Investigation report

C7/2010L

Airliner fuel system malfunction: incident during an approach to Helsinki-Vantaa aerodrome on 5 July 2010

Translation of the original Finnish report

OH-ATK (FCM256K)

ATR 72-212A

Onnettomuustutkintakeskus
Centralen för undersökning av olyckor
Accident Investigation Board

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SUMMARY

AIRLINER FUEL SYSTEM MALFUNCTION: INCIDENT DURING AN APPROACH TO HELSINKI-VANTAA AERODROME ON 5 JULY 2010

The incident occurred on 5 July 2010 on Finnish Commuter Airlines Oy scheduled flight FCM256K from Kuopio to Helsinki-Vantaa. The aircraft was an ATR 72, registration OH-ATK. There were 18 passengers and four crew members onboard. When the aircraft landed at Helsinki-Vantaa aerodrome its right main fuel tank was almost empty.

Accident Investigation Board of Finland (AIB) classified this occurrence as an incident. On 8 July 2010 it appointed investigation commission C7/2010L for this incident. The investigation revealed that during the pre-flight checks the electrical pump in the left main tank was found to be broken. Nevertheless, it was permissible to fly the flight in accordance with the instructions of the Minimum Equipment List (MEL). The mechanic that was summoned to the aircraft advised the pilots to keep the fuel crossfeed valve open at all times. The pilots took this as a recommendation to keep the cross-feed on during the entire flight. This was an erroneous notion, which the pilots did not double-check from their own MEL.

Due to the fuel system malfunction and the incorrect fuel feed selections both engines received fuel only from the right main tank. The return leg from Kuopio to Helsinki was flown with analogous fuel feed selections. The aircraft was not refuelled in Kuopio. When the aircraft was parked at Helsinki-Vantaa aerodrome the right main tank gauge indicated zero fuel. The occurrence did not result in any injuries to persons or damage to equipment. As a result of the situation an emergency alert was issued at Helsinki-Vantaa.

The investigation also established whether both engines would have flamed out if the right main tank had emptied. According to the aircraft manufacturer's (ATR) comments, in such a case the left main tank would have continued to supply fuel to both engines and they would not have flamed out.

The basic cause of the occurrence was that the pilots failed to complete their MEL and the Dispatch Deviation Guide (DDG) at both Helsinki-Vantaa and Kuopio. Rather, they relied on the mechanic's missunderstood advice.

Another cause was that the pilots did not determine the reason for the fuel imbalance. They calculated that they had enough fuel for the return flight and, subsequently, did not have the aircraft refuelled. The pilots had an inaccurate notion of how the fuel system functioned.

The third cause was that the pilots did not follow the instructions in the abnormal procedures checklists to land as soon as possible when they noticed the impending fuel shortage.

Contributing factors included the pilots' limited experience in their present duties and lacking airmanship, the captain's degraded performance, insufficient Crew Resource Management as

well as the uncomfortable work environment caused by the hot weather and the feeling of haste due to the delayed departure.

The investigation commission issued no safety recommendations.

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ABBREVIATIONS

AIP	Aeronautical Information Publication
AMM	Aircraft Maintenance Manual
APU	Auxiliary Power Unit
ARR-E	Arrival – East
ARR-W	Arrival – West
ATPL	Airline Transport Pilot Licence
ATR	Avions de Transport Régional
BEA	Bureau Enquêtes Accidents
CAVOK	Ceiling and Visibility OK
CB	Circuit Breaker
CBT	Computer Based Training
CPL	Commercial Pilot Licence
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DDG	Dispatch Deviation Guide
DCVR	Digital Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
EASA	European Aviation Safety Agency
FDR	Flight Data Recorder
FL	Flight Level
FFS	Full Flight Simulator
HIL	Hold Item List
hPa	Hectopascal
ICAO	International Civil Aviation Organization
IPC	Illustrated Parts Catalog
JAR	Joint Aviation Requirement
LFC	Line Flying Check
MEL	Minimum Equipment List
MHz	Megahertz
MMEL	Master Minimum Equipment List
NM	Nautical Mile
QAR	Quick Access Recorder
QNH	Altimeter setting
OM-A	Operation Manual – A
OM-B	Operation Manual – B
OPC	Operator’s Proficiency Check (Simulator)
RAD-E	Radar East
RAD-W	Radar West
TMA	Terminal Area
PC	Proficiency Check (Simulator)
TRTO	Type Training Organisation
TWR	Control Tower
UTC	Co-ordinated Universal Time

SYNOPSIS

Already on the outward leg of scheduled flight FCM255K from Helsinki-Vantaa to Kuopio both engines were only receiving fuel from the right main tank. This happened as a result of a fuel system malfunction and flawed fuel feed selections. The return leg from Kuopio to Helsinki (FCM256K) was flown with analogous fuel feed selections; the aircraft was not refuelled in Kuopio. When the aircraft landed at Helsinki-Vantaa aerodrome the right main tank was nearly empty. The occurrence did not result in any injuries to persons or damage to equipment. As a result of the situation an emergency alert was issued at Helsinki-Vantaa.

The pilot-in-command and the persons in charge at the air traffic control filed the appropriate incident reports. Tampere Area Control Centre (ACC) reported the incident to the AIB duty officer.

Accident Investigation Board of Finland classified this occurrence as an incident. On 8 July 2010 it appointed investigation commission C7/2010L for this incident. Investigator Jouko Koskimies was named Investigator-in-Charge, accompanied by Investigators Risto Timgren, Pertti Kalttonen and Kari Kallio serving as members of the commission. AIB sent a notification of the incident to ICAO, EASA and BEA. Pursuant to ICAO Annex 13, BEA appointed an accredited representative of the State of Manufacture to participate in the investigation.

All times in this investigation report are in Coordinated Universal Time (UTC). The course of events was determined through the use of FDR and CVR recordings, the air traffic control's radio and telephone communications recordings, radar recordings as well as by interviewing the parties concerned.

Comments on the draft final report were requested from the parties concerned, the operator, TraFi, Finavia, Finnish Pilot's Association and Keski-Uusimaa Rescue Department as well as from EASA, BEA and ATR. The comments given were received by 11.4.2011.

The investigation was completed on 4.5.2011.

The material used in the investigation is stored at Accident Investigation Board of Finland.

1 FACTUAL INFORMATION

1.1 History of the flight

The incident occurred on 5 July 2010 on Finnish Commuter Airlines Oy scheduled flight FCM256K from Kuopio to Helsinki-Vantaa. The aircraft took off from Kuopio at 16:43 UTC and landed at Helsinki-Vantaa aerodrome at 17:33 UTC. The aircraft was an ATR 72 airliner, registration OH-ATK. There were 18 passengers and four crew members onboard.

The flight crew reported for duty at noon (09:00 UTC) for a round trip to Jyväskylä. After this flight they took a lunch break. The next flight scheduled for this crew was from Helsinki-Vantaa to Kuopio.

When they were preparing for the flight to Kuopio the co-pilot, who was on the flight deck, noticed that the left main fuel tank circuit breaker (CB) had tripped. He informed the captain of this. The CB was pushed in before the engines were started but it popped out again during engine start. Following this the flight crew summoned a duty mechanic to the aircraft to investigate the fault. A certificated mechanic from Finnish Aircraft Maintenance (FAM), responsible for the company's maintenance, came to the aircraft and noticed that the left main tank's electrical fuel pump was out of order.

The mechanic entered the fuel pump fault on the Hold Item List (HIL) and carried out the maintenance procedures that the Minimum Equipment List (MEL) required of him. The investigation concluded that the mechanic recorded the fault on the HIL and carried out the MEL-procedures. The recordings, however, were not as per valid instructions.

The pilots and the mechanic spoke together in English, which was not their mother tongue. During the discussion the mechanic underscored that the fuel crossfeed valve should be open at all times. The pilots asked him to confirm that he really meant this. The pilots remained under the assumption that the mechanic thought that the crossfeed valve should be open during the entire flight. The investigation revealed that the flight crew failed to read the MEL list or the Dispatch Deviation Guide (DDG). This being the case, the crossfeed valve was left open (in line) for the entire flight even though it should have been closed after engine start.

Takeoff was delayed due to the above-mentioned technical fault and air traffic flow management. A heat wave prevailed in southern and central Finland and the sky was nearly cloudless. Temperatures in Helsinki and in Kuopio exceeded heat wave temperatures. In order to generate electricity and provide air conditioning, the flight crew ran the right engine at idle with the prop brake on (hotel mode). According to the flight crew's account the temperature on the flight deck was still remarkably high, which made the working environment uncomfortable.

They took off from Helsinki-Vantaa approximately 1.5 hours later than the original schedule. The flight crew started the engines at 15:17. At this time there was an

indicated imbalance between the fuel tanks of 90 kg, with the right tank containing less fuel. This imbalance was caused from running the right engine in hotel mode for the purpose of air conditioning.

The aircraft became airborne at Helsinki-Vantaa at 15:22 and landed in Kuopio at 16:13 (19:13 Finnish time). There were 68 passengers onboard. After landing the cockpit instruments indicated 960 kg of fuel in the left tank and 480 kg in the right tank. The fuel imbalance was 480 kg. According to the aircraft's operation manual (OM-B) the maximum permissible fuel imbalance is 730 kg.

During this stopover the flight crew noted the imbalance and recorded it into the journey logbook. They did not try to determine the reason for the imbalance. As per their calculations they had sufficient fuel for the return leg from Kuopio to Helsinki-Vantaa and, consequently, the aircraft was not refuelled. The flight crew did not read the MEL list or the DDG before engine start.

Engines were started at 16:38. Takeoff occurred at 16:43. At this time the aircraft's Digital Flight Data Recorder (DFDR) recorded a 560 kg fuel imbalance.

At approximately 16:58, as they were climbing through FL 170, the fuel imbalance, which according to the DFDR was approximately 600 kg, got the flight crew's attention. According to cockpit voice recordings the pilots believed that they had sufficient total fuel for the remainder of the flight. At 17:03 they reached FL 200 (6100 m), which was their cruising altitude.

The flight crew tried to find the reason for the increasing fuel imbalance from the abnormal procedures lists (Fuel Leak and Fuel Lo Level). The first item on both lists is the instruction LAND ASAP (land as soon as possible). The flight crew was unable to determine the cause of the fuel imbalance. At approximately 17:10 the aircraft was ca. 22 NM southeast of Mikkeli with 84 NM still to go to Helsinki-Vantaa.

At 17:12 the flight crew made the first attempt to contact the FAM's duty mechanics by radio. At this time the fuel imbalance had reached 800 kg, exceeding the OM-B's maximum permissible limit. At 17:14 they received a Fuel Lo Level caution from the right main tank. The flight crew, together with a FAM supervisor, tried to sort out the malfunction in several different ways, but to no avail.

At 17:16 the flight crew requested that the ACC issue a direct clearance to Helsinki-Vantaa due to a minor technical fault. Nevertheless, they said that they could operate normally. The fuel imbalance at this stage was approximately 880 kg and there were only 130 kg of fuel left in the right main tank. The captain said that the imbalance had no effect on controlling the aircraft.

At 17:18 the captain informed the head of the cabin crew of the situation and called for normal cabin preparation for landing. At 17:20 they left the cruising altitude for the approach. Because of the Fuel Lo Level caution the flight crew pondered whether they

ought to turn off the right engine and called the maintenance personnel again on the radio. At this time there were approximately 80 kg of fuel in the right tank.

The DFDR indicates that the flight crew set the right engine to idle from 17:23–17:31. They did not mention this in their incident report, nor did they tell this to the investigation commission.

At 17:24 Helsinki Approach (APP) cleared the aircraft to 5000 ft. The flight crew noted that there were 890 kg of fuel in the left main tank and, in concert with the technical personnel, they decided to keep the right engine running for as long as possible.

At 17:29 the pilots requested a priority landing clearance due to a suspected fuel leak. At this time there were approximately 50 kg of fuel in the right tank. Helsinki air traffic control issued an air emergency alert.

At 17:30 Helsinki APP asked the flight crew to provide the number of passengers and crew as well as the quantity of fuel onboard. The crew replied and, following this, requested a visual approach to runway 15. They received the clearance. At 17:31 Helsinki APP asked whether the aircraft was carrying any hazardous substances; the flight crew replied that they were not.

At 17:32 the flight crew contacted Helsinki TWR after which they were cleared to land on runway 15. At 17:33, after 50 minutes of flying, the aircraft landed with both engines running. At this point in time the right fuel gauge indicated approximately 20 kg of fuel in the right tank. At 17:35 the right fuel gauge indicated zero fuel and the left gauge indicated 870 kg. At 17:36 (20:36 Finnish time) the aircraft arrived at its stand on the apron. In accordance with the company's Operation Manual (OM-A) the flight crew turned off the cockpit voice recorder (CVR) by pulling its circuit breaker out.

The captain submitted the appropriate flight safety occurrence report to the authorities. Tampere ACC and Helsinki APP also filed their respective reports regarding the incident.

The flight crew discussed the situation among themselves as well as with the maintenance staff and their superiors. No actual defusing session was held.

1.2 Injuries to persons

There were no injuries to persons.

1.3 Damage to aircraft

There was no damage to aircraft.

1.4 Other damage

There was no other damage.

1.5 Personnel information

OH-ATK pilot-in-command Age 36.

Licences Air Transport Pilot's Licence (ATPL), valid until 11 Feb 2013.
Medical certificate Class 1 was valid until 17 Jan 2011 and Class 2 was valid until 17 Jan 2015.

Ratings: All required ratings were valid

Flight experience	*Last 24 hours*	*Last 30 days*	*Last 90 days*	*Total experience*
All types				2523 hours
Type Concerned	3½ hours	29 hours	87 hours	2233 hours

OH-ATK co-pilot Age 27.

Licences Commercial Pilot's Licence (CPL), valid until 9 Jul 2013

Medical certificate Class 1 was valid until 23 Mar 2011 and Class 2 was valid until 23 Mar 2015.

Ratings: All required ratings were valid

Flight experience	*Last 24 hours*	*Last 30 days*	*Last 90 days*	*Total experience*
All types				
Type Concerned	3½ hours	47 hours	133 hours	753 hours

1.6 Aircraft information

Type information

Type	Twin-engine turboprop ATR 72-212A
Engines	2 Pratt & Whitney 127F
Manufacturer	Avions de Transport Régional
Registration and Certificate of registration	OH-ATK, 2101
Certificate of airworthiness	Valid until 8.10.2010
Serial number and year of manufacture	848, 2009
Maximum Takeoff Mass	22.500 kg

Takeoff mass in the beginning of the occurrence flight at Helsinki-Vantaa	22.168 kg	
Landing mass at the end of the flight at Helsinki-Vantaa	15.982 kg	
Fuel load	left tank	right tank
- beginning of flight (HEL)	1110	1110 kg
- stopover (KUO)	960	480 kg
- end of flight (HEL)	870	0 kg
Owner	Finncomm Finance Six Oy	
Operator	Finnish Commuter Airlines Oy	

Supplementary information

According to logbook information the mass and the centre of gravity were in the permissible range. During preflight cockpit checks it was discovered that the left main tank's electrical fuel pump was out of order and that its circuit breaker had tripped. The Minimum Equipment List permitted the flight once the relevant technical checks had been completed. The fault was recorded in the Hold Item List, to be repaired no later than 15 July 2010.

1.7 Meteorological information

The prevailing weather as well as the forecast for the takeoff and landing aerodromes was good. The aircraft landed at Helsinki-Vantaa at 17:33 UTC.

Observed weather at Helsinki-Vantaa aerodrome on 5 July 2010:

METAR 1650 (UTC): Wind 170 degrees 9 knots, CAVOK, temperature +25°C, dew point +11 °C, QNH 1014 hPa, NOSIG.

METAR 1720 (UTC): Wind 170 degrees 8 knots, CAVOK, temperature +25°C, dew point +11 °C, QNH 1014 hPa, NOSIG.

METAR 1750 (UTC): Wind 170 degrees 8 knots, CAVOK, temperature +25°C, dew point +11 °C, QNH 1014 hPa, NOSIG.

The Helsinki-Vantaa forecast valid from 5 July 1500 UTC to 6 July 1500 UTC was as follows: wind 190 degrees 9 knots, CAVOK, on 6 July from 03–06 UTC a 40% probability of scattered CU clouds at 4000 ft; on 6 July from 12–15 UTC a 40% probability of scattered CU clouds at 5000 ft. In the evening of 5 July the weather followed the forecast.

Meteorological conditions had no effect to the conduct of the flight.

1.8 Aids to navigation

All onboard navigation equipment and radar operated normally and did not generate any cautions.

The radar systems at Tampere ACC, Helsinki APP and Helsinki TWR operated normally and did not generate any cautions.

1.9. Communications

The aircraft's radiocommunication systems operated normally. Radiocommunications and telephone systems at Tampere ACC, Kuopio ATC and Helsinki-Vantaa ATC operated normally.

On 5 July 2010 at 0000 UTC, yielding to the renovation of the control tower, Helsinki TWR moved to temporary premises on the top floor of Finavia's office building. Apart from alarm communications, which had been substituted by another system, this move did not affect the functioning of Helsinki TWR radio or telephone communications. The change impacted air traffic flow management by reducing the number of operations.

1.10 Aerodrome and air traffic services information

1.10.1 Aerodromes

Helsinki-Vantaa aerodrome was the first point of departure for the flight. Kuopio aerodrome was the stopover location. Helsinki-Vantaa aerodrome was the point of landing where the incident materialised. The aircraft landed on runway 15. Relevant aerodrome information can be found in the Finnish Aeronautical Information Publication (AIP).

1.10.2 The functioning of air traffic services

Following the takeoff from Kuopio, FCM256K called Tampere ACC and reported being in a climb to FL 200. The air traffic controller confirmed radar contact and said that runway 15 was in use at Helsinki-Vantaa. In practice FCM256K was heading directly from Kuopio towards Helsinki-Vantaa. At 17:03 the aircraft reported maintaining FL 200.

At 17:04 the ACC controller cleared the aircraft to descend to FL 100 and to fly the standard arrival route ORM 2M.

At approximately 17:16 FCM256K requested a direct clearance to initial fix (IF) ELKUN for runway 15, reporting a minor technical problem, albeit normal operations for the time being. The ACC controller called Helsinki APP and relayed this information to them. Helsinki APP replied that they would wait for additional information with regard to the aircraft's problems. The aircraft was routed directly towards IF ELKUN. At this time FCM256K was 35 NM north-northeast from Helsinki TMA.

At approximately 17:17 the supervisor of Helsinki APP called the ACC supervisor in order to make certain that FCM256K was operating normally. The ACC supervisor confirmed this.

At 17:20 FCM256K called radar controller RAD-E and said that they would descend to FL 100 and head directly towards ELKUN. RAD-E confirmed radar contact and reaffirmed that runway 15 would be in use for landing. At 17:24 RAD-E recleared the aircraft to 5000 ft and told them to contact arrival control ARR-E. At 17:26 the aircraft called ARR-E which further recleared the aircraft to 2000 ft. At 17:28 ARR-E told FCM256K to reduce speed to no more than 210 kt. This limitation was caused by the traffic situation.

At 17:29 FCM256K reported that they were possibly experiencing a fuel leak and that they would have to land ASAP. ARR-E immediately rerouted the aircraft flying ahead of the FCM256K and cancelled their speed limitation.

FCM256K requested the possibility of a visual approach for which the ARR-E answered affirmatively. The pilots took this as a clearance for a visual approach. ARR-E replied that this was not the case because another aircraft was still flying ahead of them and ARR-E was in the middle of clearing the airspace for FCM256K.

At 17:29 the arrival controller ARR-W whose workstation is next to that of ARR-E, relayed the FCM256K's report of a fuel leak and the need to land ASAP to the Control Tower which sounded an emergency alert.

The TWR alerted the aerodrome's rescue units by speakerphone. The loudspeaker system had been taken into use the previous night when the TWR had moved into its temporary premises. Simultaneously the supervisor of Helsinki APP called the emergency number 112 and made the alarm as per the alerting flow diagram. The controller also called Finncomm who replied that they already were aware of the situation.

At 17:30 ARR-E asked FCM256K how many persons and how much fuel they had onboard. They also cleared FCM256K for a visual approach to runway 15. The aircraft acknowledged the clearance and reported the number of passengers by saying *17 plus 1 passengers, still fuel*.

At 17:31 ARR-W relayed the aforementioned information by telephone to the Control Tower. ARR-E asked FCM256K whether they carried any hazardous substances to which the flight crew responded they did not.

At 17:32 ARR-E told FCM256K to contact Helsinki TWR. The aircraft reported making a visual approach to runway 15. The TWR cleared the aircraft to land on runway 15. Landing occurred at 17:33. Medi-Heli asked the TWR to provide additional information with regard to the air emergency. The ATC controller replied that the aircraft was presently on the runway and that rescue units had arrived at the scene.

At 17:37 the incident alert was called off as per standard procedure.

1.11 Flight recorders

Digital Flight Data Recorder (DFDR)

Type	Digital Flight Data Recorder
Manufacturer	L3 Communications
Part number	2100-4043-00
Serial number	000511443

The DFDR recording was downloaded at Finncomm and sent to Accident Investigation Board where it was analysed as applicable.

Quick Access Recorder (QAR)

Type	Quick Access Recorder
Manufacturer	SAGEM
Part number	ED35 E109-01-04
Serial number	2206

For the most part the Quick Access Recorder records the same information as the DFDR, albeit unpacked and uncoded. When it comes to the investigation of this occurrence, Finncomm used QAR information to determine the functioning of the OH-ATK's engines and fuel system.

Digital Cockpit Voice Recorder (DCVR)

Type	Digital Cockpit Voice Recorder
Manufacturer	L3 Communications
Part number	2100-1020-02
Serial number	000579151
Recording capacity	Two hours (120 minutes)

The investigation commission took possession of the Cockpit Voice Recorder following its removal from the aircraft. The recording was downloaded at Finnair's avionics repair shop under the supervision of the investigation commission and subsequently analysed at AIB. Thereafter, the DCVR was erased and returned to Finncomm.

1.12 Wreckage and impact information

The investigation commission did not inspect the aircraft. On 7 July 2010 the maintenance company (FAM) and Finncomm Safety conducted an engine fuel feed test. The procedure and results are explained in more detail in subparagraph 1.16.

1.13 Medical and pathological information

No medical or pathological tests were conducted.

1.14 Fire

There was no fire.

1.15 Survival aspects

At 17:16 FCM256K reported a minor technical problem to the ACC, adding that they could operate normally. The ACC relayed the information to Helsinki ATC at which time they decided to wait for additional information. No alert was made.

At 17:29 FCM256K reported a possible fuel leak and informed the ATC of the need to land as soon as possible. Helsinki TWR immediately sounded an air emergency alert, alerted the Helsinki-Vantaa aerodrome fire station by loudspeaker. Simultaneously the supervisor of Helsinki APP reported the emergency to the ERC of Itä- and Keski-Uusimaa.

At 17:33, according to the alert log, the ERC dispatched rescue and ambulance units from Keski-Uusimaa Rescue Department to Helsinki-Vantaa aerodrome as per a *full emergency – large* response. The air ambulance Medi-Heli, too, was dispatched. According to the emergency log, rescue units were on their way at 17:34-17:35. Depending on the distance from their station to their destination they arrived between 17:35-17:38. FCM256K landed at 17:33 at which time only Helsinki-Vantaa aerodrome fire station units had made it to their positions along runway 15. Four Keski-Uusimaa Rescue Department units took over the rescue preparedness of Helsinki-Vantaa aerodrome while the aerodrome's own fire station units were on the mission. When it became evident that the aircraft had already safely landed the other rescue units' alerts were called off. All alerts were rescinded between 17:40–17:49.

According to the report of Keski-Uusimaa Rescue Department the dispatched response was appropriate to the given task; units participating in the response were able to roll within the required time frame and resources were sufficient.

1.16 Tests and research

1.16.1 Technical inspections

Description of the ATR 72 fuel system

Both wings contain fuel tanks. The tank comprises the actual main tank and a feeder tank. In both wings the system also houses

- A tank jet pump which supplies fuel from the main tank to the feeder tank. The tank jet pump is responsible for keeping the feeder tank full at all times.

- An electrical fuel pump which feeds fuel from the feeder tank to the engine during engine start. Unless the crossfeed is on, the electrical pump is normally not on during the flight.
- An engine feed jet pump which supplies fuel to the engine after start-up and during the flight. The engine feed jet pump kicks in automatically.
- A fuel motive flow valve which turns the engine feed jet pump on and off.

Additionally, the system comprises

- A fuel quantity gauge (Fuel Qty) as well as a feed low pressure warning (Feed Lo Pr). In addition, the system provides a fuel low level warning (Fuel Lo Level).
- A crossfeed valve (1) which makes it possible to supply fuel to both engines from a single tank or to only supply fuel to the engine on the opposite side. The electrical fuel pumps kick in when the crossfeed valve is opened. The fuel system pumps cannot transfer fuel from one tank to another.

The probability of the engines flameout

On 7 July 2010 Finncomm conducted an engine fuel feed test on the OH-ATK in order to determine whether the engines would flame out in a configuration which corresponded to the situation in the occurrence: i.e. one tank would become completely depleted of fuel. The conclusion that the operator made from the test run was that the engines would not have flamed out.

The investigation commission tried to find out the probability of the engine fame out. On 3 August 2010 the commision wrote to ATR and requested their opinion on the matter. On 7 December ATR replied with their comments, dated 19 November 2010. As per their analysis the engines would not have flamed out. Instead, when the right tank became empty the left engine feed jet pump that was running would have supplied fuel from the left tank to both engines. The salient points of the comments as well as fuel system diagrams are included in appendix 1 of this investigation report. The comments in their entirety are stored in AIB archives.

1.16.2 Training and check flight operations

Pilot training

Pending successfully completed aptitude tests the airline mostly recruits pilots from various flying academies in Finland. Some of the pilots have received their basic flight training abroad. Pilots that start flying with the airline receive their type training on courses organised by the company's type training organisation . The company provides flight instructors to said courses. Aeroplane systems training on type training courses is mainly done through Computer Based Training (CBT). Systems training normally takes altogether ca. 36 hours. After the type training course a pilot flies as a co-pilot for 3–4 years before his/her possible promotion to captain. The company's flight operation`s management group chooses the pilots for the captain course.

The company also recruits captains that have terminated their employment contracts with other airlines.

Pilots receive annual recurrent training which lasts one simulator shift. The authorities have grouped annual recurrent training (OPC cycle) in such a manner that the aircraft's most important systems are reviewed once every three years.

Minimum Equipment List (MEL) instruction is provided as theoretical knowledge instruction in conjunction with simulator training on the type training course, on the captain course, as part of simulator exercises and in fleet chief commander symposia. A member of the technical staff has provided the instruction. As a result of this investigation the company has decided to change the content of MEL training so as to better serve the needs of pilots and persons with a flying background are now selected as instructors.

Both pilots in this occurrence had completed Finncomm's type rating training course in Finland. The captain completed the course at the turn of 2006–2007 and began flying as a co-pilot in March 2007. The co-pilot completed the course in 2009 and began flying as a co-pilot in August 2009.

Captain course syllabus

In order to be eligible for the captain course a pilot must have flown at least 2000 hours for the company and also meet the other requirements mentioned in the OM-A. The syllabus encompasses e.g. the following topics:

- Supervised captain training flights as co-pilot prior to the captain course,
- Captain training as theoretical knowledge instruction (ratings, OM-A, flight procedures and Crew Resource Management); altogether 24 hours,
- Two simulator training flights,
- Line flying and destination aerodromes familiarisation, and
- Line-orientated flight training culminating in a Line Flying Check.

During the first year of flying as a captain the pilot receives recurrent training in flight safety, management and business-oriented topics.

Check flight operations

A skill test is flown after the type rating training course. Check flight operations also includes annual proficiency tests flown on the simulator (TPC and OPC) as well as Line Flying Checks (LFC) flown on aircraft. The company's own flight examiners as well as the flight examiner designated by the aviation authority are responsible for proficiency check flights.

Maintenance staff training

Finnish Aircraft Maintenance Oy (FAM) recruits their staff in Finland and abroad from among persons who have received technical training or already possess maintenance

certifications. At the time of the occurrence the maintenance staff consisted of ten different nationalities.

The training of FAM personnel is defined in the company's Maintenance Organisation Exposition (MOE), section 3.17.2.

When needed, the company provides type rating training on the ATR's CBT software, which takes approximately 120 hours to complete. Instruction covers the aircraft's systems one area at a time. The instructor briefs each system prior to the commencement of its instruction. Following this, the students proceed at their own pace. The instructor is always available to answer any potential questions.

The syllabus regards reference material as a single entity. For example, the MEL is only referred to with the mention that it can be used to confirm whether the next flight can be flown when a fault is detected. Neither the MEL nor its problematic segments are explored in any detail.

1.17 Organizational and management information

Finnish Commuter Airlines Oy was established in 1993 at the behest of prominent businessmen in the province of Southern Bothnia. The company's headquarters are in Seinäjoki. During the 2000s the company's operations expanded and the organisation changed. In 2003 the company started Helsinki-centred feeder traffic operations. Seinäjoki and Helsinki-Vantaa aerodromes are still the company's main operating locations.

The administrative branches of the company that report to the CEO are based in Seinäjoki. Reporting to the Accountable Manager at Vantaa are Flight Operations, the Flight Safety Manager, the Quality Manager and the Emergency Response/Security Manager as well as the supervision of Continuous Airworthiness and the Ground Operations Manager. Flight Operations is led by the Flight Operations Manager. He is in charge of the ATR and EMB groups, led by their respective fleet chief commanders, as well as Training and Cabin Operations.

In 2008 the company's previous line maintenance organisation was reorganised as Finnish Aircraft Maintenance Oy (FAM), jointly owned by Finncomm and Finnair. It is part of the Finncomm Group. The company's fleet encompasses eight ATR 72, four ATR 42 and two Embraer 170 aircraft.

The company employs approximately 130 pilots, which shall be finnish speaking. During recent years turnover among the company's pilots has remained low. Nonetheless, due to the company's recruiting policies the age distribution is broad. FAM staff is multinational, and all of them do not speak Finnish. Hence, English is the operating language. The company's operating manuals are written in English.

The company's reporting rate is high and pilot reports (Occurrence Reports) are not filtered or edited, but are sent onwards as such. The Flight Safety Manager publishes

the *Safety First* magazine on a quarterly basis. Topical information bulletins for aircrews are constantly displayed on briefing room bulletin boards. Pilots also receive the most important bulletins by e-mail. In addition, they are discussed in staff briefings.

1.18 Additional findings

The investigation commission perused the manufacturer's DDG which the company uses. In the section *Engine and Fuel Control* (73-23-2) is the fault EEC (Engine Electronic Control). It became evident that this item on the abnormal procedure list in the DDG presupposes that pilots remember by heart that MAN IGN ON (manual ignition on) must be turned on, among other things, in Engine Flame Out and Emergency Descent situations. The abnormal procedures lists for said flight conditions do not contain the MAN IGN ON reference. The investigation commission believes that, in practice, it is diffucult for pilots to remember an item on the DDG's abnormal procedure list by heart in the aforementioned extremely challenging and stressful situations. This finding doesn`t directly connect with the occurence under investigation.

2 ANALYSIS

2.1 Personnel action prior to the flight at Helsinki-Vantaa aerodrome

The occurrence began at Helsinki-Vantaa aerodrome prior to the flight to Kuopio when the left electrical fuel pump broke. Notwithstanding the fault, it was permissible to fly the flight in accordance with the requirements of the Minimum Equipment List (MEL).

The FAM mechanic who was summoned to the flight deck determined the fault and completed the MEL-required Maintenance Actions: he pulled out the circuit breaker and tagged it with a note. The fault was recorded on the Hold Item List (HIL) and assigned with a repair no-later-than-date. These actions were not done in the appropriate manner.

When it comes to this fault, the flight crew must also complete all procedures that bear the letter (o) in the MEL. They are compiled into a Dispatch Deviation Guide (DDG). Both pilots have to complete these kinds of checklists together. The flight crew did not go through the DDG procedures at all before engine start. The interview revealed that the captain had placed the aircraft's OM-B readily available in case they received a Fuel Lo Level caution. During the first start-up they did received the warning. The co-pilot assumed that the captain had read the MEL checklist.

The conversation between the mechanic and the flight crew was conducted in English. The pilots said that it was a bit difficult to understand the mechanic's English. After having completed the requisite actions the mechanic had underscored that the fuel crossfeed valve had to be open at all times. The pilots were not entirely convinced that this was what the mechanic actually meant and, therefore, they asked him to reconfirm this. The pilots were left with the notion that the crossfeed valve had to be open throughout the flight. The investigation revealed that the mechanic had meant that the crossfeed valve only be kept open during engine start. Still, the mechanic could have had the impression that the crossfeed should be on throughout the flight. The investigation could not categorically establish whether this was the case.

As a result the fuel crossfeed valve was left open throughout the flight and, following engine start, fuel was only supplied to the engines from the right tank.

The weather on the day of the occurrence was sunny and hot, which is why the flight crew ran the right engine with the prop brake on so as to provide air conditioning. Fuel was supplied from the right tank. The fuel pump fault as well as air traffic flow management restrictions at the time of the flight delayed the takeoff for about 1.5 hours. Because of this, the right tank contained approximately 90 kg less fuel compared to the left tank at engine start-up. Running the engine on the ground for air conditioning and electricity generation is standard practice.

2.2 The flight from Helsinki to Kuopio

The pilots began their shift on the day of the occurrence with a return flight to Jyväskylä. They took a lunch break before their flight to Kuopio. Up to that point their shift had not been particularly strenuous.

The discovered fault and air traffic flow management caused an approximately 1.5 hour delay. Due to the hot weather the temperature on the flight deck and inside the cabin rose considerably. The aircrew said that the heat caused fatigue.

Takeoff occurred at 15:17 at Helsinki-Vantaa aerodrome. There were no extra persons on the flight deck during the flight. On the leg to Kuopio the flight crew recorded the total fuel quantity into the flight plan, as per instructions in section 8.1.8.2.5 of the company's OM-A. The pilots did not discuss the fuel pump malfunction during the flight.

2.3 Flight crew action before the return leg

According to journey logbook entries there were 960 kg of fuel in the left tank and 480 kg in the right tank after landing in Kuopio. The pilots recorded the total fuel quantity into the flight plan in accordance with the OM-A's section 2.3.5. The flight crew assumed that the fuel imbalance (480 kg) was caused by running the engine for air conditioning at Helsinki-Vantaa. Hence, they did not give it any further thought. They were aware of the maximum permissible fuel imbalance (730 kg) between tanks. They did not react to the situation. They presumed that by keeping the crossfeed valve open the fuel imbalance would decrease. The imbalance could have been rectified during the stopover by refuelling the aircraft. However, this was not even taken into consideration.

The pilots noted that the total fuel would be sufficient for the return leg to Helsinki. In section 2.3.5 of the OM-B's checklist there is an item that requires flight crews to check the fuel balance between the tanks as well as the sufficiency of fuel for the next flight. Evidently the flight crew did not consider this checklist item closely enough before the engines were started.

Since the pilots had not completed the DDG when they started the engines at Helsinki-Vantaa, they were unaware of the fact that these particular procedures had to be completed before each engine start. This being the case, they did not complete the checklist in Kuopio either.

2.4 Flight crew action on the return leg to Helsinki

The flight crew took off from Kuopio to Helsinki with the crossfeed valve still in the open position. The maximum permissible fuel imbalance was exceeded during the flight.

During the climb the pilots began to pay attention to the fuel imbalance. To some extent, their attempts to determine its cause interfered with their normal flight procedures. They suspected a blockage in the fuel system. They went through the abnormal procedures lists (Fuel Leak and Fuel Lo Level). Still, they did not complete any of the procedures in

these lists. Both lists contain an item that orders the flight crew to land as soon as possible. At this point in time, at approximately 17:10, the nearest aerodromes were Mikkeli, which was approximately 22 NM from them, or Utti (42 NM). These were, at any rate, already closed at the time of the occurrence. The nearest open aerodrome was Jyväskylä (55 NM). They still had 84 NM to go to Helsinki-Vantaa, which translated into approximately 20 minutes of flight time.

The pilots continued the flight towards Helsinki-Vantaa and contacted FAM personnel on the ground. The FAM supervisor was unaware of the aircraft's fuel setting selections at that time. During the interview he said that he originally suspected a fuel leak, followed by an instrument fault. When the captain told him that the left tank was not depleting at all, the supervisor recommended that the flight crew keep the crossfeed valve open and fuel pumps on so as to guarantee fuel supply to both engines. Nevertheless, the supervisor said that his instructions were more or less guesswork. As his final instruction the supervisor told the pilots to push the tripped fuel pump circuit breaker back in. Once they did so, the circuit breaker immediately tripped again.

In section 8.3.23 of the company's Operation Manual OM-A there are instructions for pushing in a tripped circuit breaker. The instructions state that a tripped circuit breaker should not be pushed in during the flight unless necessary for the safe conduct of flight. Additionally, the instructions note that one should only try to push in a tripped circuit breaker once. The valid instructions regarding a circuit breaker that trips during a flight had not reached the pilots or the technical personnel involved in the occurrence.

Approximately 68 NM from Helsinki-Vantaa a Fuel Lo Level caution was given in the cockpit. At this time Utti was the nearest aerodrome. The captain decided to continue the flight to Helsinki-Vantaa. The pilots, together with the technical supervisor, considered turning off the right engine. However, they decided to keep it running as long as possible.

Following this the pilots requested a direct routing to ELKUN, the initial fix to runway 15 at Helsinki-Vantaa. They reported a minor technical problem, while simultaneously noting that operations were normal. Nonetheless, the Fuel Lo Level caution light was on in the cockpit and they had an approximately 880 kg fuel imbalance. The remaining flight time was approximately 17 minutes. Had they reported the low fuel situation to the ATC at this stage, the rescue units would have had sufficient time to man their assigned positions.

When they still had a little over four minutes to landing the pilots reported that they had to land as soon as possible because of a potential fuel leak. This is when the ATC sounded an air emergency alert. Because of the belated information Keski-Uusimaa Rescue Department units did not make it to their emergency positions before the aircraft had landed. The pilots did not even consider declaring an emergency at any stage of the flight.

2.5 Training

2.5.1 Pilot training

The investigation established whether there were any such shortcomings in pilot training that could have caused the erroneous action. Both pilots had successfully completed their type training.

The captain's basic training took place abroad. The captain had not flown at all for about a year and a half prior to Finncomm's type rating training course which was arranged in Finland during the turn of 2006-2007. It was the captain's opinion that the type training course was not quite sufficient and that they did not get to fly enough on the simulator. In 2007, following the type rating training course, the captain participated in the supplementary training that the aviation authorities had ordered the company to provide. The captain enrolled on the captain course in November 2009 and began flying as a captain on 13 April 2010.

It is the opinion of the investigation commission that the description of the fuel system in the type rating training course's CBT programme was cursory and that it did not sufficiently focus on the most salient details for the pilots. For the most part the fuel system description covers refuelling the aircraft. In order to thoroughly acquaint oneself with the fuel system one must actively engage in self studies and consult the aircraft's manuals so as to gain information that complements the CBT programme. The investigation revealed that the pilots were not sufficiently knowledgeable of the aircraft's fuel system. Journey logbook entries give the impression that the captain presumed that crossfeed makes it possible to transfer fuel from one tank to another. This is an erroneous assumption.

In light of these events it seems possible that during the MEL training the captain had formed the opinion that the topics and procedures included in the MEL were primarily the responsibility of technical personnel. Therefore, the captain relied on the mechanic's instructions rather than confirming the matter from the pilots' MEL list.

The investigation revealed that the content of MEL instruction has been overly theoretical, largely overlooking the practical application of the MEL. The captain of the occurrence flight believes that MEL training was not sufficient. Training records indicate that the captain had flown a fuel system fault exercise on a simulator in 2008, while still a co-pilot.

Instructor pilots had not made any unusual observations with regard to the flight crew during their type rating training. Neither did their annual proficiency check flight reports contain any mention of shortcomings in theoretical or practical skills.

Type rating training does not include the consequences of action that violates valid instructions. Hence, the pilots had no way of knowing whether the engines would have kept running after the right tank became empty. The investigation commission has assessed their actions taking this into account.

2.5.2 Technical personnel training

It is the opinion of the investigation commission that the company's CBT type training for technical personnel was at the satisfactory level. According to the company, instructors were available to answer students' questions during the course. Nevertheless, the type training syllabus included too little time for document studies.

The investigation revealed that MEL training for technical personnel relied too much on self study. The technical staff was not entirely aware of how MEL procedure responsibilities were divided between technical personnel and flight crews. Technical training does not venture into any operational procedures that are within the domain of pilots.

2.6 Organizational culture

There is a Flight Safety Manager in the company. The company has tried to improve flight safety culture in several different ways. The company's operations management continually monitors flight and maintenance activities and promptly tackles observed shortcomings and problems.

The company is presently developing an Alternative Training and Qualification Programme (ATQP) which aims, among other things, at the following:

- to maintain continous process of data collecting and analysis in order to identify the need of changes in the pilot training and syllabus
- to react the changes in the operational environment and to modify the training
- to take into account the special needs of the operator better than in the traditional training

The training programme is designed to adapt to the present needs at any given time. This being the case, the subject matter of instruction is of paramount importance.

2.7 Human factors

2.7.1 Stress factors

Both pilots' work rosters prior to this flight were normal. According to the pilots' accounts they had rested sufficiently before the shift which began at noon. The captain had felt tired after the flight to Jyväskylä and even considered opting out from the flight to Kuopio. Personal reasons may also have had a role in this. Even so, the captain decided to continue working the shift.

They had to wait for approximately 1.5 hours at Helsinki-Vantaa for takeoff. During this time, as the sun kept shining, the temperature on the flight deck rose considerably in spite of running the right engine in hotel mode. Both pilots said that they felt uncomfortable and fatigued because of the high temperature. During the hiatus the pilots would have had ample time to revisit the situation caused by the fuel pump malfunction. Still, the captain considered the MEL issue resolved because, in the

captain's opinion, it was the responsibility of the technical personnel. Furthermore, the mechanic had expressed his view on the crossfeed valve position in no uncertain terms: "all the time, don`t touch it."

During the leg to Kuopio the pilots' fatigue diminished as heat stress decreased. The work load on the flight was normal. The shortcuts taken in checklist completion during the stopover may have been caused by a feeling of haste due to the flight being delayed for approximately 1.5 hours. The feeling of haste constituted mental stress for the pilots.

There were no physical stress factors on the return leg. The pilots recognised the fuel imbalance and the fuel feed malfunction. The fuel low level caution at the final stage of the flight exposed an impending fuel shortage. These factors amounted to constantly growing mental stress which increased the work load during the flight and, among other things, degraded cockpit crew resource management.

2.7.2 Crew Resource Management (CRM)

The company's instructions pertaining to Crew Resource Management (CRM) are sufficient. However, even previous investigations have revealed shortcomings in compliance with said instructions. When it comes to this investigation, cockpit crew resource management was unsatisfactory on the leg from Helsinki to Kuopio. This was manifest in, among other things, that the pilots did not complete the DDG together. On the return leg to Helsinki crew cooperation was unsound as the captain concentrated on solving the fuel system fault, leaving other activities to the co-pilot. At times the pilots were unaware of each other's actions. It is the opinion of the investigation commission that the looming fuel shortage increased the captain's stress to the extent that it degraded the captain's capacity to be the team leader in cockpit crew resource management.

2.7.3 Mental imagery and other psychological factors

The investigation revealed that the captain had meet an event of personal nature and that the captain was preoccupied with it. This also decreased the captain's performance. The co-pilot had no ongoing personal issues affecting his performance.

The captain said that there would have been ample time to consult the OM-B regarding procedures related to a fuel pump malfunction. Rather than doing so, the captain relied on the mechanic's description and instructions. It was the captain's opinion that the procedures that were completed in Helsinki prior to the flight were both sufficient and correct. The captain did not reconsider the situation. Yet, had this been done, the mistakes would probably have been noticed. The captain put out of mind the observed fault and considered the matter resolved.

During the stopover in Kuopio they noted and recorded the fuel imbalance. The pilots did not infer that fuel had only been supplied to the engines from one tank. Their fuel calculations included the premise that the fuel contained in both tanks would be usable. For this reason they did not consider refuelling necessary.

The growing fuel imbalance on the return leg, ultimately exceeding the maximum permissible imbalance, did not lead the flight crew to consider the primary fault in the fuel system. They kept an eye on the fuel low level (Fuel Lo Lvl) caution. Even though they suspected a fuel feed malfunction they did not complete any of the procedures in the abnormal procedures lists. This is an indication of growing uncertainty in pilot performance. The CVR recording shows that the captain discussed the situation over the radio with a FAM supervisor, to no avail. Neither did the captain receive any support from the co-pilot as regards solving the problem.

2.7.4 Experience and good airmanship

Experience

Experience is an important factor in maintaining flight safety. The pilot-in-command is responsible for the aircraft, its airworthiness, flying, procedures and passengers. The flight crew must constantly monitor the progress of the flight, be able to detect anomalies and take appropriate action in maintaining the safe conduct of flight.

The captain had only flown in this position for less than three months and, therefore, the captain had only limited experience. Given the fact that the co-pilot was in the early stages of his career, he could not have accrued any significant experience.

The captain's total flying experience was approximately 2500 hours, ca. 2200 of which on the ATR. Finncomm's feeder traffic flights are short and for the most part they follow the same repetitive routes. Therefore, the accrued experience tends to be narrow and flying easily becomes a routine process.

Airmanship

So far there is no established Finnish term for the concept of airmanship. In literature it is sometimes called good airmanship or sound pilot practices.

The concept of airmanship has been explained, for example, in TraFi's flight safety seminar on 27 November 2010 as well as in certain other sources as follows:

> *Airmanship covers a broad range of cognitive and practical skills desirable for aviators. It does not only entail technical prowess. Rather, it also manifests the pilot's awareness of the aircraft, the surrounding elements, and of his own capabilities.*
>
> *Airmanship includes*
> - *A sound understanding of the principles of flight,*
> - *The ability to operate an aircraft safely and efficiently, both on the ground and in the air, and*
> - *The capability to anticipate upcoming situations and the preparedness to employ alternative and even unconventional solutions when needed.*
>
> *The three fundamental principles of good airmanship are skill, professionalism and self-discipline, resulting in the competence to apply them in a safe and efficient*

manner. Discipline is the keystone of airmanship. The complexity of the aviation environment demands good airmanship and sound judgement in preventing pilot error.

Airmanship is the outcome of a person's mental characteristics. Different persons develop it in different ways, due to their way of thinking as well as their respective training and experience backgrounds. These form a healthy safety attitude and good airmanship.

It is the belief of the investigation commission that limited experience and airmanship were some of the causes of this occurrence. These were noticeably manifest in the following situations:

- The omission of completing the MEL lists,
- Not determining the reason for the detected fuel imbalance and the decision to not refuel in Kuopio, and
- Disregarding the option to land on alternative aerodromes along the route despite the looming emergency.

The incident could have been prevented by taking appropriate action as regards even one of the aforementioned shortcomings.

2.8 Technical analysis

2.8.1 The company's test run

Two days after the occurrence the company conducted a test run on the very same aircraft (OH-ATK) so as to determine the functioning of the fuel system on the occurrence flight. There was no prepared test plan.

During the test run the fuel system selections were similar to those in the occurrence. The engines did not flame out during this test run. As a result of the test run the company's opinion was that the engines would not have flamed out during the flight.

2.8.2 ATR's test results

The manufacturer`s comments were dated 19 November 2010. These comments included an analysis which state that when the right tank drains empty during the flight the right engine feed jet pump also stops. The left engine feed jet pump, which is on, takes over, supplying fuel to both engines from the left tank in which there is plenty of fuel. Even though the direction of fuel flow changes, the engines would not have flamed out. The comments, including diagrams, are appended to this report.

2.8.3 The opinion of the investigation commission

The operator's test run results and ATR's analysis comments back each other up. ATR reported having discussed the analysis with the EASA and that the functioning of the

fuel system in the described manner was demonstrated during the type certification process.

The investigation commission considers ATR's analysis consistent and accepts the position therein.

2.8.4 HIL recording

The investigation revealed that the company's Hold Item List (HIL) recording practices include mention of the maintenance/operational procedures. In this occurrence the markings were missing.

3 CONCLUSIONS

3.1 Findings

1. The airworthiness certificate and the certificate of registration were valid.

2. The flight crew had valid licences and ratings.

3. The technical personnel had valid licences and certifications.

4. The flight was a scheduled passenger flight.

5. The weather was hot, which indirectly affected the occurrence.

6. During the preflight check it was noticed that the electrical pump in the left fuel tank was out of order.

7. The FAM mechanic who was summoned to the aircraft determined the fault, completed the MEL-required Maintenance Actions and recorded them on the Hold Item List (HIL).

8. When the pilots requested advice from the mechanic he instructed them to keep crossfeed on at all times. The advice was either erroneous or incorrectly understood.

9. The pilots failed to confirm the required procedures from their own MEL instructions or from the Dispatch Deviation Guide.

10. The crossfeed was left on throughout the entire HEL-KUO-HEL flight. As a result the engines only received fuel from the right tank.

11. Due to the detected fault and air traffic flow management constraints the aircraft had to wait for approximately 1.5 hours for a takeoff slot.

12. Due to the hot weather the pilots ran the right engine at Helsinki-Vantaa in hotel mode for air conditioning. This used approximately 90 kg of fuel from the right tank.

13. During the stopover in Kuopio the pilots noted a fuel imbalance of 480 kg; the maximum permissible imbalance is 730 kg.

14. The pilots presumed that crossfeed also made the fuel in the left tank available and, therefore, they did not consider refuelling necessary.

15. Even though the pilots should have completed their MEL lists and the Deviation Dispatch Guide in Kuopio, they failed to do so.

16. During the return leg the pilots noticed that only the right tank was depleting. However, they did not consider flying to an alternate aerodrome.

17. The captain of the flight suspected some other fault in the fuel feed and discussed the situation with a FAM supervisor. This, however, did not clarify the situation.

18. Approximately 17 minutes before landing the aircraft's systems cautioned of low fuel level at which time approximately 160 kg of fuel remained in the right tank.

19. The pilots reported a minor technical fault to the Area Control Centre. Yet, they simultaneously said that operation was normal.

20. Approximately three minutes before landing the pilots requested a priority landing clearance due to a fuel leak. Nonetheless, they did not declare an emergency. The air traffic control sounded an air emergency alert.

21. The aircraft landed at 17:33 with both engines still running. After having taxied to their stand at 17:36 the left fuel gauge indicated 870 kg of fuel and the right gauge zero fuel.

22. Because of the short lead time only the aerodrome's own fire station rescue units made it to their positions along runway 15.

23. The company did not arrange any actual defusing session for the aircrew.

3.2 Probable causes and contributing factors

The basic cause of the occurrence was that the pilots failed to complete their MEL and the Dispatch Deviation Guide (DDG) at both Helsinki-Vantaa and Kuopio. Rather, they relied on the mechanic's missunderstood advice instead.

Another cause was that the pilots did not determine the reason for the fuel imbalance they noticed in Kuopio. In their flight plan they only considered the sufficiency of the total fuel quantity, choosing not to refuel the aircraft in Kuopio. The pilots had a mistaken notion of how the fuel system functioned.

The third cause was that the pilots did not follow the instructions in the abnormal procedures checklists to land as soon as possible when they noticed the impending fuel shortage in the starboard fuel tank.

Contributing factors included the pilots' limited experience and lacking airmanship, the degradation of the captain's performance, inadequate Crew Resource Management, the uncomfortable work environment caused by the hot weather as well as the feeling of haste caused by the delayed takeoff.

4 SAFETY RECOMMENDATIONS

4.1. Safety actions already implemented

By the time the investigation report was completed Finncomm informed AIB of the following actions they had already implemented:

- In order to clarify the responsibilities between the operator and technical staff a Safety Alert Bulletin (SAB 3/2010) was published on 22 July 2010. On 9 August 2010 pilots were urged to report any possible problems between pilots and technical personnel. The repair organization, too, was invited to pay attention to the matter.
- The company has improved its MEL training; instructors now include technical pilots. The training was implemented during the fleet chief commander symposium between 15 December 2010 and 15 January 2011. Training focused on how the MEL should be applied in practice.
- Flight operations management has reviewed the company's systems and recurrent training practices. The present training was considered to be sufficient. The erroneously interpreted segment belonged to the company's 2/2008 Recurrent training.
- The tripped circuit breaker procedure was republished in the Safety Alert Bulletin of 10 August 2010. Its appendix contained the EASA's Safety Information Bulletin No. 2009-7.
- The informing of the air traffic control of the situation was unsatisfactory. However, Finncomm Airlines perceives this as being a global problem which seems to be associated with the unnecessarily high threshold of declaring an emergency.
- The captain has been debriefed with regard to the decision-making process that led to the decision to continue with the flight as well as the underlying reasons.

4.2. Safety recommendations

The company has already implemented the actions which the investigation considered significant. Hence, the investigation commission issues no safety recommendations.

4.3. Other remarks

All of the alerted rescue units did not make it to their stations because of the belated emergency alert. It would promote rescue preparedness if flight crews kept the air traffic control informed of the situation as soon as any indications of an emergency became evident.

Helsinki 4.5.2011

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The aircraft manufacturer ATR's analysis of the fuel feed problem

The original English language comments have not been translated into Finnish

3. ANALYSIS

3.1 ENGINE FUEL SUPPLY DURING FLIGHT

(Refer to annex I)

Engine 2 is supplied by fuel from tank 2 pressurized by electrical pump 2 and engine jet pump 2. Engine I is supplied by fuel from tank 2 pressurized by electrical pump 2 and fuel from feeder tank I pressurized by engine jet pump I.
As fuel from tank 2 is used to supply both engines, fuel quantity decrease rate in tank 2 is higher than the one in tank l.
Once fuel quantity gauged is less than 160kg on tank 2, fuel low level warning is triggered. As this configuration is kept during the whole flight, fuel unbalance occurs.

3.2 ENGINE FUEL SUPPLY IN CASE OF FUEL TANK 2 BEING EMPTY

(Refer to annex 2)

MSN 848 landed with 20kg in tank 2.
Should the tank 2 be completely empty during the flight, with the same configuration of the system, engine jet pump I would have supplied both engines from fuel tank I.

This has been demonstrated during certification of ATR72-210 (PWI27) (ref. CC 28.02.02) During this flight test, both engines have been supplied by right engine jet pump from Flight Idle to Max Continuous.

3.3 OPERATIONAL CONSIDERATIONS

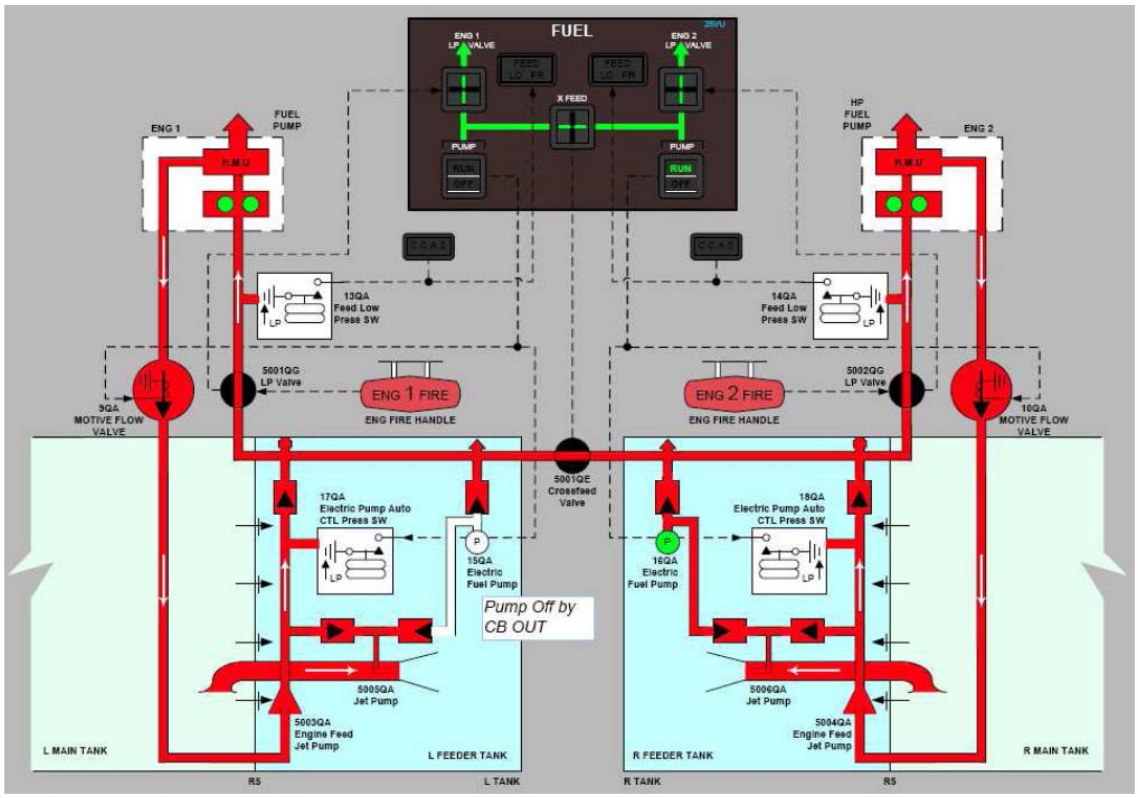
MMEL 28-21-2 allows dispatch with one electrical fuel pump inoperative (Refer annex 3). In this case, starting of engine on affected side is done using Xfeed fuel supply.
After engine start, inoperative pushbutton shall be pushed IN and Xfeed valve shall be closed. (refer annex 4)

MSN 848 event is due to deviation from normal MMEL Dispatch Deviation Guide procedure (28-21- 2). Crew left the Xfeed valve opened after engine start while procedure request Xfeed to be isolated after engine start.

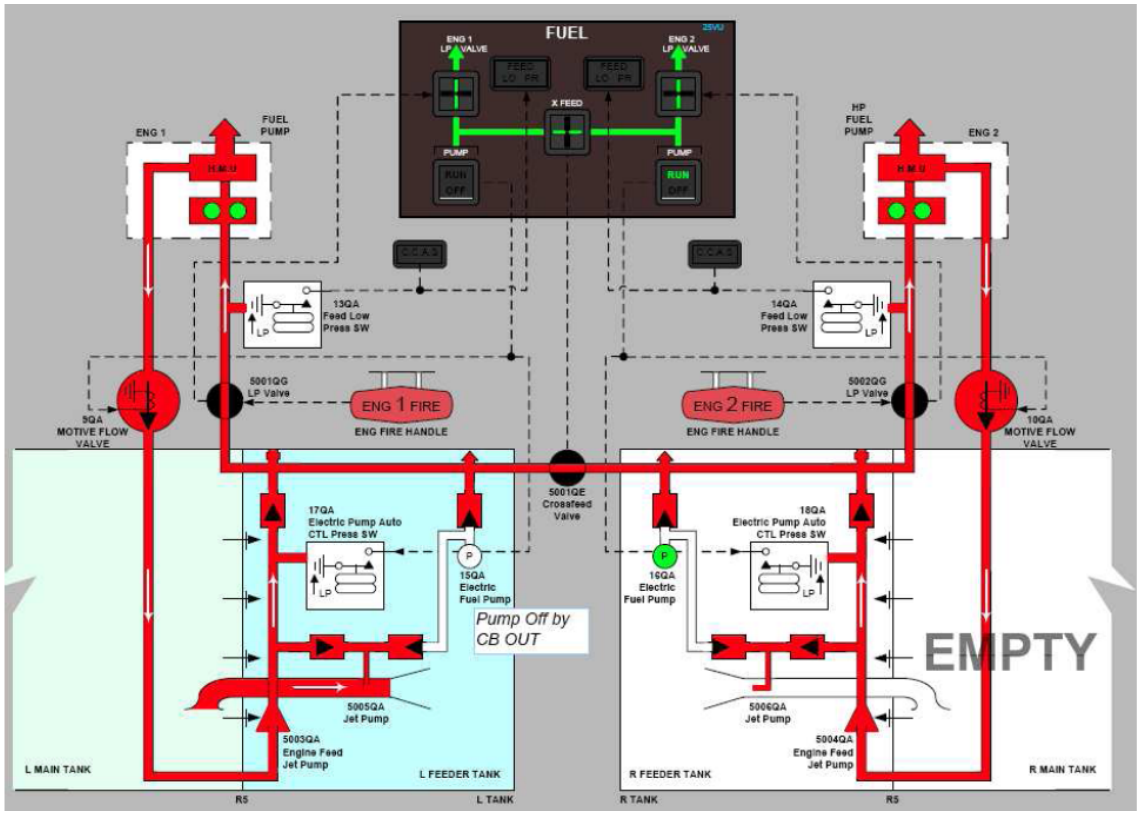
Maximum fuel unbalance is limited to 730 Kg in AFM as been exceeded is this configuration. Monitoring of fuel quantity during flight, should have alerted crew of improper fuel transfer prior to low level indication and should have lead crew to take appropriate actions to address this condition. (Refer annex 5)

4. CONCLUSION

MSN 848 event is due to deviation from operational procedure.



Annex 1. Fuel system diagram during flight



Annex 2. Fuel system diagram if tank 2 is empty