Incident report

C34/1997 L

Translation of the Finnish original report

Incorrect fuel calculation of a German aircraft required special traffic arrangements at Helsinki-Vantaa airport

CL-600 Regional Jet

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SYNOPSIS

A scheduled flight of Lufthansa Cityline from Munich to Helsinki asked for traffic priority and requested runway 04 for landing instead of runway 22, which was currently in use. The reason for the request was low fuel. However, the fuel quantity actually meant was that required for proceeding to an alternate aerodrome (alternate fuel) and for holding (final reserve fuel). The aircraft was assigned runway 15 for landing. Because of a misunderstanding, ATC filed an incident report. The Finnish Accident Investigation Board decided to investigate the case. The task was assigned to airline pilot Mr. Martin Blomqvist and flight instructor Mr. Tarmo Kulmala.

1 FACTUAL INFORMATION

The Canadair Regional Jet aircraft departed for Deutsche Lufthansa flight DLH-5204 from Munich to Helsinki on December 17, 1997. At the initial stage of the flight the pilots noticed that, as a result of incorrect fuel calculations and a refuelling order based on them, the fuel quantity was too low. Therefore they had to make new in-flight calculations to determine if there was enough fuel to proceed to Helsinki with the required reserve fuel, or if they would have to make a refuelling stop. The pilots calculated that the fuel would be sufficient if they could make a radar approach to runway 04 without having to fly the arrival and initial approach procedures required for runway 22. They concluded that even a radar-controlled ILS approach to runway 22 would not be possible, unless the flight was given priority handling. Other preconditions for a successful landing were that the actual effect of wind at cruising altitude would be the same as originally estimated, the remainder of the flight would be flown with more fuel-economic speeds than the usual en-route flight speed, and that an optimal descent profile would be used in Helsinki. The fuel reserve required to be remaining on landing at the destination, consisting of alternate fuel and final reserve fuel, could be reduced by changing the destination alternate from Turku to Tallinn.

An hour before landing at Helsinki, DLH-5204 asked Stockholm area control centre (ESOS) for weather information at Turku (EFTU) and Tallinn (EETN). The inquiry was relayed from Stockholm to Tampere area control centre, which gave the current METAR report immediately. After a few minutes, Stockholm centre requested the forecast for Turku on behalf of DLH-5204. The forecast could not be given at once and after a while Turku METAR was transmitted again to Stockholm. The Stockholm centre then handed the aircraft over to Tampere area control centre, so that it could receive the weather information directly.

When DLH-5204 contacted Tampere area control centre (ACC), it was above the Baltic Sea at a distance of about 70 NM from the reporting point KOSKA, at FL330. ACC cleared the aircraft for arrival by the route ETTAN 1 Tango immediately after acknowledging the initial call. The crew then requested weather information for Helsinki-Vantaa, and within the next minute ACC gave the METAR report for Helsinki. Turku or Tallinn fore casts were no longer requested.

Based on the arrival clearance, the pilots judged the remaining distance to be flown en-route and during the approach to Helsinki. Arrival route ETTAN 1 Tango with possible radar vectoring for an ILS approach to runway 22 over the south and east of Helsinki was too long considering the remaining fuel. Weather information showed that runway 04 could be used, and the crew requested this immediately from ACC, but did not explain the reason. ACC replied that runway 22 was in use. The crew continued flying towards Helsinki at FL330 on the route KOSKA - ETTAN.

After 23 minutes, at 23.04, the crew considered it imperative to make a decision about the rest of the flight. The aircraft was then at approximately 75 NM from Helsinki. The captain contacted ACC and asked again if it would be possible to use runway 04. This

time he justified his request by saying that the fuel was low. He specified that the fuel shortage was about 100 kg from the required destination fuel ("Out of dest fuel").

The ACC controller immediately informed Helsinki of the request for using runway 04 and stated "low fuel' as the reason. The traffic coordinator (controller at COR work station) of Helsinki-Vantaa approach control (APP) refused to accept the request because of the traffic situation. As alternative solutions he suggested diversion to an alternate aerodrome or the use of runway 15.

Within the next minute ACC reported to DLH-5204 that runway 04 was not available, but runway 15 could possibly be used.

To ensure that the fuel reserves would not be further depleted during approach and landing, the crew asked for traffic priority. ACC relayed the information about the intended use of runway 15 and priority request to Helsinki COR, who confirmed that he would allow an approach to runway 15 with priority over other traffic. However, DLH-5204 was not advised that priority had been granted.

At 23.06 the aircraft started to descend for approach. It was then at 62 NM from Helsinki and reported soon reaching the reporting point ETTAN. ACC handed the aircraft over to COR frequency 119.10 MHz.

At 23.08 the approach controller asked the aerodrome control tower (TWR) to alert rescue services because of the low fuel situation of DLH-5204.

DLH-5204 contacted COR at 23.09. The controller gave the heading 045^{o}, cleared the aircraft to continue descent to FL 80 and told the crew to expect radar vectoring for an ILS approach to runway 15. The aircraft was also exempted from the usual speed restrictions.

During radar vectoring, the controller reported the remaining distance and asked whether it would be sufficient for the descent, which the crew confirmed. At 23.18 the radar controller gave the heading for intercepting the ILS and issued an approach clearance to runway 15. At 23.19 the crew reported following the approach procedure. When the aircraft was at 7 NM from touchdown point, the controller had to instruct it to reduce speed because of traffic on intersecting runway.

The aircraft was handed over to TWR frequency for landing when it was approximately at 4.5 NM final. Landing clearance was issued a little later, after the intersecting runway was vacated. Wind information was 260 degrees, 12 kt.

At the same time TWR informed the COR that rescue services had been alerted and were on standby as required in local aerodrome regulations. Approach controller notified the TWR that the APP supervisor had asked the captain of DLH-5204 to contact him.

According to the TWR log, DLH-5204 landed uneventfully on runway 15 at 23.23 and rescue services were called off.

The captain called the supervisor at 23.47 as requested. During the conversation, the supervisor tried to find out more about the fuel situation during the flight and on landing. The captain stated several times that the fuel amount had been about 50 kg above that required for landing, using expressions "above our destination fuel" and "above our diversion fuel, normal diversion fuel". The supervisor, however, thought that the stated amount was the total fuel remaining. This misunderstanding appeared in the incident report, ATS watch logs and alerting forms. Otherwise the conversation was about the reasons for the fuel situation and why the use of runway 04 had been denied.

The controller who was working at the COR station at the time of the occurrence made an incident report upon the supervisor's suggestion. Entries in the ATS watch log and alerting forms had been signed by the supervisor, although some were written by the COR controller. An internal PHI report ("occurrence and observation report"), dated December 18, 1997, had been signed by the Chief of ATC.

1.1 Basic information

1.1.1 Aircraft

The aircraft was a twin-engined Canadian CL-600 Regional Jet, Series 100.

1.1.2 Type of operation

The flight was a scheduled flight from Munich to Helsinki operated by Lufthansa CityLine GmbH.

1.1.3 Injuries to persons

There were no injuries.

1.1.4 Aircraft occupants

There were four crew members and 42 passengers on board. The captain and first officer were male, aged 37 and 27 respectively.

1.1.5 Air traffic control staff, Helsinki-Vantaa APP

The approach controller (COR) was male, 50 years of age. The supervisor was also male, aged 51. Both controllers had valid licenses and ratings for their duties.

1.1.6 Weather at Helsinki-Vantaa

TAF for the period 20-05 LMT: 260^{o}/10 KT, 8000 OVC005 TEMPO 1801 3000 BR OVC003 BECMG 0103 9999 BKNO12=

METAR at 22.50 LMT: 260°/10 KT, 240V300 4500 –DZ BR OVC004 01/01 Q1021 TEMPO 5000 RMK 2219//69=

METAR at 23.20 LMT: 260°/11 KT, 6000 –DZ OVC004 01/01 Q1020 TEMPO 8000 RMK 2219//69=

The self-recording anemometer at Helsinki-Vantaa airport showed that during the hour before DLH-5204 landing, surface wind speed had been slowly increasing from 7 kt to about 10 kt. Towards the time of landing wind speed was still increasing, the peak value of 19 kt being reached soon before the landing. However, mean wind speed did not exceed 12 kt during the whole hour.

1.1.7 Aids to navigation

All navigational aids located at Helsinki-Vantaa aerodrome and Terminal Control Area according to the Aeronautical Information Publication (AIP) were in operation. The aircraft mainly used DVOR/DME HEL, PSR/SSR radar system and runway 15 ILS.

1.1.8 Radio communications and telephone conversations

Radio communications and telephone recordings with relevance to the occurrence were read out.

1.1.9 Aerodrome information

The coordinates of Helsinki-Vantaa airport are 60°19'01" N and 024°57'59" E. Elevation is 167 ft (51 m).

Runway characteristics:
Runway 04/22 is 3440 m long and 60 m wide, runway 15/33 is 2900 m long and 60 m wide.

Due to wind conditions and noise abatement procedures, runway 22 was in use, though some take-offs were also conducted from runway 33. DLH-5204 landed on runway 15.

1.1.10 Flight recorders

Flight data and cockpit voice recordings were not read out.

1.1.11 Rescue services

Rescue services were alerted by Helsinki-Vantaa TWR as instructed by the COR. In addition to aerodrome rescue services, the Regional Emergency Center (REC) alerted five rescue units from the town of Vantaa, one from Espoo, and Kerava REC was also alerted. Five ambulances were called. There were 19 rescue units and 12 medical units in all.

1.1.12 Tests and research

As described in part 2, Analysis, the investigation was mainly focused on:
- DLH-5204 flight planning and fuel management;
- advising ATC of fuel problems and use of related expressions;
- transmission of information between ATS units; traffic priority; and
- reporting and subsequent handling of the occurrence.

1.1.13 Organizational and management information

The Analysis part contains the investigators' views on the following organizational and management issues:
- supervisor's duties as ATC foreman;
- refresher training and documentation of working procedures;
- instructions and working procedures of alerting services;
- incident handling process of the Finnish CAA.

2 ANALYSIS

According to the Canadair Jet group chief of the company, the first officer and dispatcher had made and checked the fuel calculations during flight preparation and asked the refueller to fill the tanks to 3600 kg. The group chief told that both pilots had checked the calculations. The procedure was in accordance with instructions in the company Flight Operations Manual (FOM) on fuel calculations and their checking.

The calculations had resulted in correct fuel quantities for the planned flight to Helsinki (Trip Fuel), possible diversion (Alternate Fuel), holding (Final Reserve Fuel) and unexpected situations (Contingency Fuel), which was 5% of the trip fuel. The sum of the above was 3910 kg. Trip fuel had been calculated using the longest departure route that could be expected and arrival route Nakki 1 S in Helsinki. The mean headwind component was determined to be 17 kt.

Extra Fuel needed was 590 kg, which was equivalent to 30 minutes flight time at cruising level. The fuel at take-off would actually have been 4500 kg, but due to a miscalculation the result obtained was 3500 kg. The taxi fuel of 100 kg was then added to that amount. This produced the result 3600 kg, which was given to the refueller.

The flight planning section of the FOM specified that take-off should not be commenced unless the aircraft had been refuelled with a sufficient amount of fuel for the expected operating conditions, consisting of:

1) Trip Fuel to complete the planned flight safely; and
2) Reserve Fuel, including:
   - Contingency Fuel, which was 5% of Trip Fuel,
   - Alternate Fuel,
   - Final Reserve Fuel, required to fly for 30 minutes at holding speed at 1500 ft above the alternate aerodrome in standard temperature. The constant amount of 400 kg was used in the calculations.

In addition, Extra Fuel could be used to account for unforeseeable factors, such as deviations from planned routes, levelling fuel price differences etc. The quantity was at the pilot-in-command's discretion. Extra fuel is also a necessary reserve, for example when the route must be flown at a lower altitude than planned or the headwind is stronger than calculated.

The dispatcher had made the computerised OFP, including the fuel calculations, already in the morning. The dispatcher and first officer reprinted it at about 20.20 with updated wind forecasts (18 UTC) and loading information. The calculation contained the following fuel quantities:

-Trip fuel 2900 kg,	equivalent flight time 2 h 37 min
-Contingency Fuel 150 kg,	flight time 8 min
-Alternate Fuel 460 kg,	flight time 27 min
-Final Reserve Fuel 400 kg,	flight time 30 min

The minimum fuel at take-off calculated by the program was 3910 kg, which corresponded to 3 h 42 min flight time.

The print-out also had a column for the reserve by the PIC for expected deviations (Extra Fuel), to be completed manually. In this column they entered a “rounded" sum of 590 kg, which was equivalent to about 30 min flight time. This would have resulted in a minimum take-off fuel (MIN. TOF) of 4500 kg. However, there was a miscalculation in the hand-written column, and the result obtained was only **3500 kg.** The computer-printed quantity of 100 kg for taxi fuel was added to this number, which gave 3600 kg as the required fuel quantity before start-up. The correct minimum fuel with the above mentioned planning criteria would have been 4010 kg. Consequently, the amount refuelled was 410 kg smaller than the required minimum fuel.

Extra Fuel is intended as a reserve above the mandatory planning minimum, determined by the pilot-in-command on the basis of his experience. Its purpose is to ensure that the fuel quantity does not fall below the required Alternate Fuel and Final Reserve Fuel during the en-route phase or when flying arrival and approach procedures for the destination aerodrome. In practice, this reserve is usually increased by OFP calculations based on longest possible departure and arrival procedures and preferential runways.

In the OFP print-out of the calculation program used by the operator, there is a column on the right side of the route description, in which the minimum fuel that should be remaining and available at each waypoint is calculated in hundreds of kilograms for in-flight fuel management purposes. In that column, the minimum fuel remaining and available at waypoint ANKER, 6 minutes after takeoff, had been recorded as 3.7 (3700 kg). Therefore, if the columns BLK, FUEL, MINTOF and MIN AVLB at the bottom of the OFP form had been cross-checked, the miscalculation would have been noticed.

The group chief told that both pilots had checked the fuel quantity before engine start and found that it was 3700 kg, which seemed acceptable according to the calculation. Inaccuracies in fuel meter readings and delays in closing fuel valves may have caused that the amount actually refuelled was 3700 kg instead of the ordered 3600 kg. The flight was thus commenced with fuel quantity about 310 kg below the acceptable minimum.

The fuel reserved for start-up, taxiing and waiting for take-off clearance was probably consumed in full, since the ground operations took 12 minutes according to the OFP entries. Departure route ANKER 2 Q used by the aircraft was about 10 nm (roughly 2 min at cruising speed) shorter than ANKER 2 N, on which the calculations were based. This saved about 40 kg of fuel.

From Anker the aircraft followed airway W31/UW31 to Klasdorf, south of Berlin, and then UW 815 to Alma in southern Sweden. Thereafter the flight continued almost straight to reporting point Koska above the Baltic Sea at the boundary of Tampere Flight Information Region (FIR), and further to Ettan and Helsinki.

The pilots noticed the fuel problem at some point after reaching the cruising level, but decided to continue towards Helsinki. The decision was logical, since the alternate

aerodrome was also situated in the same direction. As the flight went on, the pilots obtained weather information for the destination and alternate aerodromes and made revised fuel calculations, on the basis of which they made the final decision to proceed to Helsinki. The airline company or air navigation services were not advised of the problem at this stage. The fuel amount was still 270 kg below the required minimum.

According to the FOM, the company must be informed if the actual fuel amount is below that required in the instructions. It seems that the pilots did not make this report. Fuel was saved by using Long Range Cruise (LRC), a power range with lower speed and fuel consumption. Tampere Area Control Centre SSR recordings showed that, considering the actual wind conditions, the aircraft flew about 30 - 40 kt slower than its normal cruising speed at least from Visby onwards. Another fuel saving method was to maintain cruising altitude close to Helsinki and minimize fuel consumption during approach. Both air traffic controllers interviewed confirmed that the aircraft had maintained cruising altitude closer to the airport than usual.

The ATO (actual time over waypoint) column of the OFP had not been completed during flight. When comparing the actual flight time with OFP calculations, however, it appears that the ETO (estimated time over waypoint) times were sufficiently accurate as such, since the entire flight time was only 2 minutes longer than the calculated time from departure until reaching Helsinki DVOR/DME and heading for arrival route NAKKI 1 S. Thus the speed reduction did not have considerable, effect on flight duration, and wind conditions did not adversely affect the flight or contribute to the fuel problem. According to the investigators' estimate, the fuel saving procedures used during en-route phase and the favourable conditions saved about 150 kg of fuel. The shortage was approximately 120 kg.

There were four preselected alternate aerodromes in the OFP, but the one used in flight planning and fuel calculations was Turku. However, the weather information obtained before flight and en-route made it possible to change the alternate, which was also permitted by FOM paragraph "Change of Alternate When Approaching Destination Aerodrome". Therefore, in the prevailing weather conditions, half of the fuel deficiency was covered by selecting Tallinn as the alternate aerodrome.

Weather information for EETN was not included in the flight preparation material, and it seems that Tallinn was not one of the preselected alternate aerodromes. The decision to change was probably based on the actual weather information for EETN, received from Tampere ACC via ESOS. Helsinki-Volmet was also available later on.

The OFP route crossed over DVOR/DME HEL to arrival route NAKKI 1 S and further to the approach procedure for runway 15, which had been reported as the primary runway for landings in Helsinki. The calculated distance for this was 47 nm. If the approach could be made directly to runway 04, this part would be left out and the en-route phase shortened. The time saved would be 6.5 minutes and fuel amount about 120 kg.

At Helsinki-Vantaa, flights were usually radar vectored to the final approach segment, and it was reasonable to expect this again. The only question was whether runway 04 could be used. If it was available, the problem would be solved and the fuel remaining for landing would be about 60 kg above the minimum reserve.

The result of the calculation met the requirements of FOM sub-paragraph ”In-Flight Monitoring of the Fuel Situation". The decision to continue flight was in accordance with FOM paragraph "Precautions in the Event of a Foreseen Fuel Shortage", particularly since it also improved the chances of using alternate aerodromes, except for Stockholm.

Documentation required by paragraph "Range Control" was not found in the OFP, and the revised calculations had not been made in the OFP columns reserved for this purpose. However, the calculations had been hand-written on a print-out containing weather forecasts and meteorological information obtained during flight. The exact time of the revised calculations cannot be concluded from these markings or from the OFP.

The OFP also lacked other in-flight entries which, according to the group chief, should have been made. These included e.g. altitude clearances not pre-printed on the OFP and instructions for contacting ATC units.

The aircraft contacted Tampere ACC at 22.42 when flying at FL330 about 70 nm from KOSKA reporting point. It was cleared for standard instrument arrival (STAR) by the route ETTAN 1 TANGO. With the racetrack pattern at PORVOO VOR, this would have been about 56 nm (104 km) longer than a direct ILS approach to runway 04. This corresponded to 9 minutes flight time and approximately 150 kg of fuel. The procedure would be too long and the fuel reserve would fall about 90 kg below the acceptable minimum. Radar vectoring via the south and east of Helsinki to runway 22 would also require too much time and fuel, since even the reserve for runway 04 was only around 60 kg or 3.5 minutes flight time.

The crew asked and received the current weather report for Helsinki. Immediately thereafter they requested runway 04 for landing, without justifying the request, but ACC advised them that only runway 22 was in use.

ACC did not discuss with APP about this unjustified request for using other than the primary runway. The reply given to the crew was in compliance with the Letter of Agreement, which states that APP informs ACC of the runway in use based on prevailing conditions and specific procedures, such as noise abatement procedures, and any deviations from this practice must be justified.

At that point, if the flight was continued according to the clearance and accepted routing, the crew could not be sure whether there would be enough fuel to fly the rest of the flight and, if necessary, divert to an alternate aerodrome with the required fuel reserves. Nevertheless, the flight was still in compliance with the FOM, as the alternate aerodrome was in the same direction and Alternate Fuel or Final Reserve Fuel was not yet being used.

At 23.04 near ETTAN, about 75 nm from Helsinki, the crew requested again runway 04 for landing. This time they justified the request by fuel problems, explaining that their fuel was about 100 kg below destination fuel ("out of dest fuel"). The crew intended this to mean the fuel amount remaining if the cleared arrival route and subsequent approach, or a radar vectored ILS approach to runway 22, would be flown.

Now the DLH-5204 crew had to receive ATC acceptance for a quick and straight approach to Helsinki before leaving en-route flight level, or otherwise request clearance for the alternate aerodrome at Tallinn.

ACC relayed the request to APP, but the controller firmly denied the use of runway 04 and recommended diversion to alternate aerodrome. When requested again, the approach controller accepted that runway 15 could be used, justifying his decision by wind speed and direction as well as the large number of flights (both departing and arriving) under his responsibility. After new calculations and some reflection, the crew accepted to use runway 15, as that would make the distance only about 10 nm longer and take 2 minutes more time than using runway 04.

With these arrangements, the fuel was sufficient. At 63 nm from Helsinki the aircraft started to descend for approach. As a precaution, the captain asked for priority handling by saying "and we request for priority". ACC relayed this request to APP, which promised on the telephone that the flight would be number one in traffic. However, this information was not relayed back to the aircraft.

It is possible that the pilots, from their earlier experience, knew that traffic density in Helsinki at the time of arrival would be high. Therefore they wanted to be cautious when estimating any delays caused by other traffic, which would increase the flight time and distance under radar vectoring.

In addition, requesting priority handling before leaving en-route flight level was more in the spirit of FOM fuel policy, and a safer alternative than just counting on there being no further delays. Nevertheless, if delays had been encountered, the crew could still have applied FOM paragraph ”Fuel Management Approaching Destination Aerodrome", which gives the options of diverting to the alternate aerodrome from a lower altitude or requesting a definite approach time from ATC.

The crew had been aware of the fuel situation for a long time. Already when they first requested runway 04 for landing at 22.42, the crew certainly knew that there would not be any extra fuel reserves available. The investigators cannot see why they did not justify the request at that time, unless the fact that it is not expressly required by the instructions is accepted as a reason.

Nevertheless, any request for priority must be justified when an ATC unit so requires. Priority handling was only requested after APP had accepted a radar vectored approach to runway 15, and the given reason was low fuel. Despite the fact that the priority re quest came rather late, ATC seems to have implemented it without difficulty. The aircraft

landed only 19 minutes after the request and 16 minutes after the completion of telephone and radio conversations about the traffic arrangements.

The investigators see that correct information about the fuel situation should have been provided at an earlier stage, so that ATC would have had more time to handle the situation. On the other hand, the controller should have tried to find out more about the actual fuel amount, which would have enabled the controller and the pilots to establish that fuel was low but would be sufficient on certain conditions.

During the telephone conversation, ACC controller used the expression "low fuel" without explaining the fuel situation in more detail. APP did not know what the actual fuel amount in kilograms or litres was and how long it would last in minutes. APP did not ask this at a later stage either, since the crew had already accepted to use runway 15 and the flight was being radar vectored for approach.

It was justified for the crew of DLH-5204 to assume that APP was clearly aware of the fuel remaining and that the quantity had been transmitted to APP as they had reported it to ACC.

When interviewed, the approach controller told that he had not understood the "low fuel" statement and request for priority, when expressed in that way and at that stage, as being so urgent that it would have required the use of runway 04 under the prevailing conditions. He also said that he had not seen the aircraft on his radar display at the time of the telephone call, and had assumed it being farther away. Therefore he first recommended using the alternate aerodrome. However, when he saw that the aircraft was soon about to enter the Terminal Control Area (TMA), he suggested the use of runway 15 as an option during the same telephone conversation.

Both during the interview and in the written statement given before it, the controller stated that in his opinion, a request for priority does not indicate such a serious fuel problem that it would justify passing over other traffic or accepting exceptional runway changes. Only the use of expressions such as Emergency Landing or Fuel Emergency would necessitate absolute priority. He also told that the controllers do not know the exact meanings of expressions used by aircraft crews when referring to different fuel amounts and minimums (Destination Fuel, Diversion Fuel, Holding Fuel etc.), and there are not any standard phrases intended for the use of controllers when talking about fuel amounts or shortages. Neither of the controllers had actually encountered the expression "Fuel Emergency" before this investigation, but they believed that the use of the word ’emergency’ would make the expression clear enough and justify traffic priority, as well as using other than the usual runway for landing. The Aviation Radiotelephony Manual (Ilmailun radiopuhelinliikenne) and National Manual of ATC Instructions (Lennonjohtajan käsikirja) published by the Finnish CAA do not contain any phraseology intended for this purpose, nor does ICAO Doc 4444.

On the other hand, controllers cannot be reasonably expected to know the exact meanings of fuel terminology used by different operators in their Flight Operations Manuals, since the same or nearly the same concept can be expressed by a different term or the

same term can be understood in various ways by different operators. One example is the terminology used to describe the fuel reserved for possible diversion to an alternate aerodrome: Lufthansa CityLine uses the words "Alternate Fuel", whereas e.g. Finnair uses ”Diversion Fuel”. Besides the term itself, the methods of calculation differ significantly.

The investigators see that although the situation had to be handled quickly and other traffic caused additional pressure, Helsinki approach controllers should have questioned the crew about the nature of the fuel problem. They should have tried to find out the fuel amount expected to be remaining at destination and the approximate flight time for which the fuel would suffice. The fuel amount should have been reported to rescue services, and the information about remaining flight time would have facilitated the controllers' own work. On the other hand, if the controller had informed the crew of traffic priority and questioned them in more detail, he would probably have found out that with these arrangements, any fuel problem would not exist. Therefore it would have become clear that there was no need to alert rescue services, and the misunderstanding in subsequent handling of the occurrence would have been avoided.

The approach controller did not regard the situation as a distress or urgency, and tried to find a flexible solution that would consider the traffic situation as a whole and be in compliance with local instructions. However, he saw that the ”low fuel" situation mentioned in the alerting instructions required some action.

Both in the incident report, written statement and during interviews, the controllers justified denying the use of runway 04 also by many practical reasons, one of which was inconvenience caused to other traffic.

During the period between the priority request at 23.06 and landing of DLH-5204 at 23.23 (17 minutes), 6 aircraft landed at Helsinki on runway 22, the last of them only a little over 1 min before DLH-5204. In the prevailing weather conditions, non-precision approach procedures could not be used for either runway. In Helsinki the ILS LLZ transmitters for runways 04 and 22 cannot be in operation simultaneously, and the use of runway 04 would have required switching runway 22 ILS off and that of 04 on at about 23.13. Before this, all aircraft approaching runway 22 should have landed. The last of them could have entered the final approach segment at approximately 23.10 in order to land before the change, and at least FIN-814 and FIN-834 should have been issued an alternative missed approach clearance to somewhere other than directly to ESPOO. The approach of BCS-6524, KFB-8830 and FIN-918 should have been discontinued and they should have been instructed to hold at KORSO, from where the first aircraft could have started approach at about 23.22, after the ILS system would have been switched back. It would have landed at about 23.28. Extended radar vectoring routes or PORVOO and NAKKI holdings should have been used for three more aircraft. The traffic arrangements would have delayed 8 approaching flights and, consequently, 2 departing flights.

Simultaneous operability of runway 04 and 22 ILS systems was tested. The test confirmed that both systems could not be in operation at the same time without causing interference to each other, and so the switch-over would have been necessary. The con-

troller also saw that runway 04 ILS should have been available to DLH-5204 at the distance of 25 - 30 nm already, since those aircraft approaching directly from TENHO are about to intercept the localizer at that stage. The investigators based their own calculations on the assumption that the ILS change would not have been needed until DLH-5204 was about 12 - 15 nm from the airport, while radar vectors would have been used until then.

The approach controller at COR work station therefore had only 3 minutes to determine how serious the fuel problem was, how other traffic would be affected if the request was accepted, and what traffic and ATC co-ordination measures would be needed.

At the time of the request, the controller did not see DLH-5204 on his radar display and did not know its exact position. However, he had had an ATC strip for the flight at his disposal for 40 minutes already, and it contained the aircraft's estimated time of arrival at the TMA limit. He could have quickly checked this time and calculated the approximate time of arrival at Helsinki, which would have enabled him to estimate the traffic situation at the time of approach with sufficient accuracy. On the other hand, he told first having thought that the plane was still farther away, somewhere near Stockholm.

The decision seems simple and logical, as all aircraft flying ahead were already approaching the airport along their planned radar routes, and DLH-5204 was approaching the intersecting runway in its turn. This made the distance only 9 nm longer and, without speed restrictions, required about 2.5 minutes more time. In addition, three flights approaching runway 22 after DLH-5204 were slightly delayed, since they could not be vectored for final approach until 5204 had landed safely. The first of these aircraft landed at 23.28.

The traffic situation as a whole was not quite as busy as indicated in the first report by the ATC. The total number of flights during the hour was 25, of which 15 were inbound and 10 outbound. Considering the traffic density, it was a mere coincidence that 5 of the 8 flights approaching the airport before 5204 during the same hour were about to execute an approach to runway 22 just within the same 9 minutes in which DLH-5204 would have wanted to use the opposite runway and its ILS system.

Another reason for denying the use of runway 04 was strong wind. In his written statement, the COR controller recalled that surface wind had been "from west and the peaks about 16 - 18 knots". His recollection was quite correct. During the previous hour and shortly before the occurrence, wind speed had been constantly increasing. When the decision was made, short interval wind was about 16 kt and near the landing time momentarily even 19 kt. However, mean wind speed did not exceed 12 kt and wind direction was 260^{o}. Therefore the wind component for runway 04 would not have been a major hindrance to landing. According to the wind information given by Helsinki TWR to the other 8 aircraft landing around the same time, surface wind was from 260 - 270 degrees, 10 - 12 knots, which indicates that the mean tailwind component at surface level would not have exceeded 8 knots.

The controller told in his written statement that ”upper wind at 1000 ft was also such that it was not wise to use runway 04 in particular but also runway 15". In principle it was absolutely correct to consider other wind conditions besides the surface wind when making the decision about runway use, but the wind information was not up-to-date. At 23.20, when DLH-5204 was about to enter the final approach segment for runway 15, the upper wind at 1000 ft measured within the previous 10 minutes at Kivenlahti, which was the measuring point nearest to Helsinki-Vantaa, had been 15 m/s (about 29 kt) from 260^{o} and speed only about 16 kt.

The upper wind speed at 1000 ft had increased to the above values within the preceding 10-minute period from 12 kt. The controllers were not aware of this, since they did not have continuous upper wind speed indication available. Upper wind information could be seen on a TV screen, updated by meteo at three-hour intervals. The same page showed wind information at 2000 ft and on FL50 and FL100. The page must be selected using shortcut keys or by the menu page. Where necessary, current upper wind information could be obtained from the meteo by telephone.

According to the controllers, the third reason for denying the use of runway 04 were the noise abatement regulations at Helsinki-Vantaa. Instructions on preferential runways are given in AIP section EFHK AD 2.2.2, Noise Abatement Procedures. The instructions were clarified for the controllers by a bulletin issued by the Chief of Helsinki ATC on 10 November 1997 (LPOM 36/97). The bulletin states that in the night-time (for jet traffic at 22-07 LMT), instructions on noise-preferential runway allocation must always be followed as far as safety considerations permit. The other controller said during the interview that noise abatement regulations had been given so much priority that "they even seem to override safety regulations in a way... because it is said everywhere 'when permitted by noise regulations". However, the investigators regard this as an individual opinion only, since any available oral or written noise abatement instructions do not support the view that they would have been attached so much importance.

The ANS priority system - classification of arriving aircraft in the order of priority – seemed to be clear for the controllers. They saw that aircraft in a distress or urgency situation would have absolute priority, and after them would come the other privileged traffic, such as air ambulance, search and rescue flights etc, which were considered equal to each other. All other requests for priority could be interpreted in different ways. They were often mainly based on internal arrangements of the airline, such as the need to land before others to ensure connecting flights for passengers, and did not have flight safety significance. The controllers saw that this kind of priority requests should not be favoured, since it is not justified by ATC instructions. The controllers mentioned cases similar to that under investigation, coming up from time to time, where flights inbound from south contact Helsinki ATC already when above the Baltic states, Poland or even Germany to inquire about expected holding, explaining that their fuel is low. After this they count on being allowed a straight approach, since ATC is aware of their situation. A common reason for this is to avoid costs of an intermediate fuel stop. The difficulty is that different airlines should be treated equally, and it is not desirable for it to become common knowledge that a quick approach to Helsinki can be ensured by asking for pri-

ority because of low fuel reserves. The situation seems not uncommon, since the controller commented on the action taken and decision made by saying "To my mind, it was quite normal in a case like this".

DLH-5204 passed at least three aircraft that would have preceded it in the approach sequence. The investigators find it appropriate that an aircraft requesting priority because of low fuel was given priority and allowed a quick approach. In fact, unexpected delays could have been met on the final section of the flight (missed approach, wind shear, obstructions on runway), in which case the fuel situation would have left no other option than to land at the originally planned destination aerodrome.

On January 25, 1990, an Avianca (Aerovias Nacionales de Colombia SA) Boeing 707-321 B airliner crashed 25 km north of JFK airport in New York, USA, after running out of fuel. The aircraft had exhausted its alternate fuel when holding for 1 hour 17 minutes and then having to reject the approach because of strong headwind and wind shear. Due to language problems and misunderstandings, ATC did not realise the catastrophic fuel situation of the aircraft. The crew replied the controller's inquiry about fuel status, but used such expressions that the controller believed the fuel to be sufficient.

The common factor for these two cases is that both indicate there not being any mutually understandable, unambiguous way between ATC units and operators, who use different terminology in their FOMs, to describe the fuel situation. In the case under investigation, information on fuel amount was not transmitted from ACC in the same way as the pilot had intended, probably because the controller did not understand the meaning of the expression.

Based on the information received from ACC by telephone, the approach controller asked the TWR controller to alert rescue services at 23.08, which was one minute before DLH-5204 switched over to APP frequency. Rescue services were alerted immediately of a danger of aircraft accident and the action taken was recorded, although mainly not until 15 minutes later. The area control centre also recorded the occurrence in ATS Watch Log and on separate forms as required for alert phases. The remaining amount of fuel was registered in both units only after the telephone conversation between the captain of DLH-5204 and APP supervisor.

Within the next four minutes there were telephone conversations to make sure which aircraft was in question and what was the number of persons on board. At 23.13 the TWR controller asked about the fuel amount expected to be remaining at landing. The APP controller did not contact the aircraft to find this out, but gave his own estimate by saying "five hundred maximum cause he's asking for that" (priority).

It was important for the rescue services to know the number of passengers and crew, as well as the amount of fuel remaining. However, the controller saw that the number of aircraft occupants was more important than fuel amount. In his opinion, the remaining fuel would have no importance if the aircraft landed successfully, since there is always fuel left after landing. On the other hand, if it did run out of fuel, the fuel would not cause any hazard during rescue operations. Although this view is somewhat logical, it is not in

accordance with applicable instructions. The possibility that rescue operations would be needed for other reasons than fuel exhaustion should also have been taken into account, and in that case the rescue units would not have been prepared to handle the remaining 860 kg (1050 l) of fuel, since the assumption was that the tanks were empty.

Alerting forms of both ATC units stated ”low fuel” as the reason for the action taken, without specifying the fuel amount or remaining flight time. Alerting regulations in the National Manual of ATC Instructions or the Rescue Services Manual do not make any reference to remaining flight time either. Helsinki controllers told that whenever a low fuel situation is reported, for example using such expressions as in the case now investigated, rescue services will be alerted regardless of the details. At the time of landing, DLH-5204 actually had enough fuel to fly for about 60 minutes, depending on which decisions would have been made.

The investigators see that it could be worth considering to specify the alerting instructions, so that they would require questioning the crew about the fuel expected to be remaining at landing and available flight time, and to alert rescue services only if the fuel would be about to fall below Final Reserve (fuel to hold for 30 min). This would make the alerting threshold same as in the operator's crew instructions in the case under investigation, which require the crew to declare an emergency by radio at that stage.

When the ATC supervisor was interviewed, he told that he had initially not even known about the priority request and low fuel, but had only understood that the crew asked runway 04 for landing. The controllers could not hear each others communications, because they used headsets. Only after the supervisor learned that rescue services had been alerted, he could reduce his own communications and monitor the situation better. According to the radio communications recording, the supervisor’s own radio traffic was rather busy during the period from 23.08 to 23.16.

At 23.17 the supervisors attention was drawn away from ATC work and alerting services for two minutes because of administrative duties. According to the staff regulations in force, the ATC supervisor acts as a substitute for the Airport Manager outside office hours. In this capacity, he had a telephone conversation with airport security and access control officer about the access of one of his colleagues and accompanying visitors to restricted airport areas.

In the investigators' opinion, it would have been impossible for the supervisor to perform his supervisory duties and co-ordinate alerting and rescue services as required by staff regulations, while he was working at ARR work station. Moreover, his capacity was restricted by issues completely irrelevant to air navigation services. As the supervisors' duties at Helsinki-Vantaa ATC have been brought out earlier in several investigations, a new safety recommendation is not issued in this matter. Instead, the investigators refer to e.g. Incident Report No 2/1993, recommendation 3 (Improvement of supervision of ATC operations) and Incident Report No B 8/1997 L, recommendation 4 (Amendment of normative documents governing daily work). It is particularly important that the supervisor's resources are directed to supervisory duties and co-ordination, and he should be able to concentrate exclusively on ATC-related functions.

As DLH-5204 was approaching runway 15, the supervisor requested the other controller to ask the captain to contact him. The captain called after landing at 23.47. During the conversation, the supervisor asked for more information about the situation and the captain told several times that the fuel amount after landing had been about 50 kg above the required minimum. However, the supervisor understood this to mean the total amount of fuel remaining. The captain explained that the fuel problem had been caused by adverse wind and low flight level used, but also described briefly the miscalculation made during flight preparation. The supervisor, in his turn, explained why the use of runway 04 had been denied, referring to the traffic situation and ATC capacity. He also informed the captain that an incident report would be made.

As a result of the misunderstanding, the incorrect information that there had been only 50 kg fuel left was entered in the incident report, as well as in ATS Watch Logs and alerting forms at both APP and ACC.

All parts of the recorded telephone conversation were not clear due to background noise and other disturbance. As far as the conversation could be clearly heard, the investigators do not consider it fully appropriate. The investigators are of the opinion that this kind of speculation immediately after the incident between two persons involved is not at all necessary. In this case the conversation caused the misunderstanding that affected the handling of the incident for some time.

The controllers could have submitted the reports, as far as considered necessary and required, to the management and aviation authorities without any settlement between the persons involved. These "negotiations" have been earlier criticised at least in Incident Reports No B 4/1996 L and 2/1993, though the reasons for the criticism were different in each individual case.

According to the instructions, the occurrence could be reported by four different channels (reporting form in Aviation Regulation GEN M1-4, ATS Watch Log, rescue services alerting forms, or PHI report). The controllers actually used three of these channels. In addition, a PHI report (an internal occurrence report) signed by the Chief of ATC was filed on the next day. Any one of these reports alone would have been sufficient to initiate at least some kind of investigations.

The controllers criticised this multiplicity of reporting channels. They also complained that refresher and complementary training were almost non-existent when new methods were introduced or old practices changed, and although empty forms for different purposes were usually available at work stations, the instructions for completion and use had to be searched from some place farther away. Some reporting instructions, such as the new regulation GEN M1-4, received criticism for being intended to serve for all parties involved in aviation operations at the same time, and therefore being ambiguous and superficial in their content. The form annexed to that regulation had, however, been completed and submitted to the Chief of ATC for further action. When interviewed the controller who had filled in the form told that, due to the multiplicity of reporting forms as well as recent changes made to them and lack of complementary training, he was still not quite sure whether he had acted in accordance with current instructions.

It is actually true that the only instructions not subjected to recent modifications were those contained in the AIP (Aeronautical Information Publication) for reporting near misses or serious air traffic incidents.

The former regulation OPS M1-4 had been changed to GEN M1-4 with slightly modified contents on November 10, 1997. It became effective on December 15, 1997, only two days before the incident under investigation. Instructions about entries to be made in ATC or AFIS Watch Logs had been renewed on 1 July 1997, and a new internal reporting system called "ATS Occurrence and Observation report" (ATS poikkeama- ja havaintoilmoitus, PHI) was introduced on the same date. This system had its own instructions, which also described the report handling and feed-back procedures.

The PHI system received positive comments from the controllers for being an effective channel of information, especially due to wide applicability and feed-back procedures.

The investigators see that the different reporting forms and their use should be co-ordinated so that only one report would be sufficient. If the most "serious" report was made, this would need to cover all other reporting obligations. ATC management should be responsible for distributing the reports and initiating any further actions required.

The most recent instruction, "Incident handling processes at the Finnish CAA", had been introduced on 1 December 1997. At the time of the incident, the controllers remembered having heard the name but were not otherwise familiar with it. This publication describes how an incident report is handled, target schedules for the process, responsibilities of personnel at different levels of organisation, as well as feed-back and debriefing procedures.

Investigators examined the above mentioned instruction and regard it as a useful step towards a quality-oriented approach. In addition, material collected for the initial analysis will be rapidly available for use when making the decision about starting the actual investigation. However, relevant managers should make sure that all original material needed for the investigation is retained as described in Incident Report No 2/1993.

The controllers also wished their refresher training to include information about the changes made since 1995 to the organisation and practices of incident investigation, as well as the use of investigation results. Even though the purpose of investigation and use of results is now explained on the cover of investigation reports, fears and suspicions still exist that the results would also be used to apportion blame or impose punishment.

3 CONCLUSIONS

3.1 Findings

1 When departing for the scheduled flight, the aircraft had less fuel than would have been required.

2. There was an error of 1000 kg in OFP fuel calculations, which was only discovered during flight.

3. The low fuel situation was not caused by technical factors.

4. The crew did not report the low fuel situation when they noticed it, nor did they prepare for a refuelling stop.

5. The pilots ensured that the situation would not develop into an emergency by using fuel saving procedures and in-flight replanning in accordance with the FOM.

6. According to the operator's instructions, Fuel Emergency must only be declared when fuel amount is about to fall below Final Reserve Fuel.

7. The controllers did not find out the real nature of the fuel situation, and therefore could not make the decisions about runway change, priority handling and rescue services based on the actual needs.

8. Information about the fuel amount was not relayed from ACC to APP in the same way as the pilot had intended.

9. The controllers did not ask the actual fuel amount for the purpose of informing rescue services. Only the COR controller's estimate was given on the subject.

10. The fuel amount remaining after landing was in accordance with FOM requirements.

11. The controller made an incident report because he misunderstood the remaining fuel amount.

12. There is no uniform, internationally agreed radio phraseology for expressing different degrees of fuel shortage.

13. Rescue services were alerted in accordance with relevant instructions.

14. The situation involved no danger.

3.2 Cause

The occurrence was caused by a mistake in fuel calculations, resulting in insufficient refuelling, which was only noticed during flight. When the crew reported the situation, the controllers failed to determine the exact nature of the fuel shortage.

4 RECOMMENDATIONS

New safety recommendations are not issued.

Helsinki, 21 October 1998

Martin Blomqvist Tarmo Kulmala

LIST OF REFERENCES

The following reference material is available at the Accident Investigation Board:

1. Incident Report filed by the controller
2. Copies of ATS Watch Logs and entries concerning the alert phase
3. COR controller's initial written report on his actions
4. Radio communications, telephone and radar data recordings
5. Aerodrome characteristics and instructions on preferential runways
6. Chief of ATC's instructions on noise abatement procedures
7. Correspondence related to the investigation
8. Copy of the PHI report
9. Extracts from ANS and alerting instructions in force at the time of the occurrence
10. Weather and wind information
11. SSR maintenance recording
12. Instructions on CAA incident handling procedures