



Investigation report

C 9/2002 L

Loss of separation over BALTI on 6.9.2002

OH-LYV DC-9

OH-LBX B757

According to Annex 13 of the Convention on International Civil Aviation, paragraph 3.1, the purpose of aircraft accident and incident investigation is the prevention of accidents. It is not the purpose of aircraft accident investigation or the investigation report to apportion blame or to assign responsibility. This basic rule is also contained in the Investigation of Accidents Act, 3 May 1985 (373/85) and European Union Directive 94/56/EC. Use of the report for reasons other than the improvement of safety should be avoided.



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ABBREVIATIONS

| | |
|-------|---|
| ACC | Area control centre |
| APP | Approach control |
| ARR | Arrival radar controller |
| DEP | Departure radar controller |
| FL | Flight level |
| FMS | Flight management system |
| ICAO | International Civil Aviation Organization |
| JAR | Joint Aviation Requirements |
| LNAV | Lateral navigation |
| METAR | Aviation routine weather report |
| OPF | Operational flight plan |
| PF | Pilot flying |
| PNF | Pilot not flying |
| QNH | Altimeter sub-scale setting to obtain elevation |
| RA | Resolution advisory |
| TA | Traffic advisory |
| TAF | Aerodrome forecast |
| TCAS | Traffic alert and collision avoidance system |
| UTC | Co-ordinated universal time |
| VNAV | Vertical navigation |



SYNOPSIS

On Friday 6 September 2002 at 09.52 UTC (the investigation report uses UTC times, whereas the Estonian and Finnish local times were UTC +3 h) a loss of separation between two aircraft occurred over the Gulf of Finland, near reporting point BALTI. Both aircraft were operated by Finnair Oyj. The flight paths of the DC-9 airliner, flight number FIN754J, and the Boeing 757 airliner, flight number FIN2234, crossed vertically two times while the aircraft were flying in sequence with a horizontal distance of about 2,7 nautical miles (NM).

The Accident Investigation Board (AIB), Finland, was notified of the incident by the Estonian investigation authority on 27.9.2002.

AIB Finland decided to start an official investigation of the incident on 30.9.2002 (decision No. C 9/2002 L). Airline pilot Jussi Haila and air traffic controller Erkki Kantola were appointed as investigators. The investigation was based on the Act (373/1985) and Decree (79/1996) on the investigation of accidents, ICAO Annex 13 and EU Council Directive 1994/56/EC.

Estonia appointed Mr. Tõnu Ader, director of the accident investigation department, as an accredited representative for the investigation.

To obtain more detailed information on the incident, the investigators made the following interviews: pilot-in-command of FIN754J on 8.10.2002, co-pilot of FIN2234 on 14.10.2002, co-pilot of FIN2234 on 15.10.2002, Helsinki approach radar controller, air traffic control assistant and check pilot of FIN2234 on 17.10.2002, co-pilot of FIN754J on 22.10.2002 and Tallinn approach radar controller on 30.10.2002.

Moreover, the investigators received recordings of radar data, radio communications and telephone conversations from Tallinn approach control, as well as Winradar, radio communications and telephone recordings from Helsinki-Vantaa airport. The investigators also examined the radar recording from the EFHK-APP workstation at Helsinki approach control on 3.12.2002.

In accordance with the Investigation of Accidents Decree (79/1996), the final draft of the investigation report was sent for comments to the Estonian investigation authority and CAA Finland, Flight Safety Authority, on 13.1.2003. Comments were also requested from Finnair Oyj on the same date. The comments received have been enclosed in the final report.

The investigation was closed on 7.3.2003.



1 FACTUAL INFORMATION

1.1 Sequence of events

1.1.1 Events within Tallinn ATC's area of responsibility

FIN754J was flying in Estonian airspace at flight level (FL) 270 in the direction of airway M857 from reporting point SOKVA towards reporting point BALTI. At 09.44.30 the crew contacted Tallinn approach control (TLL-APP), reporting also that they were ready to descent to a lower level. TLL-APP reported radar identification and cleared FIN754J to descent to flight level 110. The crew reported leaving FL 270 and descending to FL 110. This investigation uses UTC times as recorded at Helsinki approach control (HK-APP). The time recorded at Tallinn APP was 40 seconds ahead of that recorded at Helsinki APP.

At the same time, FIN2234 was flying towards BALTI along airway M608 via reporting point VADAN. Tallinn area control centre (TLL-ACC) had cleared it to descent to flight level 240. At 09.47.00 the crew of FIN2234 contacted TLL-APP and reported that they were descending through FL 277. TLL-APP reported radar identification and cleared the aircraft to descend further to FL 200, which the crew acknowledged. FIN754J and FIN2234 were approaching BALTI on flight paths intersecting at an angle of about 30°.

At 09.31.10 TLL-ACC telephoned HK-APP and reported the estimates on FIN754J and FIN2234, asking also if it was acceptable them to be descending to their cleared flight levels 110 and 130: *"Estimate Finnair 754J, squawk 4344, BALTI time 09.52, FL 110 descending"* and *"next one Finnair 2234, squawk 4347, BALTI time 09.53 FL 130 descending."* The controller in Helsinki accepted the requests, and the assistant relayed the information to Tallinn. After this there was no discussion between Tallinn and Helsinki about these flights until they were coming over BALTI and were controlled by HK-APP.

At 09.47.50 TLL-APP asked about FIN754J's rate of descent: *"Finnair, report rate of descent."* The crew reported that the aircraft was descending 2000 feet per minute. At 09.48.00 the controller told FIN754J to maintain the rate of descent 2000 ft/min or more: *"Finnair 754J, maintain rate of descent 2000 feet per minute or more."* The crew read back the restriction: *"2000 feet per minute or more, Finnair 754J"*. Thereafter TLL-APP called FIN2234 and, at 09.48.10, cleared it to descend to FL 130 at a rate of descent of 2000 ft/min or less: *"Finnair 2234, continue descent to FL 130, rate of descent 2000 feet per minute or less."* The pilot-in-command of FIN2234 (PNF, pilot not flying), who was handling the radio communications, read back the clearance: *"130 and 2000 or less, Finnair 2234."* According to radar recordings, the vertical distance between the two aircraft when they acknowledged the rate of descent restrictions issued by the controller was about 3500 feet, while FIN754J was flying lower.

The co-pilot of FIN2234 (PF, pilot flying) told in the interview that he had flown the plane by the FMS (Flight Management System), using the LNAV (lateral navigation) mode for

navigation and VNAV (vertical navigation) level change mode for vertical control, adjusting the rate of descent by changing flight speed. There was also a check pilot on FIN2234's flight deck, who was conducting a line check.

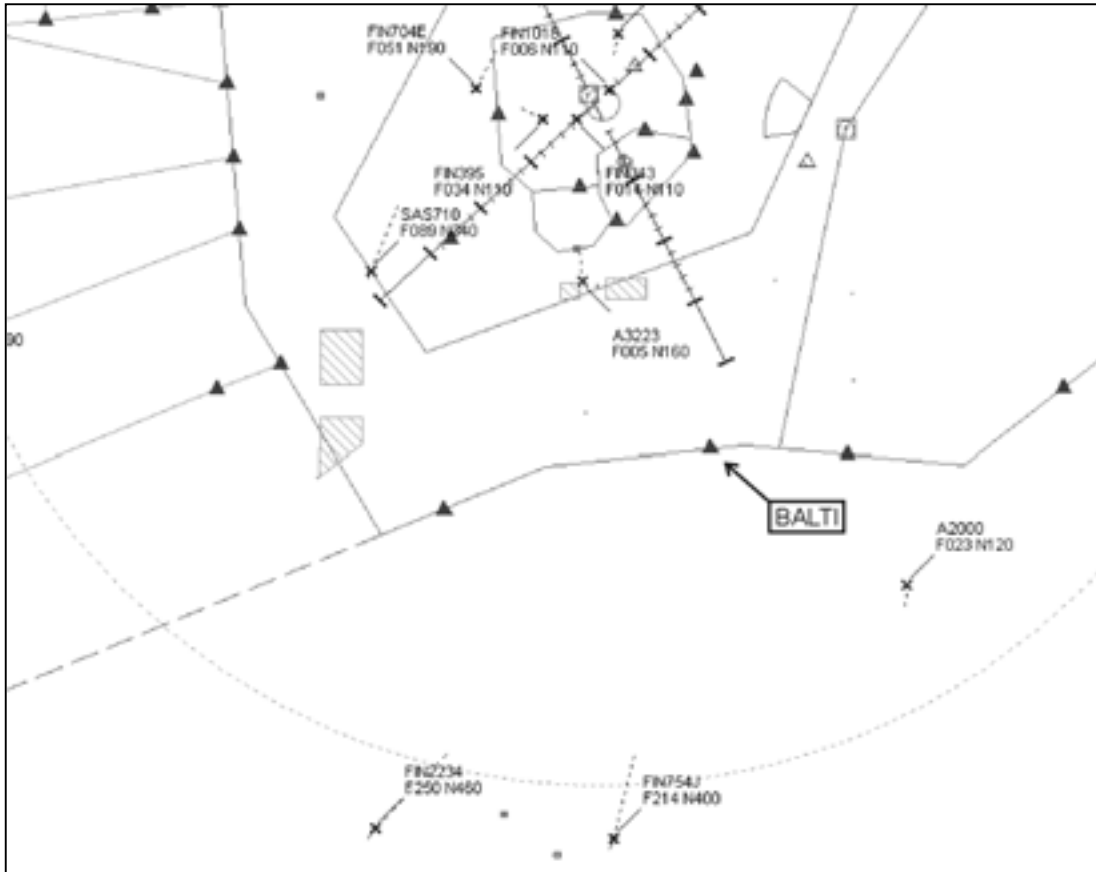


Figure 1. Positions and flight levels of the aircraft when the rate of descent restriction was issued at 09.48.00 UTC

When interviewed, the FIN754J pilots did not remember which of them was the pilot flying (PF) and which was monitoring the flight and handling radio communications (PNF). This could not be determined from the retained flight documents either, which included the operational flight plans (OFP, log) for both pilots. The rate of descent restriction issued by Tallinn approach control had only been entered on the co-pilot's flight log. The flight documents of FIN2234 only contained the co-pilot's OFP, which had no entries about the rate of descent restriction issued by Tallinn APP or clearances received from Helsinki APP. However, the closest distance to the other aircraft as shown by the TCAS, three nautical miles, and the time 09.52 had been entered on the OFP form.

The rate of descent of FIN754J after the restriction was issued, as calculated from the flight level information contained in the radar recording, was 2000-2200 ft/min within TLL-APP's area of responsibility. FIN2234 had a rate of descent of 2700-2900 ft/min. The rate of descent curves for the aircraft are shown in Figure 2. The aircraft were flying under TLL-APP's radar control, and their separation was based on issued and acknowledged clearances. The TLL-APP controller told in the interview that he had monitored the flights on his radar display. At 09.50.30 he asked FIN754J and a moment later



FIN2234 to contact HK-APP by radio. At that time, the vertical distance between the aircraft was about 1500-1700 feet, while FIN754J was flying lower.

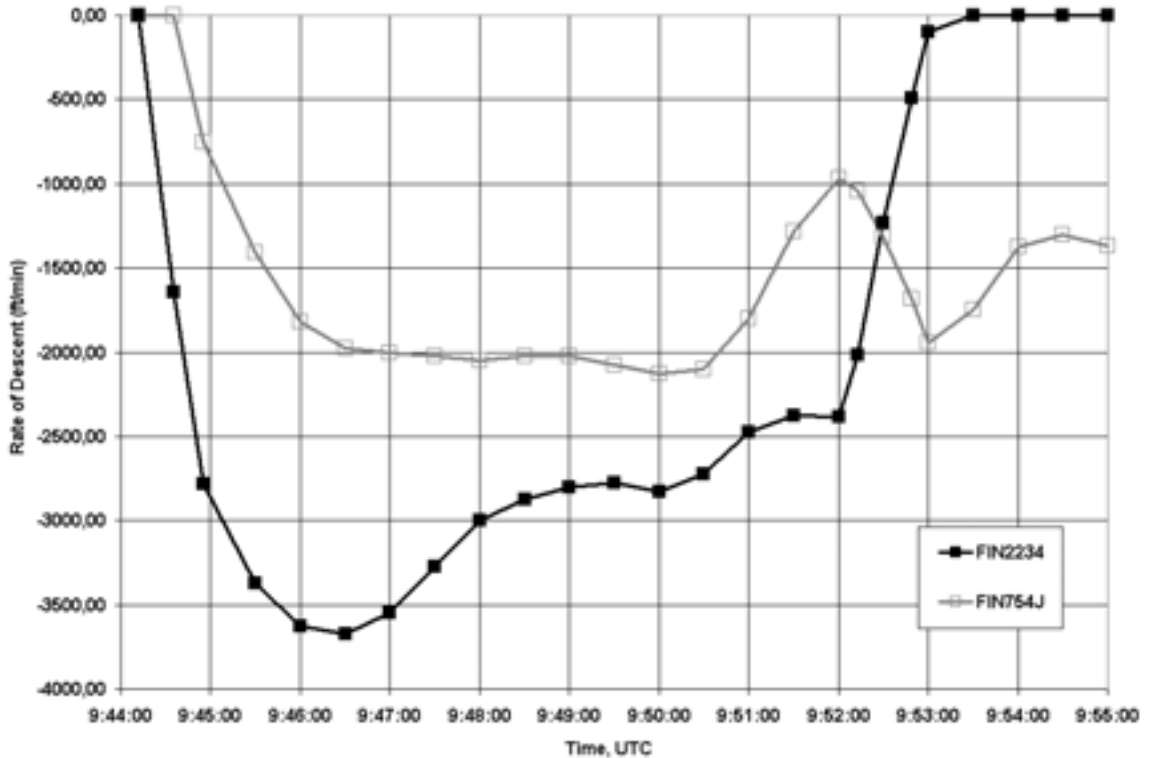


Figure 2. Rate of descent curves of the aircraft

1.1.2 Events within Helsinki ATC's area of responsibility

At 09.50.50 FIN754J contacted HK-APP and reported passing FL 150, descending to FL 110. The controller did not have the flight strip for FIN754J in front of him. He reported radar contact and instructed the crew to fly heading 360° and to maintain FL 130, but corrected the cleared flight level immediately for FL 120, reporting that runway 15 was in use. FIN754J read back the clearance and asked about the speed, to which the controller replied that there were no speed restrictions.

Due to other ATC radio communications, FIN2234 established contact with HK-APP at 09.51.50, and reported reaching flight level 130. The controller reported radar contact and cleared it via the arrival route Porvoo 1 C, to maintain FL 130 and advised that runway 15 was in use. The crew acknowledged the clearance at 09.52.10.

At 09.52.15 the controller cleared FIN754J to descend further to flight level 70. At the same time, the flight paths of FIN754J and FIN2234 crossed at FL 137 so that FIN754J was left above FIN2234, which was flying behind it. The longitudinal distance between the aircraft was 2,7 NM according to recorded radar data. FIN2234 reached FL 130 at 09.52.45, when the flight paths of the two aircraft intersected again as FIN754J descended below FIN2234.

The average rate of descent of FIN2234, as determined from radar records, was 2300 ft/min during the time 09.51-09.52. At this time it descended from FL 166 to FL 143, and at 09.52 it started to level off at the cleared flight level 130. FIN754J's rate of descent was 2200 ft/min at 09.50.30, but after this it started to slow down rate of descent. During the time 09.51-09.52 its average rate of descent was 1200 ft/min. At this time FIN754J descended from FL 151 to FL 139. At 09.52.00 its rate of descent was about 1000 ft/min, but it increased to 2000 feet per minute during the next minute. According to radar recordings, FIN2234's groundspeed was approximately 50 knots higher than that of FIN754J during the whole descent until reporting point BALTI was reached. FIN2234 was the overtaking aircraft. The planes passed over BALTI with a time interval of 20-25 seconds. The groundspeed curves for the aircraft are shown below.

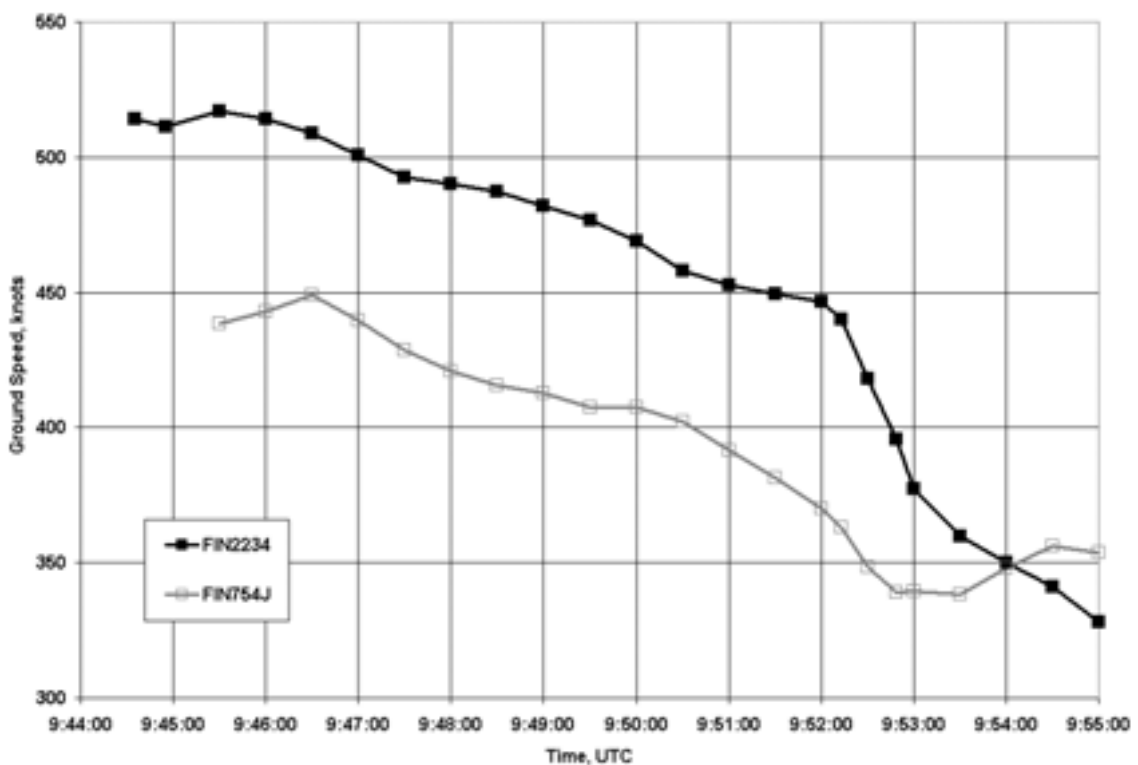


Figure 3. Groundspeed curves of the aircraft

The conflict alerter system at Tallinn approach control gave a warning about infringement of separation minima. The TLL-APP controller telephoned the assistant at HK-APP at 09.52.20 and told that he had assumed FIN754J to maintain a rate of descent of 2000 ft/min or more and FIN2234 2000 ft/min or less, but the planes were now passing BALTI at the same level although this should not have happened. He told having assumed that they would have had more than 2000 feet vertical separation when they arrived at HK-APP's area of responsibility. At first the HK-APP assistant could not make out what the TLL-APP radar controller was saying, and the message had to be repeated entirely. When the controller ended the telephone call at 09.53.30, the situation was already over and the required vertical separation had already been established.



There is no direct selective telephone connection between TLL-APP and HK-APP radar controllers. The telephone connection between the HK-APP assistant and TLL-APP controller is usually used to exchange estimates and flight plan data. When TLL-APP telephones HK-APP, the call is normally answered by the HK-APP assistant.

The HK-APP controller noticed that FIN754J and FIN2234 were flying in sequence at the same flight level and instructed at 09.52.35 FIN2234, which was behind the other aircraft, to turn immediately right to heading 090°: *"Finnair 2234 right heading 090, immediately."* The crew acknowledged the message at 09.52.40, reporting also that they had visual contact to the other aeroplane: *"Right heading 090 and traffic in sight, Finnair 2234."* When interviewed, the FIN2234 co-pilot told that he had understood this instruction to indicate an avoiding manoeuvre. However, the aircraft were flying farther away from each other even before the controller's instruction to turn. FIN754J was descending below FIN2234, and there was no risk of collision. At 09.53.40 the controller assigned FIN2234 the heading 360°. At that time, the aircraft were already flying in accordance with required vertical separation standards.

The pilots of FIN2234 told in the interview that they had monitored the other aircraft both on TCAS display and visually. The closest distance between the aircraft as shown by TCAS had been three nautical miles, and the TCAS had not given any resolution advisory (RA).

1.1.3 Reporting

The FIN754J pilots did not make any TCAS or visual observation about FIN2234 during the event, and were not aware that a loss of separation had occurred. The FIN2234 pilots, on the other hand, had seen the other aircraft and determined from TCAS display that it was flying at the same level three nautical miles ahead of them. After the flight, the pilot-in-command telephoned the HK-APP radar controller and discussed the incident with him. Neither of them filed an incident report.

The investigation material was sufficient to determine the sequence of events, but the failure to report the incident in Finland delayed and hampered the investigations unnecessarily, since all flight recorder data from the aircraft had been lost. Moreover, due to the long time interval between the incident and the interviews, the recollections of those involved were somewhat inaccurate.

The TLL-APP radar controller filed an incident report, which was forwarded to the Finnish Accident Investigation Board by Estonian investigation authorities on 27.9.2002.

1.2 Basic information

1.2.1 Aircraft

FIN754J was a twin-engine DC-9-51 airliner with 122 passenger seats. FIN2234 was a twin-engine Boeing 757-200 airliner with 227 passenger seats.

1.2.2 Types of operations

FIN754J was on a scheduled flight from Budapest to Helsinki-Vantaa. FIN2234 was conducting a charter flight from Rimini to Helsinki-Vantaa.

1.2.3 Number of persons on board

FIN754J had 103 passengers and six crew members. FIN2234 had 195 passengers and 10 crew members.

1.2.4 Injuries to persons

There were no injuries.

1.2.5 Damage to aircraft

The aircraft were not damaged.

1.2.6 Other damage

There was no other damage.

1.2.7 Personnel information

FIN754J pilot-in-command: Male, 38 years

Licences: Airline transport pilot, valid until 16.11.2005

Medical certificate: JAR class 1, valid until 16.11.2002

Ratings: All required ratings were valid.

Total flying experience about 7000 hours, of which about 3000 hours in DC-9.

FIN754J co-pilot: Male, 24 years

Licences: Commercial pilot, valid until 1.10.2006

Medical certificate: JAR class 1, valid until 1.9.2003

Ratings: All required ratings were valid.

Total flying experience about 900 hours, of which about 550 hours in DC-9.

FIN2234 pilot-in-command: Male, 55 years

Licences: Airline transport pilot, valid until 25.4.2006

Medical certificate: JAR class 1, valid until 20.11.2002

Ratings: All required ratings were valid.

Total flying experience about 16900 hours, of which about 2500 hours in B757.



FIN2234 co-pilot: Male, 34 years
 Licences: Airline transport pilot, valid until 20.10.2005
 Medical certificate: JAR class 1, valid until 20.10.2002
 Ratings: All required ratings were valid.
 Total flying experience about 8600 hours, of which about 1100 hours in B757.

FIN2234 check pilot: Male, 50 years
 Licences: Airline transport pilot, valid until 6.5.2007
 Medical certificate: JAR class 1, valid until 27.10.2002
 Ratings: All required ratings were valid.
 Total flying experience about 16000 hours, of which 2539 hours in B757.

EFHK-APP radar controller: Male, 42 years
 Licences: Air traffic controller, valid until 29.4.2003
 Medical certificate: JAR class 2 and air traffic controller's medical certificate, both valid until 29.4.2003
 Ratings: All required ratings were valid.

EETN-APP radar controller: Male, 28 years
 Licences: Air traffic controller, valid until 5.2.2003
 Medical certificate: Class 2 L, issued 31.1.2001
 Ratings: All required ratings were valid.

1.2.8 Weather

A cold front with associated showers and thunder had moved east-north-east over Tallinn and Helsinki in the morning of 6.9.2002. At the time of the incident, the front was on a line from Narva to Kuopio. Behind the front the weather was clear.

Weather at Helsinki-Vantaa on 6.9.2002:

Aerodrome forecast (TAF) for 09-18:

Wind 220° seven knots, cavok, temporarily 09-11 visibility 8 km, showers, clouds few at 4000 feet cb, bkn at 5000 feet.

Weather observations (METAR):

At 09.20: wind 210° five knots, direction variable between 180°-240°, cavok, temperature +19° C, dewpoint +13° C, atmospheric pressure QNH 1010 hPa, no changes expected.

At 09.50: wind 220° six knots, cavok, temperature +19° C, dewpoint +13° C, atmospheric pressure QNH 1010 hPa, no changes expected.

At the flight levels of FIN754J and FIN2234 within Tallinn terminal control area, the wind was about 20-25 knots from south-west.

The FIN2234 pilots told having seen FIN754J clearly when the aircraft passed through each other's flight levels, and also for some time before this. None of the pilots remembered having observed any icing or convective clouds, which should have been avoided.

1.2.9 Mass and balance

Both aircraft's mass and centre of gravity were within allowable limits. The total amount of fuel on board was about 8000 kg.



2 ANALYSIS

2.1 Actions by Tallinn ATC

Tallinn approach control was normally manned and the traffic situation was quiet.

The area control centre had, after co-ordinated with approach control, cleared FIN754J from the direction of SOKVA and FIN2234 from the direction of VADAN directly towards BALTI.

At 09.44.30 FIN754J contacted Tallinn approach control and reported being ready to leave its en-route flight level: *"Finnair 754J level 270, we are ready for descend."* The aircraft was still within Tallinn area control centre's area of responsibility. Approach control reported radar identification and cleared FIN754J to descent to flight level 110.

The crew acknowledged the clearance and reported that they were leaving FL 270. According to radar records, the aircraft's initial rate of descent was slightly over 2000 ft/min.

At 09.47.00 the crew of FIN2234 contacted approach control, stating that they were descending to flight level 240 as cleared by the area control centre: *"Approach Finnair 2234, good afternoon, out of level 277 down to level 240."*

The approach controller reported radar identification and cleared the aircraft to descend further to FL 200. According to radar records, this aircraft descended at a rate of about 3500 ft/min at that stage. The aircraft flight paths were at an angle of 30 degrees to each other. FIN2234's groundspeed was about 50 knots higher than that of FIN754J. The horizontal distance between the aircraft was 17 NM and FIN754J was about six nautical miles ahead.

Tallinn approach control had given an estimate on both aircraft to Helsinki approach in good time, at 09.31.00 - 09.31.30. The approach controller in Helsinki had accepted the planes to descend to flight levels 110 and 130. The estimates had been received by the air traffic control assistant. The messages and the estimated times of 09.52 and 09.53 had been duly entered on the flight strips in Helsinki.

The approach controller in Tallinn decided to use a rate of descent restriction to ensure vertical separation between the aircraft. He questioned first about FIN754J's rate of descent, and then instructed it to descend at 2000 ft/min or more: *"Finnair 754J maintain rate of descent 2000 feet per minute or more."* The crew read back the clearance correctly: *"2000 feet per minute or more, Finnair 754J."* After this the controller cleared FIN2234 to FL 130 and assigned it with a rate of descent restriction of 2000 ft/min or less: *"Finnair 2234 continue descent to flight level 130, rate of descent 2000 feet per minute or less."* This crew's read-back of the clearance and restriction was also correct: *"130 and 2000 or less, Finnair 2234."*

According to the controller, radar vectoring or horizontal speed adjustment is rarely used for ensuring separation when traffic is released to Helsinki. Also in this case, he did not try to establish a horizontal radar separation between the aircraft, but aimed at vertical separation using the previously mentioned rate of descent restriction. The restrictions were issued about four minutes before the estimated time over BALTI, at 09.48.00 - 09.48.10. At the time when the restrictions were issued, the vertical distance between the aircraft was approximately 3500 feet.

The controller had not observed any particular weather phenomena during his shift, such as icing or thunder, which could have restricted the aircraft flight paths. There were no pilot reports on such conditions either. The controller told having calculated that FIN754J, which was flying ahead, would have passed through FL 130 before BALTI, and the required vertical separation would thus have been achieved.

The controller monitored both aircraft's descent and noted that FIN2234 was faster and the vertical distance was decreasing, but assumed that a vertical separation of at least 1000 feet would be maintained until the planes were handed off to Helsinki approach frequency. The Tallinn controller did not adjust their speeds, since he was not sure which one Helsinki approach would take in first. The controller did not inform Helsinki approach of the restrictions, because he assumed that vertical separation would be maintained by the rate of descent restrictions. When the radio contact was transferred to Helsinki approach, the planes had not reached their cleared flight levels yet.

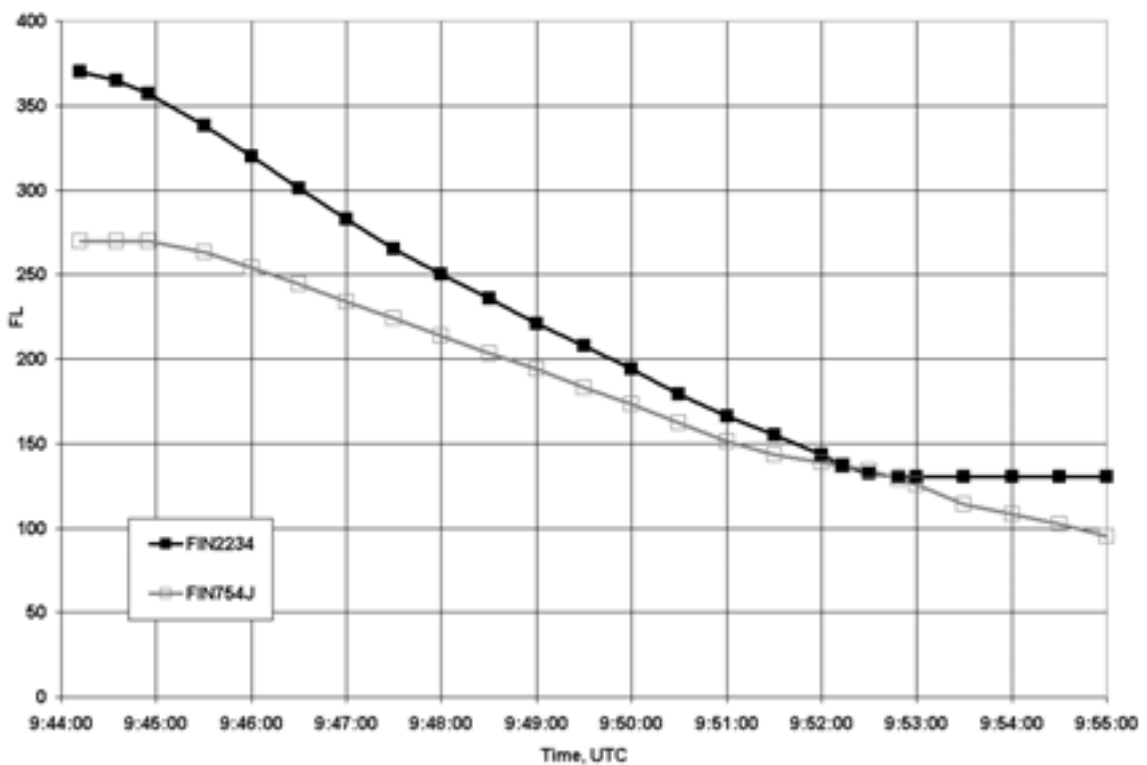


Figure 4. Flight profiles

Although the controller noticed that the vertical distance between the aircraft was decreasing, he did not ask the pilots to check the descent rate. If the crews had complied

with their received and acknowledged clearances, the vertical distance between the aircraft would have remained at least the same. The Tallinn approach controller handed both aircraft over to the Helsinki approach frequency at 09.50.30. At that time their vertical distance was still about 1700 feet.

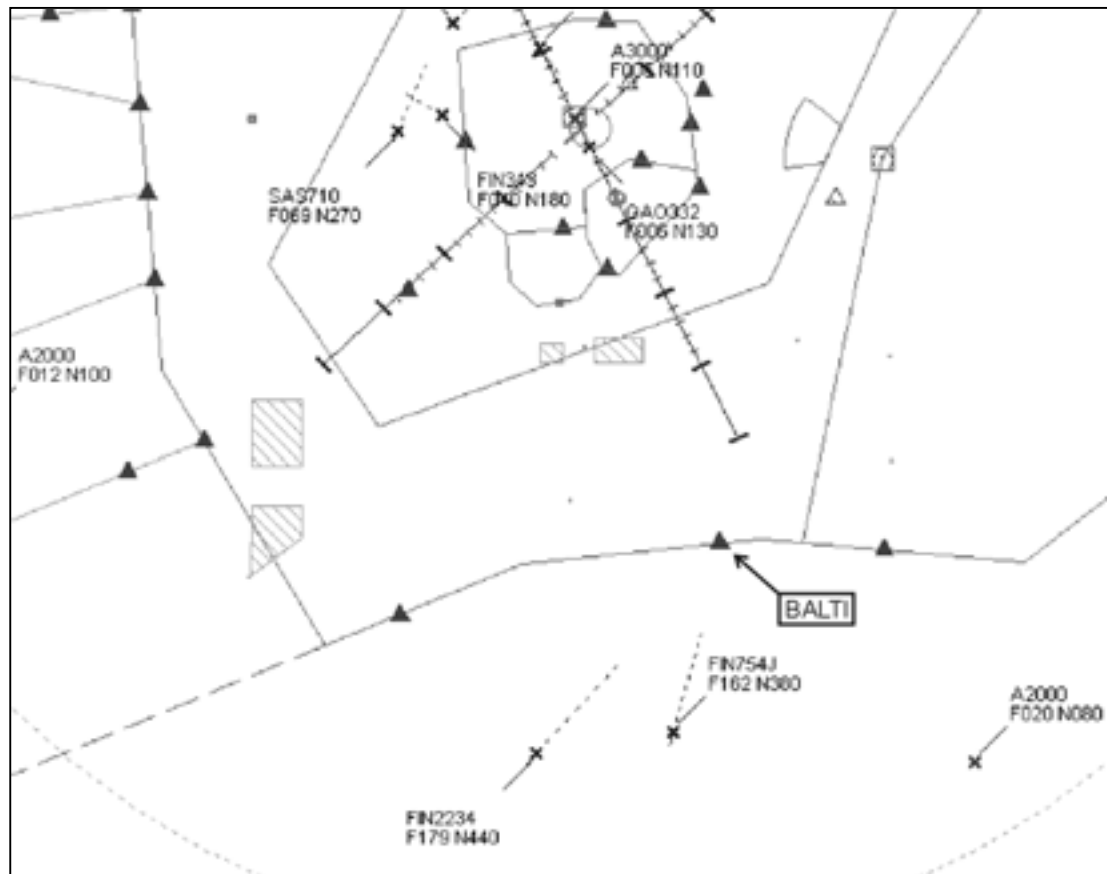


Figure 5. Positions and flight levels of the aircraft at 09.50.30

When the aircraft were already on Helsinki approach frequency, the Tallinn approach controller received a warning from the radar conflict alert system and noticed that the planes were on the same flight level at a distance of about 2,7 - 3 NM from each other. After the change of frequency, FIN2234 had continued to descend at a rate of 2400 ft/min, but FIN754J had reduced its rate of descent to about 1000 ft/min. The controller telephoned Helsinki approach at 09.52.20 and told about the restriction issued. He also said that the aircraft should not be at the same flight level.

TLL-APP controller should have informed HK-APP controller about the restrictions issued to the aircraft, especially in this case when the aircraft had not yet reached their cleared flight levels. This information had presupposed also "a fully released function" before the transfer of radio communication, but this procedure did not take place.

The telephone call was answered at Helsinki approach by the air traffic control assistant, which was the usual practice. Because of the unusual nature and partial obscurity of the message, the Tallinn controller had to repeat it, during which time the situation was practically over. The assistant conveyed the information to the controller.

2.2 Actions by Helsinki ATC

At the time of the incident, the briefing for controllers working in the evening shift was in progress at Helsinki approach. For this reason the DEP and APP control positions had been combined and the traffic was handled by the APP controller. The ARR and assistant control positions were also manned. The traffic situation was rather quiet.

According to the APP controller, a thunder front was moving from south-west to north-east over Helsinki-Vantaa at the southern side of the airport, which increased the workload and need for letter of between the area control centre for Southern Finland (EFES) and TLL-APP, since the planes had to avoid the worst buildups. However, the statements of the crews involved or the Tallinn controller did not support this, as they had not observed such weather phenomena at the time of the incident.

FIN754J contacted Helsinki approach at 09.50.50 and reported descending to flight level 110: *"Helsinki radar, päivää Finnair 754J, DC9, information India, level 150 descending 110."* The controller reported radar identification and instructed the crew to fly heading 360°. Moreover, without noting the cleared flight level 110 reported by the crew and marked on the flight strip, he initially advised the crew to maintain FL 130, which he immediately corrected into FL 120: *"Finnair 754J radar contact, fly heading 360, maintain 130 when ... correction cleared to level 120, vectors for runway 15."* The confusion about cleared flight levels may have resulted from the fact that, when FIN754J became visible on the controller's radar display, its label gave FL 130 as the cleared flight level and not FL 110, as given in the estimate and entered on the flight strip. This happened because the default flight level for inbound traffic from BALTI has been defined as 130 in the Eurocat radar system used at Helsinki ATC. If the cleared flight level is something else, the controller has to change it manually. In addition, the controller did not have the flight strips for aircraft arriving from BALTI ready in front of him, but he took them out only after the planes came on his radio frequency.

The estimates of the arriving aircraft had been given by TLL-ACC in good time at 09.31.00 - 09.31.50, but TLL-APP controller did not relay any information concerning the release of the aircraft or the restrictions issued (e.g. "fully released" or "rate of descent restriction") before the radio contact HK-APP was transferred.

FIN2234 changed over to Helsinki approach frequency at 09.51.50 and reported reaching flight level 130: *"Radar, Finnair 2234 good afternoon, reaching level 130."*

The Winradar recording showed that at 09.52.00, both aircraft were still south of BALTI at a distance of about three nautical miles from each other. FIN754J was at FL 139 and FIN2234 at FL 143. FIN2234 had reduced its horizontal speed and rate of descent when approaching BALTI, but its groundspeed was still about 30 knots greater and it was the overtaking aircraft.

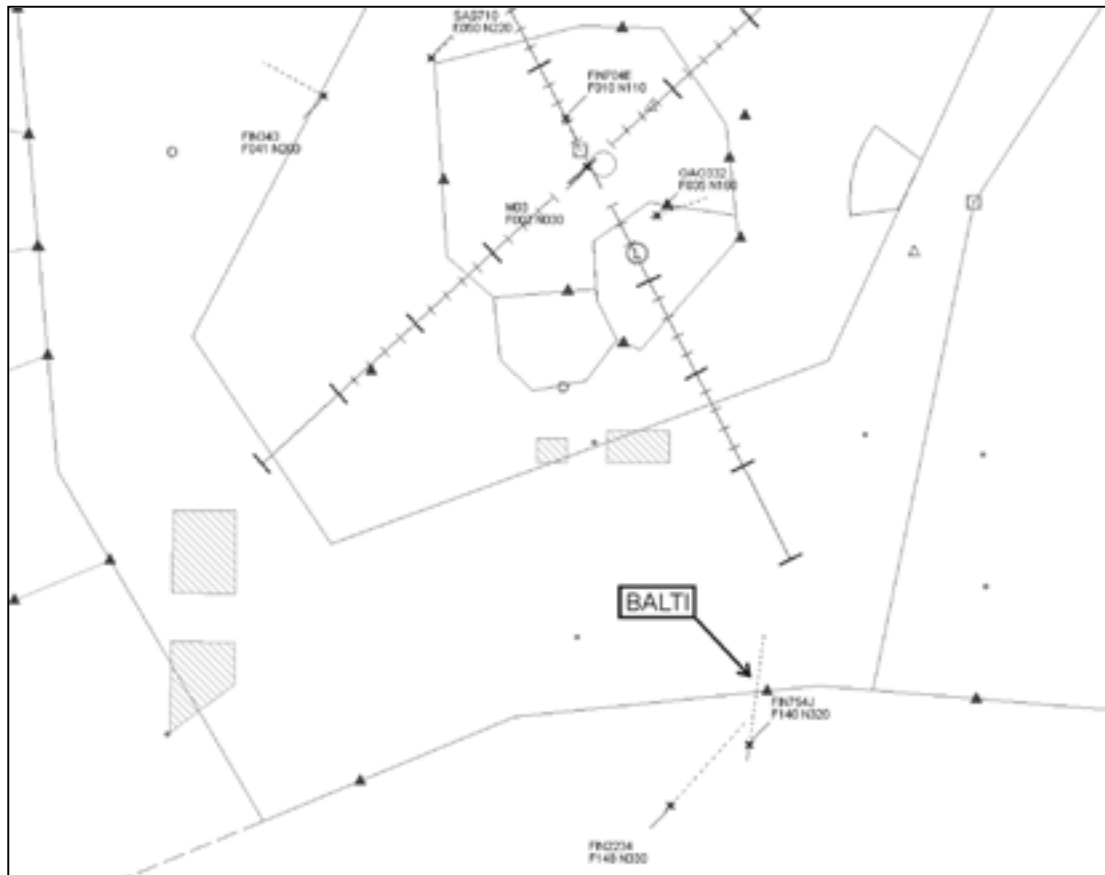


Figure 6. Positions and flight levels of the aircraft at 09.51.50

The controller cleared FIN2234 to follow the standard arrival route and maintain flight level 130: *"Finnair 2234 radar contact, Porvoo 1C, flight level 130, runway 15."* He had adjusted the radar measurement scale to 46 NM. Both aircraft became visible on the radar screen at the same time when they made their initial radio contact. The controller corrected FL 110 as FIN754J's cleared flight level on the label, after which his attention was drawn to other traffic within the terminal control area for a while. When he looked at the direction of BALTI for the next time, he noticed that FIN754J had been left about 200 feet above FIN2234 and was just passing again through its flight level downwards. The controller had cleared FIN754J to descend to flight level 70.

If TLL-APP had informed HK-APP of the restrictions issued and transfer of radar control, HK-APP controller had probably paid more attention to these two aircraft.

The controller was not sure whether the planes had the required horizontal separation, since he stated that the scale used in his radar display was large and the labels of the aircraft were partly overlapped. However, the overlapping of the labels could not be seen on the radar recordings.

The controller noticed the loss of standard vertical separation between the aircraft. Although FIN2234's flight path would have passed behind FIN754J at an angle of about 30°, he instructed FIN2234 to turn right using the word "immediately": *"Finnair 2234 right heading 090 immediately."* The crew read back the heading and reported having the

traffic in sight: *"Right heading 090 and traffic in sight, Finnair 2234."* Simultaneously at 09.52.20 the Tallinn controller, who had perceived the situation developing, telephoned and told about the restriction issued. The call was answered by the assistant. Because of the unusual nature and obscurity of the message, the Tallinn controller had to repeat it, and the situation was practically over during the phone call.

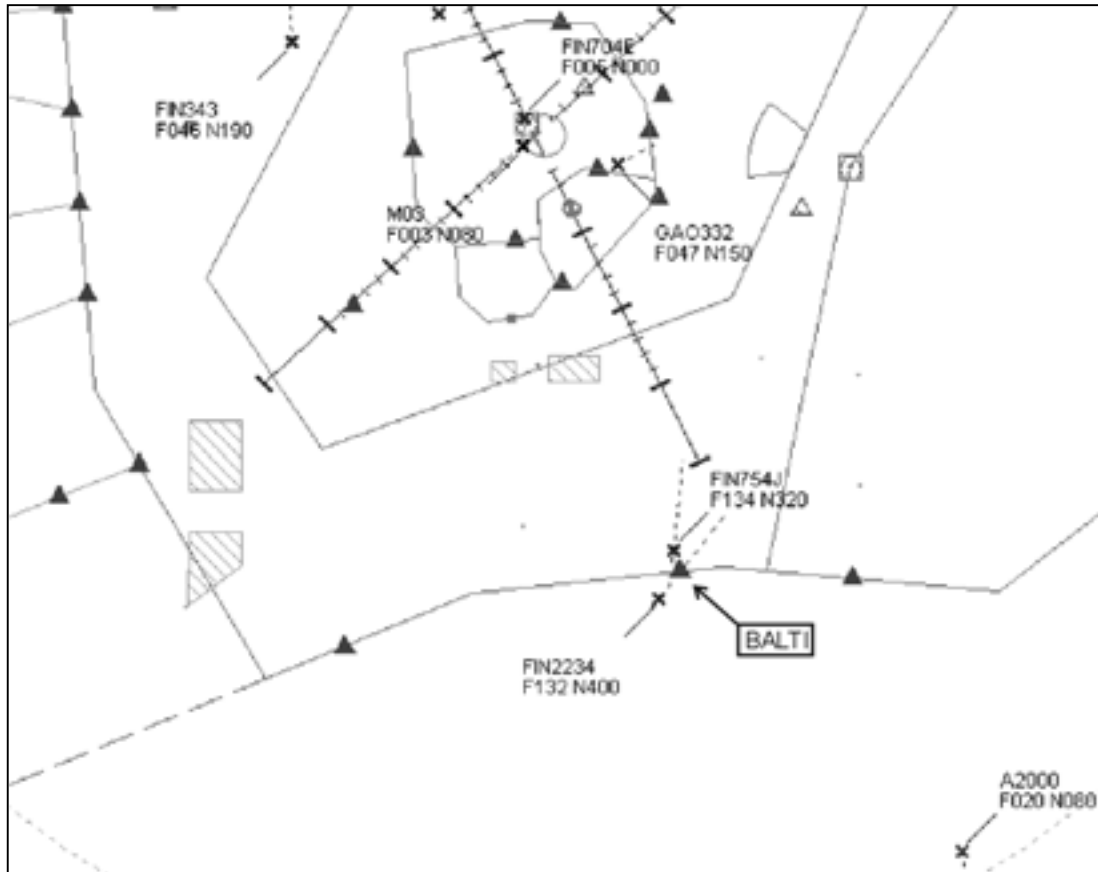


Figure 7. Positions and flight levels of the aircraft at 09.52.30

2.3 Actions by FIN754J pilots

Tallinn area control centre had cleared FIN754J from SOKVA direct to BALTI at flight level 270. FIN754J called Tallinn approach control by radio at 09.44.30 and reported to be ready to descend to a lower level: *"Tallinn approach, good day, Finnair 754J, level 270, we are ready for descent."* The controller reported radar identification and cleared the aircraft to descend to flight level 110: *"Finnair 754J, Tallinn approach, identified, descend to FL110."* The crew acknowledged the clearance and reported leaving FL 270.

At 09.46.50 the controller advised that runway 15 was in use at Helsinki-Vantaa. The crew acknowledged the information. At 09.47.50 the controller requested FIN754J to report the rate of descent: *"Finnair 754J, report rate of descent."* The crew reported that the rate of descent was 2000 ft/min. Immediately after this the controller gave them a restriction to maintain a rate of descent of 2000 ft/min or more: *"Finnair 754J, maintain rate of descent 2000 feet per minute or more."* The crew read back the restriction: *"2000 feet*



per minute or more, Finnair 754J." The co-pilot wrote the clearance down in the margin of his operative flight plan form.

FIN754J descended at a rate of 2000-2200 ft/min, but reduced the rate of descent after passing through FL 150 at 09.50.30, when the Tallinn controller asked it to change over to Helsinki approach frequency. At 09.52.00 the rate of descent was 1000 ft/min, increasing thereafter momentarily to 2000 feet per minute. The vertical speeds of the aircraft are presented as a graph in Figure 2.

At 09.50.50 the crew contacted the Helsinki approach radar controller, reporting the aeroplane type, information "India" and that they were at FL 150 descending to FL 110: *Helsinki radar, päivää, Finnair 754J, DC-9, information India, level 150 descending 110.*" The radar controller reported radar contact, gave a heading of 360° and a new flight level clearance, which was first for FL 130 but corrected immediately into FL 120, and informed about radar vectors for runway 15: *"Finnair 754J radar contact, fly heading 360, maintain 130 when...correction cleared to flight level 120, vectors for runway 15."* The crew read back the clearance and asked about speed: *"Heading 360 and maintaining level 120, runway 15. How about speed? Finnair 754J."* The controller told that the speed could be chosen freely. At 09.52.15 the controller cleared FIN754J to descend further to FL 70: *"Finnair 754J continue descend to flight level 70"*. At the same time he noticed that FIN754J and FIN2234 were at the same flight level in sequence, close to each other.

The investigation could not determine why FIN754J's rate of descent was reduced. A similar change of flight profile occurs for DC-9 aircraft when icing begins during descent. In this case, engine power must be increased to use the anti-icing system, which reduces the rate of descent. The FIN754J pilots did not remember very much about this flight when interviewed, and neither of them recalled any icing. The FIN2234 pilots told that they had seen FIN754J clearly and any clouds had not obscured the visibility. The Tallinn controller did not remember that the weather would have caused any changes to flight profiles or that the planes should have needed to avoid any cumulonimbus clouds at the time of the incident. Due to the above mentioned reasons, it is not probable that FIN754J's rate of descent was reduced as a result of using the anti-icing system.

On the other hand, FIN754J pilots may have felt that they were rather low with respect to the optimal flight profile, since there is still about 50 NM track to go from BALTI to runway 15. For this reason they may have slowed down the descent and thought that the vertical speed restriction issued by Tallinn ATC would not be valid after they had changed over to Helsinki ATC frequency. However, an air traffic control clearance or restriction is always valid until the controller issues a new clearance, which cancels the previous one or, as in this case, the cleared flight level 110 is reached. Changing over to another ATC unit's radio frequency does not affect the validity of a clearance in any way.

When FIN754J contacted the Helsinki radar controller, he changed the cleared flight level into FL 120. This is not a probable reason for the reduction of FIN754J's descent rate either, since it still had to descend about 3000 feet, and so there was no immediate need for slowing down the descent. According to the Winradar recording, the rate of de-

scent reduction had already begun approximately half a minute before the crew contacted Helsinki approach.

According to the ICAO publication Air Traffic Management (Doc 4444), paragraph 4.7.1.4, flight crews must inform the ATC unit if they are unable to comply with a specified rate of climb or descent. In such cases, the controller must apply an alternative method to achieve an appropriate separation minimum between aircraft, without delay. In the incident under investigation, neither of the flight crews reported that they would not comply with the restriction which they had read back.

The FIN754J pilots did not see FIN2234 during the incident and did not receive any TCAS advisory. They were not aware that a loss of separation had occurred, but had understood from radio communications that the controller was instructing another aircraft to turn.

2.4 Actions by FIN2234 pilots

FIN2234 was flying towards BALTI from the direction of VADAN and descending from its en-route flight level as cleared by Tallinn area control centre. It contacted Tallinn approach and reported passing through FL 277 downwards to FL 240. At that time, its rate of descent was about 3500 ft/min. Tallinn approach reported radar identification and cleared it to FL 200 immediately thereafter. The controller then asked about FIN754J's rate of descent and issued the above mentioned restriction. After this at 09.48.10, he cleared FIN2234 to FL 130 and assigned it with a rate of descent restriction of 2000 ft/min or less: *Finnair 2234, continue descend to FL130, rate of descent 2000 feet per minute or less.* The crew read back the clearances: *"130 and 2000 or less, Finnair 2234."* From the read-backs received the controller concluded that the pilots of both aircraft had understood their clearances.

The co-pilot was flying FIN2234 by the FMS, and it is not possible to enter a desired rate of descent into the FMS system. The VNAV (vertical navigation) mode controls e.g. the climb and descent profiles. The co-pilot told having selected the VNAV SPEED mode. In this mode, the system controls the aircraft speed by pitch adjustment. The co-pilot told that he had adjusted the rate of descent by changing the speed selection. Before the restriction was issued, FIN2234 had descended at a rate of about 3000-3500 ft/min. When the FMS flies the aircraft in accordance with the calculated profile, the descent is initially rather steep after leaving the en-route flight level. At first the rate of descent is more than 3500 ft/min, but is reduced after the plane has reached the airspeed determined by the FMS for descent. After the restriction was given FIN2234's rate of descent was about 2400-2900 ft/min, until it was reduced from 09.52.00 when the aircraft was approaching the cleared flight level 130, which had probably been entered in the FMS. The actual descent rates of the aircraft obtained from the Winradar recording are shown in Figure 2.

The co-pilot did not manage to adjust the descent rate to comply with the ATC restriction *"2000 feet per minute or less"* by using the FMS. For this reason, FIN2234's descent profile was steeper than required by the clearance. When the crew changed over to Hel-



sinki radio frequency, the plane was about 2500 feet lower than the Tallinn controller had calculated. As FIN754J, which was flying lower, had reduced its rate of descent at the same time, the 1000 feet (about 300 m) vertical separation minimum between the aircraft was infringed around 09.51.40. The aircraft were at the same flight level 137 at 09.52.13, when FIN2234 had already started to level off for FL 130. At 09.52.30, FIN754J was about 200 feet (60 m) above it, but descended below the flight level of FIN2234 at 09.52.49. Half a minute later the planes achieved the required vertical separation of 1000 feet. According to the Winradar recording from Helsinki, the horizontal distance between the aircraft was about 2,7 NM when they were at the same flight level.

According to the airline, the FMS is usually set for approach in good time before leaving the en-route flight level. When approaching from the direction of Estonia, the usual practice is to enter FL 130 for BALTI in the FMS. When interviewed, the pilots could not remember if they did so on this flight, but it seems probable since FIN2234 reached FL 130 exactly at BALTI. This practice of preparing for the approach is good and recommendable as such, but the pilots must also be able to deviate from the descend profile determined by the FMS if required by the ATC clearance. To comply with the rate of descent restriction issued by the controller, the FIN2234 co-pilot should have stopped using the FMS and selected the autopilot vertical speed (V/S) mode. By this means, it would have been possible to set the desired rate of descent accurately with the vertical speed control knob. Using the V/S mode would probably have produced a gentler descent than that determined by the FMS, but FIN2234 did not have an imperative need to reach FL 130 at BALTI, since the approach track to the active runway 15 was still about 50 NM. The air traffic control clearance did not contain any requirement to reach the cleared flight level at any specified place either.

FMS is a rather demanding system for the user, and it takes considerable time for the pilots to learn using it. On the other hand, it brings significant benefit to the airline in the form of shorter flight times and fuel economy, for which reason the flight crews are encouraged to use the system effectively. It is possible that the co-pilot was inclined to use FMS as much as possible, since a check flight was being conducted. However, he should have used all available flight deck automation in the most appropriate way for the situation, which would have meant selecting the autopilot V/S mode, setting the rate of descent required by the clearance and stopping the use of FMS, as he could not adjust the descent rate to comply with the ATC restriction by this means.

The radar controller in Helsinki had noticed the situation and requested FIN2234, which was flying behind, to turn immediately to heading 090° at 09.52.35: *"Finnair 2234 right heading 090 immediately."* According to the estimate, FIN754J and FIN2234 should have arrived at BALTI with an interval of one minute, but the groundspeed of FIN2234 was about 50 knots higher and it was taking over the aircraft flying ahead.

2.5 General observations about flight crew actions

The cockpit resource management was not appropriate in either aircraft. The pilot not flying (PNF) received the air traffic control clearance by radio, but did not ensure that it was complied with, nor did he draw the PF's (pilot flying) attention to following the re-

striction issued by the ATC. When interviewed, none of the pilots could clearly remember that they had received such restrictions. For this reason it seems probable that the pilots did not discuss the meaning of these restrictions in the cockpit. Since the pilots of both aircraft heard the restrictions issued to each other, it seems obvious for them to have understood that the aim was to ensure separation between the aircraft. However, maintaining the planned separation requires that the aircraft comply with the restrictions.

The flight documents retained from FIN754J included both pilots' operational flight plans (logs). The pilots could not recall, or determine from the flight log, how the cockpit duties had been divided on that route segment. The rate of descent restriction issued by Tallinn approach had been entered in the co-pilot's log, but not in that of the pilot-in-command.

The flight documents retained from FIN2234 only included the co-pilot's log. It had entries about clearances to flight levels 240, 200 and 130, as well as to BALTI. There was no entry about the rate of descent restriction acknowledged by the pilot-in-command, but the co-pilot had written down the time 09.52, when the other aircraft was at a distance of three miles as shown by TCAS. Any ATC clearances issued by Helsinki approach had not been marked on the log.

The purpose of preserved flight documentation is to be able to verify afterwards, in as much detail as possible, how the flight was planned and performed. To achieve this, it is important to accurately write down all ATC clearances received and other in-flight events. The airline should emphasize to its pilots that the operative flight plan form should be carefully filled in.

2.6 Directions and EETT-EFES-ATC letter of agreement

Instructions for giving estimates are contained in the letter of agreement between Tallinn and Helsinki approach control, paragraph C 1.2.1. VERBAL ESTIMATES. Item D of this paragraph deals with the cleared flight level: *"Cleared flight level, specifying climb or descend conditions if applicable, at the transfer of control point."*

Nevertheless, this paragraph could not have been applied when the estimates were given, since there were no restrictions at that time.

Paragraph F.2.2.1. of the letter of agreement, TRANSFER OF RADAR CONTROL, contains the following instruction: *"Transfer of radar control may be effected after prior letter of provided the minimum distance between the aircraft does not fall below 5NM between APP Tallinn and ACC Tampere or APP Helsinki."*

This paragraph could not actually have been applied either, since no radar separation was used, but vertical separation.

ICAO Doc 4444, paragraph 8.7.5. TRANSFER OF RADAR CONTROL, Item F gives the following instruction: *"The accepting controller is kept currently informed of any level, speed or vectoring instructions given to the aircraft prior to its transfer and which modify its anticipated flight progress at the point of transfer."*



The last-mentioned instruction is included in basic radar training, and therefore needs not be stated in the letter of agreement. However, it means that the Tallinn controller should have informed the Helsinki controller of the rate of descent restrictions issued to FIN754J and FIN2234.



3 CONCLUSIONS

3.1 Findings

1. The flight crews of both aircraft had valid licences and ratings for their duties.
2. Both air traffic controllers had valid licences and ratings for their duties.
3. The traffic situation was rather quiet in both air traffic control units.
4. Estimates on FIN754J and FIN2234 had been given in good time.
5. According to the pilots and the controller in Helsinki APP, rate of descent restrictions are quite unusual in Tallinn FIR.
6. According to the controller in Tallinn APP, rate of descent restrictions are rather commonly used.
7. The rate of descent restriction was given to the aircraft four minutes before the estimated time over BALTI.
8. Both flight crews read back the clearance and restriction correctly.
9. FIN754J complied with the rate of descent restriction until it was instructed to change over to Helsinki approach frequency, after which its descent rate was reduced.
10. FIN2234 used a greater rate of descent than instructed all the time.
11. Neither of the flight crews reported to the controller that they were not complying with the restriction.
12. When the Tallinn approach controller issued the restriction at 09.48.00, the vertical distance between the aircraft was about 2700 feet.
13. When FIN754J contacted Helsinki at 09.50.50, the vertical distance was 1500 feet.
14. When FIN 2234 contacted Helsinki at 09.51.50, the vertical distance was 800 feet.
15. The Tallinn controller noticed that the vertical distance between the aircraft was decreasing, but did not verify their rate of descent.
16. The Tallinn controller did not tell about the restriction issued when he handed the aircraft over to Helsinki approach frequency.
17. The Helsinki controller did not notice the loss of standard vertical or radar separation, when the aircraft changed over to his frequency.
18. After the Helsinki controller realized the situation, he gave FIN2234 instructions for an avoiding manoeuvre.
19. The Tallinn controller received a radar alert and telephoned Helsinki to report the loss of separation and informed about the restriction issued. By the time the Helsinki controller was informed the situation was practically over.
20. There was no risk of collision.



3.2 Probable cause

The standard vertical separation was lost and the incident occurred, since neither FIN754J nor FIN2234 complied with the rate of descent restrictions issued by the controller and read back by the pilots when descending to their cleared flight levels.



4 RECOMMENDATIONS

The FIN2234 co-pilot was flying the aircraft by the FMS during the descent, but did not manage to adjust the rate of descent to comply with the air traffic control clearance using the speed selection in the SPEED mode. He did not use the autopilot V/S mode, which would have been most suitable for this purpose.

1. Finnair Oyj should, in its training, pay attention to the appropriate use of flight deck systems when rate of descent restrictions are given by air traffic control.

When interviewed, the pilots of neither aircraft could, to an extent sufficient for the investigation, recall the in-flight events and clearances received from the log entries made during the flight.

2. Finnair Oyj should, in its training, emphasize to the company pilots that the operative flight plan form must be carefully completed, so that the in-flight events can be verified afterwards.

Helsinki 7.3.2003

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