
Airliner landing with low fuel at Helsinki-Vantaa airport on 3.10.2003

Micro-summary: This Airbus 330-300 landed with low fuel.

Event Date: 2003-10-03 at 0556 UTC

Investigative Body: Finland Accident Investigation Board (AIB), Finland

Investigative Body's Web Site: <http://www.onnettomuustutkinta.fi/>

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Investigation report

C 9/2003 L

Translation of the Finnish original report

Airliner landing with low fuel at Helsinki-Vantaa airport on 3.10.2003

OY-KBN A330-300B

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SUMMARY

On Friday 3.10.2003 at 05.56 UTC (Co-ordinated universal time) landed SK946, Airbus 330-300 with Danish registration OY-KBN, operated by Scandinavian Airlines, in Helsinki-Vantaa airport, Finland, with the fuel less than the required final reserve fuel.

The scheduled flight SK946 had departed from Chicago O'Hare airport, USA, bound for Stockholm Arlanda, Sweden. The planned destination alternate airport was Gothenburg, Sweden. The fuel consumption en route was higher than calculated in the Operational Flight Plan of the flight. All the contingency fuel of 1300 kg and extra fuel of 200 kg was used before the top of descent. There were low visibility procedures (LVP) in force in Arlanda when SK946 entered the Stockholm terminal control area (TMA). The commander requested a category II (CAT II) approach. The air traffic control cleared SK946 to holding, but the commander of SK946 reported that they do not have time for holding due to the fuel situation and requested a radar vectoring for approach. SK946 managed to change the approach sequence with an other aircraft of the same airline. The pilots expected a short vectoring, but the capacity of the Arlanda airport was reduced due to the LVP. SK946 flew during approach in TMA 20 minutes and about 65 track miles instead of 12 minutes and about 40 NM which the pilots had expected. The pilots noticed during approach that they would not, in case of a missed approach, have enough fuel to fly to the planned alternate airport Gothenburg. They decided to take Helsinki-Vantaa, Finland, as a new alternate because of 400 kg less fuel consumption. The runway visual range varied in Arlanda between 400 and 450 m during the CAT II approach, which was stable, but the pilots did not obtain visual contact to the approach or runway lights at the decision height. The commander initiated a missed approach procedure and the first officer requested a route clearance to Helsinki-Vantaa. SK946 contacted the Tampere area control centre on cruising flight level 270 and reported that the flight would have less fuel than required upon landing in Helsinki-Vantaa. The ATC issued a direct routing and an approach clearance without restrictions to runway 15. The rescue services was alarmed by the Helsinki ATC. SK946 landed uneventfully in Helsinki-Vantaa at 05.56 o'clock with the fuel of 1800 kg when the required minimum fuel was 2300 kg.

SK946 used on the flight from Arlanda to the alternate airport Helsinki-Vantaa, fuel 600 kg more than calculated in the OFP. The pilots did not pay in flight planning attention to a possible traffic delay in the destination airport Arlanda. The commander did not take enough fuel for a long approach caused by the low visibility procedures which involved reduced capacity of the airport. The fuel consumption during cruise was higher than calculated and all of the contingency and extra fuel was used en route.

The investigation commission made three safety recommendations to Scandinavian Airlines. The commission recommended the airline to check the alternate fuel calculation basis used in the operational flight plans of the airline. The airline was recommended to draw the attention of their flight crews to the approach fuel calculated by the *RODOS Planning system*. The commanders should be recommended to take extra fuel for possible approach delay caused by the weather conditions and/or intense traffic. The airline recommended to order the flight crews to make the fuel checks also on the last part of the flights, enter the checks in the OFPs and check and mark the remaining block fuel or the total consumed fuel of every flight appropriately.

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ABBREVIATIONS

ACC	Area control centre
AIB	Accident investigation board
APP	Approach control/ approach radar controller
ARR	Arrival control/ arrival radar controller
ATC	Air traffic control
ATIS	Automatic terminal information service
CAT II	Category II instrument approach
CFMU	Central flow management unit
DH	Decision height
DME	Distance measuring equipment
ETOPS	Extended range operations with two-engined aeroplanes
FCOM	Flight crew operations manual
FL	Flight level
FMGS	Flight management guidance envelope system
FOM	Flight operations manual
GPS	Global positioning system
HCL	Aircraft Accident Investigation Board, Denmark
HF	High frequency
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
ILS	Instrument landing system
IRS	Inertial reference system
JAR	Joint Aviation Requirements
KT	Knot(s)
LVP	Low visibility procedures
MCDU	Multifunctional control and display unit
METAR	Aviation routine weather report
NM	Nautical mile(s)
OFP	Operational flight plan
OM-A	Operations manual A
PAPI	Precision approach path indicator
PF	Pilot flying
PNF	Pilot not flying
RNAV	Area navigation
RNP	Required navigation performance
RVR	Runway visual range



SHK	Accident Investigation Board, Sweden
SID	Standard instrument departure
SW	Significant weather
TAF	Terminal area forecast
TMA	Terminal control area
TOF	Take off fuel
TOW	Take off weight
UTC	Co-ordinated universal time
VHF	Very high frequency
VOR	VHF Omni-directional radio range



SYNOPSIS

On Friday 3.10.2003 at 05.56 UTC (Co-ordinated universal time, the Finnish summer time -3h is used in this investigation report) landed SK946, Airbus 330-300 with Danish registration OY-KBN, operated by Scandinavian Airlines, in Helsinki-Vantaa airport with fuel less than the required final reserve fuel.

The Helsinki ATC filled an incident report of the event.

The Accident Investigation Board (AIB) Finland decided on 6.10.2003 to conduct an investigation and appointed airline pilot Jussi Haila as investigator-in-charge. Airline pilot/ air traffic controller Antti Ruuth was appointed as member of the investigation commission.

AIB Finland informed HCL/Havari kommissionen for Civil Luftfart, Denmark and SHK/Statens Haverikommission, Sweden of the investigation according to ICAO Annex 13. The Danish and Swedish Investigation Boards nominated accredited representatives to participate in the investigation.

The members of flight crew of SK946 were interviewed by the investigators in Arlanda on 14.10.2003. The air traffic controllers of Helsinki ATC were interviewed by phone on 8.10.2003. The representative of SHK Sweden provided the investigation commission with the statement of the Arlanda ATC and radar plots of the approach and missed approach paths of the SK946.

The investigation commission sent the final draft of the investigation report for comments according to the ICAO Annex 13 on 12.2.2004. The received comments are taken into account in the final report.

The investigation was closed on 3.6.2004.

1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1. Flight planning

The flight crew of Scandinavian Airlines flight SK946 from Chicago to Stockholm had a pick-up from their hotel one hour and 45 minutes before the scheduled departure time. The crew consisted of three pilots; a commander, a first officer and a relief pilot. The first officer was in transition training to convert his Airbus A340 type rating also to A330.

The flight planning was done according to the airline normal procedures. The fuel calculations were made by the commander and the first officer using the *RODOS Planning - Longhaul Aircraft*-system stated in the Flight Operations Manual (FOM) of the airline. The calculations were available in the form of Operational Flight Plan (OFP) printed at 17.41 UTC (co-ordinated universal time) when the scheduled departure time was 21.15. The relief pilot prepared the ETOPS-charts (Extended Range Operations with Two-Engined Aeroplanes).

The weather information used by the pilots on planning reported a good weather for the departure airport Chicago O'Hare. For the destination airport Stockholm Arlanda there was a forecast with temporarily fog and visibility 500 m in the morning between 06 and 07 UTC. The scheduled arrival time of the flight was 05.35 UTC.

There were the following calculations and markings in the OFP:

In the left column are the calculations printed in the OFP and on the right column the markings made by the pilots.

ZFW (zero fuel weight)	161.2/	162.8
TOF (take off fuel)	50.1/	50.3
TOW (take off weight)	211.3/	213.1
TRIP (trip fuel)	42.4/	42.4
LW (landing weight)	168.9/	170.7

There were the following reserve calculations in the OFP:

CONT FUEL 3: 1.3/0:16, COMP 0.0/0:00, ADD 0.0/0:00, FINAL RES 2.3/0:30

There were additional calculations:

ALTN	WC	ALTNFUEL	FUEL 30 NM	TOTFUEL/TIME
GOT/ESGG	-30	4.1/0:46	7.0/FL280	50.8/ 8:58

The pilots had marked in the item XTRA FUEL 0.2/0:02 and in the item TOTFUEL/TIME 51.0/8:52. They had marked above the FUEL 30 (7.0) "MIN DIV 6.4".

There were two additional alternate fuel calculations:

**FUEL INFO FOR OPTIONAL ALTN:**

TKU/EFTU	+17	2.7/0:34	5.6/FL170	49.4/8:38
HEL//EFHK	+19	3.7/0:41	6.6/FL290	50.4/8:45

In the OFP was reported the individual fuel consumption coefficient of the aircraft OY-KBN: "fuel factor" $F-F = .1$.

The pilots concluded that no problems would be expected during the flight. The pilots agreed to take the 51.0 metric tons (t) fuel uplift which included 200 kg extra to the 50.8 t calculated in the OFP. Calculations included 0.7 t for taxi, 42.4 t of trip fuel to Arlanda, 1.3 t of en route contingency fuel and 6.4 t of alternate fuel from Arlanda to Gothenburg including alternate trip fuel of 4.1 t and final reserve fuel of 2.3 t. The commander got information that take-off weight (TOW) would be 1.6 t more than that 211.3 t calculated in the OFP and decided for that reason to take 0.2 t extra fuel.

1.1.2 Flight from Chicago to Stockholm

The departure time was 21.45 UTC and take-off fuel (TOF) 50.3 t, which was 200 kg more than calculated in the OFP. SK946 was able to obtain its planned cruising flight level, a minor short-cut was received and the wind component was as forecasted. A constraint of Mach 0.82 was used during cruise. The first officer acted as pilot flying (PF) and the Commander as pilot not flying (PNF). The pilots divided the flight time after departure for active duty and rest time. The commander took the last rest turn. He was resting for approximately two hours before the top of descend.

The fuel consumption was getting higher than calculated, 200 kg extra was used 45 minutes after departure. After two hours and 58 minutes flight the fuel onboard was 500 kg less than calculated in the OFP. The pilots told to the investigators in their interview that they were not concerned about the fuel as long as it was within the contingency. According to their statements it is normal that the fuel goes below the calculations and comes back again to the calculated values, and that the fuel quantity indicators of A330 are not very reliable. On the longitude 30 W, after 4 hours and 36 minutes flight time, the aircraft had used 900 kg more than calculated and the flight was four minutes behind the time calculated in the OFP. The commander started his rest period at around this time.

After five and half hours the fuel amount was 1100 kilos below the planned and all the contingency fuel of 1300 kg was consumed. The extra fuel of 200 kg was also used by the reporting point *SOPAR*, where totally 1500 kg more than calculated was burned and SK946 had no more planned reserve fuel remaining. The flight was five minutes behind the calculated flight schedule.

When the flight SK946 approached Stockholm Arlanda low visibility procedures (LVP) were in force and the commander decided to request a category II (CAT II) approach and took the controls at *ELTOK* when the altitude of the aircraft was 10000 feet. The ATC (Air traffic control) cleared SK946 to holding, but the commander answered that they have no time for any holding. He instead requested direct radar vectoring for runway 01L due to fuel situation. The Local Operation Centre of the airline helped SK946 to

change the approach sequence with an other flight of the same airline. This flight entered holding instead of SK946. The Scandinavian Airlines has a note in its Operations Manual that during peak hours all flights except long-haul flights, should have extra fuel of 15 minutes for holding in Arlanda.

In the *RODOS Planning* system the fuel from a point 30 NM before destination airport is calculated as follows:

Fuel for flight from a point 30 NM from, and 3500 ft above threshold, clean aircraft to 10 NM, from 10 NM aircraft in landing configuration, missed approach, climb to specific FL following the normally used SID that gives the longest distance, long range cruise (to the alternate airport) and descent to main aid, approach to least favourable runway, landing and Final Reserve.

In the OFP of SK946 the *FUEL 30 NM* was 7.0 t. The pilots checked that they had seven tons of fuel remaining when SK946 passed reporting point *ELTOK* at 04.56. In the OFP was printed on the next line after *ELTOK: STAR Stockholm/Arlanda 30* (distance in nautical miles) and 12 (flight time minutes). The direct distance from *ELTOK* to *ARL VOR* (VHF omni-directional radio range) is 29.9 NM. The VOR is situated in Arlanda airport on the west side of runway 01L about in the middle of the runway. Thus a normal radar vectoring followed by an ILS instrument approach means about 40-45 NM track distance from *ELTOK* to threshold 01L.

SK946 flew from *ELTOK* to missed approach point 20 minutes. Calculated from the flight time with an average approach speed of 210 KT the flight flew from *ELTOK* to threshold 01L about 65 track miles. The Arlanda ATC reported in its statement that SK946 received a normal vectoring and no special treatment in the traffic. The vectored flight route flown by SK946 according to the Arlanda *radar plot recordings* is presented in the figure 1.

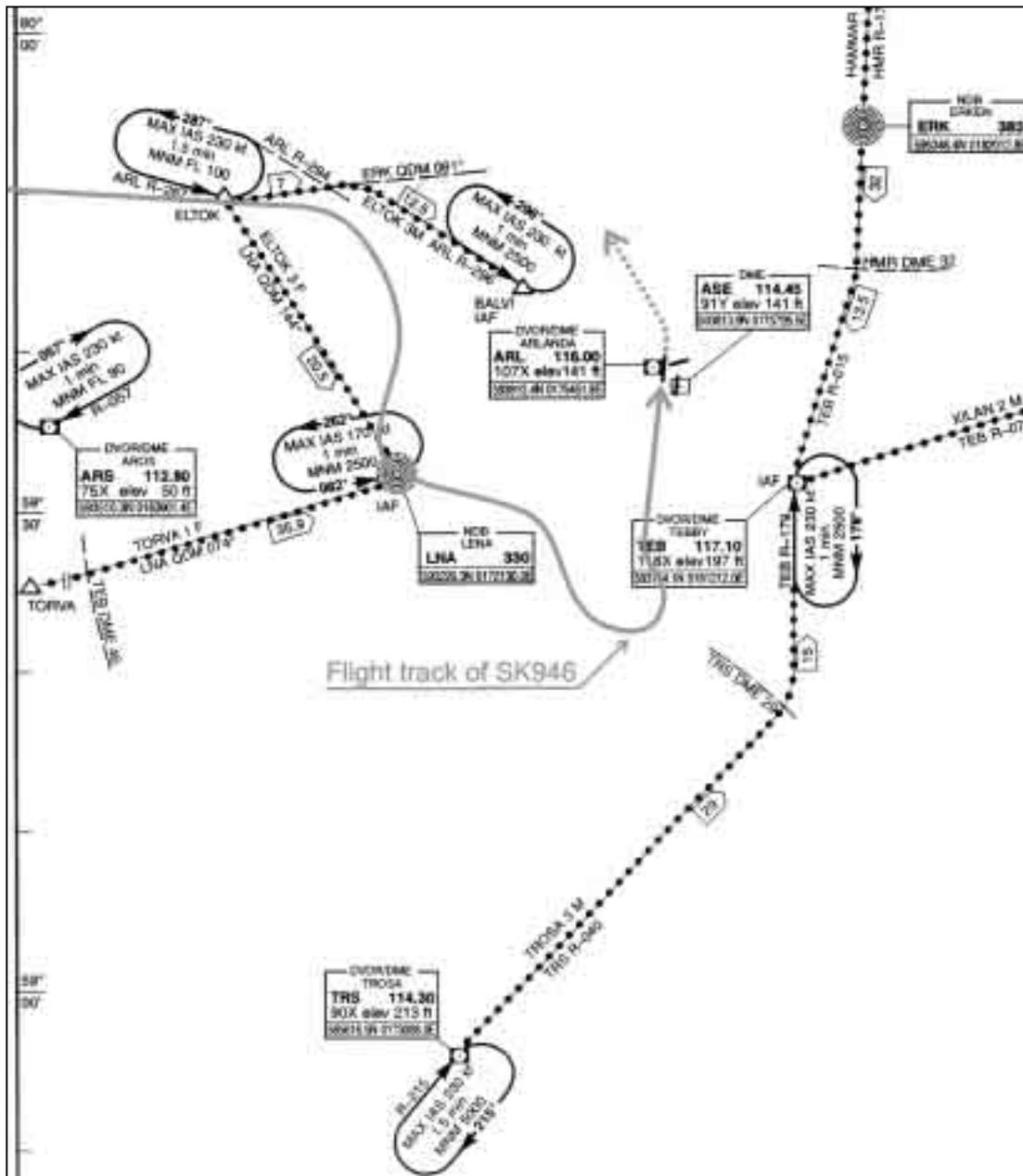


Figure 1. The approach track of SK946 according to Arlanda radar plot recordings

The pilots told in the interview that they had expected a privilege to the other traffic in the approach and wondered the long approach track which they had to fly. They noticed during approach that they would, in case of a missed approach, not have enough fuel to fly to the planned alternate airport Gothenburg. There were also calculated *fuel info for optional alternate* in the OFP. The calculated fuel consumption to Gothenburg was 4.1 t and to optional alternates Turku 2.7 t and Helsinki-Vantaa 3.7 t. There was fog also in Turku and the visibility was below landing minima. The pilots decided to take Helsinki-Vantaa as a new alternate because of 400 kg less fuel consumption than Gothenburg. They did not report the alternate change to the ATC or enter a new route data to the Flight Management and Guidance System (FMGS) of the aircraft.

1.1.3 Category II approach in Arlanda

The CAT II approach to 01L was stable according to the pilots statements but the commander did not see the approach or runway lights at the decision height (DH) of 165 feet. The height is measured from the lowest point of the aircraft, the main wheels in landing attitude, and indicated in the cockpit in radio altimeter. According to the A330 FCOM (Flight Crew Operation Manual) the cockpit is 34 feet above the wheels and the pilots sit at a height of 199 feet above the runway level when the aircraft is on Arlanda 01L CAT II decision height.

The commander started a missed approach at 05.16 and the first officer requested clearance to Helsinki-Vantaa. The pilots saw the runway lights for a moment during the missed approach. When starting missed approach the fuel on board was 6.1 t. The required fuel from the Arlanda missed approach point to Helsinki-Vantaa was according to the OFP 6.0 t including an alternate trip fuel of 3700 kg and a final reserve fuel of 2300 kg.

The missed approach procedure was according to the Aeronautical Information Publication (AIP) Sweden:

Climb straight ahead to 600 feet or ARL DME 1.0 (past ARL DME) whichever is latest. Turn left to track 330 degrees, climbing 1500 feet, radar vectoring for a new approach.

The flight SK946 received shortly a clearance to climb to 3000 feet. It took some time before the ATC was able to issue a new route clearance which was requested without any precautionary information. The ATC had also to co-ordinate the climb of SK946 with the approaching traffic. The pilots told that they had to maintain this altitude for a rather long time which hampered the fuel economy. According to the ATC *radar plot recordings* SK946 flew on 3000 feet about 2-3 minutes. According to the recording SK946 passed flight level 83 climbing about five minutes after it had started the missed approach.

1.1.4 Diversion to Helsinki-Vantaa

SK946 contacted TAMPERE ACC at 05.27.50, 11 minutes 50 seconds after missed approach, and reported maintaining flight level 270. The calculated cruising level was 290 in the OFP. After radar identification SK946 received direct clearance to VOR VTI which is entry point from west to Helsinki TMA (Terminal control area). SK946 reported to ACC at 05.31.40: *"Sir, we calculate now that we have upon landing at Helsinki less than our minimum fuel, so formally we are getting into an emergency situation due to the fuel."* The weather in Helsinki-Vantaa was good, sky almost clear and light winds. The ACC issued entry clearance to Helsinki via a transition route, but the crew asked for radar vectoring. ACC said he would relay the request to *HELSINKI APPROACH*. The ACC issued an arrival clearance to runway 15 at 05.42.00 and a descend clearance when the crew asked for it at 05.42.40. According to the radiotelephone recordings SK946 was allowed to fly inbound Helsinki-Vantaa without any ATC restrictions.

TAMPERE ACC transferred SK946 to HELSINKI APPROACH at 05.45.30. The APP offered after radar identification a short approach, but the pilots requested a normal approach. The ACC and APP used the silent co-ordination system when the traffic was handed over. The information of the exact fuel situation of the flight SK946 did not reach the APP controller. He asked twice, whether the commander will declare an emergency or not, but did not get a clear answer. The controllers in the APP were uncertain of the situation, but decided to call rescue services and gave a full alarm according to the check-list for a fuel emergency. SK946 reported at 05.50.00: *“Approach, Scandinavian 946, if for any unforeseen reason we have to make a missed approach, we will make a circuit for the new attempt.”* APP replied: *“Scandinavian 946, roger, in case of missed approach, you will make a visual approach runway 15.”* APP added a few seconds later: *“If necessary for shorter track miles, the runway 22 left is available in case of missed approach.”*

Flight landed uneventfully at 05.56. The remaining fuel was 1800 kg. The final reserve fuel of 2300 kg was calculated based on the actual landing weight of the aircraft and the alternate airport elevation over the mean sea level corresponding to 30 minutes holding at 1500 feet above alternate airport elevation at the most economical green dot speed in the clean configuration. SK946 had used fuel 4300 kg from missed approach in Arlanda to landing in Helsinki-Vantaa. The consumption in OFP was calculated to be 3700 kg.

1.2 Injuries to persons

No injuries.

1.3 Damage to aircraft

No damages.

1.4 Other damage

No other damages.

1.5 Personnel information

Commander of SK946:	Male, 55 years
Licence:	Airline transport pilot, valid until February 15, 2006
Medical certificate:	Class 1, Norway, valid until April 26, 2004
Ratings:	All necessary ratings were valid.
First officer of SK946:	Male, 40 years
Licence:	Airline transport pilot, valid until June 14, 2006
Medical certificate:	Class 1, Sweden, valid until November 12, 2003
Ratings:	All necessary ratings were valid

The First officer was pilot flying except during CAT II approach to Arlanda. He was on an instruction flight to convert his earlier A340 rating valid also for A330.

Relief pilot of SK946: Male, 57 years
 Licence: Airline transport pilot, valid until February 24, 2007
 Medical certificate: Class 1, Sweden, valid until March 3, 2004
 Ratings: All necessary ratings were valid.

Supervisor of Helsinki APP: Female, 42 years
 Licence: Air traffic control officer, valid until March 1, 2004
 Medical certificate: Air traffic control officer, valid until March 1, 2004
 Ratings: All necessary ratings were valid.

Radar controller of Helsinki APP: Male, 35 years
 Licence: Air traffic control officer, valid until August 29, 2004
 Medical certificate: Air traffic control officer, valid until August 29, 2004
 Ratings: All necessary ratings were valid.

Radar controller of Helsinki ARR: Male, 31 years
 Licence: Air traffic control officer, valid until October 16, 2004
 Medical certificate: Air traffic control officer, valid until October 16, 2004
 Ratings: All necessary ratings were valid.

Controller of Helsinki-Vantaa TWR: Male, 26 years
 Licence: Air traffic control officer, valid until June 14, 2004
 Medical certificate: Air traffic control officer, valid until June 14, 2004
 Ratings: All necessary ratings were valid.

1.6 Aircraft information

SK946, OY-KBN, was Airbus 330-300, two-jet-engine airliner with 261 passenger seats, operator Scandinavian Airlines, maximum take off weight 233 000 kg.

1.7 Meteorological information

There was a ridge of high pressure over the Baltic Sea and eastern Sweden. The sky was clear but local fog occurred especially close to sea and lakes in the morning hours.

In Arlanda light southerly wind carried moist air from lake Mälaren to the airport. The terrain forced the air to rise and caused turbulence as consequence fog in Arlanda. The meteorological visibility was 200 m and the RVR varied in hours 03.20 - 06.20 between 300 and 500 meters.

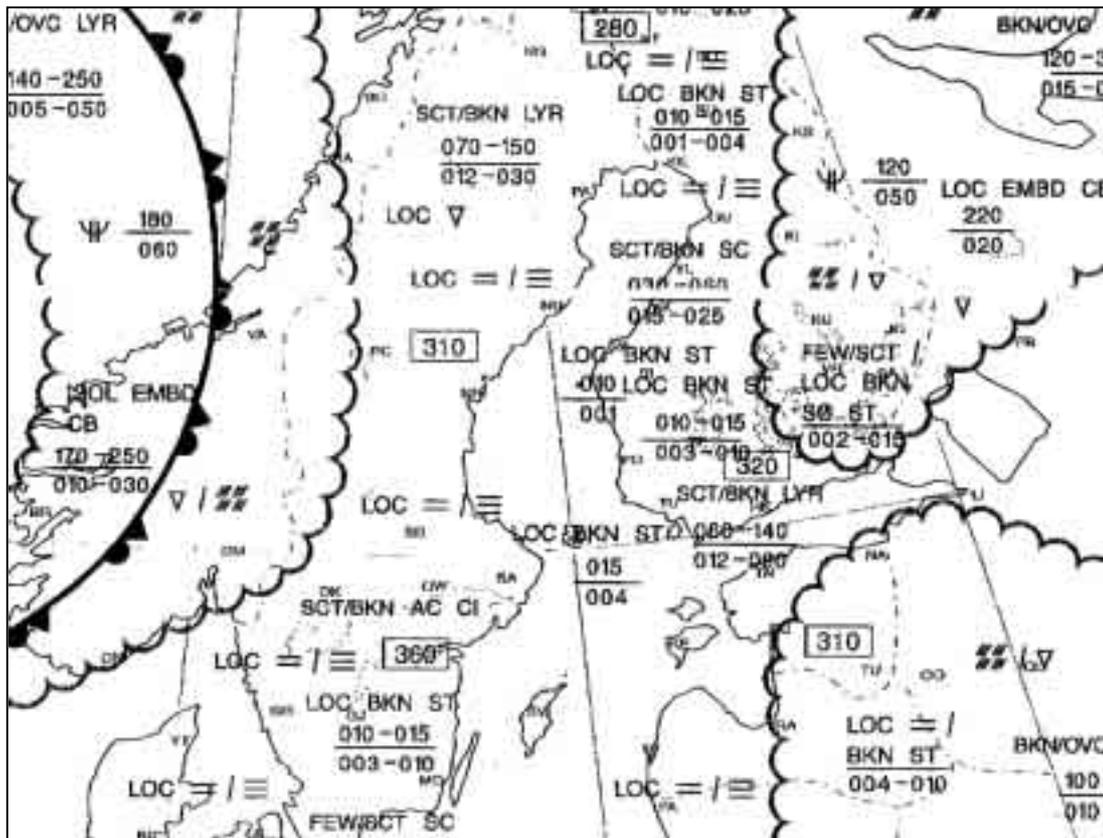


Figure 2. SW chart valid time 06 UTC 03.10.2003

The pilots had in the flight preparation in Chicago the following forecast for Stockholm-Arlanda available: FTSN32 ESSA 022200. Terminal area forecast, TAF

Stockholm Arlanda, ESSA, 022210Z valid 3.10 between 06 and 24 UTC:

Wind 190° 8 KT visibility 10 km, clouds scattered 3000 ft, temporarily between 06 and 07 UTC visibility 500 m fog, vertical visibility 200 feet
Temporarily between 07 and 09 UTC visibility 4000 m mist, clouds broken 800 feet, probability 30% between 13 and 24 UTC rain.

Stockholm Arlanda weather 3.10.2003 published by MET office:

Terminal area forecast, TAF, valid between 03-12 UTC:

Wind variable 3 KT, visibility 5 km mist, clouds scattered 200 feet, probability 30% between 03-07 visibility 700 m, fog.

Amended TAF at 02.00, valid between 03-12 UTC:

Wind variable 3 KT, visibility 5 km mist, clouds scattered 200 feet, probability 40% between 03-07 visibility 300 m, fog, vertical visibility 200 feet, probability 30% between 07-09 visibility 4 km mist, clouds broken 700 feet.

Weather observations, METAR:

At 04.20 UTC: Wind 170°/4 KT, visibility 250 m, RVR rwy 01L 550 m no change, rwy 19R 600 m no change, fog, vertical visibility 200 feet, temperature +8 °C, dew point +7 °C, QNH 1007, no change expected.

At 04.50 UTC: Wind 190°/4 KT, visibility 200 m, RVR rwy 01L 500 m no change, rwy 19R 500 m no change, fog, vertical visibility 200 feet, temperature and dew point +7 °C, QNH 1007, no change expected.

At 05.20 UTC: Wind 170°/6 KT, visibility 200 m, RVR rwy 01L 450 m no change, rwy 19R 450 m no change, fog, vertical visibility 200 feet, temperature +8 °C, dew point +7 °C, QNH 1007, no change expected.

Helsinki-Vantaa weather 3.10.2003:**Weather observation, METAR:**

At 05.50 UTC: Wind variable 2 KT, visibility more than 10 km, clouds few 800 feet broken 6600 feet, temperature +6 °, dew point 0 °C, QNH 1008, no change expected.

1.8 Aids to navigation

The aircraft was equipped with a modern Flight Management Guidance Envelope System (FMGS). It generates optimum vertical and lateral flight profiles and predicted progress along the entire flight path and computes performance and guidance commands. FMGS guides the aircraft along the pre-planned lateral and vertical flight plans. The pilots have opportunity to receive information from the system and modify selected navigation or performance data and specific functions of flight management via Multipurpose Control and Display Unit (MCDU). Optimisation and predictions include to the performance function and are available for in-flight calculations.

For lateral navigation FMGS uses Global Positioning System/ Inertial Reference System (GPS/IRS) data and radio navigation aids. It is certified for basic (B) and precision (P) area navigation (BRNAV and PRNAV) operations as well as for operations in Required Navigation Performance (RNP 10) airspace, for example Oceanic/ remote area operations.

1.9 Communications

VHF (very high frequency) radio communications were used between SK946 and the air traffic control units except over the western Atlantic where HF (high frequency) radio communications were used.

The VHF radio communications in the Finnish airspace were listened from Tampere ACC and Helsinki-Vantaa ATC recordings.

1.10 Aerodrome information

1.10.1 Stockholm Arlanda information

The co-ordinates of the Arlanda aerodrome reference point are 59°39.07' N, 017°55.07' E. The elevation is 137 ft (41.9 m), the elevation of threshold 01L is 98 feet (30 m). There are three runways at the aerodrome. Category II approach is available for approach and landing to runways 01L, 01R and 19L. The runway 01L, which SK946 approached, is equipped with high intensity approach, runway centre line and runway edge lights as well as threshold, touchdown zone and PAPI lights.

In AIP Sweden paragraph AD 2-ESSA-1-19 is stated:

ESSA AD 2.23 MISCELLANEOUS

1. Low visibility procedures (LVP)

- 1.4. LVP will be in force when the RVR (Runway visual range) falls below 600 m and/or ceiling/vertical visibility falls below 200 ft. The application of LVP will be announced by ATIS (Automatic terminal information service)*
- 1.5. Category II operation will mean 7 NM spacing between arrivals in order to keep the ILS critical and sensitive area free for every landing.*
- 1.6. Category II operation will reduce landing capacity to 65%. Supervisor TWR will always inform CFMU (Central flow management unit) of current restrictions on traffic flow including the expected flow rates.*

It is possible to convert the meteorological visibility to runway visual range by multiplying visibility in daylight conditions by 1.5, e.g. visibility 500 m x 1.5 = RVR 750 m. At the time of flight planning before departure the forecast for Stockholm-Arlanda was "TEMPO visibility 500 m".

The purpose of this method is to make it on in-flight conditions possible to convert the reported meteorological visibility to RVR when RVR-value is not measured or reported. This method is not aimed to use as a flight planning tool.

1.10.2 Helsinki-Vantaa information

The co-ordinates of the Helsinki-Vantaa aerodrome reference point are 60°19.02' N, 024°57.48' E. The elevation is 179 feet (55 m). There are three runways at the aerodrome. Category I ILS -approach is available to runway 15, which SK946 approached. The runway is equipped with high intensity approach and runway edge lights as well as runway centre line, touchdown zone and PAPI lights.

1.11 Flight recorders

Recordings of flight recorders were not available.

1.12 Wreckage and impact information

Not relevant in the investigation.

1.13 Medical and pathological information

No medical tests.

1.14 Fire

No fire.

1.15 Survival aspects

The supervisor of Helsinki Approach Control gave a full alarm when SK946 had reported shortage of fuel. The rescue units for a heavy aircraft were in their operation positions on the airport when the aircraft landed uneventfully.

1.16 Test and research

1.16.1 Statistics from the flight SK946 Chicago - Arlanda

The investigators had in their use copies of used master operational flight plans from 34 flights with the same designator SK946 from Chicago to Arlanda between dates 8.9.2003 and 15.10.2003 operated with A330. The calculated and actual landing weight as well as calculated and actual take off fuel in every OFP was checked. The weather conditions were checked by comparing the calculated and actual flight time to all reporting points. All markings made by the pilots were checked and compared to the calculations of the OFPs. A comparison of the burned total fuel was not possible, because the total fuel consumption or the remaining block fuel was not marked in any of these flight plans. The last fuel check was marked in three copies during the last 45 minutes, in 13 copies between 45 minutes and 90 minutes before landing and in 28 cases earlier than 90 minutes before landing.

The actual TOF was in six of the plans the same as in the OFP. In three of these cases the actual TOW was less than calculated in OFP and in three cases more. The maximum TOW deviations were -7.2 t and +2.9 t. In 18 of the flight plans the extra fuel uplift was between 0.1 t and 2.0 t and in 10 of the flight plans more than 2.0 t. The maximum extra fuel uplift was 6.7 t.

Depending on the wind conditions the flight time from the longitude 10 W to Arlanda is about two hours or a little less. The fuel used from take off to 10 W was analysed based on these OFPs. In 11 cases was fuel used less than calculated in the OFP. The maximum difference to OFP was +0.9 t. In 23 cases was fuel used more than calculated, -2.2 t as maximum difference. In seven cases the fuel difference was 1.2 t or more.

The flight time to 10 W was on all flights the same or longer than calculated in OFP. The maximum difference was +11 minutes.

1.17 Organizational and management information

Scandinavian Airlines includes to SAS Group representing about 44% of the operation volume. The other business areas of SAS Group are: Subsidiary & Affiliated Airlines, Airlines Support Business, Airline related Business and Hotels. SAS is a flag carrier of the Nordic countries Denmark, Norway and Sweden operating about 200 aircraft including three Airbus 330-300. The head office of the airline is in Stockholm.

Scandinavian Airlines as also the other airlines has operated in a demanding environment during the last years. The demand for travel has reduced and competition of the low-cost companies has intensified. For cutting costs the airline has cut down flight services and reduced personnel.

Scandinavian Airlines flight operations are performed according to SAS Flight Operations Manual, FOM, which fulfils the OM-A requirements in JAR (Joint Aviation Requirements) and according to SAS Flight Crew Operating Manual, FCOM, which fulfils the OM-B requirements in JAR. The operation procedures are officially adopted by the Scandinavian Civil Aviation Authorities.

2 ANALYSIS

2.1 Flight planning

The flight planning was done according to the airline normal procedures. The fuel calculations were made by the commander and the first officer using the *RODOS Planning - Longhaul Aircraft* calculations. The relief pilot prepared the ETOPS-charts.

The weather on the departure airport was good as well as en route and on the planned alternate airport Gothenburg. On the destination Arlanda the weather was good, but there was forecasted temporarily fog and visibility 500 m on the morning between 06 and 07 UTC. The scheduled arrival time of the flight was 05.35 UTC. The pilots concluded that no problems would be expected and agreed the 51.0 t fuel uplift. The fuel calculations in the OFP included 0.7 t for taxi, 42.4 t trip fuel to Arlanda, 1.3 t contingency fuel and 6.4 t minimum diversion fuel from Arlanda to Gothenburg containing alternate trip fuel of 4.1 t and a final reserve fuel of 2.3 t. The commander received information that take-off weight (TOW) would be 1.6 t more than the 211.3 t calculated in the OFP and decided for that reason to take 0.2 t of extra fuel. The actual difference between the planned and the actual TOW was 1800 kilos. The actual TOW was 213.1 t and maximum TOW of the aircraft was 233 t.

The flight departed seven minutes behind the schedule, taxiing went normally and the take-off fuel was 50.3 t.

2.2 Flight en route

The received flight levels were according to the flight plan and SK946 got a slight short-cut one hour and twenty-five minutes after departure. Fuel used was more than calculated in the OFP. 200 kg extra was burned 45 minutes after departure and after 2 h 48 min of flight time 700 kg of contingency was used. On 30 W 4 h 36 min after departure the fuel used was 900 kg more than calculated and the flight was four minutes behind the time calculated in OFP.

The commander had gone to rest and the first officer and the relief pilot operated the aircraft. They told to the investigators in their interview that they were not concerned of the fuel. According to their statements it is normal that the fuel goes below the calculations and comes back again to the values calculated in the OFP and that the fuel quantity indicators of A330 are not very reliable. If the fuel quantity indicators are unreliable the fuel should be checked more closely, compare the quantity indicators to the used fuel indicators and use a more economical cruising procedure if the fuel quantity indication is suspected to be misleading.

The pilots flew on the planned flight level maintaining the cleared speed Mach 0.82. Even though the flight was over the Atlantic it would have been possible to be active and use the Optimisation and predictions ability of the FMGS. Even though the communica-

tions are handled via the HF -radio over the Atlantic, it is possible to request a change of the flight level or the cruising Mach-number with a short delay.

SK946 had used by the longitude 10 W all of the contingency fuel of 1.3 t and was five minutes behind the time calculated in the OFP. By the reporting point SOPAR the fuel used was 1.5 ton more than calculated. After this point the pilots had marked no fuel checks in the OFP.

The commander took his leadership lightly during cruise. He rested and did not worry about the progress of his flight. The 500 kg of fuel which was lacking in landing on the alternate airport would have been possible to save during the cruise if the pilots had operated the aircraft keeping the fuel economy as goal, because the weight of the aircraft was not heavy and a wide performance envelope was available for saving fuel. When the fuel quantity goes below the calculated value during cruise, a good habit of action of the pilots is to try to improve the fuel economy of the flight.

The first officer and the relief pilot told in their interview that the contingency fuel is for an unexpected additional fuel consumption during cruise and the purpose is not to save the contingency fuel for the approach. During the flight in question there were no unexpected factors, such as lower flight level or longer flight route which would have differed from the calculation of the OFP. The fuel flow was higher than calculated during all stages of the flight and extra fuel was needed for the approach.

2.3 Approach to Stockholm-Arlanda

When SK946 descended for the approach to Arlanda the runway visual range (RVR) on rwy 01L was 500 m and low visibility procedures (LVP) were in force. The commander took his position on the left cockpit seat and controls by *ELTOK*. The pilots requested CAT II approach. The ATC cleared SK946 to holding, but the pilots informed that due to fuel situation they were unable to hold and requested approach. SK946 managed to change approach sequence with one other aircraft of the company. According to the relief pilot's statement it is stated in the Operations Manual of the airline that when arriving to Arlanda during the morning peak hours the aircraft should have 15 minutes of extra fuel. This instruction is not applicable on long-haul flights, such as SK946. According to the pilots' statements it is a normal procedure to change approach sequence with another company aircraft which have a better fuel situation.

In the OFP fuel calculations of the flight SK946 the fuel at the point of 30 NM was 7.0 t. There was also printed in the flight log part of the OFP on the next line after *ELTOK* abbreviation STAR, distance of 30 NM and time 12 minutes. The pilots told that they had 7.0 t of fuel at the reporting point *ELTOK*. According to the aircraft *FM ACTIVE POST-FLIGHT REPORT* the fuel on board by *ELTOK* was 7.2 t. The direct distance from *ELTOK* to rwy 01L threshold is a little more than 30 NM and in a normal radar vectoring it takes approximately 40-45 NM track miles. Thus the 30 NM, which is prescribed in *RODOS* -calculations is not at *ELTOK* but somewhat later.

In the RODOS OFP the line after *ELTOK* was misleading because the text “*STAR Stockholm/Arlanda 30....12*” is possible to understand that via a standard arrival route the flight distance to Arlanda is 30 NM and the flight time is 12 minutes. When the pilots had calculated the estimated arrival time to Arlanda they had added to the time by *ELTOK 04.51* 12 minutes and had got the arrival time of *05.03*. Based on these markings the pilots had an assumption that the flight time from *ELTOK* to landing would be 12 minutes.

The LVP were in force and CAT II operation will reduce landing capacity to 65% according to the AIP Sweden. CAT II operation means 7 NM spacing between arrivals causing longer tracks for approaching traffic. The ATC applies speed restrictions and it is not possible to fly in clean configuration until 10 NM as it is calculated in *RODOS Planning system*. A CAT II approach to Arlanda requires more fuel than the planning system calculates. The pilots should consider in flight planning which kind of approach they may possibly have to make in the destination. Also the possible holding must be taken into account. It is not a good airmanship to use the alternate fuel for the approach to the destination in bad weather conditions.

The pilots told that they expected to be as number one in the approach sequence when they had got the privilege approach without holding. The commander told that they believed to be already on the left base leg when they got a 90 degrees right turn to the opposite direction of the final approach. According to the *FM ACTIVE POSTFLIGHT REPORT* the flight time from *ELTOK* to runway 01L threshold took 20 minutes when the calculated flight time in the OFP was 12 minutes. Calculated from the flight time with an average approach speed of 210 KT the actual distance flown by SK946 from *ELTOK* to threshold 01L about 65 track miles instead of the 30 NM printed in the OFP. The approach route of SK946 can also be seen in the figure 1.

The runway visual range on the used runway 01L was during the CAT II approach above the landing minima 400 m and the approach was stable, but the pilots did not see the approach or runway lights from their decision height of 165 feet measured by radio altimeters. The commander started the missed approach procedure at 05.16 and the pilots saw the runway lights for a moment during the missed approach. The fuel on board was 6.1 t and the required fuel from the missed approach point to Helsinki-Vantaa was 6.0 t according to the OFP. According to the FM POSTFLIGHT report SK946 used from *ELTOK* to missed approach point fuel 1100 kg. The flight time was 20 minutes and the average consumption 55 kg/min. Based on this consumption the approach fuel of 600 kg for 12 minutes approach (50 kg/min) calculated in the OFP is not sufficient for a radar vectoring followed by a CAT II approach in Arlanda LVP conditions. Scandinavian Airlines should order the commanders to take fuel enough for approach paying attention to possible delays caused by the traffic and weather conditions.

The decision height (DH) is measured from the lowest point of the aircraft, from the main wheels. According to the A330 FCOM the cockpit is 34 feet above the main wheels and the pilots sit at a height of 199 when they are on CAT II DH. Thus a considerable longer slant visibility is required to get the lights in sight in a A330 than in a smaller aircraft where the cockpit height is only a little more than 100 feet above the runway level at the DH. This has to be taken into account when determining the required RVR for the A330,

but in practice in a thick fog and RVR of 400 m the slant visibility from 199 feet is not adequate for a successful landing as in this case happened.

The reported surface wind at 05.20 was 170° and six knots. During the approach the prevailing tailwind was about 5-8 knots. The wind transferred moist air to the airport and to the final approach line from the lake Mälaren south of Arlanda. The terrain caused turbulence and forced the moist air to rise, which caused the fog to intensify on the airport with the RVR varying between 400 and 500 meters during the approach of SK946. About 10 minutes later the RVR was according to the Meteorological Office recording 350 m and in the METAR at 05.50 the vertical visibility was reported to be 100 feet.

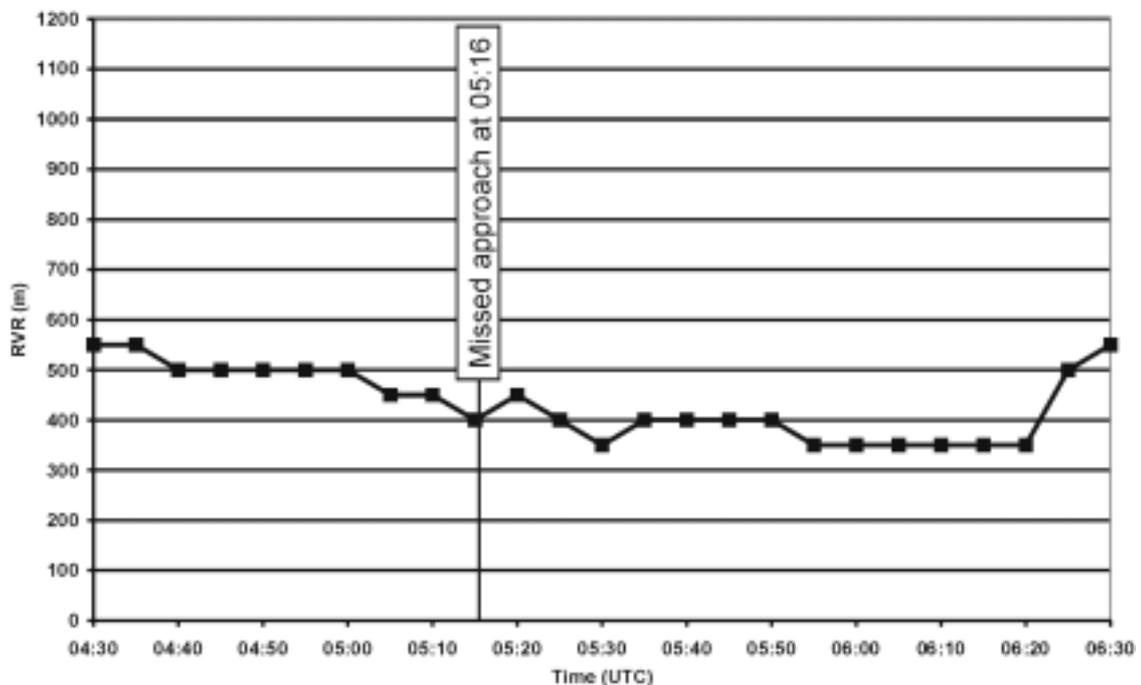


Figure 3. Arlanda runway 01L RVR between 04.30 and 06.30 UTC on 3.10.2003

The pilots of SK946 estimated when planning the flight in Chicago that the forecasted temporary fog and visibility of 500 m has no effect to their flight. The pilots had an unrealistic impression that they would be treated as number one in the approach sequence and would get a short vectoring when they had changed sequence with the other aircraft even though LVP were in force and CAT II approaches used. Estimated from distance and flight time which SK946 flew, its sequence number, when the flight left *ELTOK*, was about six to eight. The pilots had during vectoring changed the alternate Gothenburg to Helsinki-Vantaa because 400 kg less fuel was required for flight to Helsinki-Vantaa. They did not inform the ATC of the alternate change and after the missed approach requested a clearance to Helsinki-Vantaa which came unexpectedly to the ATC controller. The pilots were convinced of the landing in Arlanda and were not mentally prepared for the missed approach and the diversion.

2.4 Diversion to Helsinki-Vantaa

The Arlanda rwy 01L missed approach procedure calls: *Climb straight ahead 1.0 DME mile past ARL VOR then turn left track 330° climbing to 1500 feet, radar vectoring for a new approach.* After the missed approach the commander decided to divert to Helsinki-Vantaa because of the fuel situation. SK946 had to maintain according to the missed approach procedure 1500 feet altitude for a while which after it initially got a clearance to 3000 feet because of the approaching traffic. The pilots criticised the flying at low altitude, but in this kind of a sudden situation, when the flight does not have a valid flight plan filed, it takes a while before the ATC is able to issue a new route clearance and some delay in clearance to higher flight altitude should be accepted. According to the available information SK946 got a normal handling in traffic and the flight time at low altitude was only a few minutes.

SK946 received clearance to Helsinki-Vantaa, contacted *TAMPERE ACC* at 05.27.50 and reported maintaining flight level 270. It had climbed to cruising level in less than 12 minutes after the missed approach, which means that the average rate of climb was more than 2200 ft/min. In the OFP calculations the cruising altitude from Arlanda to Helsinki-Vantaa was FL 290 but a 2000 feet lower flight level had a very minimal effect to fuel consumption when long range cruise was used as ordered in the A330 FCOM. After radar identification SK946 received a direct clearance to VOR VTI which is the TMA entry point from west to Helsinki-Vantaa. SK946 reported to ACC at 05.31.40: *"Sir, we calculate now that we have upon landing at Helsinki less than our minimum fuel, so formally we are getting into an emergency situation due to the fuel."* From the ATC point of view a clear fuel emergency report should have been made because the pilots knew that they would have less fuel than the final reserve fuel at landing. The controller must decide what kind of alarm he/she will give and the rescue services need some more preparing time in case of a heavy aircraft than a small aircraft incident. The weather at Helsinki-Vantaa was good, sky almost clear and winds were light. The ACC gave an arrival clearance to runway 15 at 05.42.00 and a descend clearance at 05.42.40. SK946 was allowed to fly inbound Helsinki-Vantaa without restriction and the pilots could plan their flight profile freely.

TAMPERE ACC transferred SK946 to *HELSINKI APPROACH* at 05.45.30. The APP offered after radar identification a short approach, but the pilots requested a normal approach. SK946 reported at 05.50.00: *"Approach, Scandinavian 946, if for any unforeseen reason we have to make a missed approach, we will make a circuit for the new attempt."* APP replied: *"Scandinavian 946, roger, in case of missed approach, you will make a visual approach runway 15."* APP added a few seconds later: *"If necessary for shorter track miles, the runway 22 left is available in case of missed approach."* SK946 got from ATC as good service as possible and the pilots were allowed to make as economical and safe flight profile as they could.

The rescue service was alarmed for the SK946 landing. Flight landed uneventfully at 05.56. The remaining fuel was 1800 kg. According to the A330 FCOM of the airline the fuel quantity corresponding to 30 minutes holding is 2300 kg at 1500 feet above the alternate airport elevation at green dot speed in the clean configuration and the calculations are based on the actual landing weight of the aircraft. Calculating according to this

FCOM rule the remaining 1800 kg corresponds to about 23 minutes of flight time, but a possible missed approach requires fuel about 500 kg which reduces the usable flight time considerably.

According to the *RODOS* calculation of the airline FOM the diversion fuel is calculated according to the SID giving the longest missed approach distance and to the least favourable landing runway. In Arlanda the runway 26 would have given the longest distance but SK946 followed the SID from runway 01L and in Helsinki-Vantaa it landed to the most favourable runway 15. The cruising level used was 270 instead of 290, but the difference is marginal when flying long range cruise. SK946 had reached flight level 270 when it contacted *TAMPERE ACC* 11 minutes 50 seconds after the missed approach. SK946 used however fuel from the missed approach in Arlanda to landing in Helsinki-Vantaa 4300 kg. The consumption in the OFP was calculated to be 3700 kg. Scandinavian Airlines should check the basis of the alternate fuel calculations of *RODOS Planning system*.

2.5 Procedures of the airline

The investigators had available the copies of used master operational flight plans from 34 flights using the designator SK946 from Chicago to Arlanda between dates 8.9.2003 and 15.10.2003 operated with A330. The total fuel consumption or the remaining block fuel was not marked in any of these master OFPs. The last fuel check was marked 45 minutes to 2 h 32 min before landing. To make it possible to verify afterwards the fuel consumption, the checks should be marked until the top of descend. The total fuel consumption should be marked as well. Scandinavian Airlines should order the pilots to enter the markings accordingly.

According to the researched OFPs a third part of the flights had consumed fuel according to the calculations or less and two thirds had consumed fuel more than calculated. In three cases the fuel difference was more than the calculated contingency fuel and the maximum difference to the OFP calculation was -2.2 t. The basis of the cruise fuel consumption calculations seems to be realistic and it is possible to operate within the contingency fuel by optimising the fuel economy during flight. Supposing that the rest of flight from 10 W went according to the *RODOS* calculations, in three these flights, if diversion to alternate had been needed, the fuel remaining in the alternate airport had probably been less than the calculated final reserve fuel of 2.3 t.

The manner to change the approach sequence between the approaching aircraft in TMA without clearing any emergency is not according to the ICAO ATC regulations or recommendations. It adds workload in ATC, disturbs the precalculated traffic flow and hampers flight safety. Scandinavian Airlines should order their pilots to take necessary fuel uplift including extra fuel required by the probable slow traffic flow and holding in the destination airport.

The approach procedure from 30 NM as used in the *RODOS Planning system* is possible in good weather and low traffic conditions, but when the intensity of the traffic increases and/or the weather deteriorates and the traffic flow slows down, the calculations

are not realistic. The 30 NM point is difficult to determine by the pilots when standard arrival routes are not used in approach, but the ATC applies radar vectoring and the traffic is slowed down. In this case SK946 had to fly approximately 65 track miles after the 30 NM point printed in the OFP. In high intensity traffic and/or LVP in force it is not possible to fly the aircraft in the clean configuration to 10 NM from threshold. Scandinavian Airlines should draw the pilots attention to the fuel margins and encourage the pilots to take extra fuel required for a possible long approach and holding.

The fuel is a considerable cost in the flight operations. Carrying extra fuel adds the costs. According to the rule of thumb, used by the airline, about a quarter of an extra fuel uplift is used for carrying that extra fuel from Chicago to Arlanda. With good flight planning and effective use of the aircraft and its equipment the optimal fuel economy is possible to reach without hampering the flight safety.

3 CONCLUSIONS

3.1 Findings

1. The pilots held valid licences and ratings required by their duties.
2. The air traffic controllers held valid licences and ratings.
3. The airworthiness certificate of the aircraft was valid.
4. The commander decided to take 200 kg extra fuel due to 1.6 t higher zero fuel weight.
5. The take off weight of the aircraft was 1.8 t more than calculated in the operational flight plan (OFP).
6. The fuel consumption of SK946 was during cruise higher than calculated in the OFP. All contingency fuel of 1.3 t and the extra fuel of 0.2 t was used by reporting point SOPAR 6 hours and 28 minutes after departure.
7. In the destination airport Arlanda low visibility procedures (LVP) were in force.
8. The commander requested category II (CAT II) approach. The weather minima for CAT II approach was RVR 400 m.
9. When the flight SK946 entered Stockholm terminal control area (TMA), the air traffic control (ATC) cleared it to holding, but the commander reported that SK946 had no time for holding due to the fuel situation and requested radar vectoring for approach.
10. The Local Operation Centre of the airline helped SK946 to change approach sequence with an other aircraft of the same company. The procedure is not according to the ICAO recommendations.
11. The pilots had the impression that SK946 would get a privilege to all other traffic and would obtain a short vectoring for approach.
12. The pilots supposed that they would have a flight time of 12 minutes from *ELTOK* to runway 01L threshold but in the radar vectoring they had to fly 20 minutes and approximately 65 track miles.
13. In a radar vectoring for CAT II approach the minimum track distance from *ELTOK* to threshold 01L is about 45 NM.
14. The ATC reported that SK946 received a normal treatment in the traffic.
15. The calculation basis for a flight from a point 30 NM to the threshold of the landing runway are described in FOM of Scandinavian Airlines in the part *RODOS Planning*

- *Longhaul Aircraft.* Calculations are based on a clean aircraft to 10 NM and the aircraft in landing configuration after that. This kind of a flight profile is possible in a good weather and low traffic flow, but in low visibility and/or intense traffic extra fuel should be taken for longer and slower approach.
16. The pilots noticed during approach that in case of a missed approach they would not have enough fuel to fly to the planned alternate airport Gothenburg. They changed the alternate to Helsinki-Vantaa, because 400 kg less fuel was required according to the OFP calculations for a flight to Helsinki-Vantaa compared to Gothenburg.
 17. The CAT II approach was stable but the pilots did not get approach or runway lights in sight on the minimum decision height (DH) of 165 feet.
 18. The commander made a missed approach and the first officer requested an ATC clearance to Helsinki-Vantaa.
 19. The remaining fuel at the missed approach point was 6.1 t. The calculated required fuel from the missed approach point to Helsinki-Vantaa was 6.0 t including an alternate trip fuel of 3.7 t and a final reserve fuel of 2.3 t.
 20. The pilots realised on cruising level that they would not have the required final reserve fuel upon landing in Helsinki-Vantaa and reported it to the Tampere Area Control Centre.
 21. The ATC issued SK946 a direct route clearance and free flight profile inbound Helsinki-Vantaa runway 15.
 22. The ATC gave a full alarm to the rescue services.
 23. SK946 landed uneventfully. The remaining fuel was 1.8 t instead of the required final reserve fuel of 2.3 t.
 24. SK946 had used 4.3 t of fuel from the missed approach in Arlanda to the landing in Helsinki-Vantaa when the calculated fuel consumption was 3.7 t. The fuel consumption was about 16% higher than calculated.
 25. The alternate fuel calculations of the flight SK946 should be checked because SK946 flew a shorter flight path than stated in the calculation basis and used more fuel than calculated.
 26. The total fuel consumption or the remaining block fuel was not marked in the 34 researched OPFs. The last fuel check was marked 45 minutes to 2 h 32 min before landing. To make it possible to verify afterwards the fuel consumption, the checks should be marked until the top of descend. The total fuel consumption should be marked as well.

3.2 Probable cause

The cause of the incident was that the actual fuel consumption from missed approach in the destination airport Stockholm Arlanda to landing at alternate airport Helsinki-Vantaa was considerably higher than calculated in the Operational Flight Plan of Scandinavian Airlines.

Contributory factors were:

SK946 did not have in addition to minimum diversion fuel any extra fuel because

- The fuel consumption during cruise was higher than calculated in the Operational Flight Plan of the flight and all of the contingency and extra fuel was used en route
- SK946 used during the approach in Arlanda fuel 500 kg more than calculated in the Operational Flight Plan of the flight because of a long approach caused by use of low visibility procedures. The flight crew did not take into account in the flight planning a possibility of low visibility procedures and a long approach in Arlanda and the commander did not take extra fuel for approach.

4 RECOMMENDATIONS

The flight SK946 used fuel during flight from the missed approach in Arlanda to landing in Helsinki-Vantaa 4300 kg when the calculated fuel consumption was 3700 kg. The fuel consumption was about 16% higher than calculated in the Operational Flight Plan of Scandinavian Airlines. The flown missed approach departure route in the destination airport was not the one giving the longest distance and the approach in alternate airport was not made to the least favourable runway as it is stated in the bases of the calculations in the *RODOS Planning system* description.

1. Scandinavian Airlines should check the alternate fuel calculation basis used in the operational flight plans of the airline.

In the fuel calculation basis of *RODOS Planning - Longhaul Aircraft* is described the flight path from a point 30 NM distance to the threshold of the landing runway and also diversion. The calculated flight time from 30 NM to the threshold is 12 minutes and the approach fuel 600 kg. In the OFP of SK946 was printed the remaining flight time of 12 minutes and the remaining distance of 30 NM from the point of *ELTOK*. SK946 flew from *ELTOK* to missed approach point 20 minutes and about 65 NM and used fuel 1100 kg. It is in the *RODOS* calculations assumed that the approach is flown aircraft in clean configuration to 10 NM from the threshold and after that point in landing configuration. In heavy traffic and in low visibility conditions the traffic slows down and the approaching aircraft are forced to use high lift devices before 10 NM from the threshold which increases the fuel consumption considerably. In these conditions also the flown approach tracks become longer which increases the approach time and fuel consumption.

2. Scandinavian Airlines should draw the attention of their flight crews to the bases how the approach fuel is calculated by the *RODOS Planning system*. The commanders should be recommended to take extra fuel for possible approach delay caused by the weather conditions and/or intense traffic.

The investigators had available copies of the used master Operational Flight Plans from 34 flights from Chicago to Arlanda between 8.9.2003 and 15.10.2003 operated with A330. The total fuel consumption or the remaining block fuel was not marked in any of these master copies. The last fuel check was marked 45 min to 2 h 32 min before landing. To fulfil the meaning to afterwards verify the progress of the flight, the fuel checks should be marked until the top of descent. The total fuel consumption should also be possible to verify.

3. Scandinavian Airlines should order the flight crews to make the fuel checks also on the last part of the flight and enter the checks in the Operational Flight Plan. Also the checks and markings of the remaining block fuel or the total consumed fuel should be done appropriately.

Helsinki, 3.6.2004

Jussi Haila

Antti Ruuth

APPENDIX 1



Statens haverikommission
Swedish Accident Investigation Board

2004-06-11

IntL-04/04

Accident Investigation Board
Sörnästen rantatie 33 C
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Finland

2004/06/11

1. 1. 35 2004
268/54

Amendment to Investigation Report C 9/2003 L regarding the incident at Helsinki-Vantaa airport on October 3, 2002 involving a SAS aircraft, A330-300B, registration OY-KBN

Many thanks for the Final Report and for the fruitful cooperation during the investigation. Unfortunately the Final Report was issued without the final comments to the Draft Final Report given by the Swedish accredited representative incorporated.

Since some of the comments are considered to be important, the Swedish AIB would like the Accident Investigation Board Finland to complete the Final Report with the amendments below:

Chapter 3.2, Probable cause

The following text is suggested:

The cause of the incident was that the actual fuel consumption from missed approach in the destination airport Stockholm Arlanda to landing at alternate airport Helsinki-Vantaa was considerably higher than the RODOS-calculation in the Operational Flight Plan of Scandinavian Airlines.

The following factors are suggested to be moved from "Contributing factors" to Chapter 3.1, "Findings":

- The fuel consumption during cruise was higher than calculated in the Operational Flight Plan of the flight and all of the contingency and extra fuel was used en route.
- SK946 used 500 kg more fuel during approach in Arlanda than calculated in the Operational Flight Plan of the flight because of a long approach caused by use of low visibility procedures. The flight crew did not take into account in the flight planning a possibility of low visibility procedures and a long approach in Arlanda and the commander did not take extra fuel for approach.

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The following "Contributing factor" is suggested to be added:

The consumed approach fuel at Stockholm Arlanda was considerably higher than the RODOS-calculation in the Operational Flight Plan.

Yours faithfully

Mats Öfverstedt
Accredited representative

Statens haverikommission / Swedish Accident Investigation Board

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