Loss of sepration over Espoo on 15.12.2000, Disappearance of aircraft from ATC radar.

Micro-summary:

Event Date: **2000-12-15 at 1646 Finnish time**

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

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

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Aircraft Incident Report

C 19/2000 L

Translation of the Finnish original report

Loss of separation over Espoo on 15.12.2000 Disappearance of aircraft from ATC radar

RA 86532 IL62M

OH-LMG DC-9-83

Onnettomuustutkintakeskus
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ABBREVIATIONS

AIP	Aeronautical information publication
APP	Approach radar controller
ARR	Arrival radar controller
CAT	Category
CTR	Control zone
DEP	Departure radar controller
DME	Distance measuring equipment
FDR	Flight data recorder
FL	Flight level
ICAO	International Civil Aviation Organization
ILS	Instrument landing system
JAR	Joint Aviation Requirements
LJKK	Air traffic controller's handbook (Finnish)
METAR	Aviation routine weather report
MHz	Megahertz
MNPS	Minimum navigation performance specifications
MSSR	Monopulse secondary surveillance radar
NM	Nautical miles
PHI	CAA confidential reporting system
QFE	Atmospheric pressure at aerodrome elevation
QNH	Corrected mean sea level pressure
SSR	Secondary surveillance radar
STD	Standard
TCAS	Traffic alert and collision avoidance system
TMA	Terminal control area
TWR	Tower controller
VOR	VHF omnidirectional radio range

SYNOPSIS

On Friday 15.12.2000 at 16.46 (Finnish time is used in this report) there was an air traffic incident over Espoo, where the required separation minima between two aircraft were violated. An MD-83 airliner operated by Finnair Oyj, registered OH-LMG, call sign FIN2162, was approaching Helsinki-Vantaa airport and was about to reach its cleared flight level (FL) 80, when it received a resolution advisory "*Climb*" from its TCAS (Traffic Alert and Collision Avoidance System). The device showed that the other aircraft, an airliner of type IL62M, registered RA 86532, call sign AFL204, was at level flight 500 ft (about 150 m) below FIN2162, on its front left side at a distance of approximately half a nautical mile. AFL204 had been cleared to FL70. It appeared on ATC secondary radar (SSR/MSSR) screens for the first time at the same time when FIN2162 received the TCAS resolution advisory. The ATC radar data showed that AFL204 was then at FL76.

There were altogether 230 passengers and 17 crew members in the aircraft. No one was injured and no damage was caused.

The Accident Investigation Board (AIB), Finland was informed of the incident on 18.12.2000, when it received the incident reports filed by the captain of FIN2162 as well as Helsinki-Vantaa APP (approach) and DEP (departure) radar controllers.

The AIB decided to start an investigation on 20.12.2000 (decision No C 19/2000 L). Two experts of the AIB, airline pilot Jussi Haila and air traffic controller Erkki Kantola, were appointed as investigators. The incident 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.

The material obtained by the investigators from Helsinki ATC included a list of 11 occurrences in which a Russian-built airliner had disappeared from ATC radar screen during the period 3.11.2000 - 15.12.2000. In addition, the Air Navigation Services department of CAA Finland provided a list on aircraft disappearances from radar between 30.8.2000 and 24.11.2001. The latter list contained 41 occurrences. The scope of investigation was therefore widened to cover the reasons for disappearance from radar.

Jouko Saikkonen, M.Sc., assisted in the investigation as expert in radar technology.

The captain and co-pilot of FIN2162 gave their statements of the incident on 2.1.2001. The APP controller gave his statement on 3.1.2001 and the DEP controller on 8.1.2001.

The pilot-in-command of AFL204 gave his statement in writing on 18.1.2001.

The final draft of the report was sent for comments to the Russian Aviation Authority, as required by ICAO Annex 13, on 18.5.2001. The draft was also circulated at the same time for comments at CAA Finland, Flight Safety Authority.

The investigation was closed on 16.8.2001.

1 FACTUAL INFORMATION

1.1 Course of events

At the time of the incident on 15.12.2001, runway 22 was used for take-off and runway 15 for landings at Helsinki-Vantaa airport.

The Aeroflot Iljushin IL62M, flight number AFL204, was heading for Moscow. ATC cleared it for take-off at 16.40.40. AFL204 took off from intersection Y runway 22, following the standard instrument departure PVO 3B (Porvoo three bravo) for which it had been cleared.

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Figure 1. Standard instrument departure PVO 3B.

The tower controller (TWR) noticed that the position symbol and label information for AFL204 was not shown on the radar screen after take-off. (A ”label” is a box on the radar screen, containing aircraft call sign, altitude, ground speed, type and wake turbulence category.) He informed the departure radar controller (DEP) of the problem in accordance with the Letter of Agreement of Helsinki ATC. At the same time, AFL204 contacted the DEP controller by radio as instructed in the published standard instrument departure. AFL204 was not visible on the DEP controller’s radar screen, but he only acknowledged the initial radio contact by the call sign of the aircraft *”Aeroflot 204”*. The flight crew reported approaching the initial climb altitude of the standard instrument departure 4000 ft on altimeter setting QNH 994: *”Aeroflot 204 approaching 4000”*. DEP instructed them to maintain altitude. Although AFL204 was not shown on the DEP radar screen, the controller did not inform the crew of this, nor did he try to correct the situation e.g. by asking if the aircraft transponder was on.

At the same time FIN2162, bound for Helsinki-Vantaa from Malaga, was approaching from south-west. The APP controller intended to vector it for approach via left circuit to runway 15. APP had given FIN2162 a heading of 065º and cleared it to 5000 ft on QNH 994 hPa.

As AFL204 could not be seen on radar screen, DEP and APP co-ordinated the departing and approaching traffic and made a new traffic plan. They agreed that FIN2162 would be vectored for approach to runway 15 via right circuit and AFL204 would pass it below.

APP then gave FIN2162 a new clearance to FL80. At that time FIN2162 was passing FL100, descending somewhat slower than usual since it was flying in icing conditions and had to use more power than normally for anti-icing.

DEP cleared AFL204 to fly direct to PVO VOR beacon via left turn and to climb to FL70. AFL204 acknowledged the clearance, but did not report leaving 4000 ft. After a while DEP asked the altitude of AFL204, and the crew replied that they were at FL50 climbing to FL70. One minute later AFL204 reported maintaining FL70, but was still not visible on the radar. At 16.45.20 DEP asked AFL204 to report when crossing HEL VOR radial 180.

At 16.45.10 APP gave FIN2162 a new heading of 360º and asked it again to maintain FL80 when reaching. The crew acknowledged the clearance and reported reaching FL80.

AFL204 became visible on Helsinki ATC radar screens at 16.45.56. It was then in front of FIN2162 about half a nautical mile on its front left side. The radar showed that AFL204 was flying at FL76. The tracks of FIN2162 and AFL204 intersected at an angle of almost 90º.

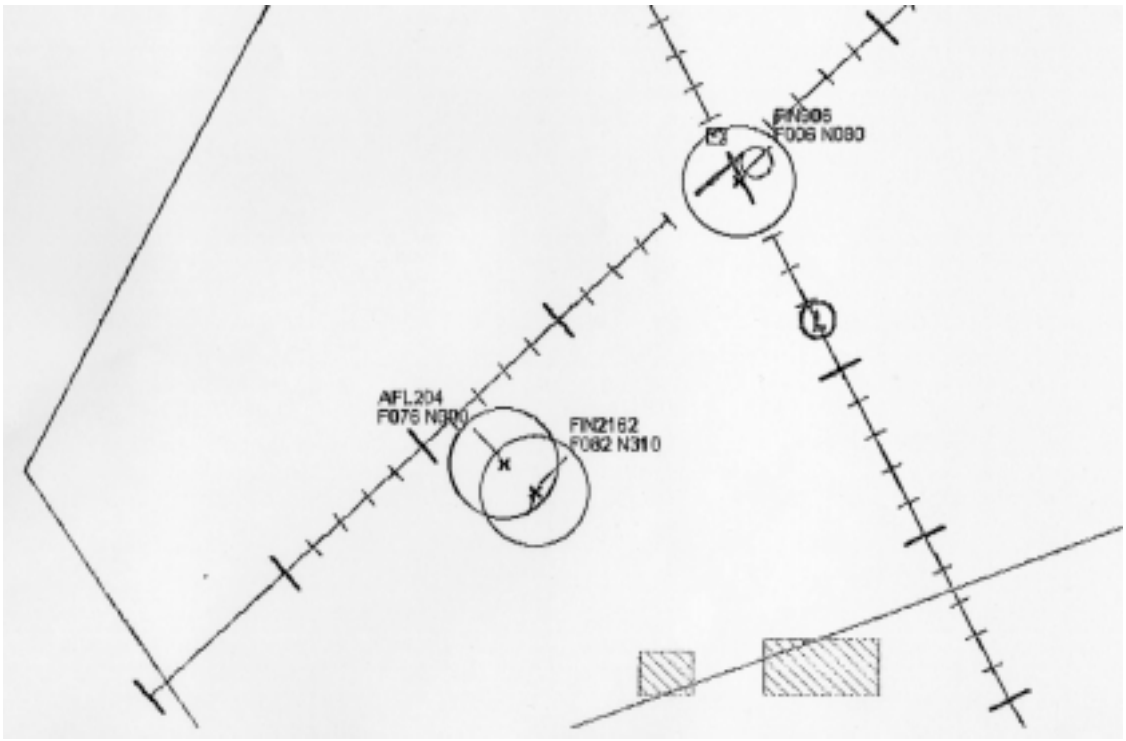

Figure 2. First radar observation of AFL204 at Helsinki ATC.

DEP did not inform AFL204 of their incorrect flight level. At that time, the radar showed FIN2162 to be at FL82. FIN2162 received a TCAS resolution advisory about traffic in

level flight 500 ft below it. However, the pilots determined that there was no need for an avoiding action since the other aircraft was at level flight. A few seconds later the TCAS reported that the situation was over: *"Clear of conflict"*. The device had not given any traffic advisory beforehand. Neither of the controllers had time to warn the pilots of the conflict. Secondary radar contact with AFL204 was established also simultaneously by two radars at the South Finland Area Control Centre and three radars of the Finnish Air Force. None of these systems had received transponder replies from AFL204 before this, but the aircraft had been visible on Air Force primary radar screens since airborne. The primary radar of Helsinki ATC had not been approved for operational use at the time of the incident.

The AFL204 captain told in his statement (Appendix 1) that the crew had changed to the standard altimeter setting at *transition level.* He also reported that when flying within Helsinki TMA, they were not informed about the inoperative transponder or deviation from cleared flight level. In a letter dated 22.2.2001, the airline asked the investigators to pay attention to flight data recorder (FDR) recordings provided by it, which show that *the pressure setting was changed from QNH (QFE) to the standard setting at transition level (5100 m).* Actually the transition altitude at which the altimeter setting must be changed during climb at Helsinki-Vantaa from QNH (QFE) to the standard setting (1013,2 hPa), is 5000 ft (about 1500 m). According to the captain everything went normally. AFL204 was equipped with a western-built TCAS system, but the captain did not report that AFL204 would have received any TCAS advisory about FIN2162. However, this should have happened if the TCAS, receiving information from the transponder, was operative.

AFL204 had a flight crew of six instead of the normal five, since this was a check flight for the radio operator. According to company procedures, the radio operator is also required to read the checklists used in the cockpit. The airline reported that the other captain was sitting in the cabin at the time of the incident, and the other crew members were on their assigned seats with the pilot-in-command sitting on the left-hand pilot seat.

At the time of passing the aircraft were almost directly one on top of the other, AFL204 being slightly ahead of FIN2162. At 16.47.10 AFL204 reported crossing HEL VOR radial 180, at FL75 according to the radar data. DEP cleared it for a climb to FL150. APP gave FIN2162 a heading of 330º, recleared it to 5000 ft at QNH 994 and handed the aircraft over to the arrival controller (ARR).

1.1.1 Disappearance of aircraft from radar

The investigation material provided by Helsinki ATC included a list showing that, during the period 3.11.2000 - 15.12.2000, 11 Russian-built airliners had not been shown normally on Helsinki ATC radar screens. On 11.1.2001 the Air Navigation Services department of CAA Finland reported to the media that other aircraft manufactured elsewhere had also disappeared from radar, but did not inform the AIB of this. On 20.11.2000 the Air Navigation Services department had provided the Flight Safety Authority with a list containing 41 occurrences, starting from August 2000. Five of these were classified as transponder failures. The other cases involved 25 Russian-built and 11 western-built aircraft. The investigators received this list on 1.2.2001.

On the investigators' request, a revised form was introduced in Helsinki ATC for more accurate reporting of any occurrences of disappearance from radar screen. In January 2001, 19 cases of disappearance were reported, of which 17 concerned Russian-built and two western-built aircraft.

The investigators found out 63 occurrences between 1.8.2000 and 31.1.2001, in which aircraft were not shown normally on Helsinki ATC radar screens. Five of these cases were classified as transponder failures by the Air Navigation Services department of CAA Finland. The problems were caused by Russian-built airliners in 45 cases, and 13 cases involved western-built aircraft, some of which were light aircraft equipped with older transponders. Of the Russian-built aircraft, 19 were T154 and one IL62M (15.12.2000) operated by Aeroflot, and 17 were T134 aircraft and one T154 operated by Pulkovo Aviation Enterprises. The remaining seven aircraft were T134, YK40, IL62M and IL76 types operated by other companies.

ATC personnel told the investigators that all occurrences may not have been recorded in the lists mentioned above. In fact, only six of the 63 cases known to the investigators were reported through the CAA confidential reporting system (PHI).

1.1.2 Transponders used by Aeroflot

Aeroflot informed that it uses the following transponder equipment in its aircraft:

- IL62M: mode A&C and S transponders manufactured by Collins
- T154M: 11 aircraft are equipped with mode A&C and S TCAS II systems manufactured by Collins and 10 aircraft with a Russian-built mode A&C device of type CO-72M
- T134A: Russian-built mode A&C device of type COM-64.

Pulkovo Aviation Enterprises reported that their T134 aircraft and some T154 types use a mode A&C transponder. Some T154s are equipped with a mode S transponder manufactured by Honeywell.

After the incident of 15.12.2000, Aeroflot inspected the transponder of the aircraft registered RA86532 and concluded that it was operating normally.

1.2 Basic information

1.2.1 Aircraft

AFL204 was a four-engine jet airliner of type Iljushin IL62M with a passenger configuration of 132 seats.

FIN2162 was a twin-engine jet airliner of type MD-83 with a passenger configuration of 156 seats.

1.2.2 Types of operations

AFL204 was a scheduled flight from Helsinki-Vantaa to Moscow. FIN2162 was a charter flight from Malaga to Helsinki-Vantaa.

1.2.3 Number of occupants

There were 230 passengers and 17 crew members on board the aircraft.

1.2.4 Injuries to persons

No one was injured.

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

Aeroflot 204 flight crew

Pilot-in-command:	Male, 48 years
Licences:	Airline transport pilot, valid until 1.6.2001
Medical certificate:	Valid until 1.6.2001
Ratings:	IL62M captain, IL62M instructor, CAT II

Total flying experience 11310 hours, of which 4300 hours on IL62.

Captain:	Male, 55 years
Licences:	Airline transport pilot, valid until15.1.2002
Medical certificate:	Valid until 15.1.2002
Ratings:	IL62M captain, IL62M instructor, CAT II

Total flying experience 19917 hours, of which 7620 hours on IL62. The captain was an additional crew member and was sitting in the cabin at the time of the incident.

Co-pilot:	Male, 42 years
Licences:	Airline transport pilot, valid until 1.3.2001
Medical certificate:	Valid until 17.1.2002
Ratings:	IL62M co-pilot, CAT II

Total flying experience 9026 hours, of which 4950 hours on IL62.

Navigator:	Male, 45 years
Licences:	Navigator, valid until 28.4.2001
Medical certificate:	Valid until 28.4.2001
Ratings:	IL62M, CAT II

Total flying experience 10910 hours, of which 3350 hours on IL62.

Radio operator:	Male, 41 years
Licences:	Aircraft radio operator, valid until 3.11.2001
Medical certificate:	Valid until 3.11.2001
Ratings:	North Atlantic MNPS approval

Total flying experience 4250 hours. The flight in question was the radio operator's check flight to obtain an IL62M rating.

Flight engineer:	Male, 55 years
Licences:	Flight engineer, valid until 11.8.2001
Medical certificate:	Valid until 11.8.2001
Ratings:	IL62M flight engineer, FE instructor

Total flying experience 13480 hours, of which 6243 hours on IL62.

Finnair 2162 flight crew

Pilot-in-command:	Male, 45 years
Licences:	Airline transport pilot, valid until19.3.2005
Medical certificate:	JAR class 1, valid until 19.9.2001
Ratings:	MD80 captain, A300 co-pilot, DC8 second officer

Total flying experience 12794 hours, of which 3565 hours on MD80.

Co-pilot:	Male, 31 years
Licences:	Commercial pilot, valid until 28.4.2005
Medical certificate:	JAR class 1, valid until 28.4.2001
Ratings:	MD80 co-pilot, SF34 co-pilot

Total flying experience 3273 hours, of which 1590 hours on MD80.

Air traffic controllers

Departure radar controller:	Male, 33 years
Licences:	Air traffic controller, valid until 19.10.2002, glider pilot and private pilot, valid until 19.10.2005
Medical certificates:	FIN 1 and JAR 2, valid until 19.10 2002
Ratings:	Approach control EFHK, terminal area radar EFHK and aerodrome control EFHK, valid until 19.10.2002.

Approach radar controller:	Male, 33 years
Licences:	Air traffic controller, valid until 22.11.2001
Medical certificate:	Medical examination 22.11.1999
Ratings:	Approach control EFHK, terminal area radar EFHK and aerodrome control EFHK.

1.2.8 Meteorological information

There was a low pressure area south-west of Finland, and a light south-easterly wind prevailed in Helsinki region. Occasional showers and moderate icing occurred in clouds.

Weather at Helsinki-Vantaa on 15.12.2000:

METAR at 16.20: wind 140º 6 kt, clouds sct 800 ft bkn 1500 ft, temperature +6ºC, dewpoint +4ºC, QNH 994, no significant change.

METAR at 16.50: wind 160º 8 kt, variable 130º-280º, clouds few 800 ft bkn 1700 ft bkn 2100 ft, temperature +6ºC, dewpoint +4ºC, QNH 995, no significant change.

1.2.9 Weight and balance

The mass of AFL204 was about 105500 kg and that of FIN2162 about 55800 kg. The weight and balance of aircraft were on permitted area. The total amount of fuel on board was 25500 kg.

1.3 Investigations

1.3.1 General

The investigation material consisted of incident reports filed by the captain of FIN2162 and by the DEP and APP controllers, extracts from Helsinki-Vantaa ATC log and flight strips, radar recordings from Helsinki ATC, South Finland ACC and Finnish Air Force, interviews of FIN2162 crew and air traffic controllers, radio communication recordings, and information obtained from various documents, manuals and instructions. The material also included data provided by Aeroflot, as well as meteorological information at Helsinki-Vantaa for the time of the incident.

Moreover, radar instructors from the Aviation College of CAA Finland and on-the-job instructors from Helsinki-Vantaa ATC were interviewed about the controllers' radar training.

The investigation also comprised interviews of technical experts from CAA Finland and transponder/ TCAS specialists from Finnair Avionics Department. The Finnish Air Force provided assistance in radar technology investigations.

Aeroflot delivered the FDR (flight data recorder) recordings from AFL204, which they had read out and interpreted. Both aircraft were equipped with mode S transponders and TCAS systems, but their data is not recorded.

The investigators also asked the Air Navigation Services department of CAA Finland to provide details of occurrences involving disappearance of aircraft from radar screen, which had been reported in the CAA confidential reporting system (PHI). All reports were delivered by the quality assurance and safety management unit. However, they were not very useful for the investigation, as it came out that only six of the 63 cases known to the investigators had been reported.

1.3.2 Radio communications

The investigators listened the radio communications from a recordings of Helsinki-Vantaa airport. Reception was good and correct phraseology was used. Transcripts of relevant communications between the crews and the controllers are in Appendix 3.

1.3.3 Flight data recorders

Aeroflot read out the FDR recordings of AFL204 and sent their interpretation to the investigators (see Appendix 4). FDR recordings of FIN2162 were not analysed.

1.3.4 Flight crew actions

IL62M cockpit layout and actions by AFL204 flight crew

AFL204 had a flight crew of six instead of the usual five, since this was a check flight for the radio operator. A senior pilot acted as check-pilot and pilot-in-command. The other instructor captain, who was an additional crew member, was sitting in the cabin at the time of the incident.

IL62M has two altimeters in the left-side instrument panel, one of which shows the altitude in metres (m) and the other in feet (ft). The right-side instrument panel is equipped with two altimeters, both of which indicate the altitude in metres. Both metric altimeters use millimetres of mercury (mmHg) for barometric pressure setting. The altimeter showing feet has two windows for barometric pressure setting, one of which uses hectopascal/millibar (hPa/mbar) and the other inches of mercury (inHg).

In accordance with company procedures, the metric altimeters are on the QFE setting on the ground at Helsinki-Vantaa (indicating 0 m) and the altimeter indicating feet is on the QNH setting (indicating the altitude from sea level, i.e. about 160 ft on the apron). After take-off the metric altimeters indicate height from aerodrome elevation, and the feet altimeter indicates altitude from mean sea level. Within Helsinki-Vantaa terminal control area (TMA) all altitudes are reported from mean sea level (QNH), using feet for altitude and hectopascals (hPa) for barometric pressure. Flight levels based on an altimeter setting of 1013,2 hPa are used above the transition level and altitude.

AFL204 received a normal start-up approval and an ATC clearance, which instructed it to follow the standard instrument departure Porvoo three bravo (PVO 3B). The TWR cleared AFL204 for take-off at 16.40.40. After take-off the crew contacted Helsinki radar (DEP) as required by the standard instrument departure procedure. DEP acknowledged the initial contact only by the aircraft call sign *"Aeroflot 204"*. At 16.42.00 AFL204 reported approaching the initial climb altitude of the standard instrument departure, which was 4000 ft. DEP requested the crew to maintain that altitude. At 16.43.00 DEP cleared the aircraft to fly direct to PVO VOR beacon via left turn and climb to FL70.

AFL204 acknowledged the clearance but did not report leaving 4000 ft. DEP then asked which level AFL204 was on, and they replied to be passing FL50, climbing to FL70. The crew reported reaching FL70 at 16.44.00. At 16.47.10 they reported crossing HEL VOR radial 180 as requested by DEP. The aircraft was then cleared to FL150, and one minute later direct to the GOGLA reporting point.

The flight crew could have used the altimeter showing feet directly to determine the initial climb altitude (4000 ft) for the standard instrument departure. Instead, deriving the clearance altitude based on a QNH setting and reported in feet from a metric altimeter required the use of conversion tables. When AFL204 was cleared to FL70, the flight level could be seen directly from the altimeter showing feet, in case its barometric pressure setting had been changed to the standard setting of 1013.12 hPa above the transition altitude. However, to be able to determine flight level 70 from the metric altimeter, it was necessary to use a conversion table and adjust the barometric pressure setting to 760 mmHg.

The AFL204 FDR data shows that the metric altimeter in the left-side instrument panel had been adjusted to the standard setting, whereas the pressure setting for the altimeter indicating feet cannot be determined from the recording.

In IL62M, the switch panel for the transponder and TCAS equipment is located in the left wall panel of the cockpit, approximately at shoulder height for the pilot sitting on the left seat. Because of this location, the switch panel cannot be easily seen by the other flight crew members, and they are not able to use it from their usual positions. In accordance with the company procedures for IL62M operations, the transponder/TCAS is switched on just before take-off. The radio operator reads out the relevant checklist item, and the pilot-in-command is responsible for switching the device on. In the case now under investigation, none of the seven radars which were monitoring the flight, nor the TCAS system of FIN2162, received any transponder reply from AFL204 until a few seconds before the aircraft passed each other at 16.45.56. The pilot-in-command of AFL204 has not reported about a TCAS advisory either. Based on experiences gained in other companies, mode S transponder/TCAS systems have been very reliable. In fact, less than one failure per each 10000 flight hours has been reported. Moreover, in about half of the reported cases, technical examinations showed that the device was actually fully serviceable.

Actions by FIN2162 flight crew

The co-pilot was the pilot flying. The captain acted as the monitoring pilot and handled the radio communications. FIN2162 contacted APP at 16.41.20 while passing FL175 slightly before the KENON entry point. APP cleared the aircraft to descend to 5000 ft on QNH 994 hPa, gave a heading of 065º and asked it to maintain high speed. The controller also reported that FIN2162 would be vectored for an ILS approach to runway 15 via the left circuit. The pilots changed their altimeters to the QNH setting, since the clearance altitude was below the transition level.

There was some icing in the clouds, and the pilots had to apply power some more than idle in the engines required by the anti-icing system. This reduced the descent rate of the aircraft. When at 10 000 ft, FIN2162 received a new clearance to FL80 from APP and was given a heading of 050º at 16.43.00. The pilots adjusted the altimeter back to

the standard setting. At FL90 APP gave FIN2162 a heading of 360º and confirmed them to maintain FL80 when reaching. When the pilots acknowledged the new heading of 330º at 16.47.00, they also reported having just received a TCAS advisory about another aircraft 500 ft below them.

1.3.5 ATC actions

The controllers at Helsinki-Vantaa approach control were working in their scheduled shifts. The traffic density was not particularly high, but all three control positions (APP, ARR and DEP) were open and manned.

DEP noticed that AFL204 was not shown on the radar screen after take-off. He was also informed of this by the TWR controller. When AFL204 contacted DEP, he only replied by the aircraft call sign *"Aeroflot 204"*. He left AFL204 at the initial climb altitude 4000 ft and allowed it to continue along the standard instrument departure route PVO 3B (see Figure 1). DEP did not ask the crew of AFL204 to check their transponder, nor did he mention that the aircraft was not visible on the radar.

At the same time APP was vectoring FIN2162, which was approaching from south-west. APP had cleared FIN2162 to descend to 5000 ft on QNH 994, gave it a heading of 065º and reported that the aircraft would be vectored for approach to runway 15 via the left circuit. The route of the inbound aircraft had been co-ordinated with the PVO 3B standard instrument departure so that the aircraft could be cleared for a continuous descent and climb without a need for level flight at intermediate altitudes.

As AFL204 could not be seen on the radar screen, the APP controller, who was the traffic co-ordinator, decided to change the route of FIN2162 so that the aircraft would approach runway 15 via the right circuit. He changed the clearance level of FIN2162 to FL80 and gave it a heading of 050º. However, he did not tell the crew that the approach had been changed for a right-hand circuit or that the distance to be flown would be considerably shorter. Moreover, he did not inform FIN2162 of AFL204, which was flying below it and was not shown on the radar.

APP and DEP agreed that DEP would clear AFL204 to FL70 and instruct it to turn direct to the PVO VOR beacon from the standard instrument departure route, so that other aircraft could be cleared for take-off from Helsinki-Vantaa. ATC also asked AFL204, which was still not visible on the radar, to report when crossing HEL VOR radial 180, as this would help to determine when FIN2162 and AFL204 had passed each other. AFL204 could then be cleared to climb to the proper flight level for border crossing.

On the APP controller's request, DEP restricted departing traffic until AFL204 had reported passing through FL50. This caused a four-minute delay to departing traffic.

APP gave FIN2162 a heading of 360º at 16.45.10. When acknowledging this message, the crew reported reaching FL 80.

When AFL204 became visible on ATC radar screens at 16.45.56, it was about half a nautical mile from FIN2162 on its front-left side. Their flight tracks intersected at an angle of nearly 90º. According to the label information on radar screen, AFL204 was at FL76. Neither of the controllers had time to say anything to the crews before the aircraft

passed each other. At 16.47.00 FIN2162 informed APP that they had received a TCAS advisory, and APP replied that he had seen the situation on radar.

After the aircraft had passed each other, DEP reported to AFL204 that radar contact was established. However, he did not mention that the aircraft was at an incorrect flight level as shown by the C-mode information or ask the crew to check their altimeter setting. DEP cleared AFL204 to climb to FL150, and after a while to the GOGLA exit point.

1.3.6 Instructions and training of radar controllers

The Finnish Aeronautical Information Publication (AIP), section ENR 1.6-4, chapter 5. Secondary Surveillance Radar, paragraph 5.1 gives the following instructions:

Aircraft shall be equipped with a serviceable transponder when operating:

a. within Finnish flight information regions at or above flight level 95

b. within Helsinki TMA

c. within Helsinki CTR.

The transponder shall be capable of replying to Mode A (4096 codes), and Mode C (with automatic transmission of pressure altitude information).

The Civil Aviation Administration, Finland, may grant exemptions from the requirements above for short operating periods on application.

The Finnish air traffic controller's handbook (LJKK), chapter 5, paragraph 1.5.1.2 (SSR identification), item D contains the following instruction:

SSR identification must be based on aircraft label information on the radar screen.

Note 2 under the same paragraph states that:

When a specific code has been allocated to an aircraft, it must be checked at the earliest opportunity that the code selected by the pilot and the code allocated to the flight are identical. Only after this check can the specific code be used for identification purposes.

Paragraph 2.4.5, Interruption or termination of radar service, states that:

Where an aircraft has been informed that radar service will be provided, it must be immediately informed in case the radar service is interrupted or terminated for any reason.

Air traffic control service within Helsinki terminal control area (TMA) can be regarded as radar service, since the standard instrument departure instructions published in the AIP contain the phrase: *When airborne, contact immediately Helsinki radar 119.100 MHz.*

When interviewed, radar instructors from the Aviation College and on-the-job instructors from Helsinki-Vantaa ATC told that situations where an aircraft is not visible on the radar are included in the training programme as special situations. However, since the radar training course is short and intensive, every student will not have a chance to practice this kind of situation in the simulator training. All students receive theoretical knowledge instruction on the subject, and where such a situation occurs during an exercise session,

it will be discussed in the de-briefing. The same applies to practical training for various ratings: the procedures may be discussed in theoretical instruction, and if this kind of situation comes up during the practical training, the instructor will advise and guide the trainee to carry out the procedures where needed. On the other hand, a situation like this may not come up during the practical training period.

When operating within terminal control area without a primary radar, it is essential that the controllers can handle these kind of situations. Procedural separation is a method to control traffic without radar, but in a radar service environment it can only be regarded as a stand-by system, which will cause delays and traffic congestion.

The situation in refresher training is similar to that on basic radar training courses. A comprehensive review of special situations cannot be arranged due to the lack of personnel, time and economic resources.

1.3.7 Radar system at Helsinki ATC

At the time of the incident, radar data inputs to the Helsinki-Vantaa ATC radar system were fed from MSSR and SSR antennas located within the airport area.

For an aircraft to be visible on the radar screen, the radar must receive a reply to its interrogation signals from the aircraft transponder. The reply signal must meet specific criteria. Based on the reply signal, the radar plot extractor creates a plot to be fed into the Eurocat 2000 display system. (Plot means target information accepted by the radar). The plots are then processed to be shown on the screen by the Eurocat 2000 system. The system was introduced in May 2000, and a similar system is used in the Area Control Centres for Southern and Northern Finland as well as in Rovaniemi approach control. Plots received from the radars are processed into *tracks* by Eurocat 2000 and shown on ATC radar screens. (Track means aircraft position information processed by the system.) Flight plan data from the ACC Pommery system is also fed into the display system. The Pommery data is first processed by the WinATM program, after which the data is fed into the Eurocat 2000 flight data processor. The processor then transfers the flight data to display units at controller workstations, combining the flight plan data and radar data.

ATC radar data is updated every four seconds, as the radar antenna rotates 15 times per minute. For an aircraft within radar coverage to become visible on the screens at controller workstations, the radar must receive three acceptable replies from the aircraft transponder during successive radar antenna rotations. If one reply received from the transponder of an aircraft shown on the radar screen is not acceptable, the system will calculate an estimated position, which is shown on the display with a different symbol. In case the next transponder reply is acceptable, the aircraft will be shown normally on the screen. Instead, if a transponder reply is not received during three successive radar antenna rotations, the aircraft symbol will disappear from the radar screen. In that case, three successive acceptable transponder replies are required before the aircraft becomes visible on the radar again.

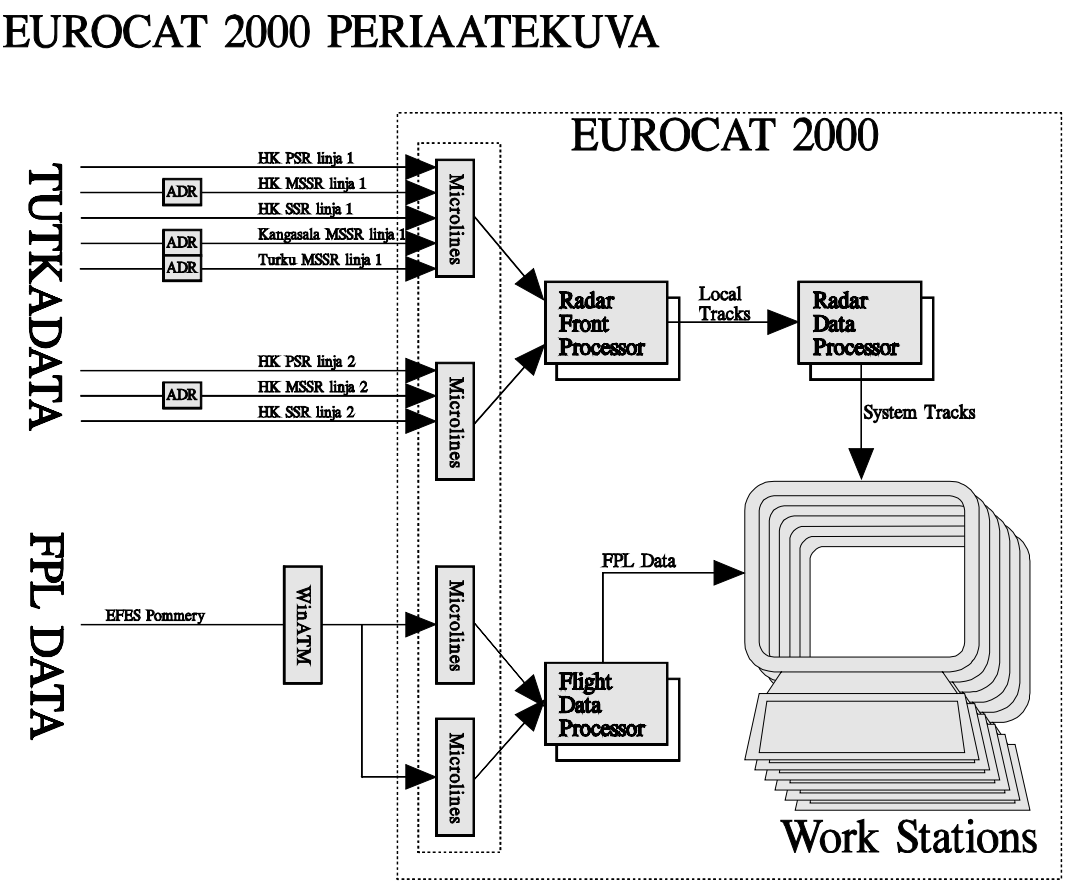

Figure 3. Eurocat 2000 radar display system used at Helsinki ATC.

Buildings in the airport area have caused occasional interference in the SSR. For this reason, ATC discontinued the use of SSR data in summer 2000, during which time the operations were based on MSSR alone. The SSR was connected back to the system on 15.10.2000.

At the time of the incident on 15.12.2000, the primary radar was not approved for use in the ATC radar system. Flight Safety Authority, CAA Finland, approved the use of primary radar after some technical modifications on 15.1.2001. The radar was connected into the system on 16.1.2001.

According to the ICAO recommendation, an ATC unit giving approach radar service may operate without primary radar provided that the Civil Aviation Authority has approved the secondary radars (SSR/MSSR) to be used.

1.3.8 Properties of aircraft transponders

Both AFL204 and FIN2162 were equipped with mode S transponders. These devices are considered very reliable, and they do not have any parts prone to mechanical wear. Any limitations based on calendar time or hours of operation have not been imposed, but a transponder may remain installed in the aircraft as long as it works correctly. However, operational checks are required to be made every two years.

Some malfunctions resulting from wear have been found in the older mode A&C transponders. In a random test made in France, about 20% of mode A&C transponders used in commercial air transport, which were brought to scheduled maintenance after two years in service, were found to be non-compliant with international requirements. It has also been discovered that wear degrades the quality of transponder reply pulses and affects the ability of the transponder to receive interrogation pulses. Moreover, it has been estimated that when the aircraft is close to an MSSR antenna, where the radar interrogation pulse is powerful, an older mode A&C transponder may become ”blocked”. As a result, the transponder can no longer distinguish those interrogations to which it should respond from the other pulses, and will not try to respond to radar interrogations.

1.3.9 Compatibility of MSSR/SSR radars and transponders

A German study conducted in Frankfurt area in autumn 2000 revealed that transponder reply pulses not in compliance with ICAO quality requirements are transmitted approximately once per hour. It was found that different radars handle these low-quality pulses differently. Some radars will accept pulses that some others would reject. Basically it would be possible to broaden the acceptance scope of the radar extractor that picks out the reply pulses, but this would mean using frequency bands reserved to other air navigation equipment, in which case e.g. DME (distance measuring equipment) signals could interfere with the radar or vice versa. If some other criteria were loosened, this would lead to an increased risk of accepting distorted replies containing incorrect information. For these reasons, new MSSR radars have been adjusted to operate strictly within the prescribed area. It is probable that these radars will not accept transponder reply signals that do not meet the quality requirements specified by ICAO. Therefore those aircraft with a transponder transmitting low-quality reply signals are not visible on radar screen.

1.3.10 Organisation and management

It came up during the investigation that some directors in the Air Navigation Services department of CAA Finland were not sufficiently familiar with the Investigation of Accidents Act or the authority of investigators appointed by the Accident Investigation Board. This hampered the collection of reference material and delayed the investigation in its early stages.

Another factor that hindered the acquisition of reference material was a clause in the supply contract of the EUROCAT system, in which the supplier required the technical data of the system to be kept confidential. The Air Navigation Services department asked for the supplier’s permission to release the information, after which the supplier demanded the AIB to sign a comprehensive agreement about maintaining the secrecy of information. The agreement would have been governed by French law. However, the AIB declined to sign the agreement, but obliged CAA Finland to provide the information by virtue of Section 10, Subsection 1 and Section 14 of the Investigation of Accidents Act. The AIB notified the French supplier of its decision.

2 ANALYSIS

2.1 Loss of separation on 15.12.2000

2.1.1 Traffic solution

Since AFL204 did not become visible on ATC radar after takeoff, the DEP and APP controllers agreed on the procedural separation between AFL204 and FIN2162, which was approaching Helsinki-Vantaa. APP had cleared FIN2162 to descend to 5000 ft on altimeter setting QNH 994. He had instructed the crew to prepare for an approach to runway 15 from the left, gave a heading of 065º and asked them to maintain high speed. The controllers agreed that the descent of FIN2162 should be limited to FL80 (on STD altimeter setting 1013.2 hPa) and the climb of AFL204 to FL70, so that the required vertical separation of 1000 ft would be maintained. In addition, the controllers decided to take FIN2162 to an approach for runway 15 right circuit, in which case the aircraft would pass each other more quickly. DEP also asked AFL204 to report crossing the HEL VOR radial, so that the controllers could determine when AFL204 was east of Helsinki-Vantaa airport. The traffic solution was appropriate for the situation and would have ensured an adequate separation, if both aircraft had complied with their clearances as acknowledged by the crew.

2.1.2 Flight crew actions

APP issued FIN2162 a new flight level clearance to FL80 and a heading of 360º. When the aircraft was at FL82, levelling off for the cleared level, the pilots received a TCAS resolution advisory about traffic 600 ft below them at a distance of half a nautical mile on their front-left side. As the other aircraft was at level flight, the pilots concluded that there was no need for an avoiding action. The aircraft were on intersecting flight paths and their vertical distance was below the applicable separation minimum. For this reason, the TCAS advisory should have been received much earlier according to the device parameters, if the transponder/TCAS system of AFL204 was operating properly. The pilots of FIN2162 informed APP about the advisory and filed an incident report as required by the Finnish aviation regulation GEN M1-4 after the flight.

AFL204 took off from Helsinki-Vantaa runway 22. It followed the standard instrument departure PVO 3B and contacted the DEP radar after takeoff as instructed. The controller replied only by repeating the aircraft call sign. After 40 seconds AFL204 reported approaching the initial climb altitude 4000 ft. The controller first instructed it to maintain altitude, but one minute later he cleared the aircraft to fly direct to the PVO VOR beacon and to climb to FL70. AFL204 read back the clearance but did not report leaving 4000 ft. After 20 seconds the controller asked AFL204 to report its flight level, and the crew replied passing FL50 and climbing to FL70. When flying to Helsinki-Vantaa, the company uses a QFE setting (pressure unit mmHg) in the metric altimeters and a QNH setting (pressure unit mbar/inHg) in the altimeters indicating feet below the transition level during approach and below transition altitude during departure. On QFE setting the height is measured from field elevation, and on QNH setting altitude from

mean sea level. At the time of the incident, the difference between the actual barometric pressure QNH 994 hPa (mbar) and the standard pressure used above the transition altitude (1013.2 hPa) was about 520 ft. This means that FL50 was at 4480 ft, and the AFL204 should have changed altimeter setting before reaching this altitude since the crew reported passing through FL50. In his statement, the pilot-in-command of AFL204 told that the altimeter setting was changed at the *transition level*, though it should have been changed at the transition altitude, which is 5000 ft in all Finnish airspace. The adjustment of pressure setting in the metric altimeter is shown in the FDR recording provided by Aeroflot, but that of the altimeter showing feet is not recorded.

Figure 4. Altimeters available to the IL62M captain and TCAS display.

AFL204 reported reaching FL70 at 16.44.00. The label information ofthe aircraft was first displayed on radar screens at 16.45.56, at which time it was shown to be on FL76. FIN2162 received a TCAS resolution advisory about the aircraft at the same time. AFL204 was simultaneously detected by two radars at Helsinki-Vantaa ATC, three

radars at the South Finland ACC and two Finnish Air Force radars. All radars indicated the same flight level for AFL204.

Considering the technical rounding used in radar systems, the difference between FL70 and FL76 is the same as the difference between the QNH and standard barometric pressure converted into altitude. It is therefore probable that the altimeter indicating feet was on QNH setting above the transition altitude, although the crew thought it to be on the standard setting. They flew at the 7000 ft altitude indicated by the altimeter and believed to be at FL70, but were actually at FL76. In his statement, the pilot-in-command told that the flight had been normal and the crew had not noticed anything unusual.

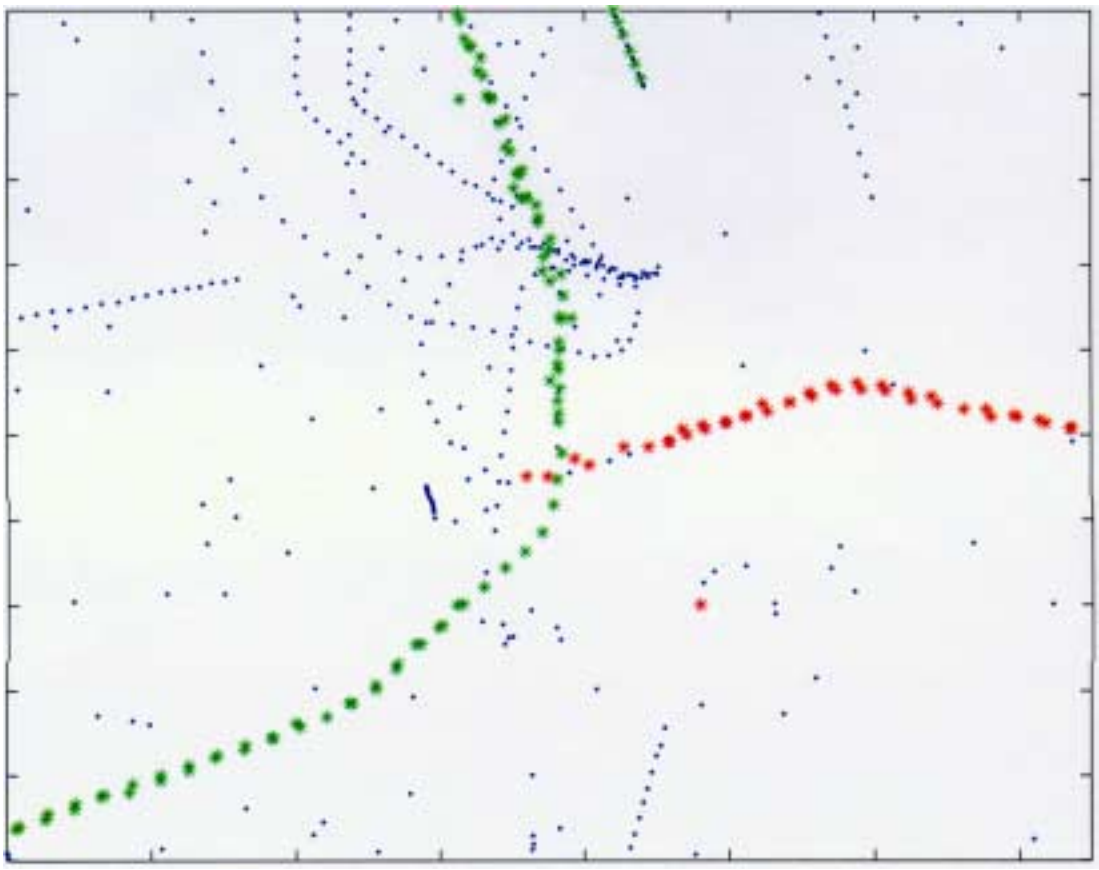

Figure 5. Aircraft tracks from the Finnish Air Force radar recording
Blue points are primary radar returns.
Red stars are secondary radar returns for AFL204.
Green stars are secondary radar returns for FIN2162.

The label information for AFL204 was not shown on ATC radar screens after take-off. The controller did not notify the crew of AFL204 that the aircraft was not visible on radar, but did not report *radar contact* established either, as radar service practice. The aircraft was equipped with a Mode S transponder, which have proved to be very reliable in operational use. A technical malfunction is highly unlikely in this case, since the transponder worked correctly after the first reply signal was received at 16.45.56. It therefore seems probable that the AFL204 transponder was switched on only just before

the first reply signal was received. The switches for the transponder are located in the cockpit wall, on the left side of the pilot sitting on the left-hand seat. The location is not very suitable from the ergonomic point of view, because only the left-seat pilot can use the switches and the other flight crew members cannot easily see the settings of the switches from their own positions.

Incorrect altimeter and transponder settings indicate a lack of crew resource management. In accordance with the safety-enhancing procedures used in aviation, and as required by the aircraft flight manual, one crew member should usually read the checklists and the others are responsible for carrying out the actions correctly. In addition, the crew member reading the checklist should make sure that the other crew members properly perform the actions read from the list. In the case now under investigation, the co-operation did not work out as intended, and therefore the altimeter and transponder settings remained incorrect.

One factor disturbing the work of AFL204 flight crew may have been that this was a check flight for the radio operator's type rating, and the company IL62M group chief was acting as the pilot-in-command and checkpilot. The checklists are normally read by the radio operator. It seems possible that the co-operation between the flight crew members did not work out quite in line with the usual routines. Moreover, it appears from the documents provided to the investigators by Aeroflot that the company is not sufficiently familiar with all of the procedures used at Helsinki-Vantaa. For example, the concepts of transition level and transition altitude had not been understood correctly.

Aeroflot should seek to develop crew resource management to ensure that all equipment on board is appropriately used. Increased CRM training could be useful for attaining this goal.

2.1.3 ATC operations

Air traffic density was not particularly high at the time of the incident, but all three control positions at the approach control (APP, ARR and DEP) were open and manned. APP was the traffic co-ordinator.

DEP noticed that AFL204 was not visible on radar after take-off, and was also informed of this by the TWR controller. However, when AFL204 contacted DEP, he only acknowledged by the aircraft call sign *"Aeroflot 204".* During the whole period when AFL204 was under his responsibility, he did not inform the crew that the aircraft was not shown on the radar or ask them to check their transponder. When the crew reported reaching the initial climb altitude 4000 ft for the standard instrument departure PVO 3B, DEP requested them to maintain that altitude.

APP had cleared FIN2162, which was approaching Helsinki-Vantaa, to descend to 5000 ft on heading 065º. He planned to vector the aircraft for approach to runway 15 via left circuit. Since AFL204 was not seen on the radar screen, APP and DEP co-ordinated the situation with each other. They decided to use vertical separation and make AFL204 pass below FIN2162. APP then issued FIN2162 a new clearance to FL80 and gave a heading of 360º, in order to take the aircraft to runway 15 from right. APP gave the clearance early enough, and the crew had plenty of time to react to the new clearance, since FIN2162 was approximately at FL100 when receiving the clearance. Nevertheless,

APP did not tell FIN2162 that the left circuit had been changed to a right-hand one and that the distance to be flown would be considerably shorter as a result.

DEP decided to turn AFL204 away from the standard instrument departure route. He cleared it to fly direct to the PVO VOR beacon and to climb to FL70. The clearances issued would have ensured an adequate vertical separation of 1000 ft between the aircraft. APP requested DEP to restrict departing traffic. Because AFL204 had not reported leaving 4000 ft, DEP asked about its flight level. The crew reported being at FL50, climbing to FL70. The next aircraft was cleared for take-off only after this information was received, which caused a four-minute delay to departing traffic. AFL204 reported maintaining FL70 at 16.44.00. DEP also asked the crew to report when crossing HEL VOR radial 180º.

When AFL204 first became visible on the radar screen at 16.45.56, it was about half a nautical mile front-left of FIN2162 at FL76. Neither of the controllers had time to inform the crews of the situation before the aircraft passed each other. The tracks intersected at an angle of almost 90º, while AFL204 was 600 ft below FIN2162. DEP did not tell the AFL204 pilots that the aircraft was at an incorrect flight level, nor did he ask them to check their altimeter setting.

The DEP controller's radar work was passive, and he did not follow the instructions given on radar service. He took no action to make AFL204 visible on the radar, although ability to see the aircraft is an essential prerequisite for radar-based air traffic control service. Moreover, he did not inform AFL204 that it was flying at an incorrect flight level after radar contact was established. The new radar display system (Eurocat 2000) had been in use for about six months by the time of the incident, so the controller should have had sufficient operating experience of the system. However, in a critical situation, he did not prioritise the basic issues of informing the crew that the aircraft was not visible on radar and asking if their transponder was on. This simple and basic action would probably have solved the whole problem.

The APP and DEP controllers together made an incident report as required by the Finnish aviation regulation GEN M1-4 after the incident.

2.2 Disappearance of aircraft from ATC radar

2.2.1 General

The display of modern monopulse radars (MSSR) is based on data contained in interrogation pulses transmitted by the radar and reply pulses received from the aircraft transponder. Monopulse radars require more accurate reply pulses from the transponder than the older type of radars. In a system comprising several radars, the data from different antennas is complementary and the track of the aircraft will not disappear from radar screen even if correct replies are not received to three successive interrogations.

Factors causing aircraft disappearance from radar have been examined in several studies in Europe. A study published by Eurocontrol in 1995 revealed that at a medium-sized airport with about 150 daily departures, the transponder signals of five aircraft each day did not meet the requirements. According to the same study, one fifth of transport aircraft transponders brought to scheduled maintenance in France were not in

compliance with equipment standards defined by ICAO. The study stated that in 1994, only 4.3% of aircraft were equipped with a Mode S transponder. However, the situation is much better today: the TCAS requirement became effective for transport aircraft on 29.3.2001 and will be applicable to commuters as well by the year 2005. The requirement means that these aircraft will also have Mode S transponders, but it will not yet become applicable to light private aircraft. In the older Mode A&C transponders used, many irregularities were found in pulse width and location as well as in reply frequencies. The tests showed that the quality of transponder reply pulses significantly affected the ability of the radar to detect the target. It was also concluded that the settings of the radar receiver and its extractor had an effect on the way in which the radar handles non-standard pulses.

According to a study conducted by Deutsche Flugsicherung GmbH in the Frankfurt North area in autumn 2000, a situation in which an aircraft transponder reply was not in compliance with the required standards occurred approximately once per hour. Non-standard replies were caused by irregular pulse chains and reflection of pulses from buildings within the airport area.

2.2.2 Radar system at Helsinki-Vantaa airport

For an aircraft to be visible on radar screen, the Eurocat 2000 display system requires accepted plots on three successive antenna sweeps. One rotation of the secondary radar antennas takes four seconds, and so the radar data is updated every four seconds. An aircraft may therefore become visible on the radar 12 seconds after its first transponder reply at the earliest. If an acceptable transponder reply is not received thereafter, the system calculates an estimated position for the aircraft, which is shown by a different symbol. If the following replies are acceptable, the aircraft track will be visible normally on the screen. In case three successive transponder replies are not acceptable, the aircraft will disappear from the radar screen. For the aircraft to become visible again, three successive acceptable replies are required. Therefore, if the transponder fails to transmit three successive replies acceptably, the aircraft will disappear from radar screen for about 25 seconds. The radar system uses three antennas as sources of information. If one radar will not detect the aircraft, the two others should receive the information for the radar coverage to be sufficient.

2.2.3 Possible causes of disappearance from radar screen

This investigation could not provide a simple explanation for the cases of aircraft disappearance from Helsinki-Vantaa ATC radar. However, an examination of the details of the reported occurrences reveals some possible and probable causes. The material received from Finnish Air Force recordings was very useful for determining the causal factors.

Low-quality transponder signal

Of the 63 cases known to the investigators from the period 1.8.2000 - 31.1.2001 in which an aircraft was not shown on radar screen, about 90% involved aircraft equipped with older Mode A&C transponders. 45 of these aircraft were Russian-manufactured T134, T154, IL62, IL76 or YAK40 types. Of the other 13 aircraft, five were older twin-

engine commuter aircraft. In addition, the Air Navigation Services department of CAA Finland has classified five occurrences as transponder failures based on its own criteria.

Mode A&C transponders have been determined to require periodical maintenance, since they are subjected to mechanical wear. The American FAR 43 regulation prescribes a maintenance interval of two years. The Eurocontrol study described above revealed that in France, one fifth of these transponder types were not in compliance with ICAO standards when they were brought to scheduled maintenance after two years in service.

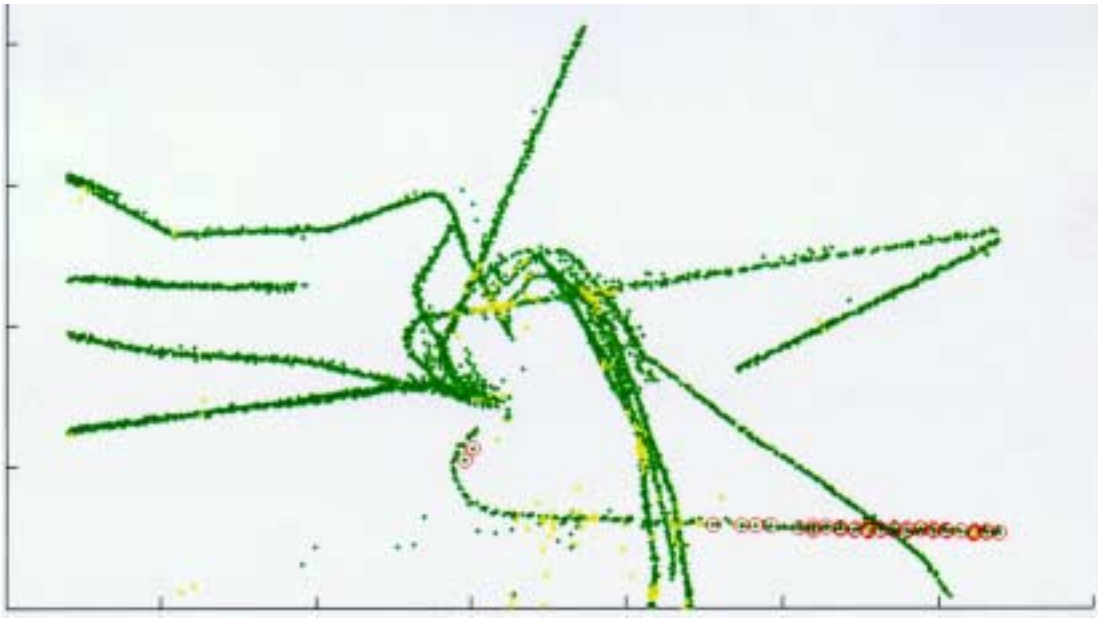

Figure 6. Radar recording by the Finnish Air Forces. An example of poor radar contact, showing PLK632 after take-off on 15.11.2000. The green spots indicate primary radar returns and the red circles transponder replies accepted by the secondary radar. The aircraft was not visible on secondary radar screen at Helsinki-Vantaa either.

The AIP Finland requires all aircraft operating to Helsinki-Vantaa to have a serviceable transponder. This also implicates that the quality of transponder reply pulses must be in compliance with ICAO standards. As the authority supervising air traffic in Finland, the Flight Safety Authority should take the necessary action to ensure that the transponders of aircraft operating to Helsinki-Vantaa meet the ICAO standards in every respect.

However, it must be remembered that those operators and aircraft that most often disappear from radar do not form a very significant proportion of all traffic at Helsinki-Vantaa. On the whole, the ATC system has been operating well and there have not been any major problems of aircraft to be visibile on radar screens.

The area control centres for Southern and Northern Finland as well as Rovaniemi approach control are equipped with the same Eurocat 2000 display system as Helsinki-Vantaa ATC. However, similar problems with disappearance of aircraft from radar have not occurred in the other ATC units. Eurocat 2000 is a system originally designed for

ACC use, which has been specifically modified to meet the needs of Helsinki-Vantaa approach control.

Location of disappeared aircraft with respect to radar antennas

The aircraft have usually disappeared from radar screen while relatively near the radar antennas, within about 20 NM and below FL80. On the other hand, this is approximately the same area within which they are controlled by Helsinki-Vantaa ATC.

Helsinki-Vantaa MSSR is also connected to the South Finland ACC radar system. Since the radar operates both as a terminal area radar for the approach control and as an ACC radar, slightly different properties are required than of other radars. Because the information on the terminal area radar must be updated every four seconds, the antenna rotates 15 times per minute, whereas an ACC radar rotates 10 times per minute. The normal range for a terminal area radar is some 70 NM, but an ACC radar is required to have a range of more than 200 NM. To cater for the longer range, the power of Helsinki-Vantaa MSSR signal is about nine times that of an ordinary terminal area radar. For this reason, the signals are rather powerful near the radar antenna.

It is technically possible that the powerful signals near the radar antenna may block a transponder which is in poor condition. In this case, the transponder can no longer distinguish those pulses to which it should respond from those which must not be replied to. As a result, the transponder ceases transmitting reply pulses. The investigators examined radar data recordings made by the Finnish Air Force about some flights which were not shown normally on Helsinki-Vantaa ATC radar screens. It appears from the recordings that even the Air Force radar systems had not received proper transponder replies, although their antennas were situated considerably farther from the aircraft routes. Since the indications on Air Force and ATC radars were identical, it can be concluded that the distance of the aircraft from radar antennas did not affect its visibility on radar screen. The Air Force recordings also show that the transponder transmitted some random responses, which indicates that the transponder was on. This leads to the conclusion that the reason for disappearance from radar screen is not in the radar but in the transponder signal, which is not accepted by some radars.

Disappearance from radar due to antenna shadow

When turning after take-off or during approach, an aircraft may temporarily be in such an attitude that the airframe, engines or other parts cover the transponder antenna and impede direct contact between the transponder and radar antennas. This may disturb the exchange of signals and cause the aircraft to disappear from radar screen for some time, as explained in paragraph 2.2.2. Factors affecting this are the number and location of transponder antennas. While the SSR was disconnected and the display system worked on MSSR data alone, some light aircraft occasionally disappeared from radar screen. These cases, as well as some disappearances of transport aircraft, may have been caused by antenna shadow. Such occurrences can be reduced by installing transponder antennas in appropriate locations and by increasing their number, as for Mode S transponders. Moreover, locating secondary radar antennas farther from each other might help.

Acceptance criteria for transponder signals

It has been shown that different radars accept the signals from the same transponder in varying degrees. Older radars seem to accept such signals that the newer ones would reject. The key factor are the parameters defined for the radar data extractor. The parameters of new MSSR radars are in stricter compliance with ICAO standards than those of the older radars. In the present operating environment it is important that every device works within its assigned signal area, since otherwise the devices may interfere with each other. For this reason the MSSR settings are justified, but their operation requires that the transponder signals also comply with the standards.

2.2.4 Confidential occurrence reporting system of CAA Finland

The investigation revealed that only six of the 63 occurrences in which an aircraft had disappeared from radar screen had been reported in the confidential reporting system (PHI) used by the CAA air navigation services. If an aircraft is not visible on radar screen when radar control is provided, the controller must use procedural separation and restrict other traffic. This is certainly an abnormal situation, which would justify making an internal report and, depending on the case, even filing an incident report in accordance with aviation regulation GEN M1-4. If occurrences are not reported, the reporting system will not work in the interest of flight safety as intended.

It came out during interviews that the air navigation services personnel do not consider the PHI system very effective. They only regard it as a means for collecting statistics, and see that any actual problems cannot be solved by reporting in the system. Moreover, the confidential reporting system includes a quick analysis of the occurrence to be made locally, which is intended to provide immediate feed-back. The intention is good, but in fact the quick analysis has often failed to determine what really happened or to find out the actual cause. In addition, the safety and quality management unit of the Air Navigation Services department usually informs the CAA personnel on the basis of the quick analyses, without examining the case further. Despite the shortcomings in these information leaflets, the professional ATC staff understands how the things actually were and make their own conclusions on the subject. This premature reporting to the safety and quality management while the case has not yet been fully investigated tends not to increase confidence in the system. In several cases, the Accident Investigation Board has also come to a different conclusion than the quick analysis.

One defect in the PHI system was that the investigating authorities were not usually informed about the reported cases. This made it possible to keep the information about occurrences affecting flight safety within the service provider’s own organisation. Only during this investigation it was agreed that the accident and incident investigation authorities will also be informed about cases reported in the internal system.

3 CONCLUSIONS

3.1 Findings

1. The flight crews and air traffic controllers had valid licences and qualifications.
2. Both aircraft had valid Certificates of Airworthiness.
3. No defects or malfunctions were reported in the aircraft prior to the incident.
4. AFL204 was not shown on Helsinki-Vantaa ATC radar until a few seconds before the aircraft passed each other at 16.45.56.
5. The DEP controller did not inform the crew of AFL204 that the aircraft was not visible on radar or ask them to check their transponder.
6. APP and DEP agreed that, in order to make the aircraft pass each other more quickly, FIN2162 would be left at FL80 and vectored to approach runway 15 from the right, whereas AFL204 would be cleared direct to the PVO VOR beacon at FL70.
7. APP did not inform FIN2162 that the approach had been changed to a right-hand one or that the distance to be flown would be shorter.
8. When FIN2162 was approaching its cleared flight level FL80, it received a TCAS resolution advisory about another aircraft that was at level flight 600 ft below it, about half a nautical mile on its front-left side.
9. The FIN2162 pilots concluded that there was no need for an avoiding action.
10. At the same time when FIN2162 received the TCAS advisory, AFL204 became visible on Helsinki-Vantaa ATC radar. The label information showed that it was at FL76. This information and the time of detection were identical with secondary radar observations of the Area Control Centre and Finnish Air Force.
11. APP and DEP did not have time to inform the crews of the situation before the aircraft passed each other.
12. DEP did not tell the pilots of AFL204 that C-Mode information on radar showed the aircraft to be at an incorrect flight level or ask them to check their altimeter setting.
13. The pilot-in-command of AFL204 stated that the flight had been normal. He was not aware that the aircraft was not visible on ATC radar or that they had been at an incorrect flight level.
14. Investigation material received from Helsinki-Vantaa ATC included a list of about 11 occurrences from the period 3.11.2000 - 15.12.2000 in which Russian-manufactured transport aircraft had not been shown normally on ATC radar.
15. The investigators found out about 63 occurrences during the period 1.8.2000 - 31.1.2001 in which aircraft had not been normally visible on ATC radar screens. These cases involved 45 Russian-built and 13 western-built aircraft. CAA Finland had classified five cases as aircraft transponder failures based on its own criteria.

16. Of the 63 cases mentioned above, only six had been reported in the CAA confidential reporting system (PHI).
17. The most probable cause of disappearance of aircraft from radar is the low quality or absence of transponder reply signals.

3.2 Probable cause

The loss of separation was caused by an incorrect altimeter setting of AFL204. A contributing factor was that AFL204 transponder was not in operation until a few seconds before the aircraft passed each other, for which reason AFL204 was not visible on Helsinki-Vantaa ATC radar.

4 RECOMMENDATIONS

4.1 The airline (Aeroflot) should:

seek to develop crew resource management training to ensure that all equipment on board is appropriately used.

4.2 The Flight Safety Authority should:

as the authority supervising air traffic in Finland, take the necessary action to ensure that the transponders of aircraft operating to Helsinki-Vantaa airport meet the ICAO standards in every respect.

4.3 CAA Finland should:

establish a reporting system which the personnel can trust, which is professionally administered and also serves the investigating authorities.

Helsinki 16.8.2001

Jussi Haila Erkki Kantola

APPENDIX 1

Mr. Jussi Haila,
INVESTIGATOR
Accident Investigation Board
FINLAND

Dear sir,

To your request concerning incident of 15.12.2000 in Helsinki TMA which involved Aeroflot IL-62, flight AFL 204, I would like to inform you about the following.

On 15.12.2000 I performed flight AFL-203/204 SVO-HEL-SVO as supervisory pilot, taking the seat of PIC.

Take-off from Helsinki was carried out from RWY 22. While performing SID PVO 3B we reached 4000 ft. At DIO HEL we were cleared to reach FL70.

The crew set standard altemeter pressure 760 mm/1013 mb at the transition level.
FL 70 was maintained for 3 min.30 sec. untill cleared to further climbing.
In the process of flight there were no any questions or remarks concerning transponder operation and violation of cleared levels from the Helsinki TMA.

Faithfully yours,

Commander of IL-62
flight division

JOINT - STOCK COMPANY

AEROFLOT
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Jussi Haila
Investigator-in-charge
Helsinki
Fax: 358-9-18257811
Tel :358-9-18257753

Date _____ our ref. _____

Incident C 19/2000 L investigation

Dear Sir,

On your letter of 14/02/2001 we would like to provide you with the rest of required documents according to p.1,2.

Also we ask you to provide us with the radio-telephone communication "air controller-flight crew" after take-off and till 16.45.56.

Besides, we would like you to pay your attention to the moment of transfer of pressure QNH (QFE) to standard 1013,2 mb on transition altitude (5100 m) in accordance with flight recorder facilities submitted to you.

Best Regards,

Chief of Flight Safety (ARA)
Capt. Mokrinsky

APPENDIX 3

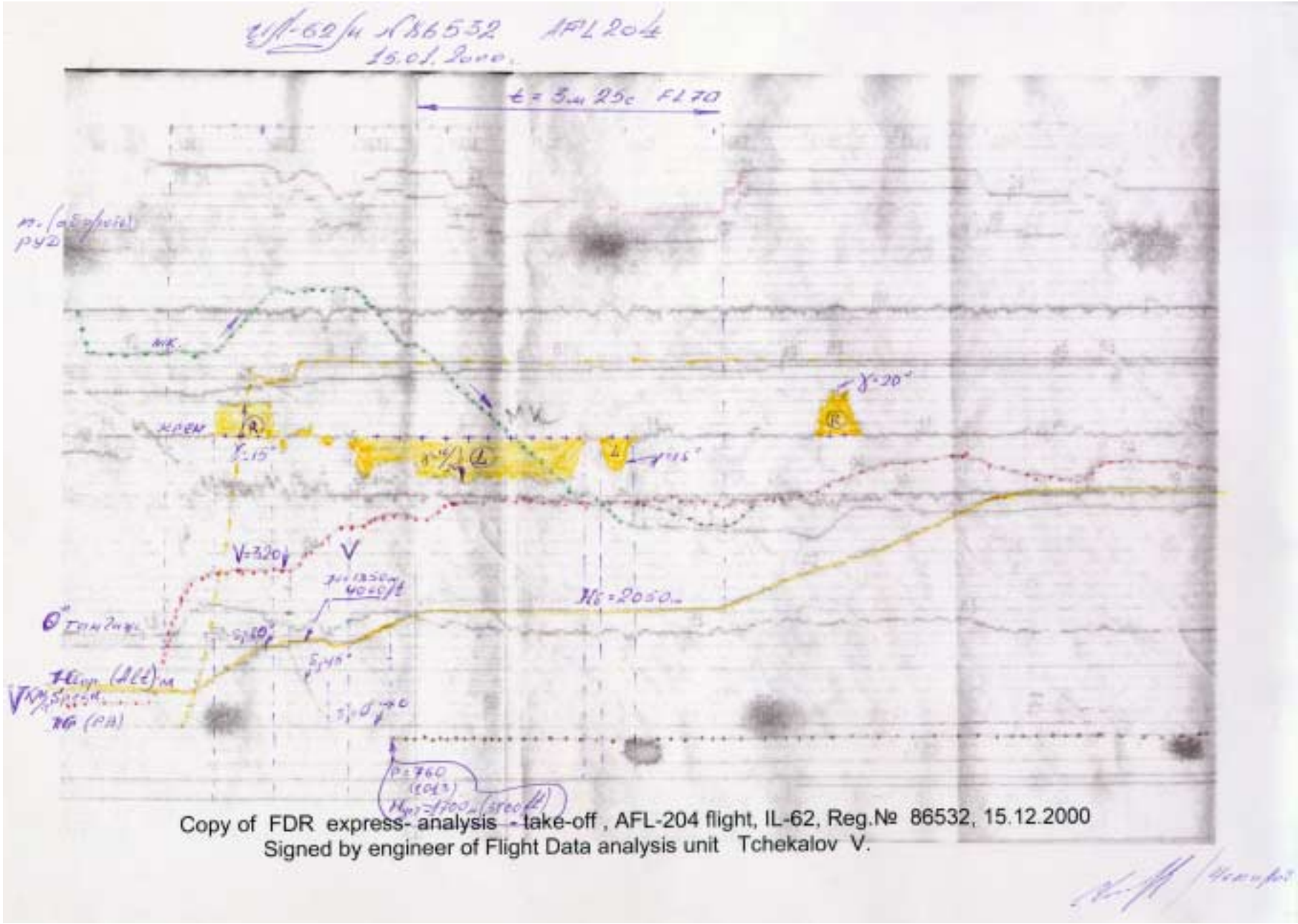
RADIO COMMUNICATIONS ON HELSINKI-VANTAA ON DECEMBER 15 TH 2000

TWR	Helsinki Tower	118,6 MHz
DEP	Helsinki Departure	119,1 MHz
APP	Helsinki Approach	129,85 MHz
AFL204	Aeroflot flight 204	
MA743	Malev flight 743	
FIN2162	Finnair flight 2162	

From	To	Time (local)	Transmission
TWR	AFL204	16.37.30	Aeroflot 204 hold short of 22 at Yankee
AFL204	TWR		Hold short of 22 at Yankee, Aeroflot 204
AFL204	TWR	16.38.20	Aeroflot 204, would you confirm cleared to left now?
TWR	AFL204		Aeroflot 204, just to confirm you'll be taking Yankee intersection to left
AFL 204	TWR		Roger turning left and hold short before Yankee 22, Aeroflot 204
TWR	AFL204		Aeroflot 204 just turn left and hold short of….before runway 22
AFL204	TWR		Roger, turn left and hold short before runway 22 Aeroflot204
TWR	AFL204	16.39.20	Aeroflot 204 line up runway 22 via Yankee, when on runway maintain only idle power untill otherwise instructed
AFL204	TWR		Cleared to line up runway 22 Yankee, Aeroflot 204
TWR	AFL204		And only idle power on the runway
AFL204	TWR		Roger idle power on the runway, Aeroflot 204
TWR	AFL204	16.40.40	Aeroflot204 wind 150 degrees 9 knots cleared for take-off runway 22 via Yankee intersection, good bye
AFL204	TWR		Cleared for take-off 22 Yankee, Aeroflot 204 thank you good day
TWR	MA743	16.43.10	Malev 743 you have to hold your position for some while, we have an aircraft just departed before you lost transportation, …transponder information, so, I will call you back in a minute or two

APPENDIX 3

AFL204	**DEP**	16.41.20	Helsinki radar, good evening, Aeroflot 204 airborne
DEP	AFL204		Aeroflot 204
AFL204	DEP	16.42.00	AFL204 approaching 4000
DEP	AFL204		Roger, maintain 4000
AFL204	DEP		Maintaining 4000, Aeroflot 204
DEP	AFL204	16.43.00	Aeroflot 204 turn left direct to PVO climb to flight level 70
AFL204	DEP		Turning left to PVO climbing to flight level 70 Aeroflot 204
DEP	AFL204		Radar
DEP	AFL204	16.43.20	Aeroflot 204, report altitude
AFL204	DEP		Aeroflot 204 now we are flight level 50 to flight level 70
DEP	AFL204		Roger, thank you
AFL204	DEP	16.44.00	Aeroflot 204 maintaining flight level 70
DEP	AFL204		Aeroflot 204.
DEP	AFL204	16.45.20	Aeroflot 204, report passing radial 180 from Hotel Echo Lima
AFL204	DEP		Will copy passing radial 180 from Hotel Echo Lima, Aeroflot 204
DEP	AFL204		Radar
AFL204	DEP	16.47.10	Aeroflot 204 passing radial 180 from Hotel Echo Lima
DEP	AFL204		Aeroflot 204 Roger, radar contact, climb to flight level 150
APP	**FIN2162**	16.43.00	Finnair 2162 recleared descend to flight level 80
FIN2162	APP		Recleared to flight level 80, Finnair 2162
APP	FIN2162	16.45.10	Finnair 2162 turn left heading 360, maintain 80 when reaching
FIN2162	APP		Left heading 360, maintaining 80, Finnair 2162
APP	FIN2162	16.47.00	2162 turn left heading 330
FIN2162	APP		Left heading 330 and we got TCAS warning from a traffic 500 feet below a few minutes ago



Copy of FDR express- analysis - take-off , AFL-204 flight, IL-62, Reg.№ 86532, 15.12.2000
Signed by engineer of Flight Data analysis unit Tchekalov V.

APPENDIX 4

APPENDIX 4

Report of Flight data analysis unit
AFL-204, 15.12.2000
A/p Helsinki

Flight AFL 204 , IL-62M, Reg. № 86532, 15.12.00 performed take-off in the Helsinki airport at 04.11 (Z) from RWY 22.

At 250 ft the right turn was performed to the heading 278° in accordance with the SID with climbing and maintaing 4000 ft during 55 sec. At that height the flaps were retracted in two stages from 30° to 0°. There are no any remarks on maintaining the speeds.
The pressure 1013 mb was set at the transition level 5100ft (1700 m.).

At 04 hours 13 min. the crew began climbing and at 04 hours 13 min 40 sec. took FL 70 (2050m). For 03 min. 25 sec. that height was maintained in accordance with the SID procedure. At 04 hours 17 min. 05 sec. the crew started further climbing.

The Flight data analysis unit has no any remarks on performing SID procedure.

18/01/2001 A. CHEKALOV