of aviation companies is founded in BSL B, Technical Requirements for Aircraft. BSL B 3-2 and 3-3 require that the internal control system be subject to company administrative documentation (BSL B 3-2, paragraph 4.2) and that the system be described in a workshop manual or equivalent, (BSL B 3-3, paragraph 9.2). The following is a quotation from the foreword to BSL B:

> "Should a company wish to formulate and develop regulations and systems which are over and above the minimum requirements, it can do so as long as the company's own requirements form the basis of its internal control and of the safety authority's inspection."

1.17.5.3 The requirements for internal control of the operational aspects of aviation companies are not directly supported in BSL D, Operational Requirements. The following is a quotation from the Operational Requirements for Commercial Aviation, BSL D 2-1, current at the time of the accident:

> "An airline company shall set up and maintain a system of inspection for their air operations, which shall be managed by a manager of operations who is approved by the Civil Aviation Administration."

Furthermore, it says nothing about the form the inspection system should take nor does it say anything about whether or not it should be approved by the inspection authority (the CAA/N).

1.17.5.4 The requirements for internal control, or an equivalent safety management system (quality assurance system) will be set in the near future through the joint European JAA regulations - JAR, which Norway has undertaken to comply with, and which will require there to be a quality assurance system for the whole organisation.

1.17.6 Internal Control - Quality Assurance System for Widerøe Airline, Operations Division

1.17.6.1 In 1990 Widerøe's operations division issued its own principles for internal control in the company's FOM, chapter 6. The introductory lines of this chapter is in fully accord with the CAA/N's own guidelines on internal control. Both documents stipulate five conditions which must be met for internal control to be integrated into the organisation, such that:

A. Company goals and flight safety standard are set.

B. Responsibilities and resources are allocated and work processes organised.

C. Company goals and flight safety standards are followed through with.

D. Discrepancies are being dealt with, and analyses and corrections are made through report systems and feedback.

E. Empirical data are evaluated (consequences, trend analyses).

One of the reasons why the company described the principles of internal control in the FOM was that the company wanted to introduce them at an early stage, as the CAA/N had hinted that they would be bringing in requirements for internal control in Norwegian air carriers.

1.17.6.2 In 1991 the airline introduced a quality assurance system for their Operations Division, which was to monitor quality. There were a number of similarities between the quality assurance system and the principles of internal control which were being applied in the operations department, but few characteristics that showed a connection between them. Both systems, according to the company, were designed to evaluate flight safety.

1.17.6.3 In 1991 the Operations Division was issued with a quality assurance manual linked to the introduction of a quality assurance system. This manual contains a number of the company's principal goals, including safety - defined as a priority area under the title of product quality. Further on, the basis for this is established as follows:

> "The quality assurance manual describes how the Operations Division is to ensure and monitor quality within the Operations Division's area of responsibility. The quality assurance system, which the quality assurance manual introduces, includes and monitors, in principal, all the Operations Division's activities, from methods and routines to organisation and division of responsibilities."

The manual mentions three levels at which the company's system of manuals is formulated. The quality assurance manual is the Operations Division's strategic document which will provide the basis for the formulation of the division's other documents at the tactical and operational level. These tactical documents include the FOM and the Administrative Maintenance Book. Operating instructions are to be found at the operational level.

As a result of introducing the quality assurance system, the company set up its own assurance control department headed by a quality assurance manager.

1.17.6.4 The Operations Division's quality assurance manual was studied by the Aeronautical Inspection Division in September 1991. In a letter dated 9 September 1991 the Division's Airworthy Departement stated that "the Civil Aviation Administration has no objection to this manual being used". The book was not, however, studied by any other of the CAA/N departments.

1.17.6.5 The company considered the reply given by the CAA/N regarding the quality control manual as an approval of the manual. The company wrote in the manual that both the book and the head of the quality control department were approved by the CAA/N. In the discussions the AAIB/N has had with those in positions of responsibility in the Aeronautical Inspection Division, the view was expressed, however, that the company's handbook had not been approved by the CAA/N and that the CAA/N had no formal relationship with it, in the sense that there is no formal requirement in the CAA/N's regulations which allows them to grant such approval. It was further stated that the CAA/N had no objection to this system being introduced as long as it did not go against the regulations. The CAA/N has also stated that the Aeronautical Inspection Division does not have any relation to the quality control manual. However, the CAA/N has approved the aforementioned quality control manager as part of the JAR 145 approval (workshop approval) which was granted to the company on 27 December 1993.

1.17.6.6 The CAA/N has approved the company's FOM subject to two conditions being fulfilled as per BSL D 2-1 paragraph 4.2.1:

- that the manual itself is written, and
- that those parts of the manual which refer to regulations are in particular approved.

Chapter 6 of the FOM discusses a range of principal considerations relating to internal control and other principles of aircraft safety, such as risk management and "quality circles". Special factors relating to the everyday running of the company, including reporting routines and calculation of risk levels, are also discussed. This chapter is not particularly approved by the CAA/N on the grounds that the authorities do not require internal control to be in place in the operations division of an airline.

1.17.6.7 The AAIB/N has studied the company's Administrative Maintenance Manual which was valid at the time of the accident, without obtaining a clear view of the different elements comprised in the quality control system. The manual contains various pieces of information on internal control and quality assurance, but does not specify how these are to be used systematically or to what extent these terms are used synonymously. The five conditions that must be present for internal control to be integrated into the organisation are not mentioned specifically.

## 1.18 Additional information

### 1.18.1 Witnesses

1.18.1.1 The AAIB/N spoke personally to 8 of the 13 passengers who survived, and interviewed the remaining 5 passengers on the telephone. According to the statements given by the passengers, they did not, generally speaking, detect anything abnormal about the flight until the aircraft crashed into the ground. No indication was given during any part of the flight that the crew were having problems. Most of the passengers thought that the flight had been rough, and that there had been increasingly strong turbulence during the final stage of the journey. A number of them had said that it had been very warm in the cabin, and some people had felt unwell because of the turbulence and the heat. Some said that they had seen lights on the ground during the last part of the flight. A couple of witnesses gave a highly detailed and precise description of the accident sequence, and the descriptions tally with what was found at the scene of the accident.

1.18.1.2 Some of the passengers said that they remembered very little about the accident itself, while others gave partially-detailed descriptions. One general fact was common to all the descriptions, which was that they remembered that it had been raining at the accident site and that the fuel from the aircraft had sprayed all over the passengers. A number of them also said that the rescue work carried out at the scene of the accident was initiated swiftly and that they had been efficiently conveyed to the hospital.

1.18.1.3 One passenger who had worked in a professional capacity with navigation systems sat in a position which enabled him to follow the activity in the cockpit. The passenger noticed that the aircraft's distance measuring equipment (DME) had a maximum reading of 14-15 NM during the base turn for the instrument approach to Namsos. Another passenger said that he had caught a glimpse of some trees, outside and to the right of the aircraft, immediately prior to the crash.

1.18.1.4 The AAIB/N spoke to some of the residents in the area of the approach path to runway 26, who had seen the aircraft below the cloud cover, but had not noticed anything abnormal. They were able to confirm that the aircraft had been following a normal approach path in the area of the Namsos radio beacon.

### 1.18.2 Coversations with AFIS employees at Namsos

The AAIB/N spoke to 3 of the employees at the Namsos AFIS unit - the manager, the duty AFIS officer at the time of the accident, and another AFIS officer. The information that was revealed from these conversations as regards the accident flight, indicates that the crew did not report the required information to the AFIS unit during the approach to the airfield. The crew failed to report either when the aircraft entered its base turn or when the flight passed Namsos NDB on final approach. In this connection it was said that it was not unusual for Widerøe crews to omit giving essential information to the AFIS unit, and that as a result it could, at times, be difficult for AFIS staff to obtain a clear enough picture of the traffic situation so that they could give other flights essential information on air traffic in the area. It was also pointed out that it would be an advantage if they were able to obtain clearer information about the various flights in case a search and rescue mission had to be mounted.

### 1.18.3 Investigating the human factor

The AAIB/N's expert on the subject of the human factor studied the material on which the company based their teaching and instruction. The Norwegian requirements on this subject were in the process of being worked out, and were not in force at the time of the accident. However, the company used the ICAO Document, Annex 1 "Human Performance and Limitations" as a guideline. The teaching material looks as though it was drawn from a number of current sources, and valuable work was done to adapt the material to the company's operations. However, the work seems to bear the mark of the instructors' own personal designs and interests, and the material might have successfully been made more comprehensive by consulting experts in the field. There seems, for example, to be a lack of any clear idea or philosophy as to how to follow up on the basic courses the company runs in Crew Resource Management (CRM).

It is worth noting that the concept of CRM has, over the few years, broadened out to cover the flight safety concept of Company Resource Management, which includes organisational management.

### 1.18.4 Why errors occur

1.18.4.1 It is important from the outset to accept that all situations are fallible. Having said that, conditions, both for the performer of a task and the system the performer of the task is operating within, need to be such that that fallibility is reduced to a minimum.

1.18.4.2 Errors not due to a weakness within a system arise in situations of mental overload, where the demands made by a task are too high in relation to the performer's capacity, or in situations of underload where the performer becomes less vigilant. Reduced mental capacity may be caused by bad ergonomics in a work situation, inadequate instruction about the task, weak training, lack of motivation, unfortunate attitudes, vibration, noise or fatigue. What we are talking about are natural error rates built into the human system. In certain repetitive tasks it is expected that errors will occur approximately every hundredth time the task is carried out. By placing particular emphasis on error reduction through training it is possible to reduce the aforementioned situation to one error for every thousand attempts. If this is applied to the cockpit situation, and an extra pilot is added to act as a supervisor, the rate of error will be reduced still further.

1.18.4.3 Errors may also occur as the result of an incorrect understanding of a situation. Sense perceptions are often created based on incomplete or ambiguous information. The natural reaction to a situation like this is that the individual himself completes the picture, which happens unconsciously and automatically. An example of this is flying in the dark and looking for visual references in an area or a situation in which there are few visual points of reference.

1.18.5 High-intensity rainfall / wing profiles

1.18.5.1 Over the last few years research has been carried out into the effects of heavy rain on wing sections. As the AFIS reported heavy rainfall in the approach area at the time of the accident, the AAIB/N consulted an aerodynamics expert to clarify whether or not it was possible for the downpour to have adversely affected the aircraft's performance.

1.18.5.2 Possible contributory factors are: loss of lifting force, the impulse transmission of the rain, the weight of the film of rain on the aircraft and the change of roughness in the wing, producing increased resistance owing to disturbances in the laminar flow over the wing profile. Research had led to the conclusion that high-intensity rainfall may have an adverse effect particularly on aircraft going in to land. Using very high-intensity rainfall over a short space of time, and converting this to rainfall per hour, calibrating from 2,000 mm/hour (very heavy) down to 100 mm/hour (light), adverse effects were recorded even on conventional wing sections at 200 mm/hour.

1.18.5.3 The highest intensity of rainfall recorded in Norway was 240 mm/hour from a thundershower over Gardermoen, according to the AAIB/N's meteorological expert. However, no sufficiently high intensity of rainfall has never been recorded in the area of the country where the accident took place. The AAIB/N has thus disregarded high-intensity rainfall as being a factor in the accident.

## 1.19 Useful or effective investigation techniques

1.19.1 Systems investigation

1.19.1.1 With reference to ICAO Annex 13 Eighth Edition - July 1994, a report on a aircraft accident shall include a section on organisation and management and causal factors behind the accident. The information given in sections 1.17 and 1.18 on the human factor and the answers to the questions selected from the question bank are the basis for the systems investigation the AAIB/N decided to implement after the accident. The AAIB/N's views on and interpretations of the contents of the information gathered are described and commented on in the analysis section of this report.

1.19.1.2 The systematisation of the material has been influenced by a model formulated by Professor James Reason from the University of Manchester, UK. The model has proved to be well suited to highlight an organisational occurence (see figure below), "a situation in which latent failures, arising mainly in the managerial and organisational spheres, combine adversely with local triggering events (weather, location, etc.) and with the active failures of individuals at the 'sharp end' (errors and procedural violations)". When inadequate or absent defences (safety barriers) fail to identify or protect against technical or human failures arising from the latent, active and local elements, accidents and incidents may take place in an organisation. The principles in Professor Reason's model are described in detail in his book entitled Human Error (1990).The model has received general approval from the aviation industry the world over.

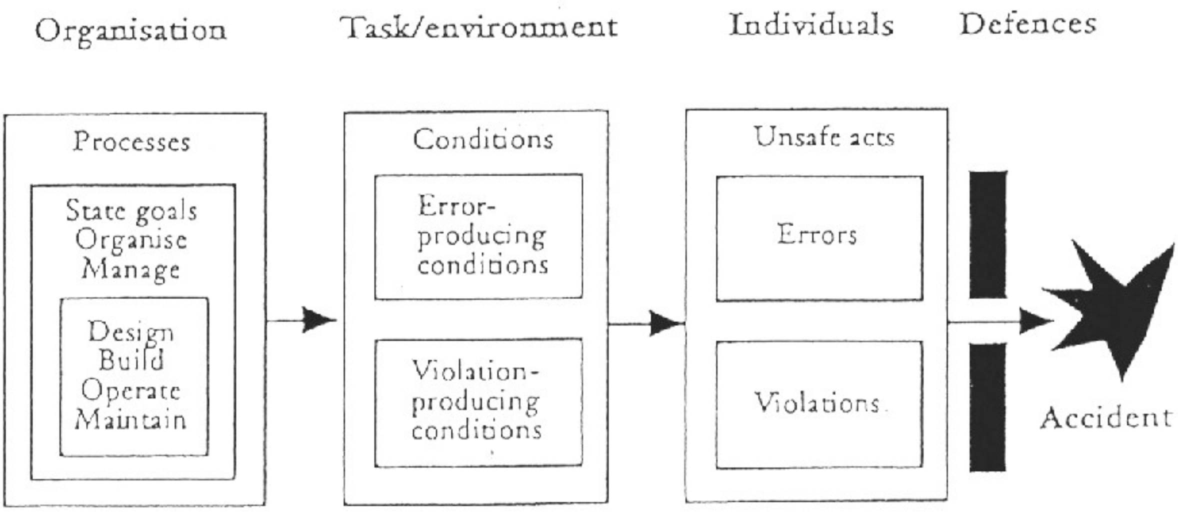



Fig. "Elements of an organisational accident" (Professor James Reason, ISASI Forum Proceedings, 1991)

1.19.1.3 By systemising the material from the accident the AAIB/N has decided to begin with the active failures, as these are the keys to any sources of failure within the system supporting the flight operations. These failures and their accompanying safety problems have been highlighted using a STEP (Sequentially Timed Events Plotting) analysis.

# 2 ANALYSIS

## 2.1 Premises - systems investigation

According to ICAO Annex 13 and the Regulations which apply to state investigations into aircraft accidents and incidents, the AAIB/N shall confine itself to an investigation into flight safety for the purposes of averting further aircraft accidents and incidents, and not for the purposes of apportioning blame or liability. It is important to emphasise in this respect that when the AAIB/N indicates apportioning of responsibility it is referring to responsibility for flight safety. As elements of the preventive flight safety work, the AAIB/N lists the factors considered to have had a direct bearing on the chain of events. There are, in addition, hidden factors within the aviation system that may have had an influence on flight safety problems brought to light through the sequence of events. It also seems appropriate to consider other factors which have come to light with regard to their bearing on preventive flight safety work.

In the AAIB/N's opinion, clear connections cannot, in practice, always be made between the various factors in Reason's model. This particularly applies to the relationship between the sequence of events and hidden factors within the aviation system. However, there is no doubt that by focusing on and analysing these latent factors it may be possible to exert some positive influence on flight safety.

In accordance with the above, the AAIB/N considers it appropriate to define all results and factors which the investigation has brought to light with regard to the possibility of improving flight safety, the definition of which provides the basis for the AAIB/N's handling of the systems investigation.

## 2.2 Introduction

The circumstances surrounding this aircraft accident corresponded to the so-called "Controlled Flight into Terrain" (CFIT). The investigation has brought to light the fact that the aircraft was able to operate normally and that the crew were apparently in full control of the aircraft during the approach. No evidence was found in the course of the investigation to indicate that any of the crew members were influenced by personal conditions which may have affected their ability to carry out their respective tasks. As the aircraft was equipped with a cockpit voice recorder, the AAIB/N was able at an early stage to eliminate the possibility of the accident being due to causal factors originating from technical conditions. The wreckage, with the exception of the instrument panel, was released once the AAIB/N had completed its work at the accident site. Resources could thus be directed towards the company's operations management and the system supporting these operations, as well as the role played by the civil aviation administration.

During the time the investigation work was carried out the AAIB/N talked, not only once, but several times, to a large number of employees in the organisations concerned. A crucial factor in obtaining results from this investigation was that the Board was met on all sides by cooperation, openness and sincerity. It seems there is a widespread understanding for the need to improve the system, if possible, in order to avert similar accidents in the future.

## 2.3 Active factors

2.3.1 Activities relating to the aircraft's operation in the final 23 minutes is illustrated with the aid of a STEP analysis (see Appendix 4). The elements involved are based mainly on information taken from the voice recorder. The safety problems which came to light are analysed and discussed below based on the company's FOM and FTM regulations and procedures.

Sections marked with a Δ and numbers 1 to 17 refer to safety problems which came to light through the STEP analysis. References to sections in the FOM and FTM are listed in the extract in Appendix 6 (not translated).

2.3.2 Δ 1 Planning with reference to the FOM and the FTM was not fully carried out by the "Flying Pilot" (FP). No planning had been done for:

the "Non-Flying Pilot (NFP) callouts". Ref. FOM section 9.5 paragraph 1.2.4.
"Timing and rate of descent". Ref. FOM section 9.5 paragraph 1.2.5. and FTM paragraph 10.24.1

"Dimming of approach and runway lights". Ref. FOM section 9.5 paragraph 1.2.6.

Time correction due to wind. Ref. FTM paragraph 8.8.17. and "Instrument Approach and Landing Chart" IAL Namsos (Appendix 1).

Also, the NFP did not correct the FP about the flying time outbound from the Initial Approach Fix (IAF). Ref. FOM section 2.5 paragraph 3.1.2. and section 2.5 paragraph 3.2.1 (duties during flight duty).

2.3.2.1 The AAIB/N considers meticulous planning as one of the cornerstones of a well-executed flight. Inadequate planning recurs as a significant deficiency in the CAA/N's statistics for aircraft accidents. Clear guidelines from the FP for "callouts, timing and rate of descent" and time correction due to wind would have forced the NFP more directly into participating in the execution of the approach. If attention had been directed towards this, that could have been the factor that broke the chain of events at later stage. It would also have been consistent with CRM training, if the NFP had taken the initiative when the FP omitted to set the right conditions. A possible explanation for the FP's reticence in this situation could have been that he simply had less flying experience than the NFP, and thus did not wish to give him detailed instructions. The FP had had a different professional occupation as his main occupation before he started his flying career. As for the NFP, he had gained experience on a heavier type of aircraft prior to being employed by the company.

2.3.2.2 Questionnaire B also shows that there were considerable differences in the way the 14 pilots considered which callouts should be given. This, in the opinion of the AAIB/N, is an area where there must be compliance so that the crews act in a standardized fashion. In the case mentioned above, the FP did not set conditions for callouts when planning/briefing the approach, neither did he indicate missing callouts during the approach (ref. FOM section 2.5 paragraphs 2.3.1 and 2.4.1. on the Pilot-in-Command's responsibility/duty during flight duty). Failure to adhere to these elements in the chain of events becomes an active factor.

There is, moreover, inconsistency between the FOM and the FTM regarding what is meant by "rate of descent" in planning.

2.3.3 Δ 2 After receiving information about the wind at 19:01:24 hours (i.e. 6 min. prior to passing Namsos NDB) blowing from 260° at a speed of 27 - 40 kts, the FP corrected the minimum altitudes stated on the IAL Namsos, 4,000 ft and 3,000 ft by adding on 1,000 ft. However, the remaining minimum altitudes of 2,100 ft and 1,100 ft were not corrected/increased (ref. FOM section 4.5 paragraph 6.1 and FOM section 0.4 "minimum altitude").

Δ 6 The FP started his descent to 2,100 ft. This altitude was not corrected (ref. FOM section 4.5 paragraph 6.1 (correction + 500 ft (wind) and approx. + 100 ft (temperature))

Δ 7 The NFP accepted the descent to the uncorrected altitude (ref. FOM section 2.5 paragraph 3.2.1 and section 4.5 paragraph 6.1)

2.3.3.1 An increase in altitude of 1,000 ft was quite in order. However, as the rule was made to ensure that the correct height over the ground is not lower than the correct altitude in standard atmosphere, the crew ought also to have assessed the lower two altitudes. In this case the wind speed was at the lower limit (40 kts) for correction, in line with the airline's regulations. Later on, at 19:13:41 hours, the wind speed fell to below the 40 knot limit, so that altitudes of 2,100 ft and 1,100 ft could be used uncorrected. So, all things considered, the AAIB/N views these two elements as departures from procedure which had no bearing on the course of events.

2.3.3.2 Questionnaire B revealed that thirteen pilots wanted to correct some of the actual minimum altitudes. There was one who did not want to correct any of them. There was strong agreement when it came to making corrections for temperature and wind, but disagreement as to how far down these corrections should go. The majority did not want to correct the minimum altitude of 1,100 ft.

2.3.3.3 The AAIB/N registers some lack of clarity as to whether or not the corrections should be applied to both approach/landing minima and for other minimum altitudes in the approach area. In the AAIB/N's view, they are relevant for both conditions. The fact that this is not sufficiently stressed in education and training such that its interpretation within the pilot corps as a whole is consistent and adequate, thus becomes a latent factor. An additional factor is that the internal control mechanisms of the PFTs and flight checks did not detect the problem.

2.3.4 Δ 3 The altitude report on the IAF and the notification of the approach procedure to be used was not communicated to the AFIS (ref. FOM section 9.1 paragraph 16.2 and 17.2).

Δ 7 The crew failed to report to the AFIS that the aircraft had left 4,000 ft (ref. FOM section 9.1 paragraph 17.3).

Δ 11 The crew failed to report the Final Approach Fix (FAF) = Namsos NDB inbound with the actual altitude reading (ref. FOM section 9.1 paragraph 17.2).

Δ 14 The crew failed to report to the AFIS regarding FOM section 4.2 paragraph 1.3 and section 9.1 paragraph 17.3 that they had changed to visual flying.

2.3.4.1 In the opinion of the AAIB/N, keeping the AFIS duty officer informed is a bonus from the viewpoint of flight safety because the AFIS officer then may obtain the essential picture of the traffic situation and find out what the Pilot-in-Command's intentions are. Should erroneous action be taken by the crew or dangerous situations arise, the AFIS officer can act as a safety net by supplying information or drawing attention to adverse situations. Should emergency services be required, it is of vital importance that the AFIS staff know where to direct the efforts. Investigation of report routines at an airport selected randomly from the airline's flight network indicated that a large number of crews reported to the AFIS as they were supposed to, while other crews were rather careless in this respect. Bearing in mind the history of the flight and the discussions with the AFIS staff at Namsos, the AAIB/N filed a provisional recommendation with the Civil Aviation Administration shortly after the accident. The recommendation formulated it being a requirement for this airline's pilots to inform the AFIS units adequately during instrument approaches.

2.3.4.2 In previous investigations AAIB/N has brought to light a general mistrust between pilots from the airline and the AFIS staff in the towers at short field airports, the main root causes of which were inaccurate information given to the pilots and a rather supercilious attitude adopted by pilots towards the AFIS staff. The general impression was that this situation had now improved considerably, and was now almost a thing of the past. However, this accident shows that the cooperation between these is still unsatisfactory.

As company regulations for reporting exist and are considered to be sufficiently clear, these failures to report are a contravention of professional discipline.

2.3.5 Δ 4 The crew flew outbound for 1½ minutes but did not start turning inbound as planned (ref. FTM section 8.8.17).

Δ 5 The recommended distance (DME 11) for commencing the inbound turn to the localizer had been exceeded, and the aircraft continued flying on track QDR 050$^0$ for a total of 2 minutes (calculated from the IAF).

2.3.5.1 The crew planned the outbound leg from Namsos NDB for zero wind at their altitude with a time of 1½ minutes, as shown on the IAL chart. However, it would have been more precise to shorten the time by approximately half a minute in the prevailing conditions and thus start the inbound turn as soon as a minute had elapsed. However, instead of keeping to the planned time for the turn, they carried on for two minutes before starting the turn. The aircraft drifted considerably when it turned and ended up approx. 14 NM out, according to the DME (this was confirmed by both military radar and a passenger), resulting in the aircraft requiring a whole 4½ minutes to fly back inbound to Namsos NDB.

Questionnaire B brought to light the uncertainty experienced by pilots with regard to the timing of flying outbound from the IAF. Five pilots wanted to fly outbound for 1½ minutes, six wanted it to use 1 minute, and three chose other timings. The company's operative supervision system did not detect this latent factor which is important for education, training and monitoring in this subject.

2.3.5.2 Because the inbound flight took so long, the AAIB/N is of the opinion that this may have influenced the crew's expectations, based on their experience, as to where they should be after a certain period of time elapsed. So, they might have thought, after passing Namsos NDB inbound, that they were closer to the runway than they actually were. On the other hand, it could be said that the crew should have been updated on their position when they passed Namsos NDB. The AAIB/N's expert on aviation psychology, however, rejects the view that an update like this as perceived by the pilots, would necessarily always be the case.

2.3.6 Δ 8 The crew did not comply with the regulations governing sterile cockpit (by a conversation regarding professional matters unrelated to the approach) after the aircraft passed the IAF outbound (ref. FOM section 3.1 paragraph 7.1).

2.3.6.1 The sterile cockpit concept was introduced in the company, a concept the AAIB/N considers to be an important element in flight safety. A chain of events is often triggered off during quiet periods during flight duty, where work discipline is required to maintain alertness with regard to the operation of the aircraft. The AAIB/N notes here a consequence of the crew flying outbound for too long, resulting in a long inbound flight. It is uncertain whether this non-compliance with the regulations had any influence on the sequence of events in this case, but the AAIB/N wishes to underline the importance of maintaining the sterile cockpit concept.

2.3.7 Δ 9 The NFP did not give a callout when the aircraft descended through 2,600 ft, i.e. 500 ft above the target altitude (2,100 ft/over the FAF). The aircraft was at that time still in clouds (ref. FTM sections 8.7, 8.8.26 and 10.26).

2.3.7.1 Making callouts in a disciplined manner forces the NFP to be more alert, as well as providing safety barriers and a valuable warning to the FP. It is of the utmost importance that the crew works as a team. The FP's requirements of the NFP and the NFP's monitoring were neither up to standard nor in line with the philosophy of CRM training.

2.3.8 Δ 10 The crew started reducing altitude after passing the inbound FAF without having planned a rate of descent and time for the Missed Approach Point (MAPt) (ref. Δ 1 and FOM section 9.5, paragraphs 1.2.5 and 2.4, and FTM paragraph 10.2.4) Both stop clocks were found in the zero position i.e. they had not been started.

2.3.8.1 As the flight ended up as a CFIT, all elements of the chain of events relating to the altitude and rate of descent are of particular importance (altitude-alertness). If the crew in beforehand had calculated the rate of descent and had then monitored this by focusing on the sink rate, it might have helped to break the chain of events. The sink rate shortly before the accident took place was approximately twice the allowed value (an established rule due to passenger comfort).

2.3.8.2 It is also good airmanship to monitor the reading of instruments by cross-checking a number of sources. Even though a DME and a marker beacon were available to determine the MAPt, the stop clocks should have been started when they passed the FAF (Namsos NDB), particularly when it sometimes has been experienced that marker beacons have been passed without being noticed. The crew used both clocks to determine the outbound time when passing the IAF, Namsos NDB, outbound.

Besides checking the information from the DME, the AAIB/N is of the opinion that, had more attention been paid to the time factor, the chain of events could have been broken, since there was, in fact, a lack of vigilance with regard to the length of time the aircraft had been in the approach phase.

2.3.8.3 The AAIB/N notes that there was a great divergence of opinion in Questionnaire B with regard to the flying time between the FAF and the MAPt (assuming a wind direction of 270$^0$ and a wind speed of 26 -37 kts). Two pilots wanted to initiate the missed approach procedure after 1:36 mins, 5 pilots wanted to execute missed approach after 2:00 mins, 3 pilots after 3:15 mins and 2 after other elapsed times.

2.3.9 Δ 12 The two ADF receivers in the aircraft were not set to the radio beacons in accordance with FTM section 10.24.2.

2.3.9.1 Well-established routines in everyday operations are highly beneficial in situations where there is potential overloading, as these routines can be carried out automatically, even under mental stress. To ensure that a missed approach is carried out to the correct radio beacon, there should be a fixed routine whereby the same ADF receiver (ADF No.2, in accordance with company procedure) is always tuned in to the radio beacon referred to in the missed approach procedure. However, the crew tuned both ADF No. 2 and ADF No. 1 to the radio beacon for missed approach procedure. The departure from procedure in this instance had no bearing on the sequence of events. However, from the viewpoint of flight safety, a safety barrier set by the airline was broken.

2.3.10 Δ 13 The FP terminated instrument flying and commenced a visual approach in the dark without visual reference to the ground below and without positively checking the aircraft's position using available navigational aids (ref. FOM section 0.4, Definition of Visual Approach, section 4.2, paragraph 1.2a and section 9.5 paragraphs 5.1 and 5.2, and FTM paragraph 10.29.)

2.3.10.1 At this point in time there is a marked difference in the way the approach was carried out. Generally speaking, the FP should, during an instrument approach, fly the aircraft with reference to the instruments and consequently direct most of his attention towards this. The NFP should monitor what the FP is doing, in addition to taking care of other tasks, and have some of his attention directed to what is going on outside the aircraft. This division of roles seems to have worked right up to the time the NFP at 19:15:30 hours alerted the FP that the field was in sight. Once a FP confirms that he can see the airfield, or some of the approach lights, he should switch his attention out of the cockpit to take care of the visual navigation and preparations to land while the NFP monitors the approach on the instruments. This is particularly important during visual flying in the dark. However, the AAIB/N is of the opinion that most of the attention of both crew members was directed outside the aircraft after the "field in sight" call.

2.3.10.2 Once a crew on an instrument flight obtains visual contact with the landing runway, a considerable part of their task is completed. It is not unusual for crews to feel that most of the job is done, and consequently have a tendency to relax more - the only thing that remains - is to land. Pilots in the airline have confirmed that this feeling can manifest itself, and, when viewed in relation to the culture and attitudes this represents, it could be a latent factor with potentially detrimental consequences in the future.

2.3.10.3 As stated in FOM section 4.3, paragraph 7.1, VFR flying at night is prohibited, but visual approaches are permissible. If visual approaches are carried out, however, company regulations require visual reference to be made to the terrain. Neither the CAA/N nor the company has, however, defined what visual reference to the ground really means - which visual references are appropriate and where the references need to be in relation to the aircraft track. In FOM section 0.4, note 2 to Decision Altitude, and section 4.2, paragraph 3.2.1b (re: Meteorological Minima - Operational Minima - Non-Precision), information is given on essential and appropriate visual references. The AAIB/N considers these to be unsatisfactory as a definition for clarifying all essential criteria.

Seeing the ground and having visual reference to the ground are not the same thing, the difference lying in the number of visual reference points. When one can see the ground there are an unlimited number of reference points. If one has too few reference points there is a danger of missing important details and /or being influenced by visual illusions. Being unable to make out the contours of important land features to the front, side and below the aircraft clearly makes flying by visual reference too risky.

The AAIB/N thus has the impression that a number of line pilots in this airline consider points of light on the ground as being sufficient contact with and reference to the ground. Since this depends on how the points of light are arranged in relation to each other, there is the danger of being influenced by the visual illusion "Black Hole" (an optical illusions which, in the dark, can lead to incorrect assessments of altitude and distance being made in relation to reference points of light on the ground).

2.3.10.4 As the airline has a route net and mode of operation that includes visual flying, it is of vital importance, in the opinion of the AAIB/N, that the concept of visual referencing be clarified. A definition which will set the criteria for this will remove one latent risk factor in the airline's operations.

2.3.10.5 To avoid being influenced by visual illusions, it is good airmanship to use all available navigational aids. By using the DME one can create an imaginary glide path by comparing the actual altitude with the remaining distance to the runway. Namsos had an operative DME that could have been used for this purpose. It would neither have affected time nor the approach in a negative way if the descent had been performed in this manner. Neither would it have been disadvantageous had the descent been stopped at the minimum altitude valid to the marker beacon, i.e. 1,100 ft.

2.3.10.6 Approaches flown during darkness, without visual reference to the ground below, as was the case here, should, in the AAIB/N's view, be carried out with reference to IFR altitudes. Shortly after the accident the AAIB/N forwarded a provisional recommendation to the CAA/N and to the airline that they should take care of this. The investigation confirmed that the accident could have been avoided if the flight had been carried out in this manner.

2.3.11 Δ 15 After passing the FAF, the FP started reducing altitude at a rate exceeding 700 ft/min. (ref. FOM section 9.5, paragraph 2.4). Between 19:15:35 hours and 19:16:35 hours the aircraft reduced altitude by an average of approximately 1,400 ft/min. The NFP did not point this out to the FP (ref. FOM section 9.1, paragraphs 1.2 and 2.2).

2.3.11.1 Up to this point in the approach the FP evidently had descended with complete control and with a moderate rate of descent. It is thus reasonable to assume that he continued this way after passing the FAF. The relatively great rate of descent (approximately 1, 400 ft / min) probably took place after the "field in sight" was called. Thus, one explanation could be that altitude was reduced on purpose in order to maintain visual contact with the runway, owing to the weather conditions. Few visual points of reference combined with turbulence in the area, may have camouflaged the pilot's impression of the actual rate of descent. Other explanations could be lack of vigilance in relation to the aircraft's actual position, being under the influence of a visual "Black Hole" illusion, inaccurate flying or a combination of these factors.

2.3.11.2 An sink rate of approximately 1,400 ft/ min. is well within the performance of the aircraft and cannot, in itself, be considered as irresponsible. The actual purpose of the requirement in FOM index 9.5, paragraph 2.4 is to prevent passengers from experiencing discomfort, as this aircraft type does not have a pressurised cabin. However, such a considerable sink rate close to the ground (below 2,000 ft) is not consistent with a stabilized approach.

2.3.11.3 Δ 16 The FP flew through 1,100 ft (ref. FOM section 9.5, paragraph 5.2), but the NFP did not inform the FP of this (ref. FOM section 9.5, paragraph 3.3 table, column 5).

2.3.11.4 Monitoring of the altimeters would have indicated that the aircraft had, in a short space of time, descended through the minimum IFR altitude for passing the marker beacon positioned further ahead. A potential safety barrier was thus passed without any attention being paid to it.

2.3.12 Δ 17 The crew did not notice the preset altitude (200 ft) warning light on the radio altimeter. The selector switch was in DIM, and the light intensity was significantly reduced.

2.3.12.1 The crew had, according to the check list, set the warning light index on the radio altimeter to 200 ft. Although the radio altimeter is not to be regarded as a GPWS, it will, when set correctly, warn a crew that the aircraft is flying at a low height above the ground also before being on short final. When the FP said that the aircraft was at an altitude of 500 ft and that he did not want to fly much lower, the DH light must have been lit due to low height and the nature of the terrain along the track leading to the accident site. Even at that altitude it was highly likely that the crew were able to see the approach lights as they were also visible from the accident site. The fact that the NFP did not register anything at this point in time indicates, in the opinion of the AAIB/N, that his attention was directed out of the aircraft.

2.3.12.2 The DH light could initially not be dimmed. It was often shining so brightly immediately prior to landing that it was a distracting factor for the crews during darkness and in bad weather. A factory-approved modification to the system was thus made, the effect of which, coupled with the fact that the radiance from the bulb was reduced due to wear and tear, in this case had an unintended result The NFP would have had to have his attention directed towards the instruments to be able to notice this information. This was the last opportunity the crew had for their attention to be drawn to the low height above the ground. However, they were obviously never aware of how close to the ground they actually were.

## 2.4 Local factors

### 2.4.1 Meteorological conditions

No evidence has come to light to indicate that the crew should not have started the flight or that they should have aborted the approach at any time owing to the weather conditions. However, it is possible that the heavy rain shower (a cumulonimbus) which the AFIS reported at 19:09:17 hours may have had some effect on the approach. Judging by the direction and speed (approx. $270^0$ / 30 kts) at which the wind blew, the shower must have been approx. 6 km east of the airfield when the NFP reported "field in sight" at 19:15:30 hours, at which time the aircraft was approx. 10 km from the airfield. This allows for the possibility that diminishing visibility to the approach lights caused by the stratus cloud below the rain shower, caused the FP to increase descent. Approximately one minute later the aircraft would have flown into the shower had the aircraft's speed been equal to its average speed between the NMS radio beacon and the scene of accident. This corresponds chronologically with the point in time when the FP said, "We're now at 500 ft" - followed by "We should not go much lower". If the aircraft had flown into the shower earlier, the effect of a strong, downdraft cannot be ruled out. Should this have been a factor, it was in any case not significant enough to cause any kind of concern in the cockpit. There was, in addition, enough engine power available to halt the sink rate of approximately 1,400 ft/ min and level off when the FP said he did not want to fly much lower.

2.4.2 Perception of time

2.4.2.1 The poor planning resulted in the aircraft being flown an unnecessarily long way out during the base turn, which resulted in a protracted approach to the FAF. The crew thus had ample time and departed from the sterile cockpit rule. A further result of this may, in the AAIB/N's opinion, have been that the crew's perception of time was misplaced and that this affected their expectations, based on previous experience, as to where they actually were. As has been mentioned earlier, it is uncertain whether one in a situation such as this is updated position wise by the navigational aids. After passing the FAF the FP may have been under the impression that they were further in than they actually were and thus did not feel there was any danger involved in reducing altitude to 500 ft. The possibility that the FP might have got a false mental impression about remaining distance to the airfield and mixed the NMS up with the marker beacon and 2,100 ft with 1,100 ft, cannot be ruled out. Misunderstandings such as this have been experienced previously in relation to accidents and incidents. Another well-known phenomenon for flight crews is the difficulty of having a totally accurate conception of the length of time that has passed e.g. since the aircraft passed a navigational aid. Even short periods of time can seem inordinately long. One has to check with the clock to be sure. In this case, the clocks were not started when passing the FAF.

2.4.2.2 In Questionnaire B, 6 of the 14 pilots wanted to reduce the NMS outbound flying time to one minute because of wind at altitude. 5 of them wanted fly as though there were a 0 wind condition, and 3 of them wanted to correct for wind using other values. The AAIB/N views the crew's lack of understanding that they should keep within a defined area, and the fact that the existing internal control system (flight check / PFT) did not reveal the problem, as being a latent factor.

2.4.3 Visual illusions

2.4.3.1 Once the aircraft was below the cloud base the conditions were right for the visual illusion "Black Hole". Strong light radiated from the approach lights, other light sources randomly spread out (the visbility may have been reduced due to low stratus clouds and rain with the passing heavy shower) and the flight's track was over terrain which was not visible in the dark. The lights from the built-up area behind the airfield may have had an intensifying effect. If the lights at an airfield are strong, the impression is created of the airfield being nearer than it actually is. A well-known effect under conditions such as these is the difficulty of judging altitude and distance. The AAIB/N is aware of the fact that pilots under such circumstances, either consciously or unconsciously, have increased their rate of descent at an early stage of the final approach. The reason for this is that they may get the visual impression that they are flying too high and thus feel that they have to descend to avoid a later high sink rate closer to the ground, just prior to flare and landing on the runway. This can also be seen in association with a possible loss of situational awareness in relation to the time factor. Another intensifying effect is experienced when rain falls onto the windshield, resulting in light being refracted (the refraction can be up to 200 ft per NM).

2.4.3.2 The fact that the FP was in the habit of setting his seat in a low position may also have had a bearing on this, as it limits the visual impression in the vicinity of the aircraft. Most modern aircraft have what is called a "Design Eye Reference Point" (DERP) to help pilots find the right seat (head ) position. No such point is designated for this type of aircraft, but it is marked in the airline's other two aircraft types. Due to the fact that there is no DERP in this type of aircraft, the airline has not paid as much attention on the sitting position in the Twin Otter as in the DHC-7 or DHC-8.

2.4.3.3 In order to avoid being affected by optical illusions, including the "Black Hole" effects, it is necessary to fly according to the information supplied by the aircraft's flight instruments. The "Aviation Safety" magazine refers to the fact that a number of older pilots lower their seats as much as possible to avoid the effect or distraction of strong light from the ground, thus making it easier for them to concentrate on instrument flying. In any case, having a good understanding of this phenomenon (so one recognises the danger signals whenever they arise), coupled with the use of available navigational aids and, in particular, good routines, is the way to avoid being influenced by such illusions.

2.4.3.4 Questionnaire A revealed a latent factor linked to the "Black Hole illusion", as so many of the company's Twin Otter pilots were unaware of the elements of danger involved in this phenomenon. Of the 45 completed questionnaire forms received by the AAIB/N there were, according to the AAIB/N's experts in this area, just two which could be said to be satisfactory. The teaching material the AAIB/N studied did not cover this phenomenon, and optical illusions are not described in the FTM.

The risk of being affected by optical illusions is, however, amply described in FOM section 4.6, paragraph 8. A number of examples of relevant illusions are given, but no mention is made of "Black Hole".

2.4.3.5 There should have been a flashing light in the center of the transverse row of the approach light system, but the transverse had been destroyed by drifting river ice and had not yet been replaced. A flashing light will attract attention when it stands out from an otherwise monotonous visual situation, which is, according to the AAIB/N's medical expert, a reflex type of reaction. This is irrelevant in this case, but it may well be worth noting that when conditions are right for a "Black Hole" effect, a flashing light may result in one being more easily affected by an illusion such as this.

2.4.3.6 The AAIB/N has also considered the possibility that the crew flew towards other lights that they thought were the approach lights. The airline has had a couple of cases of this when approaching the same runway at Namsos. These crews flew towards the wrong light a fairly short space of time after flying through clouds. In the one case the crew mistook lights on a workshop for the approach lights. In the other, the source of error was the headlights from a line of vehicles on a road running parallel to the direction of approach. In both cases, however, there was significant directional deviation in relation to the extended centre line. The crews therefore made corrections shortly afterwards using the information supplied by the aircraft's flight instruments.

2.4.3.7 When LN-BNM crashed, the wind direction was such that there could not have been any significant drift, i.e. the direction of approach corresponded to the aircraft's heading. Another significant fact in this case is that the aircraft crashed virtually on the extended centre line of the runway. Witnesses also saw the aircraft flying along the usual approach path, so the AAIB/N thinks it rather unlikely that the crew made a similar mistake.

2.4.4 Altitude considerations

2.4.4.1 When the aircraft crashed, it hit the ground at an elevation of 392 ft, i.e. 108 ft lower than the 500 ft statement made by the FP. In the two comparing altimeter checks carried out during the final 30 minutes of the flight, the altimeters were within the maximum allowable difference of 50 ft. The FP's altimeter indicated the first time to be 50 ft higher than the NFP's altimeter, while at the second check both altimeters showed the same value. This makes it possible to explain 50 ft of the deviation, if the NFP's altimeter were correct and the FP's reading too high. The temperature correction for a deviation from the standard atmosphere under the prevailing conditions was approx. minus 30 ft. The remaining 28 ft is a deviation to be expected when flying under the prevailing conditions.

Since the FP said that he did not "want to fly much lower", it may be that the aircraft was flown slightly below 500 ft.

2.4.4.2 Another possible explanation for the final altitude loss may have been that when levelling off after the descent, the aircraft could have been slightly out of trim in relation to the power setting. It would have been difficult for the FP to notice such a slight drop in altitude over a blacked-out terrain while using only brightly-shining fixed points in the distance as a visual reference.

2.4.4.3 The AAIB/N received assistance from an expert in judging whether or not the relatively strong wind above the ground could have resulted in a drop in pressure owing to the venturi effect, thus causing the pressure altimeters to give erroneous readings. However, this idea has to be rejected as the land formations required to produce such an effect are not present in the approach path.

### 2.4.5 The IAL chart

DME 11 is written in brackets on the chart as a suggested value to be observed when established on track inbound towards NMS NDB. The crew did not observe this and flew considerably further out than the approx. 10 NM limit they should have been within, taking into account the effect of the wind. In the opinion of the AAIB/N, the purpose of DME 11 should have been more clearly indicated on the chart. It would also have been a support to the crews if a nominal glide path with altitudes relating to DME distances had been printed, as is given on some IAL charts.

## 2.5 Latent factors

Supplementary information on conditions in the company organisation can be found in SINTEF's report (not translated): "Analysis of possible hidden causal factors in the aircraft accident at Namsos on 27 October 1993".

### 2.5.1 Safety policy and internal and quality control systems in the airline's Operations Division

The airline has stated in FOM section 1.1 paragraph 8.2 that safety goals should be similar to those for international airline traffic. The airline further states that:

> "This is a particularly high goal in that the outward, external factors affecting short field operations in Norway differ from international standards for scheduled airline traffic. With the external conditions we have in this country,

> such a goal will make great demands on both the airline's systems and routines and the levels of skill of all of its employees in order to ensure that the airline's safety goals are achieved."

Responsibility for safety in the airline was as of 93 10 27 defined in FOM section 1.1 paragraph 9, as follows:

> "The Chief Executive Officer and the board at WF have the overall responsibility for ensuring that conditions are met so that safety goals can be achieved and that the airline's internal and quality controls are functioning.
>
> Each section manager is responsible for safety within his/her department. This implies that the person who has access to resources and has the necessary authority, is the person responsible for taking corrective action to achieve the airline's safety goals.
>
> Managers below section managers are responsible for safety in their own particular areas. Further responsibility for implementing safety requirements is spread downwards through the organisation such that each employee is, in the end, responsible for ensuring that safety is maintained in the tasks each one of them carries out. The total safety of the airline is thus a joint responsibility."

2.5.1.1 The Operations Departement's "introduction" of an internal control system in 1990 and the Operations Division's "introduction" of a quality assurance system in 1991 did not accord with the good intentions the company had when the process was initiated. The AAIB/N has brought to light the fact that these systems were introduced over the heads of a large number of employees. The majority of the employees the AAIB/N has been in touch with, had insufficient knowledge of internal control and quality assurance. Most of them were unclear as to what responsibility they had for their particular field or fields. People in middle management, for example, were unfamiliar with the airline's quality manual. A brochure entitled "Quality at Widerøe - Our Small Green One", a copy of which was sent by the CEO to all employees, refers to NS-ISO 9004 (quality management) and describes the airline's business ideas and principal goals, and stresses the necessity for motivation and quality awareness through training. The AAIB/N has received a number of comments from the pilots about the fact that

- Chapter 6 of the FOM - Internal Control/Reporting/Documentation - is written only to satisfy the CAA/N
- this chapter makes no reference to the ordinary line pilot
- pilots did not understand the contents of Chapter 6
- Chapter 6 was meant to be a revision of the FOM for private study

- employees were informed about Chapter 6 at a base meeting where the form of the report in particular was studied.
- the airline's "Quality at Widerøe - Our Small Green One" has gone straight into the wastepaper bin as it bears no relation to reality and is thus entirely meaningless.

2.5.1.2 The airline's quality management has stated that the quality assurance system was meant to be a comprehensive tool for ensuring safety (defined as part of the airline's product quality). It has also indicated, as defined in the quality manual, that quality in the Operations Division should be ensured and managed through the introduction of the quality system. In that way the airline linked "safety" and "quality" together as synonymous concepts. A well-meant attempt was then made to create a management tool to achieve this within the Operations Division.

2.5.1.3 On the other hand, top management has stated that the introduction of the quality system was aimed more at other sections of the Operations Division than at the technical or operative departments as they had already introduced internal control management systems. For example, it was stated at management level that the introduction of a quality system had had no particular effect on the operative section of the airline. The experience the airline's quality manager had had after making certain quality adjustments to the operative organisation was that the organisation was difficult to gain access to, and that pilots surrounded themselves with a "shell". It was thus symptomatic in this case that the quality manager was unaware that an FTM existed. As a result, this important document was not included in the quality system which should take care of the document system. Situations of this kind thus affect the safety system (ref. FOM paragraph 1.1 section 9).

2.5.1.4 BSL B contains a requirement that the internal control of an airline's aircraft maintenance system should be documented in a workshop manual or equivalent. In the opinion of the AAIB/N, it would clarify matters if a description of the internal control system included a method for using internal control systematically based on the five conditions which need to be in place if internal control is to be integrated into an organisation.

2.5.1.5 The similarities the AAIB/N has found, for example, between the strategic principles defined in the quality system and the internal control system, a lack of reference to the connection between the systems and the fact that the management stated that the quality system was not especially directed towards technical and operative conditions, give the AAIB/N the distinct impression that these systems were set up and were functioning in parallel. As, however, it was stated that both systems at the same time should encompass flight safety, the whole matter became unclear.

2.5.1.6 For safety to be synonymous with quality and thus be everyone's responsibility, certain conditions are required to be in place if this is to work:

- Top management must commit themselves to and manage the process of development and implementation of the airline's quality system
- The continuous quality process must be managed by the airline's top management
- Everyone in the organisation must know their place and their responsibility in the "quality circle", and be made aware of their responsibility for quality in relation to others in the organisation
- Each individual must be aware of the quality requirements
- Each individual must be made aware of the airline's quality strategy
- Motivation towards quality must be emphasised in the training process

It is the AAIB/N's understanding that neither quality nor safety can be everyone's responsibility unless this responsibility is clearly apportioned and applied to responsibility for prescribed actions and decisions. The investigation showed that this is not adequately documented in the airline.

2.5.1.7 In the AAIB/N's view, it is of vital importance that the introduction and continuation of the work on the quality assurance system be managed by the head of the organisation, the Chief Executive Officer. It was thus not in keeping with acknowledged principles for the CEO to delegate this job to such a large extent to the director of the Operations Division. Generally speaking, it is the AAIB/N's understanding that the implementation of the internal control system and quality system was unsuccessful in the period leading up to the accident.

2.5.2 Goals and flight safety standards - internal control element

2.5.2.1 *Conflict of goals - Setting of safety goals*

There seems to be both potential and real conflicts between certain sub-goals in the airline, particularly when it comes to measuring flight safety, regularity, punctuality and economy. For example, the fact that the Short Field Division has gone over the heads of the operational management to a certain extent as regards the planned times for each segment of a route, has had a certain effect on the airline's operations. Then, as a consequence, too tight schedules and financial savings are used as an excuse for shortening the flight times, particularly shortcutting of approaches.

2.5.2.2 As the airline needs to ensure that passengers get their flight connections, goal conflicts easily arise. The short-term view that short-cuts earn the airline money must not be allowed to develop to the point where divergence from accepted procedures arises. In a conflict over goals between economy and safety, it goes without saying that flight safety must take priority.

2.5.2.3 It is a positive sign that the airline believes it has created a relatively comprehensive internal process as a basis for formulating and putting the most important goals for flight safety into effect. To counteract the consequences of possible goal conflicts when it comes to flight safety, it would be of advantage to formulate and apply more precise principles or rules as to how safety should be prioritised in relation to other sub-goals such as regularity, punctuality and economy. Rules of priority such as these will contribute to increasing the degree of safety through their implied guidance and support in decision-making, should conflict between various sub-goals arise in the process of day-to-day operation.

2.5.2.4 The airline's periodic setting of safety goals is approximately equal to the results achieved in international airline traffic. It does not ,however,appear to be of any real significance, as it is not stated how these goals are to be applied in relation to the aims of the management, and because there are no reliable data available to show the airline's position with regard to these safety goals. This must be seen in relation to the reporting of operational matters in the airline.

2.5.2.5 A number of employees have told the AAIB/N that management could have set clearer goals for flight operations. Viewed in the light of potential goal conflicts, it would be of advantage to have a more aware, systematic and visible use of effective remedies to achieve set safety goals, e.g. in the form of a programme for improving flight safety.

2.5.2.6 Goals have been set for the activities of each department, but not everyone in the flight operations department's Control Group and Training Group had a clear understanding of which goals apply to their particular job. This may have something to do with the fact that there is insufficient breakdown of sub-goals that can be checked and which individuals can easily identify with.

2.5.3 *Standardisation / Standard Operating Procedures (SOP)*

2.5.3.1 Since 1986 considerable efforts have been made on the part of the airline to standardise and develop SOPs. This investigation has shown that there has been opposition to this work in some parts of the pilot corps. Those who have stood for development in this field have felt that their work has been all uphill and that they have had too little response from certain parts of the corps. The AAIB/N has also received comments from those in opposition to the effect that they are not so much opposed to standardisation in itself as to its contents and method of implementation. The management wanted uniform operations and a uniform pilot corps. Those opposed to this wanted regulations setting the limits within which captains could operate and which were in line with the responsibility each pilot-in-command had to operate safely. In other words, there has been a conflict between control over details and greater freedom to operate according to the individual's judgement of a situation. This view seems to be deep-rooted in the airline and may derive from the operations culture from the days of the sea plane, i.e. the days before the company became an airline with scheduled operation of land planes. It has been pointed out that operations on the short field route net are so specialised that one cannot apply the same criteria to this type of operation as to other scheduled flight operations. This is inconsistent with the safety goals quoted in FOM paragraph 1.1 section 8.2.

> "The airline's safety goals are similar to those for international airline traffic. This is quite an ambitious goal since the outer, external factors for short field route net operations in Norway do not equate to international standards for airline traffic. Thus, such a goal, under our external conditions, makes great demands on the airline's systems and routines and the level of skills of all employees in order to ensure that the airline's safety goals are achieved."

2.5.3.2 The AAIB/N would like to point out that the increased standardisation and introduction of SOPs is a recognised method of achieving greater safety in a risk filled activity. This is just as relevant whether one is operating on the trunk route net, the short field route net or one is involved with oil exploration in the North Sea. The amount of work invested by the operations management in carrying out standardisation is evidence that the airline had resourceful people who realised this. In the opinion of the AAIB/N, there is no substance to the claim that dealing with details in the form of standardisation/SOPs is inconsistent with short field route net operations.

2.5.3.3 The question arises, with regard to the events of the flight leading up to the accident, as to what extent the crew can be said to have belonged to the group which was considered to be opposed to standardisation. The AAIB/N found no indications of this in the course of the investigation. The question also arises as to the extent of the effect a group such as this might have on the pilot corps. In the opinion of the AAIB/N, it is probable that attitudes like this would in time have consequences for the general standard of operational activities unless the management put a stop to such a development. It is possible, for example, for an adverse culture such as this to give individuals who comply with rules and regulations a more secure feeling than they should have (complacency) which, in turn, may lead to reduced alertness. The AAIB/N has also assessed the lack of compliance with procedure and regulations as important factors in the chain of events leading up to a number of the previous accidents and incidents experienced by the airline.

### 2.5.4 *Training levels and standards*

2.5.4.1 One of the requirements for meeting the airline's prescribed flight safety standards is to conduct a training programme using these standards as the goal. According to the operations management, the airline's operative training programmes are continually being developed and revised according to the experience gained from feedback given to management, and from discussions between the operations management and the instructor/control organisation. To the extent the AAIB/N has managed to bring to light, the fact is that the airline has no written policy as to how training levels and standards are to be set to satisfy prescribed flight safety standards. So there appears to be some lack of clarity as to how responsibility should be divided up when it comes to formulating standards and relevant training programmes.

2.5.4.2 Bearing in mind the audits which must be carried out in a quality system, it is the opinion of the AAIB/N that policy and documentation need to be developed for training programmes. This is, among other things, necessary so as to provide the quality assurance department with the basis for making audits also to the training programme.

2.5.5 *The airline's FOM/FTM regulations*

The airline's regulations were considered by certain sections of the flying corps to be generally unclear, inconsistent, too extensive, complicated and conflict filled. This often led to debate at to the meaning of what was written. The FOM and FTM were not always consistent with each other. In Questionnaire A a number of people said that they thought that the regulations were fine, but it was also said that some parts of the regulations were not read and that as a result people did not relate to them. It was also said that the regulations were written to cover the management's backs and to satisfy the CAA/N. Another factor that made people uneasy was that management gave various different answers to questions regarding points in the regulations that were unclear.

2.5.5.1 The operations management told the AAIB/N that they were aware of this lack of clarity and the need to co-ordinate the various documents, and that it was simply lack of giving priority and time that had prevented this from being done. The AAIB/N has been informed by certain sections of the pilot corps that they had so many procedures and regulations to relate to that it affected their alertness when airborne, and that this applied, in particular, to short flights.

2.5.5.2 In the opinion of the AAIB/N, some of the lack of clarity is derived from the fact that the adaptation of rules and regulations copied from other companies to the airline's own patterns of operation was less than a complete success. The AAIB/N would also like to clear up a misunderstanding in FOM section 2.5 paragraph 2.4 with regard to delegation of responsibility. Responsibility cannot be delegated. Tasks can be delegated, and with it the authority to carry out duties on behalf of the Pilot-in-Command.

2.5.5.3 The Operations Division's Quality Manual includes requirements for the manual system which are divided up into three levels, but the FTM is not mentioned. When the AAIB/N questioned the Quality Assurance Manager about this, his reply was that the manual had no formal status in the airline. There is, however, no doubt that the FTM is being used as an operations document with reference to, for example, FOM section 9.5 paragraph 4.4. The Standardisation Manager should also check and monitor that the aircraft type is being operated in accordance with the FTM.

2.5.5.4 The AAIB/N considers a suitable, consistent, easily intelligible set of rules and regulations to be the cornerstone of flight safety work. There is no question that the running of an organisation is made considerably easier when those who work in it have the same understanding of its rules and regulations, and when work is created and carried out on this basis.

2.5.5.5 If the pilot corps does not consider these rules and regulations to be the aid they should be, then they should be studied and revised and, as a result, there should be a change of attitude towards them. It seems that when tendencies such as these are allowed to perpetuate in an organisation, the control and management functions in the airline do not appear to work satisfactorily. In the opinion of the AAIB/N, it is also important that the comment made about alertness when airborne being adversely affected because of discrepancies in the regulations, should be taken seriously.

2.5.6 *Culture / attitudes*

2.5.6.1 It has been made clear to the AAIB/N by the operative management that some airline pilots did not accept decisions taken by the management. This has led to situations where it has been necessary for the operative management to force certain pilots to accept regulations and conditions they did not agree with. In turn this led to situations of conflict that have remained partially unresolved in the organisation, and which have thus been the cause of unrest in the airline's operations. It is symptomatic that opposition to standardisation was expressed in the form of a signature campaign within the pilot corps which, however, received a limited response.

2.5.6.2 As the object of the dispute has remained latent and unresolved, opinionmongers have been allowed to operate freely within the system. For example, work carried out in connection with attitude-creating activities within the "human factor" field (CRM) was met with scepticism from certain quarters. The previously mentioned situation regarding standardisation work is another example. In an investigation (after the accident) of reporting routines at a short field airport, altogether 59 irregularities out of 179 WF flights were recorded in a single month.

2.5.6.3 In the opinion of the AAIB/N, these detrimental attitudes and cultures are due to inadequate attention and effort being directed towards raising consciousness and motivating the organisation to commit itself to change. The process of change within the airline has been unsuccessful when it has come to conveying this to the operative part of the airline. Also, in some cases, there seems to have been a need for firmer action to be taken by management to neutralise or put a stop, from the viewpoint of flight safety, to the activities of negative opinionmongers.

2.5.7 Allocation of responsibilities, resources, organisation - internal control element

2.5.7.1 *The role of management at WF*

The AAIB/N is in no doubt that the airline's intention was to set up quality and internal control systems that would ensure safety and, as a result, flight safety. According to the airline's FOM section 1.1 paragraph 9.1, the CEO and board of directors have the overall responsibility for ensuring that the conditions are right for achieving the safety goal (100% safety), and that the airline's quality assurance and internal control systems are functioning, provided, in the opinion of the AAIB/N, that the airline's management has a clear policy as to how these systems are to be developed, implemented and maintained. As the AAIB/N sees it, this policy was inadequate and consequently had negative consequences both with regard to implementation and monitoring. From experience this can often be viewed in light of the fact that top management is not sufficiently committed and that there has been insufficient planning prior to implementation.

The AAIB/N is also of the opinion that it would be appropriate for the management to carry out a safety process to establish the principles and philosophy which shall contribute to the manageing of the safety in the airline.

2.5.7.2 The aim of introducing new administrative systems into an organisation is to instigate improvements. However, no improvement can be achieved without realising that the process of improvement involves change. Most people have an built in scepticism to change and often feel that change is more a threat to what they are accustomed to and what they feel secure about in their working environment than something positive and inspiring. In other words, managers who wish to make changes have to expect to encounter opposition. This opposition must be restrained and negative involvement must be transformed into positive participation in the process. This presupposes that there is a programme in place which, at some stage/level or several stages/levels, incites all those employees involved in this process to raise consciousness, motivate and educate. It is to be expected that this will take time, but such a process is of vital importance if a positive result is to be achieved.

2.5.7.3 As the airline up to the time of the accident, was not sufficiently successful in implementing two such important areas as standardisation and internal control/quality assurance, it is the opinion of the AAIB/N that management did not place enough emphasis on raising consciousness and motivating the individuals concerned.

2.5.7.4 *The role of the board of directors*

The AAIB/N sees no reason to doubt that both the airline's board of directors and CEO have been concerned about flight safety in the airline. The potential for improvement the investigation has revealed, depends rather on how safety work has been implemented. According to the chairman of the board, who has occupied this position for a full 10 years now, boards of directors in the aviation business have traditionally been formed to handle business strategy and executive financial appropriation. Formally and in reality, the board of directors has the executive responsibility for safety. Practically speaking, however, flight safety has not been a routine, set topic, as it has been thought that this area of responsibility could best be handled by the executive management. Should flight safety become a part of the board of director's area of responsibility, the composition of the board would have to be different.

2.5.7.5 Seen in the light of the serious accidents which have hit the airline in the chairman of the board's term in office, the AAIB/N is of the opinion that active monitoring of flight safety in the airline would be natural for, and of advantage to, the management. The AAIB/N realises that the board of directors neither can nor should carry out any detailed monitoring. However, the AAIB/N is of the opinion that a marked interest in and consideration given, on the part of the board of directors, to flight safety, clearly expressed in an executive safety policy, would have a positive effect on the organisation. Monitoring of safety policy would provide support at various levels for management in the decision-making process, and would increase motivation in difficult cases, such as getting the entire pilot corps to support the subject of standardisation, and control of undesirable opinion-mongering.

2.5.7.6 Subsequent to the accident, it is the AAIB/N's understanding that the airline removed the formulation of the board of directors' executive safety responsibility from the FOM. In the AAIB/N opinion, this gives a rather negative signal to the organisation which in no way contributes to solving the airline's safety problems. In other businesses which involve a considerable potential for risk it is quite usual for the organisation's safety principles and safety philosophy to be stipulated at the board of directors' level.

2.5.7.7 *Excecutive management*

The CEO said that he uses management by objectives extensively as a management principle. However, the investigation has revealed that this is not fully implemented when it comes to flight safety. The AAIB/N realises that the serious accidents the airline has suffered during the CEO's term in office have been a heavy burden on both the airline and its staff. The CEO wanted to put the tragedies behind him and develop the airline by learning as much as possible about the accidents at all levels of the organisation. However, the AAIB/N has registered requests for further information on WF's and other airlines' accidents or incidents to be made available and used in the safety work. People have also expressed the wish not to be shielded when things do not conform to the goals.

2.5.7.8 *Resources - finances*

The airline seems to have solid enough finances, so low staff levels or acquisitions should not be a limiting factor to the achievement of a satisfactory level of flight safety. Large, soundly-based investments, such as the acquisition of de-icing vehicles, investment in simulator training and CVRs for Twin Otter aircraft, have been approved by the airline's board of directors and the CEO, and have been implemented. However, at the instructor level on the operations side and in the pilot corps, the AAIB/N has noticed that enthusiasm has turned to frustration when it comes to relatively reasonably-priced investments such as the acquisition of computer-based training aids and navigational equipment for delivery flights. Applications have either not been answered or an unreasonable amount of time has been taken to answer them.

2.5.7.9 It has been said that an airline which is subsidised by the state must be subject to strict financial control, which implies that practicality must be demonstrated and that even small acquisitions must be subject to evaluation. In the AAIB/N's view, however, it is also important to maintain staff enthusiasm and a willingness of staff to make effort. In this regard, it may seem well worth evaluating whether making budgets and routines for less costly acquisitions can be made easier, such that those involved do not tire of and reject valuable flight safety work - work which has often been based on personal interest and carried out voluntarily.

2.5.7.10 It has been alleged to the AAIB/N that one reason for there being difficulties in obtaining approval for investments of the aforementioned type may be the lack of understanding of flight operations at top management level. The Flight Operations Manager was previously a member of the concern's top management. The CEO changed the set-up of the organisation so as to lessen the burden on this important position by preferring to have direct contact with his Flight Operations Manager and call him in particular cases. The director of the Operations Division was, by definition, the normal official channel between the CEO and the Flight Operations Manager in cases involving flight operations. Operations management said that they thus had to argue through an extra link about initiatives of an operative nature, and people have felt that it was more difficult for them to put forward their points of view and their requirements which, in their opinion, had to do with flight safety. The airline does not feel that this describes the true situation, as no investments proposed by flight operations were rejected by the Operations Division, so it was not even necessary to argue through an additional link to process cases such as these, as the Operations Division had the final say. Whatever the procedure used to handle cases in the management group, it was usual to call in section managers when cases in their area of speciality were being processed. This applied to the Flight Operations Manager and other section managers. The section managers could take up any matter whatsoever and be sure that this would be given fair treatment. The technical management was satisfied with this organisation.

2.5.7.11 In the opinion of the AAIB/N, the type of organisation mentioned above was not successful from the operational point of view, not least because of the vague channels of decision. As the CEO established direct contact between himself and the Flight Operations Manager on certain issues, an unofficial short cut was created outside the normal line of command (the director of the Operations Division), and as the CAA/N requires an airline to have an approved flight operations manager who is responsible for safety and who also reports directly to the aviation authority, this could have created a lack of clarity regarding the entire responsibility for safety in the airline. The CEO was of the opinion that the approved Flight Operations Manager was well-qualified to take responsibility for the flight operations side of flight safety. As the AAIB/N sees it, it is all right, in a sense, for a Flight Operations Manager to act as a safety officer, but in no way does this exonerate the board of directors or the CEO from having overall responsibility for safety and from the duty of achieving the flight safety goal should significant deviations occur. The most important argument, perhaps, for the Flight Operations Manager being so close to the airline's top management, is that he can see consequences, from the viewpoint of flight safety, of decisions which the rest of the management are unqualified to detect. All in all, the AAIB/N thinks that it is highly advantageous having a Flight Operations Manager who has the right and the duty to attend meetings at the Concern's management level.

In addition, the AAIB/N notes that the CAA/N's "Requirements for Flight Operations Managers" (BSL D 2-8), which came into force on 1 June 1994, requires the Flight Operations Manager to be directly answerable to the airline's CEO.

2.5.7.12 *In-company training*

In the course of this investigation the AAIB/N obtained information on a number of aspects of the in-company training. All new pilots are put through an internal flight safety course in connection with type training and check-out on particular aircraft types. All pilots, with a few exceptions, had taken part in a CRM course. A course in human factors had also been run for this group. The Flight Operations Manager and managers with related responsibilities, as well as managers higher up in the organisation, had been through a management development programme in 1989-90 entitled "From Words to Action" (FWtA) which was designed to develop personal skills by working on a strategy for the airline. The programme was later repeated for the technical department. The Flight Operations Manager participated in a similar course outside the airline. The management programme was, in addition, planned to be repeated and further developed. Departmental managers and section leaders had been on courses in quality assurance related to the ISO 9000 series. There was, generally speaking, a lack of appreciation in the pilot corps of the contents of Chapter 6 of the FOM on internal control and quality assurance which, in the AAIB/N's view, may primarily be the result of inadequate training.

2.5.7.13 *Management development*

Despite the good intentions the airline had towards the FWtA programme, it has been pointed out to the AAIB/N that a programme for uniform management development in line with the airline's management principles aimed at practical management was lacking. That management principles excist are referred to in FOM section 2.1 paragraph 1.3. In addition the airline's main management principle was to be management by objectives. However, the AAIB/N has not found the principles to have been set clearly down in writing anywhere or to have been implemented at all levels of management.

2.5.7.14 *Practical management*

The airline's operations management felt that they had had insufficient practical training in structuring their administrative working day such that tasks were carried out in the best possible manner. A general desire was expressed for skills to be updated in all areas pertaining to management, administration and education.

2.5.7.15 *Recruitment*

Those people recruited for management positions in the operations section are traditionally people who have shown themselves to be competent pilots, who have gained the confidence of others in the pilot corps and who have expressed the desire to take on more challenges than just that of flying. By using this method of recruitment it is not always the case that the person in question is qualified. After talking to the airline's operations management, there was no doubt that these were people who had taken on their positions with the intention of doing the best possible job. It should be noted, however, that the vast majority of employees at the middle management level, (instructors and supervisors) expressed the opinion that they wished they had received better training prior to taking up their positions. Furthermore they would have liked to broaden their skills through appropriate further training in their respective areas. In the AAIB/N's opinion, a selection process might have revealed strengths and weaknesses in candidates and possibly formed the basis for plans for individual training and skills development.

2.5.7.16 *Resources - time*

Staff at the operations management, instructor and supervision levels, have expressed that either not enough time was allocated to necessary office work or that there was insufficient time available.

2.5.7.17 The day-to-day running of an airline must have high priority if passengers are to get where they want to go by a given time. Other administrative tasks in the operations department were not done, because of, for instance, that days set aside for operations' staff to do office work, were replaced by active flying. There was too little time for dealing with or giving feedback on reports of departures from procedures or implementing and monitoring corrective action. Information meetings on flight safety matters were postponed, as was essential work with coordination of the FOM and the FTM. In the view of the AAIB/N, the effect of too little time available was boosted by the insufficient training mentioned above.

2.5.7.18 In any organisation there are times when it is necessary to make effort without the addition of extra resources. The airline went through such a period prior to the accident owing to the phasing-in of the DHC-8 and the phasing out of the DHC-6 and DHC-7. This aside, the AAIB/N's impression is that the resources available were not quite adequate for carrying out all necessary tasks in the operations departement. This seems to have had very serious consequences with regard to the continual influence of the attitude of the pilot corps towards the day-to-day flight safety work. It thus seems appropriate to evaluate whether or not available resources are adequate for carrying out normal operations.

2.5.7.19 *The trade union's role*

The pilot's union in the company has its own flight safety committee engaging itself in flight safety related questions. This is regarded positively. However, it might be as prudent to point out that the committee's role in flight safety work is informal and thus without obligation.

The same applies to the local section of the trade union for the flight technicians, Norsk Flyteknikerorganisasjon (NFO). This trade union also has a flight safety committee. The AAIB/N has noted that the trade union was particularly committed to the area of internal control and reporting on procedural anomalies, and to working to ensure that this area of the airline's organisation functioned smoothly. The trade union has even gone as far as to train one of its members in this particular area at its own expense. The union had gradually come to feel that it was taken seriously and had gained some influence. They would for instance like the airline's quality assurance department to play a more active role.

2.5.7.20 As flight safety in the airline is an interdisciplinary area, the AAIB/N is of the opinion that it would enhance flight safety work if the trade unions' flight safety committees were to cooperate more at their level.

### 2.5.8 Monitoring the pilot corps' standards (internal control element)

2.5.8.1 The airline's control group has met with active opposition from sections of the pilot corps with regard to its work. Route checks have not produced the desired effect because of the way they are carried out and because of opposition from pilots to this kind of standardisation control. This implies that the group has not functioned sufficiently well as a control body. The control group's feeling about their work situation was that there was a lack of support from the management for the importance of the standardisation work, and that there had been a lack of follow-up in the form of resources. The CEO did not understand this and considered that he had given his full support to this work.

The AAIB/N assumes that this feeling of not getting support may be due to frustration over the fact that those opposed to standardisation had continued to be influential, in addition to the fact that there had been problems finding the time for debriefings subsequent to the route checks.

Flight checks as a method of control have an inherent weakness in that some people follow procedures on flights when there are flight supervisors present. However, the checks does have the advantage, from the viewpoint of safety, that it checks whether or not people are familiar with and understand the procedures.

2.5.8.2 It is also essential in this case that reference is made to the need for consciousness raising and commitment on the part of top management. According to information supplied to the AAIB/N, the flight operations management and the administrative management were not unaware of the fact that there were problems to do with standardisation. It is thus the AAIB/N's opinion that a clean-up process should have been instigated in order to remove opposition.

2.5.8.3 The chain of events up to the time of the accident took place in a work situation where the Pilot-in-Command was the FP and the co-pilot was the NFP. The division of tasks was identical to that in the aircraft accidents at Brønnøysund and Værøy as well as in an earlier serious incident at Namsos. As this situation arises repeatedly, the AAIB/N wishes to stress the necessity of consolidating the corrective role of the co-pilot. The AAIB/N would also like to point out that the internal control and quality assurance system developed by the operations section did not possess the essential in-built elements for revealing and pre-empting the occurrence of adverse factors in the chain of events.

2.5.8.4 The AAIB/N sees the potential for improvement in the internal control and quality assurance system. As there seems to be little evidence of the pilot corps having any knowledge of what the airline's quality system involves, a positive attitude towards quality can, for example, be illustrated by the fact that most pilots in many cases are quite used to relating to and carrying out work of high quality, such as instrument approaches in bad weather where cooperation and accuracy is required when complying with precisely-set procedures. In cases such as these the right things have to be done first time every time, which is how quality is achieved. Cooperation is successful because everyone knows their place in the system, respects each other's roles and carries out their own tasks until the end product is as it should be - a safely-executed flight.

2.5.8.5 In addition to the route checks and the PFTs, monitoring of goals and flight safety standards was carried out through internal audits under the direction of the quality assurance section. What came out in conversations with interviewees from the Technical Section was that they regarded the audits as useful, but that the audits focused far too much on documentation. The AAIB/N's view is that the practical value of the audits could have been greater, if the audit reports always had contained clear requirements for corrective action to be taken when procedural anomalies were detected.

The auditing and reporting departed on certain points from the relevant guidelines for auditing quality systems. The last audit in the Aircraft Operations Division was carried out approximately 7 months prior to the accident. No weaknesses or departures from the required specifications were detected. According to the audit report, additional procedural anomalies detected in the day-to-day running of the airline were dealt with consecutively and were further processed in the form of a trend analysis aimed at implementing more long-term action. According to the SINTEF's and the AAIB/N's assessment, this does not reflect the real situation at Flight Operations. However, it is a positive sign that audits such as these were carried out, in spite of the fact that there were relatively few of them. It should be said that there is room for improvement when it comes to the method of auditing itself.

2.5.9 Report routines and the recording and correction of nonconformities (internal control element)

2.5.9.1 An important element of the airline's internal control is the reporting routines which were set up (Ref. FOM sections 6.2 and 6.4). Systems were designed for reporting paths that avoided the quality assurance department. If the quality assurance department is to be able to fullfill the role it is designed for in quality assurance theory, the airline and the operations division must set up reporting paths for both the technical and operations sections such that all professional reports also pass through the quality assurance section for analysis and follow up.

2.5.9.2 The basis for analysis was inadequate owing to the fact that too little was reported to the operations management. This was taken to mean that everything was going well and that everything was in order. There seems to be a disproportionately large difference between the reports on the technical and operational conditions, taking into account the number of flights per month. In the course of the investigation the AAIB/N was informed that there had been episodes that could potentially have developed into something more serious, but which were not reported. This indicates that there was probably a considerable amount of under-reporting of operational anomalies. According to the director of the Operations Division, the airline had tried out several different methods for reducing the amount of under-reporting, with little success. Confidential reporting had also been employed, but not even that had produced a better response.

2.5.9.3 It is the AAIB/N's opinion that the under-reporting does not, generally speaking, relate to really serious episodes, as it would be extremely difficult to keep events such as these secret. It is rather a matter of bringing to light the factors or incidents which could trigger off a chain of events or be the catalyst for an adverse development. This potentialities thus become the raw material for trend analyses and risk evaluations in which the safety gain is having the opportunity to take preventive measures before an adverse development is triggered off or breaking the chain of events before an accident takes place. The AAIB/N is under the impression that the significance of this is not fully understood in the pilot corps. However, the fact also needs to be taken into account that this situation must be seen as a lack of confidence that the system would only deal with situations such as these with the goal of flight safety in mind.

2.5.9.4 The AAIB/N wishes to emphasise that this is a problem which is not just confined to the airline concerned, but is an international situation which applies to the entire aviation industry. It is about trusting that the reporting by an employee of a mistake made in the course of the employee carrying out his job will neither result in the employee being made an exhibition of, nor in measures of punitive action being taken against the employee. In the opinion of the AAIB/N, this question must be resolved by the authorities through legislation opening up for information dissemination without the danger of punitive action being taken towards the reporting employee himself. For a system such as this to be viable, it has to be so comprehensive that one-off incidents cannot be identified in the information flow. In other words, that the minimum level should be a Nordic level, or even better, a European one. A system such as this cannot, however, replace the current requirement for reporting or internal systems for dealing with anomalies.

2.5.9.5 With regard to the position of the airline in relation to reporting, it is important for the pilot to have clear, fairly undemanding routines to follow. It is well known that pilots often want to limit the amount of paperwork as much as possible and prefer to rely on verbal solutions to get cases out of the way, and for the parties concerned to discuss and come to a decision on the matter amongst themselves. In order to deal with this problem, it is the view of the AAIB/N that conditions should be made clearer, particularly for verbal reporting (FOM section 6.2 paragraph 3.4 states that all available communication channels may be used). It is the AAIB/N's understanding that cases to do with reports on operational matters have, in the view of the pilot corps, been handled unfairly, and this might have had an undesirable effect on people's willingness to file reports. It would thus probably be an advantage if the person or persons receiving the reports do not have any sanctioning power and may act unrelated to the airline's management. This might well be a task for selected "safety pilots" who are able to evaluate the data and provide more detailed information before the operations management is made aware of the case. As far as the AAIB/N is aware, this airline used to have a position for a pilot who was responsible for flight safety within the company. This position was, however, removed from the organisational structure and his tasks divided up amongst the operations management who were already heavily overloaded with work. This fits in with the picture the pilot corps have painted of an operations management which was rather removed from the day-to-day running of the operations.

2.5.9.6 Action taken against staff for not following regulations or other internal rulings has in some cases been interpreted as misplaced demonstrations of power (overreaction) and/or as inconsistent or random discrimination.

This sensitive situation requires consistent, fair treatment if it is to result in understanding and respect. It would take very little for there to be unexpected consequences such as a reduced willingness by staff to report anomalies.

Feedback shall be given within a period of 14 days to those pilots who have submitted various kinds of reports, according to FOM section 6.2 paragraph 3.2. The fact that the airline did not always adhere to this can probably be put down to the fact that the operations management were overloaded with work, which affected task prioritisation. The Pilot's Union has, in several cases, made efforts to speed up the feedback process. Inadequate feedback routines may also have led to indifference towards reporting, as people feel that it does not lead to anything anyway.

2.5.10 Evaluation of empirical data and development trends (internal control element)

2.5.10.1 *Risk index*

One of the ways the airline has monitored empirical data is by using a risk index. This has been one of the Flight Operations Manager's tasks and, according to the FOM, is to include both flight operational and technical incidents. SINTEF researchers have adduced the following:

- Technical incidents are, in practice, almost exclusively included in the risk index, which has to do with the fact that operational incidents are under-reported.

- The index is calculated collectively for the three aircraft types the airline operates. This is unfortunate, as this might camouflage adverse trends connected to one aircraft type.

- The weighting of the various incidents may be calculated, according to the FOM, according to three different tables, but it is not stipulated which table is to be used, and the weighting is thus dependent on a subjective evaluation. The choice of table will affect the index.

- According to the positional instructions in the FOM, the Flight Operations Manager and the Chief Pilot share responsibility for checking and monitoring the standard of pilot activity. However, there are no procedures for what action should be taken if the target figure of a maximum of 7 significant incidents per 100,000 flight departures is exceeded. It is the Flight Operations Manager's responsibility to take action.

- The risk index appears in the monthly "Flight Crew Info" which gives information of the trend and on which incidents (mainly technical) have occurred over the previous month, as well as the corrective action taken. The pilots missed information as to why the incidents occurred to better to be able to utilize the information.

- Technical faults also appear in the Reliability Report. The technical section did not use the risk index as the basis for their management.

2.5.10.2 The current method used to calculate the risk index did not give a true picture of the flight operations side of the airline's activities. It seems that no one in the management team, and few or none of the staff, used the risk index as a method of directing flight safety towards prescribed goals. The risk index was thus of little practical value.

2.5.10.3 Trend analyses for flight safety were based on the risk index, results from flight checks and the PFT. Those trend analyses which were based on the risk index did not give a true picture of development. There was also a weakness in these analyses in that they were carried out by staff who lacked basic skills in risk analysis methods and mathematical statistics. This is unfortunate, as this can lead to incorrect decisions of two kinds being made:

- Systematic errors, which may be interpreted as being incidental, resulting in corrective action not being taken sufficiently rapidly

- Incidental errors may be interpreted as being systematic, which may result in unnecessary or even erroneous action being taken

The airline focused too little on analysing anomaly trends as the basis for fundamental, longer-term action rather than immediate action to improve flight safety.

2.5.10.4 Top management team meetings were held regularly every other week. As far the AAIB/N is aware, flight safety was not a regular topic at these meetings. In the opinion of the AAIB/N, flight safety should be an agenda item at all top management team meetings, particularly because of the importance of the effect such a signal of pronounced interest in safety matters would have on the organisation. The significance of this taking place at the airline's highest level should not be underestimated, as it will contribute to creating respect for the entire safety organisation, including its performance and management.

2.5.11 Information system

2.5.11.1 According to the CEO, a rather extensive organisation had been established to keep employees informed. The AAIB/N has not decided whether or not this had, generally speaking, been adequate, but it has been stated that not everyone in the pilot corps shared the CEO's assessment of the effectiveness of the information system. In addition, the AAIB/N has some opinions about how well the information system set up in the Operations Division did work.

2.5.11.2 Various meetings which directly concern flight safety - Base Meetings, Pilot Meetings, Operations Division Meetings, Maintenance Review Board (MRB) Meetings, Standardisation Meetings, Instructor Meetings and other operational meetings - were held at varying intervals. The meetings at which it was most difficult to obtain good attendance were those involving the pilot corps, because of the nature of the day-to-day running of the airline. The airline's basic structure, the location of the pilots' homes and the arrangement of working schedules were also of considerable importance. Attendance at the Pilot Meetings, which were held during free periods, was not compulsory.

2.5.11.3 In the opinion of the AAIB/N, these pilot meetings are perhaps the airline's greatest opportunity to influence attitudes towards training and control activities. As it had been difficult to assemble the pilots, and the operations management had been overloaded, these meetings had not been held regularly, in spite of the fact that they had been recorded as a requirement in FOM section 1.3, paragraphs 1.1 and 3.1. Because these meetings are so important for flight safety, it would be appropriate for people to make more effort and be more creative in order to reach as many as possible. Minutes from the meetings have been used as information for distribution, except when the agenda did contain delicate topics. According to the Pilot's Union, only brief minutes from the MRB have been seen.

2.5.11.4 Most of the aircraft accidents and incidents that have hit the airline have contained decisive, flight operative factors in their chain of events. A number of employees did say that the airline could have taken the opportunity to learn a great deal more from those unfortunate experiences. They also said that they would like more information on unsatisfactory conditions. The CEO had, for quite understandable reasons wished to put these tragic events behind him and to summon up the strength to make efforts for the future. In the opinion of the AAIB/N, however, the value of negative experiences as a basis and motivating factor for necessary change should not be underestimated.

2.5.11.5 There seems to be a great deal of attention concentrated around the singularity of short field operations. The AAIB/N has heard opinions from pilots who feel after several years with the airline that they have lost touch somewhat with the rest of the aviation environment. The AAIB/N thus sees a relevant connection between this and the wish for further information about external flight safety conditions to be made easier available to the pilots. The aim of this must be to use the information as a means of heightening awareness and influencing attitudes. To complete the picture, the AAIB/N would also like to mention that representatives from the airline's flight operations management have participated in various national and international fora that have information on how to improve flight safety as their most important goal.

### 2.5.12 SINTEF's general conclusions

In its report SINTEF has presented five situations which, in the institution's opinion, have played a particularly important role as potential, hidden causal factors in this aircraft accident. These points is supported fully by the AAIB/N.

- Within the pilot corps negative attitudes towards the management's decision to use SOPs extensively during flight duty have grown over a number of years. The management has been aware of this opposition, but has not used all available means to steer these attitudes in a more positive direction and monitor the application of the SOPs.

- The airline makes extensive use of management by objectives as a management principle, but seems to have a lesser capacity to implement this principle when it comes to flight safety than when its comes to other main and sub-goals. Flight safety is not expressed as being a priority main goal in the airline's primary goal and other management documentation, nor have clear guidelines been given as to how flight safety is to be prioritised in relation to other important goals such as special requirements for regularity, punctuality and economy.

- The airline has not used the means at its disposal to monitor flight safety adequately. There are clear weaknesses in the airline's system of reporting operative anomalies influencing flight safety, which may have contributed to painting a more favourable picture of the level of flight safety and the development of flight safety in the airline. This aside, the aircraft accidents and incidents which occurred are so serious that top management should have reacted with greater attention and taking the initiative to improve flight safety.

  The responsibility for flight safety and the direct responsibility to file reports that an approved flight operations manager has towards the CAA/N, does not exempt top management from the duty of monitoring the goal for flight safety and for taking necessary initiative when significant deviations from that goal arise.

- The airline does not seem to have adequately understood the significance of the continuous influence of attitudes as part of the flight safety work being carried out. The necessary resources have not been allocated to the planning, coordination, execution and monitoring of this work, particularly at the middle management level.

- The internal control system described in the FOM and those parts of the quality system which include flight safety are not well incorporated in the organisation, and have thus not functioned satisfactorily.

2.5.13 Medication

2.5.13.1 As reference to the finding of the co-pilot's medication and the fact that an essential health condition (back pain) was unknown to the certifying authorities, the AAIB/N wishes to emphasise the latent situation implied here with regard to flight safety. In this connection, it is noted by expert authorities on aviation medicine that it is at least as important to know the reasons why members of an air crew take medication as it is to evaluate the effect of the medication on a pilot's ability to perform his duties. It should also be emphasised that self-medication using medicine sold over the counter may have an adverse effect in cases such as this. It is thus advisable to contact experts in aviation medicine to get advice on the choice of medicine and the dosage. Having said that, the AAIB/N also wants to emphasise the seriousness of the doctor who prescribed the co-pilot's medication, deciding to do what he did in spite of his background of experience and formal training. The CAA/N should assess whether or not this can be considered to be an isolated case or whether it is necessary to update information regarding the doctors' duty to report to the Medical Board of Aviation.

2.5.13.2 In the interests of flight safety, the AAIB/N wishes to emphasise the importance of the certifying physician, and thus the Medical Board of Aviation, being informed of any illness or consumption of any medication, as specified on the personal declaration applicants have to fill in. The theme of "the effect of medication and side effects of the use of medicinal products" is, moreover, included in the curriculum for the new subject, drawn up by the CAA/N as a licence requirement - "Human Performance and Limitations".

2.5.14 Stress and strain

2.5.14.1 According to information from various sources in the airline, there is so much stress and strain involved in flying on the short field route net, particularly during the winter season, that some captains have shown signs of being burnt out. This may manifest itself in tiredness, irritability, reduced efficiency and thus reduced alertness when flying.

2.5.14.2 With the knowledge the AAIB/N has gradually accumulated on short runway operations and the weather conditions crews have to tackle, the AAIB/N find this information plausible. From the viewpoint of flight safety, it is important that the management of the airline has a system for recording signs of stress and strain on members of the pilot corps. If individuals themselves report on or show clear signs of suffering negative effects such as these, pre-emptive action must be taken prior to any serious problems relating to flight safety arising. Regarding this point, it is also essential to understand the importance and value of CRM training.

### 2.5.15 Weight and balance

2.5.15.1 Before the aircraft took off from Værnes, passengers in seat row 7 should have been moved forward and a new weight and balance calculated, as the index fell outside the rear limit, according to the system of calculation that was used.

2.5.15.2 The AAIB/N considers weight and balance falling within set limits to be an important aspect of flight safety. Even though LN-BNM was shown to have been loaded within the manufacturer's centre of gravity limits, the AAIB/N thinks it necessary to mention the situation, as the AAIB/N received information in the course of the investigation that not all captains in the airline had been equally meticulous on this point. If weight and/or balance fall outside the limits it means that the built-in safety margins are reduced. In the worst case, reduced margins which combine with other adverse factors may make the difference between a situation which turns out favourably and a situation which results in an aircraft accident or a serious incident. It is thus vital that both the airline and the individual pilot have work routines which ensure a correct result.

### 2.5.16 Latent factors mentioned elsewhere in the report

The "Black Hole" visual illusion is not described in the airline's documentation, and the airline's Twin Otter pilots had insufficient knowledge of this illusion.

The investigation has revealed uncertainty about the correction of minimum altitudes and approach minima, and the calculation of time in the approach procedure.

The airline's regulations lack a clear definition of what visual reference to the ground means.

2.5.17 The Civil Aviation Administration's position with regard to the airline's Operations Division's aircraft safety standards, internal control and quality systems

2.5.17.1 As a link in the evaluation of all systems set up for the purposes of safety management in commercial aviation, the AAIB/N also conducted an investigation into the CAA/N's role as a supervisory authority for Widerøe Airlines. A contributory factor in this evaluation was that the airline had not been particularly successful in implementing its own system of internal control and quality assurance. An important element was thus how the CAA/N supervised the airline's flight safety standards and the systems set up for internal control and quality.

2.5.17.2 The information available after the discussions with airline staff were completed, and the information supplied by responsible managers and inspectors from the Aeronautical Inspection Division, were collated. This showed that, generally speaking, the inspection had resulted in a good deal of knowledge about the airline's activities. A contributory factor in this picture was the increased supervision and access control performed during the introduction of the DHC-8.

2.5.17.3 The CAA/N conducts its survey of the aviation sector in accordance with the requirements (BSL). These requirements represent the minimum level of flight safety standards. If the airline wants to operate according to a higher standard, the CAA/N, in its introduction to BSL B, has indicated that this is acceptable "provided that the airline's own requirements are the basis for internal control and the safety authority's inspection." This basic principle is not mentioned in BSL D.

2.5.17.4 In the operations section of an airline, the requirements for internal control are not established in the regulations. However, it is required that

> "an airline shall set up and maintain an inspection system for its flight operations".

Such a system is for this airline described in chapter 6 of the FOM, which defines a system

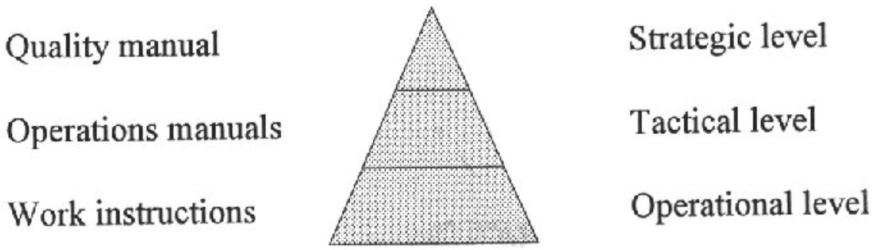
> "which shall ensure that the airline's operations are planned, run, maintained and documented in accordance with the authority's regulations, the airline's own requirements and standards, and the market's needs and requirements".

Important elements included in this internal control system are shown here (ref FOM section 6.1 paragraph 8). According to the Aeronautical Inspection Division, the FOM section 6 is not specifically approved by the safety authorities. Because of the missing requirements for internal control on the operations side of an airline in the BSLs, the Aeronautical Inspection Division has not especially approved chapter 6 of the FOM. In the opinion of the AAIB/N, such a vital area from the viewpoint of flight safety as how the airline ensures the quality of the prescribed flight safety standards, should be included in the Aeronautical Inspection Divisions's professional evaluation and survey. The regulation requirement for the setting up of a system of inspection should provide sufficient authority in this respect. The AAIB/N views the fact, from the viewpoint of flight safety, that the CAA/N is working on a regulation for the introduction of a quality control system for commercial airlines, in a positive light. Requirements such as these will, in addition, come into force in the very near future through the introduction of the JAR-OPS. The necessity of formulating requirements and guidelines for inspecting the aviation sector is thus provided for here.

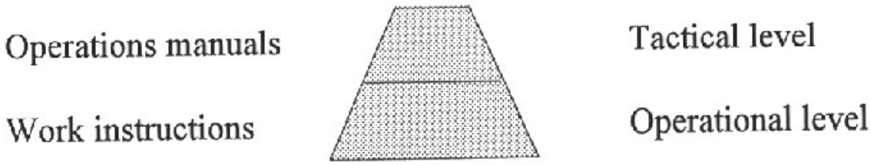
2.5.17.5 The CAA/N in its guidelines on "Internal Control" has, in the opinion of the AAIB/N, expressed it excellently when it stated that the flight safety standards in force at any time are the ones the CAA/N use to carry out inspections, and that these standards comprise the following elements: the authority's regulations (minimum requirement), the airline's own requirements and the requirements of the market, and how the authority's inspection is to be carried out. The safety authority will be able to ensure that the prescribed flight safety standards are maintained through the airline implementing its own internal control. With regard to the extensive cooperation conducted by the Scandinavian aviation authorities, it might be interesting to mention that the Swedish authorities, in the form of a regulation in its BCL on flight safety management (internal control) have stated that

> "flight safety standards are set on the basis of the requirements of the authorities who set minimum levels as well as the additional requirements which those responsible for the airline choose to set themselves. These additional requirements shall be stipulated in the enterprise's documentation system and shall be complied with as though they were requirements set by the authorities."

In the opinion of the AAIB/N, this makes it clear that the regulation sets the requirement for the standards that are to be complied with, and thus form the basis of the contents of the airline inspection. Without such a clarification misunderstandings easily arise, such as the airline, in this case, thinking that the CAA/N had approved their quality manual. The safety authorities, on their part, indicate that this is not the case, and do not use it as the basis for an inspection either. One consequence of such uncertainty can be illustrated by the fact that the airline has, since 1991, had the aim of managing safety in accordance with the quality system described in the quality manual. The CAA/N has not, however, come to a decision about this strategic document, which is important to the safety work conducted by the airline, on the grounds that there are no formal requirements to form the basis for approval. This means, in practice, that the airline is managed according to a type of organisational system, while the CAA/N carries out its inspection with the same organisation according to a different model (see fig.):




When the CAA/N decides not to use the quality manual in the inspection system the strategic level is lost, as the following model illustrates:




In the opinion of the AAIB/N, the strategic level in an airline is so vital to the way the safety systems in the organisation function that it must be subject to both approval and inspection of the safety authority. The same applies to larger, thorough, organisational changes.

2.5.17.6 The AAIB/N, as previously mentioned, considers the requirements to be the most important basis for safe flight operations. Clear, consistent and easily understandable requirements make it easier for the operators of an aviation organisation both to run and develop the organisation, and the CAA/N's inspection function becomes easier because all parties have a common basis. When essential regulations are not in place, this must be defined as latent factors.

2.5.18 <u>Safety management systems - inspections</u>

2.5.18.1 The work carried out by the Norwegian Petroleum Directorate and the Norwegian Civil Aviation Administration relating to inspections with enterprises involving risk have certain points in common. The AAIB/N has thus studied more closely the "Organising Safety Inspections, et cetera, for the Oil Industry on the Norwegian Continental Shelf, stipulated by Royal Decree on 28 June 1985", from which the following quotation from § 1 of the "Conditions and Principles for Inspection" is taken:

> "Within this frame of conditions, it is the Norwegian Petroleum Directorate's principal responsibility to check that the licensee's/concessionary's system for internal control is functioning adequately and effectively. Inspections are carried out mainly through system audits, i.e. through planned, systematic investigation of the control systems which have been set up in order to ensure that they are complied with and maintained as specified."

In the view of the AAIB/N, it is important to note that the Norwegian Petroleum Directorate stresses the importance of carrying out inspections of the licensee's/ concessionary's management of the safety system.

2.5.18.2 With the resources reserved by the CAA/N for the inspection of each airline, prioritisation of the use of resources is essential. In the opinion of the AAIB/N, the correct way to administer resources, in relation to this, is to give high priority to the maintaining of prescribed standards for flight safety by thoroughly checking that the management systems for flight safety are functioning adequately and effectively.

2.5.19 Inspection regulations

In the opinion of the AAIB/N, it is untenable for the safety authority to limit its inspection to essential elements in the standards for flight safety set up by the airline as a result of a lack of regulations. In the same way as the Norwegian Petroleum Directorate has an established role, documented in the regulations, as an inspection authority, it would be of great advantage if similar regulations specifying the aviation authority's role in Norwegian aviation were to be formulated.

## 2.6 Safety barriers

### 2.6.1 Safety barriers that did not work

This section discusses safety barriers in the system which were set up but failed due to violations or evasions, and barriers which were either not set or were incomplete.

#### 2.6.1.1 *Planning*

The planning, as it was expressed in the approach briefing, was incomplete. The barrier was set but was not adequately enforced (with reference to the elements in safety problem Δ 1). For example, the barrier failed in that timing, rate of descent and the time correction owing to the wind, were not planned for.

There was also a latent safety element in this barrier, as there was a lack of consistency between the FOM and the FTM when it came to the details of the planning of the rate of descent.

#### 2.6.1.2 *Rate of descent during approach*

The airline had set a barrier for reducing altitude such that the rate of descent should not exceed 1,000 ft/ min (the rate of descent below an altitude of 2,250 ft shall not exceed 700 ft/ min out of consideration for the passengers' comfort (Ref. FOM section 9.5 paragraph 2)). The actual rate of descent after the "field in sight" was called, however, was so high that it broke that barrier. As for the lack of planning in this area, the crew did not use concrete values in the current situation to set the barrier. The AAIB/N feels that if the crew had devoted more attention to the aircraft's rate of descent this might have broken the chain of events.

2.6.1.3 *Sterile cockpit*

This barrier refers to safety problem Δ 8. The airline had set a barrier by introducing a regulation for it into the FOM. As previously mentioned, the AAIB/N considers it to be of utmost importance to comply with this safety element. It is not clear in this case whether or not this anomaly had any effect on the chain of events. However, it cannot be disputed that alertness and concentration on the task in hand when flying should not be disturbed by conversations which draw attention away from the task of flying.

2.6.1.4 *The CRM*

The basic idea of the CRM is to use the human resources available to ensure that the tasks involving flying are carried out in a safe manner, which means that the crew plans the tasks making appropriate use of all members of the crew. The whole crew can indicate or intervene when the system does not function - for example, when procedures are forgotten or when manoeuvres are carried out which endanger safety, or when risky decisions are made. It is in the nature of the situation that it can be difficult for a junior member of the crew to interrupt or advise his flight captain. The aim of airlines that have introduced the CRM concept is to remove this obstacle by giving junior crew members the essential right to intervene when they feel it right to do so. Interventions such as these should not, however, lead to disciplinary measures being taken.

The crew in this case did not cooperate quite as they should have done from the time the planning of the approach commenced. After the call "field in sight", it appears that cooperation ceased completely. The FP did not require the NFP to do any monitoring, and the NFP did not carry out any monitoring unrequested. The airline's procedures regarding changing over from a "non-precision approach" to visual flying in the dark do not contain any special guidelines for this. It cannot be ruled out that this may have created a lack of clarity.

It should also be pointed out, in this connection, the independent responsibility for safety the NFP has been instructed to take through the airline's procedures about the duties of the co-pilot (ref. FOM section 2.5 paragraph 3.2.1). This paragraph defines the NFP's duties and at the same time gives the NFP the authority to indicate or intervene should the FP not follow prescribed procedures. By not making the FP aware of the procedural anomaly the NFP displayed a lack of professionalism when going in to the approach phase., This is a topic discussed in CRM training. As previously mentioned, the above emphasises the fact that the airline needs to consolidate the co-pilot's corrective role, particularly as this is not the first time the co-pilot's role has been a significant factor in the chain of events.

2.6.1.5 *Monitoring*

A defined safety barrier, which can be viewed in connection with the CRM, is the NFP's monitoring of the flight's progress. For example, the NFP is supposed to continue monitoring the instruments even though the approach continues visually, and he should show this by announcing with call outs important points during the approach.

The NFP neglected to give a callout when the aircraft descended from 2,600 ft (i.e. + 500 ft) towards the minimum altitude of 2,100 ft valid until passing the Namsos NDB inbound. Had the tasks to be carried out during visual approach in the dark been better specified in the FOM, it would have been natural, in the AAIB/N's view, for there to be a callout when descending through 1,200 ft, which is 100 ft above the IFR minimum.

Even after the crew had the field in sight, the NFP still did not pay sufficient attention to the altitude regulations (ref. FOM section 9.1, paragraph 2.2). When visual contact with the ground being flown over is ascertained (with the exception of unbroken snow surfaces and clear water) it is a lower priority task. However, it was impossible to have such ground contact because of the darkness. Altitude awareness should therefore have been a task of equal priority as during a full instrument approach. A callout when reaching the minimum altitude of 1,100 ft could have broken the chain of events. What might create uncertainty for the crews is that in FOM section 9.5 paragraph 4.3 the airline states that after "contact" and "field in sight", subsequent callouts relating to the approach procedure may be omitted (an exemption). In the next paragraph (paragraph 4.4) it is stated that to achieve maximum safety, standard callouts are to be used during active duty (the principal rule). The AAIB/N considers visual approach in the dark to be active duty.

The FTM paragraph 10.10.26 states that preparations for non-precision and precision approaches are similar regarding callouts. In paragraph 8.8.26 of the FTM, "Monitoring of Approaches", visual approachs are not mentioned. This must be seen in light of the lack of any clear dividing line between non-precision approaches and visual approaches in the dark. Assuming that the NFP considered the approach to be visual, the regulations described in the FOM and FTM are inconsistent and may give rise to vagueness and confusion. The AAIB/N considers vagueness and confusion in the regulations to be latent factors.

The division of tasks during visual approach is specified such that the FP should give a clear signal as to whether "sufficient guidance for landing has been obtained" by calling "contact". This is, at the same time, a signal to the NFP that visual approach has been initiated and that the NFP should continue to monitor the flight instruments (Ref. FOM section 9.5 paragraph 3.3 table, column 5). In this case the FP confirmed "field in sight" with the incorrect "Yes, well, that's fine."

2.6.1.6 *Visual reference to the ground*

The airline had set a barrier which required the Pilot-in-Command not to initate visual approach until visual reference to the ground could be maintained (Ref. FOM, section 4.2 paragraph 1.2 a). It is obvious in this case that the crew at no time were aware of how close they were to the ground and thus did not realise what was about to happen until the aircraft hit the ground, meaning that this safety barrier was breached.

An essential prerequisite for carrying out an approach in the dark using visual references is that the crew has enough visual points of reference to create a safe, unambiguous interpretation of the terrain below and the outlines of the landscape both in front and to the sides. However, the prerequisite is that visual reference to the ground be clearly and unambiguously defined. Such a definition does not exist. The AAIB/N is thus of the opinion that this barrier is incomplete.

Through conversations with pilots in the airline it appears, as was previously mentioned, that there are pilots who equate seeing some lights on the ground with "reference to the ground". This accident has shown that an interpretation such as this may result in serious consequences.

2.6.1.7 *Navigational aids*

A barrier has been set for flying in the dark which requires that available navigational aids are used to make positive checks of the aircraft's position and secure ground clearance (FOM section 9.5 paragraph 5.2). This barrier was broken, as the crew seem to have directed most of their attention outside the cockpit to determine the aircraft's position.

2.6.1.8 *PLASI procedure*

As the approach in this accident ended up below a safe altitude on the extended centre line, the AAIB/N has assessed whether a procedure for using the PLASI for approaches in the dark might have acted as a barrier in this case. It would not because the approach procedure is flown in the red sector (i.e. below the PLASI-glide path).

A procedure for utilising PLASI is not described in the FOM, but the AAIB/N thinks that it might be valuable to use such a procedure when appropriate. This procedure should thus be considered to be included as an SOP.

2.6.1.9 *Choice of approach procedure*

If the airline had instructed the crews during visual approaches during darkness to follow the IFR procedure to the approved minimum stipulated, this procedure would constitute a safety barrier.

2.6.2 Other safety barriers

These are safety barriers which had no bearing on this accident, but which the AAIB/N would like to mention because of their value to flight safety.

2.6.2.1 *Aborted approach - ADF tuning*

To reduce the possibility of making mistakes in an otherwise stressful situation it is required, according to airline procedure, to tune in ADF # 2 to the radio beacon for a rejected approach procedures as the crew did. When ADF # 1 was tuned in to the same radio beacon, it was not consistent with procedure and constituted a breach of a safety barrier set by the airline. However, this had no effect on the chain of events.

2.6.2.2 *Criteria for visual approach*

Conversations with pilots have brought to light divergent opinions as to what criteria need to be in place to commence a visual approach. The AAIB/N is of the opinion that this uncertaintly may stem from differences between the FOM and the FTM. FOM section 4.2 paragraph 1.2 states that "a visual approach cannot commence with any fewer than the following 3 criteria fullfilled: (a) the Pilot-in-Command has the runway or a section of the approach light system in sight ***and*** (underlined by the AAIB/N) can maintain visual reference to the ground", (b, and c are irrelevant). FTM section 10.29 states that "a visual approach procedure authorises an IFR pilot to expedite an approach when in flight to and landing at the airport can be accomplished under the following conditions: A RUNWAY IN SIGHT OR (underlined by the AAIB/N) WITH VISUAL REFERENCE TO THE GROUND". This safety barrier is therefore not set completely.

2.6.2.3 *Approach aids*

One of the airline's line pilots expressed the view to the AAIB/N that safety barriers are required in the form of better navigational approach aids at short field airports, the reason being that the chain of events needs to be broken when a fault occurs and that the possibility of making a mistake during an approach is greater when there are only simple navigational aids available. As the location of these airports very often presents difficulties geographically and the airports have few approach aids, the potential to make mistakes is that much greater. It was also pointed out that the major airports, which have considerably easier appproach conditions, also have better approach aids.

The AAIB/N views this contribution as being extremely valuable. It approaches to the problem - whether or not better navigational aids really are necessary - in a rather more untraditional way. So far the AAIB/N has experienced a consensus of opinion in the airline on the need to upgrade approach aids for short field route net. This has been communicated to the aviation administration on a number of occasions. Upgrading should include better lighting, glide paths and replacement for the NDBs. The authority, for their part, claims that as long as the approved procedures are followed and minimums respected, these airfields can be safely trafficked, which is, of course, in essence, true, but this line of reasoning does not take into account the human factor as a source of error.

For example, it should be mentioned that the international flight safety organisation, the Flight Safety Foundation (FSF) is in the process of studying the causal relationships involved in CFIT accidents. According to the study, one of the major causal factors relating to CFIT is step-down procedures. According to a research study prepared on behalf of the Dutch Civil Aviation Association (the result of an FSF contract, formulated by Enders Associates, Records Management Systems and the Dutch foundation, the National Aerospace Laboratory (NLR)) it has been shown in a relative risk analysis of approach aids and approach categories that precision approaches on an average international basis are 5.2 times safer than non-precision approaches.

Procedures involving step down descents are approved for approaches to short field airports. In other words, it is probable that the potential for this type of causal factor occurring may be reduced by removing the need for step down procedures, i.e. by setting up a safety barrier in the form of a glide path. The AAIB/N also wishes to draw attention to the report on and recommendations for "New Technical and Operational Standards for Short Runway Airfields in Norway" which was the result of the work of the Grimsrud Committee, a working group appointed by the CAA/N. The work carried out by the committee has formed the basis of Norwegian Parliamentary Report No. 15 (1994-95) Chapter 7 regarding 'Technical and Operational Standards at Regional Airfields".

In the opinion of the AAIB/N, however, it is not enough just to invest in equipment. If the investments are to be justified, its users need to adopt a modus operandi (mode of operation) which utilises these aids on a general basis. As far as the airline is concerned, this involves the IFR procedures being adhered to in the majority of approaches, regardless of the weather conditions, i.e. equivalent to the operational pattern followed by the large airlines at major airports. It should be added that an attempt should be made to develope procedures which, wherever possible, save time. Justifiable use of such aids also implies that operations are standardised and that the prescribed procedures are adhered to. This should also be viewed in the light of the fact that the airline is in the process of acquiring a fleet of DHC-8s, as the operational concept in this type of aircraft potentially involves the need for changes to be made.

2.6.2.4 *The GPWS*

As previously mentioned, LN-BNM was not fitted with a GPWS (the airline's new fleet of DHC-8s has this system installed). The FSF study shows that the GPWS to a great extent reduced the CFIT potential as a causal factor. In other words, it is an effective safety barrier against this type of aircraft accident. The fact that this system is a valuable addition to commercial aircraft equipment, is reflected in the regulations the JAA has proposed in JAR-OPS 1, Subpart K, paragraph 1.655 entitled "Ground proximity warning system":

> "(a) An operator shall not operate a turbine-powered aeroplane:
>
> (1) Having a maximum certificated take-off mass in excess of 16,000 kg, or having a maximum approved passenger seating configuration of more than 30; or
>
> (2) First issued with an individual Certificate of Airworthiness either in a JAA Member State or elsewhere after 1 April 1999, and having a maximum approved passenger seating configuration of more than 9; or
>
> (3) Having a maximum certificated take-off mass in excess of 5,700 kg after 1 April 2001; or
>
> (4) Having a maximum approved passenger seating configuration of more than 9 and a maximum certificated take-off mass not exceeding 5,700 kg after 1 April 2002,
>
> unless it is equipped with a ground proximity warning system.
>
> (b) The ground proximity warning system required by this paragraph must automatically provide, by means of aural signals which may be supplemented by visual signals, timely and distinctive warning to the crew of sink rate, ground proximity, altitude loss after take-off or go-around, incorrect landing configuration and downward glide slope deviation."

The AAIB/N consequently sees no reason to submit a safety recommendation regarding the GPWS.

# 3 CONCLUSIONS

## 3.1 Findings

### 3.1.1 Aircraft

a) The aircraft was airworthy and insured in accordance with the requirements.

b) The aircraft could be operated normally and was under the full control of the crew during the approach to Namsos.

c) The aircraft's weight and the position of its centre of gravity were within the permitted limits both at take off and at the time of the accident.

d) The aircraft's pressure altimeters were in working order prior to the accident.

e) The aircraft's radio altimeter were in working order prior to the accident.

f) The warning light switch for the radio altimeter was in the DIM position. The intensity of the light had been substantially reduced as a result of an approved modification to the system and the ageing of the light bulb of the warning light.

### 3.1.2 Ground-based navigational equipment

a) Control flying of navigational equipment at Namsos airfield proved it to be within the ICAO's tolerance requirements.

### 3.1.3 Flight conditions

a) No information has come to light to indicate that the crew should at any time have cancelled the flight or that they should have discontinued it owing to the weather conditions.

b) According to a calculation, the heavy shower that passed over the airfield during the approach may have met the aircraft at the point in time when the FP said he did not wish to fly much lower than 500 ft.

c) When the aircraft crashed it was raining heavily, and visibility was probably rather reduced because of the rain and possible stratus clouds.

d) After the "field in sight" call, conditions were present for influence from the "Black Hole" visual illusion. Light refraction due to rain on the windscreen may have intensified the effect of the illusion.

e) The AAIB/N has found nothing to support the view that the crew mistook other lights in the area for the airfield approach lights.

3.1.4 The crew

a) The crew members were properly licensed and had undergone the prescribed training. Working hours and rest periods prior to the accident were within the limits prescribed by the regulations.

b) There is no evidence to indicate that either of the members of the crew were affected by personal conditions which might have influenced their ability to carry out their respective tasks.

c) The post-mortems carried out on the crew revealed no traces of either alcohol, drugs or medication.

d) The crew's incomplete reporting to the AFIS during the approach was inconsistent with the airline's requirements.

e) The crew deviated from the sterile cockpit concept after passing the IAF outbound.

f) Neither the FP's demand to the NFP regarding callouts nor the NFP's monitoring were carried out in accordance with the airline's prescribed procedures.

g) The tuning of the aircraft's ADF receivers prior to the final stage of the approach was inconsistent with the airline's procedure.

h) Between 19:15:35 hours and 19:16:35 hours the aircraft had an average sink rate of approximately 1,400 ft/ min - double the rate of descent set by the airline for aircraft without a pressurised cabin.

i) When the aircraft descended through the IFR minimum altitude of 1,100 ft, this was not observed by the crew.

j) The crew did not observe the warning light for the set altitude (200 ft) on the radio altimeter.

3.1.5 The airline

a) The airline's own regulations are unclear when it comes to callouts for visual approach in the dark. Questionnaire B revealed that there were large differences in opinion as to which callouts to give.

b) There were also differences in opinion regarding the outbound wind correction, from the IAF and for the time from the FAF to the MAPt in Questionnaire B.

c) There was little knowledge of the "Black Hole" visual illusion in the Twin Otter pilot corps.

d) The airline lacked a complementary monitoring program for the CRM training.

e) The airline's regulations were not compiled in an appropriate, consistent, and easily intelligible manner. The following are listed to illustrate this:

- visual approach in the dark was inadequately described in the FOM/FTM
- there was uncertainty in the air corps as to the conditions under which a switch is made to visual approach, probably because of the differences in wording between the FOM and the FTM on this point
- the airline's regulations provided no clear line of demarcation between instrument approaches and visual approaches during darkness.

f) The quality assurance department was unaware of the existence of an FTM.

g) There seems to be both potential and real conflicts between certain sub-goals in the airline, particularly between goals for flight safety, regularity, punctuality and economy.

h) Not everyone in the Control Group and Training Group within the Air Operations Departement had a clear understanding of which goal applied to their own task. This was due to the lack of division of goals into sub-goals that are testable and which individuals could more easily identify with.

i) The division of responsibility with regard to the formulation of flight operations training policy seems to be somewhat unclear.

j) The airline's board of directors had the overall responsibility for creating the right conditions for the attainment of safety goals and for ensuring that the airline's internal control (quality assurance) systems were functioning. Flight safety was, however, not a regular topic at the board of director level, as it was thought that this area of responsibility could best be handled by the airline's general management.

k) The airline appears to be financially solid. Some rather large investments in flight safety were approved by the board of directors and followed through with. The system has worked less than adequately with regard to expenditure on smaller acquisitions, and has been construed as frustrating at the middle management and instructor level.

l) The Flight Operations Manager's position in the organisation, having an independent role, with responsibility for safety and reporting directly to the CAA/N, resulted in unclear lines of responsibility and decision-making with regard to flight operations matters.

m) The airline's management selection system and subsequent management skills development could be made more methodical and comprehensive if the organisation's and the individual's needs were taken into consideration more.

n) The administrative pilots in the airline did not have sufficient time necessary to take measures regarding flight safety over and above the day-to-day running of flight operations.

o) The pilot meetings were not made full use of as a means of influencing attitudes towards flight safety.

p) There seems to be a considerable amount of under-reporting of operational anomalies compared to the amount of technical reporting in relation to performed number of flights.

q) The implementation of the operations reporting system, including processing and feedback, had not worked as it was supposed to.

r) The method used to calculate the risk index did not give a true picture of the elements of risk in the air operations departement of the airline, neither did trend analyses based on the risk index give a correct picture of developments in flight operations.

s) Line captains in the airline have shown signs of exhaustion due to the strain and stress of trafficking on the short field route net, particularly during the winter season.

### 3.1.6 The Norwegian Civil Aviation Administration

a) The strategic level of the airline's organisational system (quality manual) and the tactical level (FOM Chapter 6), as well as the essential organisational changes which had a bearing on the organisation's safety system, had neither been approved nor inspected by the CAA/N.

b) Inspections had not been carried out in the airline in accordance with the guidelines for inspections which the CAA/N itself had specified in its guidelines on "Internal Control".

c) Owing to the lack of general regulations for supervision, important elements in the organisational system were not inspected.

d) The regulations lack an unambiguous establishment of what a set flight safety standard for an airline should encompass and for the supervision by the authority of this standard.

### 3.1.7 Significant findings

The AAIB/N has evaluated the following results of the investigation as being of particular importance from the viewpoint of flight safety, seeing as these factors either had direct consequences or might have indirectly had a bearing on the chain of events.

a) The circumstances in this accident were that of "Controlled Flight Into Terrain". The investigation revealed that the aircraft could be operated normally and was apparently under the full control of the crew during the approach.

b) The airline was unsuccessful in implementing a standardised concept for flight operations which the whole of the pilot corps wholeheartedly respected and complied with.

c) The crew's planning of the approach was not carried out in complete accordance with the airline's regulations. There was defects in

- the callouts during the approach
- the actual rate of descent (ft/min) after the FAF inbound
- the time calculation outbound from the IAF, and the time from the FAF to the MAPt.

d) When performing the "base turn" the crew did not keep to the planned timing, which resulted in the aircraft flying approximately 14 nautical miles away from the airfield.

e) The FP switched from approach utilising the flight instruments as a reference to a visual approach in the dark without reference to the ground below. During this stage of the flight the aircraft's position was not positively checked using the available navigational aids.

f) The attention of both crew members was, to all appearances, directed fully away from the cockpit towards the airfield after the NFP called out that he had the airfield in sight.

g) The crew were at no time aware how close they were to the ground below.

h) The last descent from approx. 500 ft indicated altitude to 392 ft in the last stage of the aircraft's descent may have been due to a combination of inattentiveness and the fact that the aircraft could have been slightly out of trim after the descent from 2,100 ft.

i) Crew cooperation during the approach did not comply with the CRM concept, and seems to have ceased altogether after the NFP called "field in sight".

j) Prior to the accident the airline had not been sufficiently successful in implementing the standardisation and internal control and quality system. This was in a considerable degree due to the fact that management did not attach enough importance to heightening the awareness of and motivating its employees.

k) The internal control system described in the FOM and the parts of the quality system which involved flight safety, were not implemented within the organisation and functioned poorly as elements of safety management.

l) Neither the CAA/N nor the airline had defined what visual reference to the ground actually is, what visual references are adequate and where the references have to be in relation to the aircraft's track.

# 4 SAFETY RECOMMENDATIONS

## 4.1 Introduction

Six days after the accident the AAIB/N made some preliminary recommendations to the CAA/N which included aircraft approachs to short field airports during darkness to be in compliance with the regulations for instrument flying and standardised requirements for giving information to the AFIS units during IFR approaches.

On 3 December 1993 the airline issued Flight Order No. 57 entitled "Approach to short field airports during darkness - visual". This Flight Order gives in 7 points the airline's guidelines to carry out such an approach. The AAIB/N assumes that the airline and the CAA/N have conducted a thorough risk evaluation as the basis of both the formulation and approval of these guidelines. The AAIB/N will thus not repeat the preliminary recommendation, dated 2 November 1993, regarding visual approaches during darkness.

The preliminary recommendation regarding standardised requirements for information to be given to the AFIS unit during IFR approaches is already included in the FOM.

In addition, the CAA/N, as the responsible authority for flight safety and as a result of its own evaluation and information on the investigation work, has instructed the airline

- to formulate a procedure for the use of PLASI

The AAIB/N will consequently not forward any safety recommendation on this matter.

In connection with an operations inspection of the company, Report no 95/124, CAA/N has found a possible departure from BSL D 2-1, paragraph 9.4.1.1 in that no CRM course program was presented.

All the recommendations are addressed to the Civil Aviation Administration.

The AAIB/N recommends that:

4.1.1 Regulations should be formulated for the supervision of Norwegian aviation.

4.1.2 CAA/N stipulates what flight safety standards in aviation organisations comprise, in the form of requirements.

4.1.3 CAA/N prioritises inspections on safety management systems in aviation organisations, such as quality systems and flight safety programmes.

4.1.4 CAA/N assesses improvements in navigational approach aids for short field airports based on the need to establish safety barriers which are the result of a risk analysis of each airfield.

4.1.5 CAA/N works out a definition for visual reference to the ground.

4.1.6 The airline works out principles and rules for the prioritisation of flight safety in relation to other main goals (regularity, punctuality and economy), and defines main goals broken down into sub-goals which can be tested and which the individual employees can identify with.

4.1.7 The airline revises its regulations with the aim of setting new safety barriers or improving existing safety barriers, and creating consistency amongst the regulations and procedures described in the various manuals.

4.1.8 The airline continues revising and formulating Standard Operating Procedures.

4.1.9 The airline intensifies the work of getting the entire pilot corps to carry out all flying in accordance with standard operating procedures (SOP).

4.1.10 The airline upgrades the operational flight safety work with the aim of improving skills and prioritising resources.

4.1.11 The airline sets aside time so that the operations management is able to attend to the flight safety work it is responsible for.

4.1.12 The airline improves the conditions for contact and communication between the pilot corps and management.

4.1.13 The airline improves the flow of information to the pilot corps on both internal and external experiences of flight safety.

4.1.14 The airline improves conditions for employees to identify the elements of risk and report these conditions, and that the operations management makes case handling and feedback on reporting more efficient.

4.1.15 The airline improves skills and methods for risk analysis, and that the periodic safety goals for the airline are monitored through dealing systematically with procedural anomalies. This requires that under-reporting of operational incidents is reduced to a minimum, that the use of the airline's risk index is revised and that technical faults and incidents are separated from the flight operative incidents.

4.1.16 The airline ensures greater conformity between the quality assurance department's resources and the department's formal responsibility, and that the department's responsibilities in relation to the rest of the airline are clarified.

4.1.17 The airline evaluates whether or not the resources available to the Control Group are proportional to the tasks the group has in the internal control system.

4.1.18 The airline clarifies the hierarchy of documentation, particularly the relationship between the strategic document - the Quality Manual - in the Operations Division, and the tactical documents - the Flight Operations Manual and Flight Training Manual.

4.1.19 The board of directors of the airline commit themselves more fully to flight safety work by setting a requirement for the formulation of the airline's flight safety policy and of more consistent, operational, main and sub-goals for flight safety, and monitor these systematically (periodically).

4.1.20 The Chief Executive Officer of the airline clearly identifies flight safety as a principal goal for the airline, and sets up and monitors suitable main and sub-goals for flight safety in conjunction with the Management Group. The management's day-to-day decision-making must support the goals for flight safety in order to achieve the best possible coordination betwen words and actions.

4.1.21 The airline sets up a system to monitor management decisions on flight safety.

4.1.22 The airline evaluates the need for developing skills, education and continued education for the operations management.

4.1.23 The airline establishes a complementary programme for CRM training.

4.1.24 The airline consolidates the corrective role of the co-pilot / NFP.

4.1.25 The airline assesses measures to be taken to bring to light any cases of burned-out within the pilot corps which might compromise flight safety, and takes preventive action as and where necessary.

4.1.26 The airline upgrades and systematises flight safety work through a flight safety programme (see BSL D 2-1, paragraph 3.7, ICAO Document Annex 6, Part 1 and the ICAO Accident Prevention Manual).

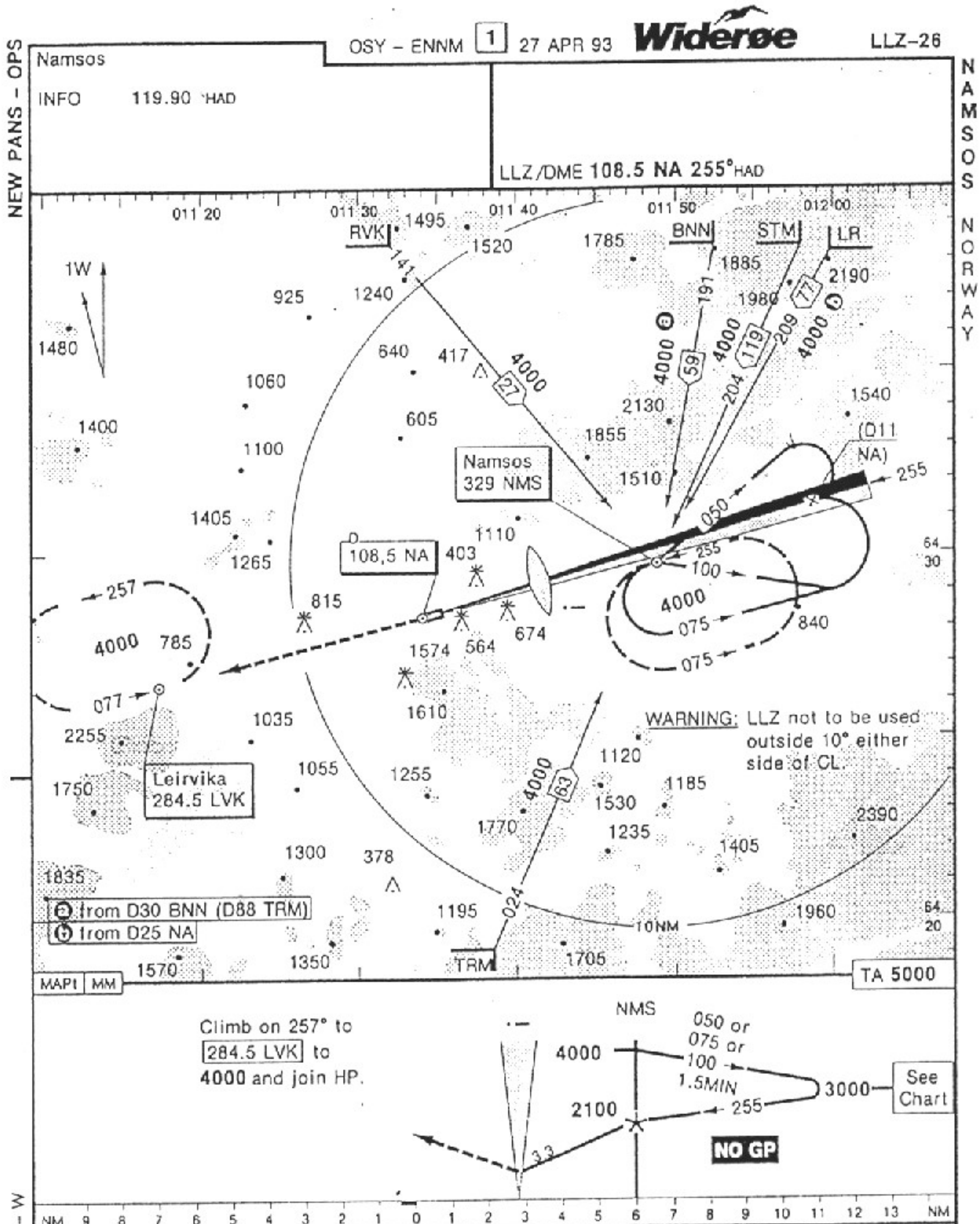
## 5 APPENDICES

1. Approach chart
2. Survey chart showing wreckage parts (not included)
3. The location of passengers and crew on board the aircraft (not included)
4. STEP analysis
5. Question bank (not translated)
6. Extracts from FOM/FTM (not translated)
7. SINTEF report (not translated)
8. Abbreviations

AIRCRAFT ACCIDENT INVESTIGATION BOARD, NORWAY

Fornebu, 26 June 1996

**Approach chart** **APPENDIX 1**




| | | | | | | |
|---|---|---|---|---|---|---|
| FAF - MAPt =3.3NM | MDA 1100 | 60KT 3:15 | 100KT 2:00 | 120KT 1:36 | 150KT 1:18 | 180KT 1:05 |

| APCH PROC -6 -7 -8 | LLZ+MKR ALL | Circling ❷ ❼ ALL |
|---|---|---|
| Planning Min WX | 1000/2.8 | 1100/2.8 |
| DA \| MDA QNH /Min VIS | 1100/1.2 | 1170/1.6 |

OCH 2.5%: LLZ+MKR 1090

❷ N of AD only OR

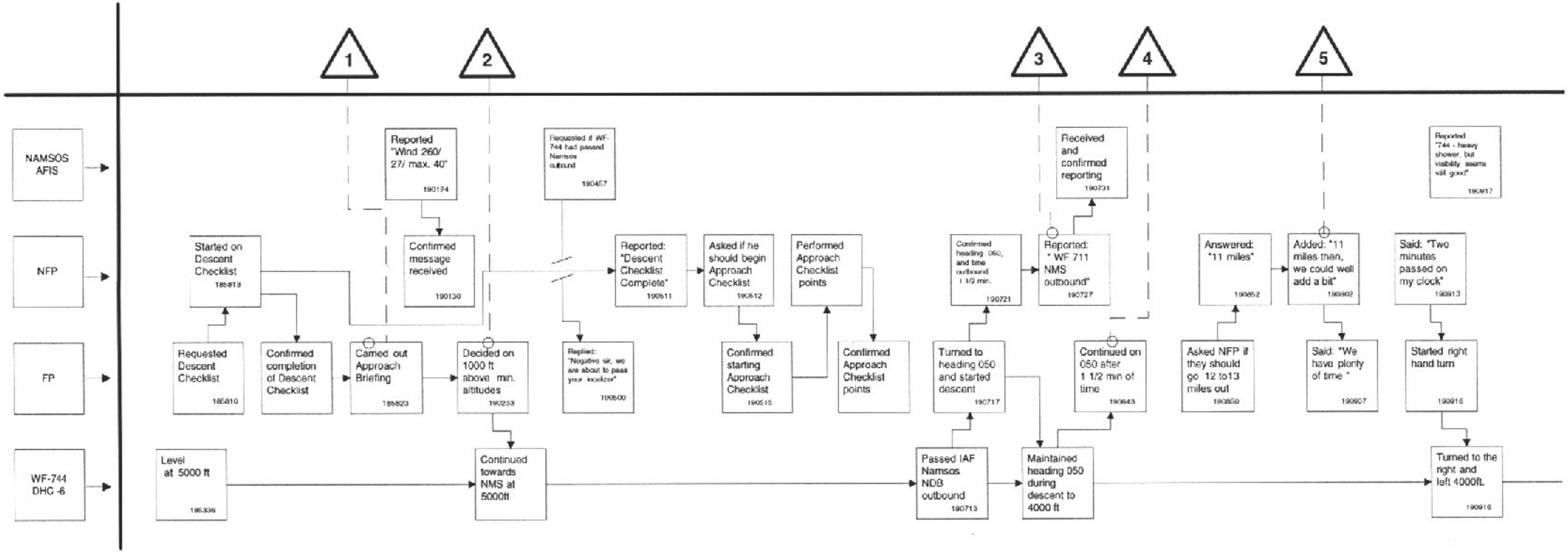
❼ "PRECISION CIRCLING" WSW of AD along circling lights – see IAL 3.

| ADD to DA,MDA/Min VIS | | |
|---|---|---|
| APL U/S | ILS/PAR | |
| | LLZ | |
| | Other | |
| Plan ALTN ADD | | 300/1.0 |

360 48 35 NMS 090 42 180

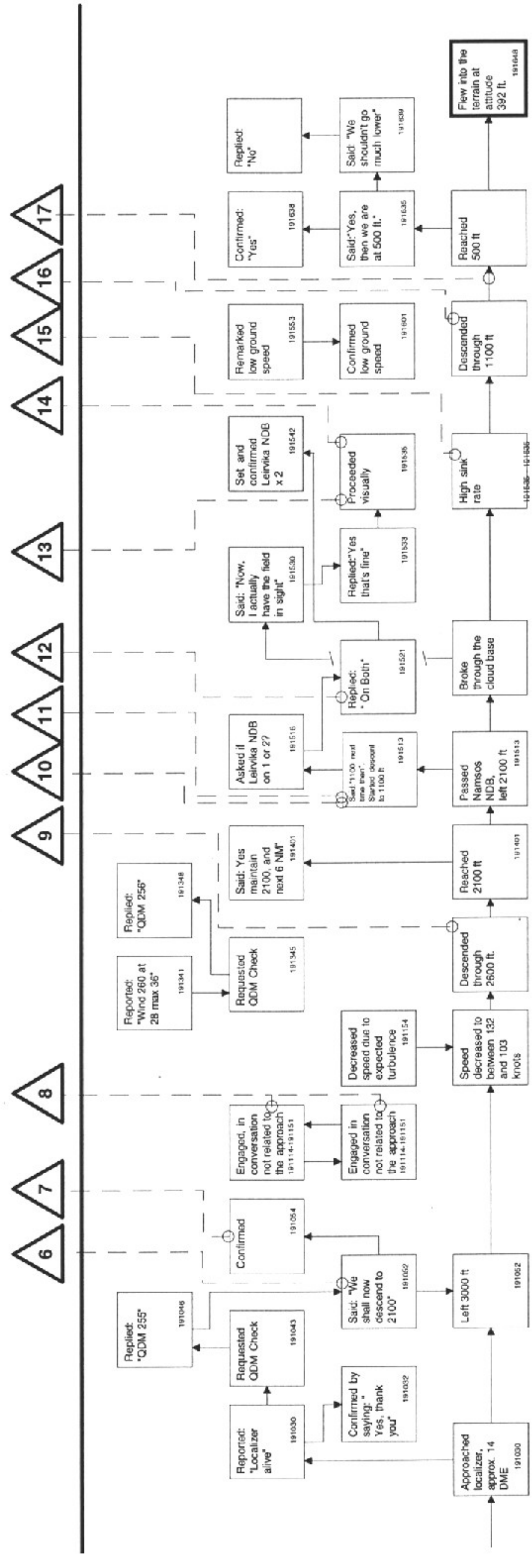


THR ELEV 7 FT/AD ELEV 7 FT Change: Min




STEP ANALYSIS OF ACCIDENT TO LN-BNM

# APPENDIX 4



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16
17
Approached localizer, approx. 14 DME 191030
Reported: "Localizer alive" 191030
Confirmed by saying: " Yes, thank you" 191032
Requested QDM Check 191043
Replied: "QDM 255" 191046
Left 3000 ft 191052
Said: "We shall now descend to 2100" 191052
Confirmed 191054
Engaged, in conversation not related to the approach 191114-191151
Engaged in conversation not related to the approach 191114-191151
Speed decreased to between 132 and 103 knots
Decreased speed due to expected turbulence 191154
Reported: "Wind 260 at 28 max 36" 191341
Requested QDM Check 191345
Replied: "QDM 256" 191348
Descended through 2600 ft.
Reached 2100 ft 191401
Said: Yes maintain 2100, and next 6 NM" 191401
Passed Namsos NDB, left 2100 ft 191513
Asked if Leirvika NDB on 1 or 2? 191516
Broke through the cloud base
Replied: " On Both" 191521
Said: "Now, I actually have the field in sight" 191530
Replied:"Yes that's fine" 191533
Proceeded visually 191535
Set and confirmed Leirvika NDB x 2 191542
High sink rate 191535 - 191636
Descended through 1100 ft
Remarked low ground speed 191553
Confirmed low ground speed 191601
Reached 500 ft
Said:"Yes, then we are at 500 ft." 191635
Confirmed: "Yes" 191638
Said: "We shouldn't go much lower" 191639
Replied: "No"
Flew into the terrain at attitude 392 ft. 191648

**APPENDIX 8**

## ABBREVIATIONS

| | |
|---|---|
| AAIB | Air Accidents Investigation Branch (UK) |
| AAIB/N | Aircraft Accident Investigation Board, Norway |
| ADF | Automatic Direction Finder - Radio Compass |
| AOM | Aircraft Operations Manual |
| AFIS | Aerodrome Flight Information Service |
| AGL | Above Ground Level |
| ASR | Altimeter Setting Region |
| ATCC | Air Traffic Control Centre |
| ATIS | Automatic Terminal Information Service |
| ATS | Air Traffic Services |
| BCL | Bestämmelser för Civil Luftfart (Swedish Aeronaut. Requirements) |
| BSL | Bestemmelser for sivil luftfart (Norwegian Aeronaut. Requirements) |
| CAA-N | Civil Aviation Administration, Norway |
| CB | Cumulonimbus |
| CEO | Chief Executive Officer |
| CFIT | Controlled Flight Into Terrain |
| CRM | Crew or Company Resource Management |
| CVR | Cockpit Voice Recorder |
| DA | Decision Altitude |
| DERP | Design Eye Reference Point |
| DH | Decision Height |
| DLI | Dead Loaded Index |
| DME | Distance Measuring Equipment |
| DP | Decision Point |
| ENBN | Brønnøysund Airport |
| ENTR | Trondheim ATCC |
| EST | Estimated |
| FAF | Final Approach Fix |
| FAP | Final Approach Point |
| FDH | Flydriftsbok (Flight Operations Manual) |
| FDR | Flight Data Recorder |
| FL | Flight Level |
| FP | Flying Pilot |
| ft | Feet/Foot |
| FOM | Flight Operations Manual |
| FTM | Flight Training Manual (for DHC-6) |
| GG | Gas Generator |
| GPWS | Ground Proximity Warning System |

| | |
|---|---|
| GS | Glide Slope |
| hPa | Hectopascal |
| HSI | Horizontal Situation Indicator |
| HSL | Havarikommisjonen for sivil luftfart (AAIB/N) |
| IAF | Initial Approach Fix |
| IAL | Instrument Approach and Landing chart |
| IAS | Indicated Air Speed |
| IATA | International Air Transport Association |
| ICAO | International Civil Aviation Organization |
| ICE | Icing |
| IFR | Instrument Flight Rules |
| IGA | International General Aviation |
| ILS | Instrument Landing System |
| IMC | Instrument Weather Conditions (Requiring flying according to IFR) |
| JAA | Joint Aviation Authorities |
| JAR | Joint Aviation Requirements |
| kg | Kilogram |
| kHz | Kilohertz |
| kt | knot/knots |
| LLZ | Localizer (the direction element of an ILS) |
| LOC | Local |
| LP | Left Pilot |
| LV | Luftfartsverket (CAA-N) |
| M | Magnetic |
| m | Meter |
| MA | Minimum Altitude |
| MAC | Mean Aerodynamic Cord |
| MAPt | Missed Approach Point |
| MDA | Minimum Descent Altitude |
| MEHT | Minimum Eye-Hight over Threshold |
| METAR | Meteorological Aerodrome Report |
| MH | Minimum Height (above ground) |
| MHz | Megahertz |
| mm | Millimeter |
| MOCA | Minimum Obstacle Clearance Altitude |
| MOD | Moderate |
| MORA | Minimum Off Route Altitude |
| MORT | Management Oversight Risk Tree |
| MSA | Minimum Sector Altitude |
| NDB | Non Directional Beacon |
| NFP | Non Flying Pilot |
| NFO | Norsk Flyteknikerorganisasjon (Norw. Air technicians Organisation) |
| NM | Nautical Miles |
| NMS | Identification letters of Namsos NDB |

| | |
|---|---|
| NOTAM | Notice To Air Men |
| NW | Northwest |
| OM | Outer Marker (part of an ILS installation) |
| PA | Public Address (announcement system on board an aircraft) |
| PAX | Passenger(s) |
| PFT | Periodic Flight Training |
| PLASI | Pulse Light Approach Slope Indicator |
| PS | Power Section |
| QDM | Magnetic heading (to a station indicated) |
| QDR | Magnetic bearing (from a station indicated) |
| QFE | Atmospheric pressure at aerodrome elevation |
| QNH | Altimeter sub scale setting (to obtain elevation when on ground) |
| RMI | Radio Magnetic Indicator |
| RPM | Revolutions Per Minute |
| SAS | Scandinavian Airlines System |
| SIGMET | Information concerning en-route weather phenomena which may affect the safety of aircraft operations |
| SINTEF | The Foundation for Scientific and Industrial Research |
| SOP | Standard Operating Procedures |
| STEP | Sequential Timed Events Plotting |
| STOL | Short Take Off and Landing |
| T | True |
| TACAN | UHF Tactical Navigation Aid |
| TAF | Terminal Aerodrome Forecast |
| TIA | Traffic Information Area |
| TIZ | Traffic Information Zone |
| TL | Transition Level |
| TSB | Transportation Safety Board of Canada |
| TURB | Turbulence |
| TWR | Aerodrome Control Tower |
| UHF | Ultra High Frequency |
| UTC | Universal Time Co-ordinated |
| $V_{app}$ | Approach speed |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| VMC | Visual Meteorological Conditions |
| VOR | VHF Omnidirectional radio Range |
| VORTAC | a VOR and TACAN combination |
| VSI | Vertical Speed Indicator |
| WF | Widerøe's Airlines ltd. (Widerøe's Flyveselskap AS) |