AGENZIA NAZIONALE
PER LA SICUREZZA DEL VOLO

(istituita con decreto legislativo 25 febbraio 1999, n. 66)

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FINAL REPORT

SERIOUS INCIDENT
occurred to FOKKER 70, registration marks PH-KZH
Torino Caselle airport
16th of February 2002

N. I/2/04

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PURPOSE OF THE TECHNICAL INVESTIGATION

The investigation of this accident, as required by Article 827 of the Italian Navigation Code, was conducted following the requirements of ICAO ANNEX 13 to the Chicago Convention, December the 7th 1944, approved and made executive in Italy by Legislative Decree of March 6th 1948, n. 616, and ratified with Law of April 17th 1956, n. 561.

Agenzia Nazionale per la Sicurezza del Volo (ANSV) performs its investigations *with the only purpose of accident and serious incidents prevention, excluding any appraisal of blame or responsibility* (art. 3, paragraph 1, Legislative Decree of February the 25th 1999, n. 66).

ANSV issues a report upon completing the accident investigation or a statement in the case of incident investigation; such report/statement may include Safety recommendations with the purpose of preventing accidents and incidents (art. 12, paragraph 1 and 2, Legislative Decree of February the 25th 1999, n. 66).

In all reports ANSV will safeguard the privacy of all persons involved in the event and of those that contributed information during the investigation. Anonymity will be granted to all persons involved in the events (art. 12, paragraph 3, Legislative Decree of February the 25th 1999, n. 66).

Reports and Statements and associated Safety recommendations are never intended to apportion blame or responsibility (art. 12, paragraph 4, Legislative Decree of February the 25th 1999, n. 66).

GLOSSARY

AFCAS: Automatic Flight Control and Augmentation System

AFL: Aircraft Flight Log

AML: Aircraft Maintenance Log

AOC: Air Operator Certificate

AOM: Aircraft Operations Manual

APU: Auxiliary Power Unit

ARTS: Automatic Thrust Restoration System

ASR: Air Safety Report

ATC: Air Traffic Control

ATIS: Automatic Terminal Information Service

ATRS: Automatic Thrust Reserve System

BASIS: British Airways Safety Information System

BOM: Basic Operations Manual

CA: Cabin Attendant

CB: Circuit Breaker

CVR: Cockpit Voice Recorder

DAQCP: De-icing/Anti-icing Quality Control Pool

DFDAU: Digital Flight Data Augmentation Unit

DFDR: Digital Flight Data Recorder

EFIS: Electronic Flight Instrument System

EFSU: Engine Failure Sensing Unit

Engine No 1: left engine

Engine No 2: right engine

EPR: Engine Pressure Ratio

ESOC: Emergency Shut Off Cock

FADEC: Full Authority Digital Engine Control

FMP: Flight Mode Panel

FMS: Flight Management System

FOD: Foreign Object Damage

FSM: Flight Safety Manager

JAA: Joint Aviation Authorities

JAR: Joint Aviation Requirements (JAA)

MCT: Maximum Continuous Thrust

MFDS: Multi Function Display System

MFDU: Multi Function Display Unit

MFO: Manager Flight Operations

MGO: Manager Ground Operations

MME: Maintenance Management Exposition

MPH: Maintenance Post Holder (JAR-OPS definition)

N1: Low pressure compressor (RPM – revolutions per minute)

N2: High pressure compressor (RPM – revolutions per minute)

OAT: Outside Air Temperature

OP/SOV: Over Pressure and Shut Off Valve

PF: Pilot Flying

PFD: Primary Flight Display

PLA: Power Lever Angle

PNF: Pilot Not Flying

QA: Quality Assurance

QNH: Atmospheric pressure referred to sea level measured in hPA

RAT: Risk Assessment Team

ROM: Regional Operations Manual

RVSM: Reduced Vertical Separation Minimum

TAT: Total Air Temperature

TGL: Temporary Guidance Leaflet

TOGA: Take-off/Go-around thrust

TOW: Take-off Weight

UTC: Universal Time Coordinated

SYNOPSIS

On February 16, 2002, flight KL 1636 (KLM Cityhopper) was scheduled to depart from Caselle Airport in Torino at 05.50 UTC (06.50 local time) for Schiphol Airport in Amsterdam. The Fokker 70, PH-KZH, arrived in Torino the previous evening and was operated by a different crew.

After receiving the flight preparation information the crew of KL 1636 determined that refuelling would not be necessary for the flight to Amsterdam. During the pre-flight inspection the Captain decided that the aircraft needed to be de-iced. After the de-icing operation the aircraft was visually inspected by the Captain. Due to the delay caused by the de-icing procedure the aircraft departed Torino at 06.33.

During rotation the left engine (No.1) developed fan vibration followed immediately by the failure of the right engine (No.2) at lift off. The crew executed a right hand turn at 1.500 feet QNH and proceeded to a holding fix to prepare for a single engine return to Torino. A PAN PAN PAN call was transmitted.

When executing the emergency procedure for the failed engine the first officer could not move the fuel lever to the closed position. Apart from the engine failure, the crew had to deal with an Autothrottle alert, Cabin Pressure alert, Fuel Asymmetry alert, Centre Tank Pumps alert, a Vibration High Engine 1 alert and an Icing alert.

Whilst manoeuvring around the holding fix the crew became aware that their only remaining engine was not running smoothly. A MAYDAY was declared.

The aircraft was eventually vectored by ATC for an ILS on runway 36 at Torino. The autothrottle was not available for the entire flight and the auto pilot was disconnected just below 1.000 feet after which a manual landing was made.

The Captain vacated the runway and stopped the aircraft to evaluate the situation. The fact that the fuel lever could not be closed was discussed again by the crew and it was decided to pull the fire handle and discharge a fire-extinguishing bottle into engine No. 2. The Captain then taxied the aircraft to a parking position.

The crew noticed when inspecting the aircraft that engine No. 2 was badly damaged and that the ignition system was still operating. The ignition circuit breaker was pulled. The local authorities were informed about the incident and after a telephone conversation with the KLC Fokker 70 Chief Pilot, the cockpit voice recorder circuit breaker was pulled.

The investigation was initiated under the responsibility of the "*Agenzia Nazionale per la Sicurezza del Volo"* – ANSV (Italian Air Safety Board) and according to ICAO Annex 13 an Accredited Representative from the Dutch Transport Safety Board (DTSB) was appointed.

After notification of the incident representatives from KLM Cityhopper (KLC) and Martinair (MPH) which is the contracted maintenance provider, arrived in Torino on the same day as the incident while representatives from Fokker Services (FS) and Rolls-Royce (RR) arrived the following day.

CHAPTER I

FACTUAL INFORMATION

1. FACTUAL INFORMATION

KLM Cityhopper (KLC) is a Regional Airline with its main hub at Schiphol Amsterdam. At the time of the incident the company operated with 13 Fokker 50 and with 15 Fokker 70 aircraft to several airports within Europe. Martinair (MPH) is the contracted maintenance provider and as such monitors its own Quality Control and provides maintenance service according to the specifications of the operator and manufacturer.

Fokker Services (FS), which is part of the Stork group of companies, as Type Certificate Holder provides all after-sales services, including modifications, major inspections and overhaul for the Fokker 70.

The Fokker 70 is a medium sized jet aircraft with 2 rear-mounted Tay 620-15 engines that were manufactured by Rolls-Royce (RR).

KLC develops and conducts flight crew and cabin crew training for the Fokker 50 and Fokker 70 aircraft. The Quality Assurance Department, apart from monitoring company procedures in general, is responsible for developing and executing audit programs for ground-handling agents at all KLC destinations.

Although the KLC aircraft was one step de-iced/anti-iced with Type II/ 50% fluid it was not the intention of the Captain to anti-ice the aircraft. For the purposes of this report therefore, the de-icing/anti-icing of the aircraft will only be referred to as de-icing.

All times mentioned in the report are in UTC.

1.1. HISTORY OF THE FLIGHT

1.1.1. General

KLM Cityhopper (KLC) operates scheduled passenger flights, with Fokker 70 aircraft, on a daily basis between Schiphol Airport at Amsterdam (EHAM) and Caselle Airport at Torino (LIMF). PH-KZH operated back and forth to Torino during the day on the 15th of February 2002 and also the last flight during the evening, KL 1649, which arrived in Torino at 20.15. The scheduled arrival time was 20.35. The aircraft had uplifted enough fuel in Amsterdam for the return flight from Torino. The crew rostered to conduct the early morning flight, KL 16.36 on the 16th February, with a departure time 05.50 had operated into Torino during the previous afternoon on the 15th February at 14.33.

SAGAT was the handling agent for KLC in Torino. They were contracted for flight planning, aircraft cleaning, ticketing, fuel services and de-icing/anti-icing. Crew information in the Regional Operation Manual (ROM) stated that one and two-step de-icing facilities were available in Torino and that the inspecting company was Alitalia.

1.1.2. Previous flight and conditions

KL 1649 was refuelled in Amsterdam at 19.05 on the 15th February with 6.785 litres of Jet A-1 (specific gravity of 0,806 kg). The aircraft departed with 7.930 kg of fuel on board. The total flying time to Torino was 1 hour and 17 minutes and the aircraft remained at a cruising level of FL 330 for approximately 40 minutes. The Outside Air Temperature (OAT) was ISA-5, which was equivalent to –55°C. According to the FDR the resulting Total Air Temperature (TAT) during cruise varied from –33°C to –26°C.

The weather conditions upon arrival in Torino were: wind 050/04, visibility 7.000 meters, light rain, scattered cloud at 800 ft, overcast cloud at 2.000 ft, temperature 2° C, dew point 0° C and QNH 1022. The Captain of the inbound flight reported to the investigation team, encountering icing conditions during the approach with snow changing to rain below 1.000 ft.

According to the Aircraft Flight Log (AFL) 5.080 kg of Jet A-1 fuel remained on board after engine shut down.

1.1.3. Parking situation

The aircraft remained overnight on the ramp at Y-4 parking position. The nose of the aircraft was pointed in a Westerly direction leaving the right hand side of the aircraft exposed to the North-Westerly wind (see Appendix A). The aircraft was parked on the Y-row together with a BAe 146 at Y-5 and a Meridiana MD 80 at Y-6.

During the night the wind was from the West, North West direction which changed later to an East, North-East direction with a speed varying from 2 to 8 knots. There was a low cloud cover, light rain and snow fell throughout the night. The temperature ranged from 2°C to 0°C and the dew point ranged from 0° to –1°C. The QNH was 1022 hPa (see Appendix B). No preventive anti-icing was requested.

1.1.4. Flight preparation

The crew for KL 1636 left their hotel at 04.30 and arrived at the airport 25 minutes later. During the drive from the hotel it was raining. They had had no contact with the inbound crew from the previous evening.

The Captain and the first-officer collected the flight plan, and were informed of a departure slot time of 06.00, which would mean a delay of 10 minutes to the normal schedule. After weather information and NOTAMs were collected from the SAGAT briefing office, the entire crew then proceeded via the crew transport bus to the aircraft.

They arrived at the aircraft at approximately 05.15. It was dark and raining. The METAR at 05.20 was: wind 010/06, 7.000 meters visibility, rain, scattered cloud at 800 feet, overcast cloud at 1.800 feet, temperature 2°C, dew point 0° C, and QNH 1022.

There was no external power connected to the aircraft and the APU was not running. The cabin attendants (CA) commenced cabin preparations while the first officer entered the cockpit to perform the power-up checklist and cockpit preparations which included starting the APU. He recorded an indicated fuel quantity of 5.010 kg in the AFL. The aircraft was not refuelled as there was sufficient fuel remaining on board for the flight to Amsterdam. The first officer noticed a loud rumbling noise beneath the floor on the right side of the cockpit. The number 2 air conditioning pack was recorded in the aircraft maintenance log (AML) as making a loud rumbling noise.

The Captain, who was to be the pilot flying (PF), took the dynalight from the forward galley position 221 and went outside to perform an external inspection of the aircraft. The SAGAT de-icing truck No.1 was standing near the aircraft.

1.1.5. Pre-flight inspection

During the external inspection it was dark and still raining. The Captain observed ridges of ice, 1.5 to 2 centimetres thick, under the leading edges of the wings. He also observed, as far as possible without using a ladder, 1 to 2 millimetres of slushy water and ice in small areas on top of the wing and slush on the trailing edge of the left wing. The Captain stated that the ridges of ice beneath the wings were starting to melt slowly. He did not touch any part of the wing surfaces because he commented that he had already decided that the aircraft would have to be de-iced.

He did not specifically ask for an anti-ice treatment, as he did not consider that icing conditions existed at the time. No fan ice check was performed.

Twenty-three of the final total of thirty passengers arrived at the aircraft at 05.30. A second bus arrived a short time later with the seven other passengers. The load sheet indicated a take-off weight (TOW) of 31.610 kg, which was 6.385 kg less than the maximum take-off weight of 37.995 kg.

1.1.6. De-icing procedures

The Meridiana MD-80, scheduled flight IG 194 from Torino to Catania, was parked at Y-6. The Captain of this aircraft decided, after noticing frost on the wings and in consultation with the Alitalia technician who was in charge of the ground operations for the flight, that a two-step de-icing/anti-icing procedure should be performed. The MD-80 was being refuelled and the fuel temperature was +4°C with a specific gravity of 0.810. The MD 80 tanked 5.100 litres of fuel to give the required block fuel of 10.000 kg. The de-icing operation started at 06.06 and the MD-80 departed Torino at 06.25. The de-icing/anti-icing operation was conducted by SAGAT de-icing truck No.2. An Alitalia technician monitored the operation and performed a post-de-icing inspection.

De-icing of KL 1636 was commenced at 05.55 using 413 litres Kilfrost ABC 3, Type II/50% de-icing fluid and spraying was completed by 06.10. The de-icing was done by SAGAT de-icing truck No.1.

According to the de-icing operator he de-iced the upper side of the wings as normally required, and on request of the Captain he de-iced the under side of the wings and the horizontal stabilizer. The Captain did not specify any specific type or mixture of de-icing fluid to be used. The de-icing truck operator stated that he requested the pilot *"to control the result"* of the de-icing, to which he also stated, the pilot answered *"OK Good*".

During the cockpit preparation the crew were aware that the de-icing operation was taking place and they had the impression that a lot of fluid was being used. The Captain and the first officer had a discussion about the quality of de-icing.

Two months prior the Captain reported a negative experience with de-icing, during which he discovered that there was still ice present on top of the wings after de-icing. On the basis of his recent de-icing experience the Captain decided that he should go outside the aircraft to check the wings. It was not normal procedure for KLC crew to perform a post de-icing inspection when

an inspecting company is mentioned in company publications.
The Captain noticed a lot of fluid coming from the wings dripping on to the ground. He did a visual check of the under surface of both wings and noticed that the ridges of ice beneath the wings had now disappeared. He did not touch either of the wings.
The de-icing operator handed over a signed document confirming the execution of the de-icing operation and the Captain counter-signed this document. The space for the supervising agent was not signed (see Appendix C).
In the meantime, due to the de-icing operation, the 06.00 UTC slot expired.

1.1.7. Engine start and taxi-out

The crew briefed the expected departure together with the non-standard engine failure procedure. The procedure in this case was that in the event of an engine failure the aircraft should maintain runway track until 1.500 feet QNH (approximately 511 feet above ground level) and then turn right onto a track of 110 degrees. The take-off was to be performed with engine anti-ice selected on, TOGA thrust, Flaps 0° and a reduced V1 speed for a wet runway operation.
The ATIS recorded by the crew was: 06.28, runway 36, wind 040/3 kts, 6.000 meters visibility, light rain, scattered clouds at 500 feet, overcast at 1.800 feet, temperature 1°C, dew point 0°C, QNH 1023. The first officer requested start-up at 06.10 and was informed by ATC that the slot had expired. At 06.17 KL 1636 received a new slot of 06.40 and start up was approved.
At 06.25 the aircraft taxied from Y-4 to the holding point of runway 36.
At 06.26 the ATC clearance: KLM 1636 cleared to Amsterdam via SIRLO 5A MATOG 7M, initial climb to FL 120, Squawk 0406, was received (see Appendix D).
At 06.28 KL 1636 approached the holding point runway 36 and called ready for departure. The aircraft was cleared to line up on runway 36 but had to wait for almost 5 minutes before take-off clearance was given.
At 06.33 the take-off clearance was received, the wind was calm.

1.1.8. Take-off roll, rotation and lift-off

During the take-off roll the crew experienced all engine indications and aircraft acceleration to be normal. According to the DFDR fourteen seconds after the engines had achieved full take-off power, rotation was commenced at 126 knots indicated airspeed.
The first officer described hearing “a kind of bang, not really loud” just as he gave the “rotate “ call to the Captain.

The second cabin attendant (CA2) seated in the rear of the aircraft heard a very loud ‘bang’ just after lift off and noticed one of the luggage bins at row number 11 fall open. She also recalled seeing a yellow flame outside on the right side of the aircraft. She had eye contact with the forward cabin attendant (CA1) who was expressing *“intense concern”* and a lot of passengers were also looking at her.

One passenger (an Italian engineer) later described that he thought he saw an *“orange object fly over the right hand wing which then hit the fuselage and moved backwards”*. After that he said he *“heard a loud bang”*. The ATC tower controller also noticed sparks behind one engine after lift-off.

During rotation an increase in fan vibration of Engine No.1 was recorded by the Digital Flight Data Recorder (DFDR). Immediately after there was a 0,04 decrease in EPR in the same engine which recovered slowly back to the target value (see Appendix E).

At lift off, fan vibration in Engine No.2 increased significantly, followed immediately by a sudden loss of oil pressure and fuel flow. At the same time the fan vibration in Engine No.1 went above the limit that triggers an alert. There was a 2-3 degree yaw to the right and a slight roll to the right was recorded. The “level 1”alert for the Engine No.1 high vibration was inhibited until 400 feet and a level 3 master warning (repetitive triple chime with two flashing red master caution lights) was generated for Engine No2. An alert message (ENG 2 FAIL) appeared on the left Multi Function Display Unit (MFDU) and the associated procedure appeared on the right MFDU. Airspeed was 141 knots. There was an initial vertical speed of 2.500 feet per minute recorded followed by a reduction to 640 feet per minute.

Just after lift off the autothrottle system failed. The level 2 alert for this failure was also inhibited until 400 feet but an amber flashing (MAN) in the thrust mode window appeared on both Primary Flight Displays (PFDs).

1.1.9. Climb-out

Fourteen seconds after lift off the DFDR indicated that a “gear up” selection was made and “heading” was selected on the Flight Mode Panel (FMP) and indicated on the Electronic Flight Instrument System (EFIS). Six seconds later one of the crew cancelled the master warning alert. At 400 feet the first officer engaged auto pilot No 1. upon command of the Captain and a master caution (one double chime with 2 flashing amber master caution lights) was presented for the dual autothrottle failure. Three alert messages were now visible on the left MFDU, (ENG 2 FAIL, AUTOTHROTTLE 1&2 and VIB HI ENG 1). The alert procedure for the engine failure was still presented on the right MFDU. (Until 400 feet both the autothrottle alert and the high vibration alert had been inhibited). The master caution lights were not cancelled and remained on for several minutes.

The Captain was aware that the autothrottle would not be available (normally the autothrottle would re-clutch at either thrust reduction altitude, FMP altitude or selection of another thrust mode) and as he commenced a right turn he asked the first officer to perform the alert procedure for the engine failure. The first officer commenced the procedure and at this time he also noticed that the autothrottle was disconnected and so he advised the Captain of this. When he attempted to select the fuel lever to shut it only moved a few centimetres before it became mechanically jammed. The first officer made 3 further attempts to shut the fuel lever. He did not feel any vibration in the fuel lever but the fact that he could not shut it bothered him. The Captain asked him to continue with the alert procedure.

There was no fire warning and the Captain confirmed that there was still N1 and N2 rotation in the right engine. The fire handle was not pulled.

The Captain continued the right turn onto a heading of 139 degrees. At 30 seconds after lift-off the first officer transmitted a PAN PAN PAN call to the tower controller at Torino during which he stated "we have an engine failure steering on the right setting on to track 110." The controller replied and requested the aircraft to call another radio frequency (see Appendix F).

One minute and fifteen seconds after lift off, at 1.500 feet above the ground the aircraft commenced accelerating to its final take-off climb speed.

Note: This speed is calculated by the flight management computer which was the best climb performance speed based on actual weight.

Although the ATC clearance was to Flight Level 120 the crew decided to continue to climb to only 6.000 feet QNH and proceed towards the holding fix 'SIRLO'. The first officer entered the SIRLO holding in the flight management system and checked the minimum safe altitude on the departure chart. At 1.500 feet a level 2 master caution alert was generated for the cabin pressurization (the last inhibition phase before cruise ends at 1.000 feet, so the alert condition must have become active at 1.500 feet). However, the visual and aural attention getters were not given, because of the not yet cancelled master caution light.

The alert message (CAB PRESS CTL CHAN) (level 1) was reportedly presented on the left MFDU but an alert procedure for (CAB PRESS CTL) (level 2) was presented on the right MFDU beneath the autothrottle failure procedure.

The cabin pressure control failure was confirmed by a fault light on the overhead panel and it could also be felt in the ears. The first officer briefly checked the emergency checklist for the cabin pressure control failure and the Captain announced that he would continue flying using manual throttle.

The radar controller called the aircraft and after the first officer initially asked the controller to "stand by" there was a brief conversation between the controller and the first officer. The aircraft was offered radar vectors for an immediate return to Torino however, the first officer informed the controller that they would first proceed to SIRLO and hold there until they were ready for an approach.

The crew decided that holding at SIRLO was more desirable than radar vectors for they would know exactly where they were in relation to the surrounding terrain.

The aircraft captured the inbound track of 105 degrees towards SIRLO and approximately two minutes later commenced levelling off at 6.000 feet. The EPR thrust limit was selected to Maximum Continuous Thrust (MCT) as the forward speed started to increase. At 3 minutes and 28 seconds after lift off, a "level 1"fuel asymmetry alert with a single chime sounded. A (FUEL ASYM) alert message appeared on the left MFDU. Both pilots were surprised by this alert. Twenty three seconds later the Captain reduced power on the left engine, and another three seconds later the fan vibration of engine No.1 decreased below the limit.

The (VIB HI ENG 1) alert procedure appeared with header "in white" on the right MFDU (Alert procedures change from amber to white when the alert is no longer valid).

At the same time the first officer commented that "the aircraft was not flying really well and that the engine did not feel smooth".

1.1.10. MAYDAY call

Approximately seven minutes after lift off (and 6 1/2 minutes after the first call to ATC) the Captain issued a MAYDAY call and requested emergency services at Torino. ATC again responded with radar vectors for an immediate return but the Captain replied that he would call when he was ready. Two minutes later the MFDS status page was selected. The Captain stated that he did not want to waste any more time going in detail through all the emergency checklists.

Note: The MFDS status page indicates all active system failures.

1.1.11. Approach preparation

The Captain called the cabin attendant by interphone to tell her what was happening and that she could expect a normal landing in 10 to 15 minutes. After this he also made an announcement to the passengers with the same information and added that if they had any questions that they should ask the cabin crew.

Both cabin attendants stood up and started walking through the cabin.

The CA1 was concerned about the vibration in the cabin floor and she had the feeling that "*this was taking too long*". She became angry with the situation and wanted the crew to put the aircraft on the ground as soon as possible. The CA2 also felt the floor vibration. She attempted to calm the CA1 and decided to talk with the passengers to take her own mind off the situation.

The Captain accidentally deleted the SIRLO holding pattern from the flight management system and the aircraft flew in a figure 8 type of pattern around SIRLO (see Appendix F). During this time a nuisance "level 1"alert for centre tank fuel pumps occurred with a single chime and the associated alert procedure appeared on the right MFDU.

1.1.12. Approach and landing

Approximately ten minutes after the MAYDAY call, KL 1636 requested radar vectors for an ILS approach to runway 36 at Torino (see Appendix D). The wind was from 040 degrees at 3 knots, visibility was 6 kilometres in moderate rain with scattered cloud at 500 feet and overcast cloud at 1.800 feet.

The aircraft was cleared to 4.000 feet and had approximately 28 track miles to touchdown. During the level off at 4.000 feet, 20 miles from the runway threshold a power increase on Engine No1 caused the fan vibration to go above the limit that triggered an alert for 7 seconds. The CA1 also felt vibration in the floor of the cabin and described it as being more severe than before.

The aircraft intercepted the localiser and glide slope for the runway and, at the outer marker an 'ICING' alert occurred. The first officer selected wing and tail de-ice on. At approximately 1.500 feet both pilots could see the runway. At 1.000 feet the Captain disconnected the auto pilot and landed the aircraft 28 minutes and 20 seconds after lift off. The landing was described by both cabin attendants as being *"very soft"*.

1.1.13. After landing

After standing on the taxiway for 8 minutes during which several actions were performed consistent with the taxi-in procedures, the status page of the MFDU was selected once again. Engine No.2 fire handle was pulled and bottle of extinguishing agent discharged. The fire brigade followed the aircraft to the parking position. The Captain then taxied onto the apron and parked the aircraft.

1.1.14. After parking

After the passengers were disembarked and external power was connected to the aircraft, the Captain contacted by mobile telephone the Chief pilot and Company MPH and gave a brief description of the incident.

Several people then entered the aircraft including ambulance personnel, police and others from the Italian Civil Aviation Authority (ENAC).

After about 1 hour the entire crew went outside and described Engine No.2 to be badly damaged. They also heard a "ticking" sound coming from the engine. The Captain returned to the cockpit and pulled the circuit breakers for the Engine No. 2 igniters and after this the "ticking" noise stopped.

The crew were surprised that the handling agent could not open the forward cargo door.

Note: It was established later in the day that a large wooden object being transported in the forward cargo hold had wedged in a position that prevented the door mechanism from operating. The cargo net, when secured, provides a 10 cm. by 10 cm. lattice type webbing between the cargo and the cargo door. However the net had not been secured.

A request to interview the crew came from the Italian Civil Aviation Authority and SAGAT transported them to the Civil Aviation Authority office. Copies were made of relevant aircraft documents, the aircraft flight log, crew licences and their medical certificates. At this time the crew were told by the officer on duty that a large flame had been seen coming out of the right engine at take-off.

After the aircraft landed a runway inspection was performed by the airport authorities several pieces of engine debris and some pieces of clear ice were found between taxiway D and C on the right hand side of the runway centre line (see Appendix A).

The crew returned to the aircraft and after another telephone conversation with the chief pilot the Captain pulled the circuit breakers for the cockpit voice recorder (CVR). The entire crew were transported to Amsterdam by another company aircraft later the same afternoon.

The KLC investigation team arrived in Torino at approximately 14:30 the same day. The aircraft had been left 'untouched'. All cockpit switch positions, instrument readings, pulled circuit breakers and other relevant information was recorded.

After co-ordination with the Italian Investigation Authority another runway inspection was performed. Several more parts of the right hand engine were recovered. Finally the aircraft was towed to a remote position for further investigation the following day.

1.1.15. Crew Communication

On board the Fokker 70 the CA1 is seated adjacent to the forward passenger entry door and the CA2 is seated at the rear bulkhead.

The CA 1 stated that the take-off run was experienced as normal but when the aircraft nose lifted a loud scraping noise was heard from right side, somewhere afterward in the aircraft. She described the noise as being *"like a platform luggage trolley was trapped between the gear and the runway*". The CA 1 sensed that the aircraft from her perspective was climbing very slowly. Because of the angle of the curtains in the galley she concluded that the aircraft was still climbing. She heard aural alerts from the cockpit and she also heard when these stopped. She had the feeling that "*the crew was still working on it*".

The CA 1 could not recall the exact moment she felt the development of vibration in the cabin floor but this raised her concern significantly. The vibrations stopped for a while but when they reoccurred they felt *"much more severe*". She recalled that after the gear was lowered the vibrations stopped.

The CA 2 experienced all as normal and routine until the aircraft lifted off the runway. Just after lift off she heard a *"very loud bang"* and at the same time one of the luggage bins at row 11 fell open and she saw a yellow flame outside the aircraft. She also experienced the floor vibration but made the association that the remaining engine had *"to work harder"*.

The CA1 immediately contacted the CA 2 by cabin interphone and expressed her concern about the situation. She made particular mention of the cabin floor vibration.

Just after the aircraft entered the SIRLO holding the Captain contacted the CA 1 by interphone. He stated that there was a failure of the right engine, which forced them to return to Torino and a normal landing was to be expected after approximately 15 minutes. The Captain did not ask if the cabin crew experienced anything abnormal and the CA 1 did not request for additional information. At this time the CA 1 did not consider to inform the cockpit about the abnormalities noticed in the cabin.

The Captain made a brief announcement to the passengers with the same information he had relayed to the CA 1. He also stated that any further questions could be directed to the cabin attendants. No further passenger announcements were made by the Captain during the flight.
The CA 2 got out of her seat and started to walk through the cabin speaking with several passengers and assuring them that the announcement by the Captain indicated a routine return to Torino due to a technical problem. A passenger in row 15 asked if the flame she saw outside was normal.

1.2. INJURIES TO PERSONS

Injuries	Crew	Passenger	Other
Fatal	-	-	-
Serious / Minor	-	-	-
None	4	30	-

1.3. DAMAGE TO AIRCRAFT

1.3.1. General damage

Several sharp pits (fingernail size) were visible above the right hand side windows (windows 3 and 7, counting from aft) on top of the fuselage. Two windows were scratched. Three scratches were found on the right wing; one in front of the engine and two near the inboard flap track. No damaged tires or loose exterior panels were found. There was no evidence of runway debris damage on the underside of the fuselage or the stabilizer.

1.3.2. Engine damage

A summary of the Rolls-Royce engine damage report along with analysis and reasons for the damage are reported in paragraph 2.2. ANALYSIS OF POWERPLANT.

1.3.2.1. Right engine (No. 2)

One fan blade was completely broken off near the root of the blade (see photograph 1 Appendix G). Three fan blades were broken off at approximately 50% of the fan blade length. One fan blade was broken at approximately 80% of the fan blade length, with 20% of the blade missing. Almost all leading edge tips of the remaining blades were damaged. There was also damage to the trailing edge of the fan blades. Some remains of the broken fan blades were found behind the fan. The accessory gearbox and the hydraulic pump housing were cracked. The PLA (Power Lever Angle) transducer was hanging on its wiring. The throttle linkage was detached from the fan case. The upper and lower cowling door opening rods were found loose with impact marks from the forward opening rod in the lower cowling door.

The automatic activation of the emergency fuel shut off mechanism caused the fuel lever in the cockpit to be locked in the open position. Operation of the mechanism modifies the geometry of the fuel lever on the engine (the straight lever changes into an angled lever). As a consequence the input lever on the HP fuel cock on the engine is pushed to the shut stop. Hence an input by the cockpit fuel lever, which is still in the open position, towards the shut position is made impossible because the HP fuel cock input lever on the engine is already at the shut stop.

There was a small hole in the engine inlet and in the by-pass duct near the low-pressure turbine. The o-ring seal around the rear engine mount was loose.

There was no evidence of bird ingestion. Scratches were found on the engine inlet, which appeared to be caused by material spiralling out of the engine.

The engine was sent to Rolls-Royce for further analysis.

1.3.2.2. Left engine (No. 1)

Five of the fan blade leading edge tips were bent forward. No damage was found on the remaining fan blades (see photograph 2 Appendix G). There was no evidence of bird ingestion.

1.4. OTHER DAMAGE

Not Applicable.

1.5. PERSONNEL INFORMATION

1.5.1. Flight crew

1.5.1.1. Captain

- Age: 52
- Nationality: Dutch
- Proficiency Check: 12th November 2001
- Medical examination: 07th February 2002
- Total Flying Hours: 14.700
- Hours on Type: 3.180
- Hours Last 90 Days: 130

1.5.1.2. First Officer

- Age: 29
- Nationality: Dutch
- Proficiency Check: 14th January 2002
- Medical examination: 10th January 2002
- Total Flying Hours: 385
- Hours on Type: 221
- Hours Last 90 Days: 108

1.5.2. Cabin crew

Cabin crew members CA1 and CA2 were both qualified and current on the Fokker 70.

1.6. AIRCRAFT INFORMATION

1.6.1. General

The Fokker 70 is low wing, T-tail, rear mounted twin engine turbofan aircraft for short to medium haul operations.

Two Rolls-Royce Tay Mk 620-15 axial flow turbofan engines power the aircraft. The engines are mounted on the left and right of the fuselage and are rated at 13.850 lbs of take-off thrust. The engines are equipped with thrust reversers.

The primary flight controls are hydraulically powered, and there is manual reversion capability.
The landing gear is a conventional retractable tricycle type gear with a steerable nose gear.
The aircraft is equipped with a dual channel Automatic Flight Control and Augmentation System (AFCAS) providing flight director, auto pilot, autothrottle and flight augmentation functions.
Primary flight and navigation information is presented on Cathode Ray Tube (CRT) screens.
The aircraft is equipped with a dual Flight Management System (FMS) providing flight planning, navigation, performance management with lateral and vertical guidance facilities.
An Auxiliary Power Unit (APU) is located in the tail section, capable of supplying electrical power (on ground and in flight) and bleed air (on ground only).
The aircraft is certified for commercial airline operations, including Cat IIIA and operations in accordance with the European Reduced Vertical Separation Minimum (RVSM).
PH-KZH was equipped with 80 passenger seats, a forward and aft galley, two stowage units (dog houses), and two lavatories; one forward and one aft.
The passenger door was equipped with an integral stair.
The Fokker 70 is capable of operating:

- at a maximum take-off weight of 37.995 kg.
- at a maximum cruising altitude of 35.000 feet
- at an average cruising speed of Mach .75 (maximum 320 Knots/Mach .77)
- a maximum range of approximately 700 Nautical Miles with a full load.

1.6.2. Aircraft specifics

Aircraft type:	Fokker F-28 Mk 0070
Registration:	PH-KZH
Date of Delivery:	February 1997
Serial Number:	S/N 11583
Certificate of Airworthiness:	ZT 5338
Total Aircraft Hours:	11.548 Hrs
Total Aircraft Cycles:	9.541
Engines:	2 x Rolls-Royce Tay M 620-15
Engines serial numbers:	Engine No.1: 17177, Engine No.2: 17178
Type of fuel used:	Jet A-1

1.6.3. Weight and Balance

KL 1636 was within weight and balance limitations for take-off and landing at Torino.
With a take-off weight of 31.610 kg the aircraft was 6.385 kg under the maximum take-off weight. The final landing weight was below the maximum certified landing weight.

1.6.4. Aircraft Fuel

The Fokker 70 wing tanks each have a capacity of 4.820 litres (3.856 Kg at specific gravity of 0,8 Kg/litre). The temperature of the fuel added in Amsterdam was approximately 8,5°C based upon the specific gravity of 0,806 that was recorded on the fuel invoice.
The aircraft departed the day prior to the incident, from Schiphol with 7.930 kg of Jet A-1 on board. A difference of 72 kg. was recorded between the quantity before refuelling plus 6.785 litres added, multiplied by Specific Gravity (0,806) and the total indication after refuelling. There remains some uncertainty in the temperature of the added fuel because of the large spread in temperature versus specific gravity relationship in general (see Appendix P).
The best estimate as to the temperature of the mixed fuel at the start of the flight to Torino is 3°C. Temperature reduction of the fuel during the flight to Torino was approximately 13°C based upon the Total Air Temperature (TAT) DFDR values.
The total fuel uplift from Amsterdam under normal circumstances would enable the aircraft to return from Torino without refuelling. The remaining fuel recorded by the crew on the inbound flight to Torino was 5.080 kg. The APU uses fuel from the left wing collector tank at the rate of 70 kg. per hour and the APU was operated for approximately 10 to 15 minutes after landing in Torino.
The next morning the first officer of KL 1636 recorded an indicated departure fuel of 5.010 kg in the AFL. The APU was started at approximately 05.15 and was still operating during the take-off roll at 06.33. At take-off the fuel imbalance was estimated to be 160 kg. in favour of the right tank.
A fuel asymmetry alert occurred 4 minutes and 29 seconds after engine 2 failed and was triggered by an asymmetry of 350 kg between the left and right wing tanks.
The fuel cross-feed valves were opened to balance the tanks. During vectoring for the ILS the centre tank pumps nuisance alert was displayed.
The recorded fuel in the AFL after landing was 3.760 kg. Engine No.1 consumed 894 kg of fuel and Engine No.2 consumed 157 kg of fuel.
In the company Aircraft Operations Manual (AOM) 2.5.1 it is mentioned under flight planning and performance that "*fuel induced ice can occur on the wing skin over and under the fuel tank*

at temperatures even far above 6°C in precipitation or with low temperature/dew point spread. Therefore do not apply economical tanking.”

In addition to the general company policy concerning the tanking of extra fuel above the basic requirements AOM 3.2.2 states:

“In addition for the Fokker 70 the following applies:

When the OAT during ground stop at the next station is expected to be 10˚C or less, no economical tanking should be performed.

Note: This instruction aims for minimizing the need for an unnecessary de-/anti-icing treatment due to fuel induced icing”.

Actual fuel uplift figures for the months of November and December 2001 and January of 2002 were obtained from company records. Uplift figures from Amsterdam for the day return flight to Torino immediately prior to the night stop flight and uplift figures for the night stop flight to Torino were obtained.

During the three month period prior to the incident there were 16 cases of economical tanking (vice/versa fuel uplift) for the day return flight and 66 cases of economical tanking for the night stop flight.

There was a 54,00 Euro profit per 1.000 kg for fuel uplifted in Amsterdam as opposed to fuel that would be uplifted in Torino.

1.6.5. Flight Warning System

A two channel Flight Warning Computer processes failure conditions and aircraft system data into visual and aural alerts, procedures and memo and status messages.

Visual alerts can be presented via MASTER WARNING lights and MASTER CAUTION lights, local lights and the Multi Function Display System (MFDS). Aural alerts, which comprise attention-getting chimes are presented via flight deck loudspeakers and headsets.

The MFDS consists of two Multifunction Display Units (MFDU) at the main instrument panel. The left MFDU will present alert messages while the right MFDU can present alert procedures and status messages.

Alert messages appear in red (level 3) or amber (level 2 and level 1) on the left MFDU and are automatically withdrawn when the alert is no longer valid.

The procedure of the alert message with the highest priority is automatically presented on the right MFDU in red for (level 3) and amber for (level 2 and level 1). If space is available a maximum of two procedures can be displayed and procedures will be presented in order of priority. If the alert is no longer valid when the procedure is being displayed then the header of the procedure on the MFDU will automatically change from red or amber to white.

1.6.6. Aircraft status

The AML showed that pack number 2 had a history of producing high noise level in the cockpit. Maintenance did not find any abnormalities with the pack itself.
After the incident the Captain entered the following information in the AML:

- (ENGINE) Engine 2 Fail on T/O TRN. Unable to shut fuel lever no.2
- (AC GEN) Hold no 1+2 door unable to open
- (ELEC) Pulled CB 29A, 31F, 31M, 31C
- (ELEC) Ignition was still active after shutdown (clicking noise outside). Pulled CB 9J&34G

Note: *No entry was made about the engine 2 fire handle that was pulled and about extinguishing agent bottle that was discharged.*

Note: *CB 29A powers CVR; CB 31F powers DFDR; CB 31M powers DFDR RVDT Excitation; CB 31C powers QAR; CB 9J powers Ignition Unit 1* Engine No. 2*; CB 34G powers Ignition Unit 2* Engine No. 2.

1.7. METEOROLOGICAL INFORMATION

1.7.1. Weather conditions en-route from Amsterdam to Torino.

The aircraft cruised at FL 330 for approximately 40 minutes with an outside temperature varying between -59°C and -53ºC at a speed of M.76, resulting in a recorded TAT varying from –33 to –26ºC.

The aircraft started its descent 17 minutes prior landing. The crew reported snow changing into rain at 1.000 feet, icing conditions and humid conditions.

1.7.2. TAF - Terminal Area Forecast

FCLIMF 20020216000
160009 VRB05KT 5000 SN BKN007 OVC025=

FCLIMF 200202160300
160312 VRB05KT 3000 SN BKN004 OVC015=

FCLIMF 200202160600
160615 VRB05KT 3000 SNRA BKN004 OVC015=

1.7.3. Torino airport weather report

FTLIMF 200202160000
160018 VRB05KT 1800 RASN BKN005 OVC015 TEMPO 0007 0800 SN
BECMG0710 4000 -RA SCT015 BKN025 OVC070=

FTLIMF 200202160600
160624 VRB05KT 1500 SN BKN003 OVC015 BECMG 1215 RA=

1.7.4 Overnight weather conditions

Following is a summary of the average conditions taken from METARS recorded every 30 minutes during the night.
There was a light breeze throughout the night varying from 050 degrees through to 250 degrees and back to 040 degrees with an average strength of 5 knots. There was scattered low cloud at 800 feet with an overcast layer above at 1.500 feet. Light rain became rain and snow at 21.50 which persisted for 3 1/2 hours. After 01.20, only rain was recorded for the remainder of the night. During the period of rain and snow the temperature and dew point were between 0 and 1ºC and –1ºC respectively. The QNH remained constant at 1022 increasing to 1023 in the early hours of the morning (see Appendix B).

1.8. AIDS TO NAVIGATION

Onboard FMS system for navigation:

- Flight Management System (FMS);
- Radar vectoring service provided by ATC during approach for landing;
- ILS Cat IIIA for RWY 36 at Torino.

Arrival charts and ILS approach plate are reported in Appendix D.

1.9. COMMUNICATIONS

Three onboard VHF radios.

Cockpit to cabin and cabin to cabin interphone system on board the aircraft.

1.10. AERODROME INFORMATION

1.10.1. Torino Caselle airport

Caselle Airport north of Torino is located near the foothills of the Italian Alps and is a civil aerodrome with an elevation of 989 feet.

The single runway (18/36) is 60 meters wide. The preferred landing runway is RWY 36 with a landing distance available of 2.950 meters. It is equipped with 900 meters of approach lights, runway edge lights, and runway centreline lights which supports an ILS Category IIIA installation. There are no approach aids for RWY 18.

Due to the high surrounding terrain KLC has published a specific engine failure procedure. The Minimum Safe Altitude (MSA) in the sector from the South-West to the North-East of the airport is 15.400 feet. From the North-East to the South the MSA is 3.800 feet. Due to the Alps in the North, the Emergency Safe Altitude is set at 17.800 feet.

Standard arrival routing and intermediate approach and arrival holding proceeds via the (TOP) VOR situated South-East of the airport. RWY 36 missed approach holding fix (SIRLO), is situated East of the airport (see Appendix D).

Torino airport meets the Rescue and Fire Fighting Category 8 of the ICAO Annex 14 standard.

1.10.2. Runway inspections

Prior to the daily airfield operation the runway was inspected at 05.25. Braking action tests were performed on the wet runway. The braking action was reported to be good and no irregularities on the runway were found. KL 1636 was the 8^{th} aircraft to take-off after the runway inspection. Immediately after the return of KL 1636 the runway was closed and inspected for debris and/or damage. During the inspection immediately after landing engine material was recovered on the runway between 950 and 1.000 meters from the runway 36 threshold on the right side of the centreline between intersections D and C. The position where most of the debris was found was coincident with the approximate rotation point of the aircraft. The debris consisted of some small metal pieces (see photograph 3 Appendix G) which were later identified as debris from the fan blades and engine acoustic lining.

Amongst the engine debris, some large pieces of ice and a lot of smaller pieces of ice were found. The pieces of ice were described as appearing like glass, clear and compact and of different areas but with similar thickness of about 1 cm. The largest pieces found were approximately 10 cm x 10 cm, of irregular shape and also 1 cm thick.

Note: The presence of the pieces of ice on the runway was not initially thought to be important by the airfield employee who conducted the runway inspection. Eventually however, the airport supervisor was informed and a written declaration was made in order to specify the event and particulars referring to the pieces of ice that were found (see Appendix H).

1.10.3. Parking area

Due to the limited amount of gates available ramp parking positions (X and Y) are utilized with a bus service for the passengers from the departure hall to the aircraft. KL 1636 was parked during the night at position Y-4 (see Appendix A).

1.11. FLIGHT RECORDERS

1.11.1. Cockpit Voice Recorder - CVR

The Fokker 70 is equipped with a solid state Allied Signal CVR part number 980-6020-001. This CVR records the last 30 minutes of flight deck audio. All voice communication is recorded.

Flight deck conversation is recorded via the area microphone.
Operation is automatic when either fuel lever is open until five minutes after last engine shut down. Operation prior to engine start is obtained by depressing the DFDR/CVR GND CTL p/b. KLC pre-flight checklist requires the crew to activate the CVR prior engine start.
When the aircraft is on the ground with the parking brake set, depressing the ERASE button can erase the information on the tape.
The Captain pulled the CVR circuit breaker approximately two hours after engine shut down. (The CVR had kept running because the right hand fuel lever could not be shut). There were no useful sounds recorded on the CVR. The CVR was found to be serviceable and there were no interface deficiencies found between the aircraft and the CVR.

1.11.2. Digital Flight Data Recorder - DFDR

The Fokker 70 digital flight data recording system comprises a Digital Flight Data Recorder (DFDR) – Honeywell part number 980-4700-003-, a Digital Flight Data Acquisition Unit (DFDAU), and an underwater locator beacon. The DFDAU processes input signals received from various systems, such as power plant, flight controls, air data computer and automatic flight control systems. Automatic and manual DFDR system control is provided. The DFDR system runs automatically whenever either Fuel Lever is open, and then continuously during flight. On the ground before engine start, depressing the DFDR/CVR GND CTL push-button will activate the system. KLC pre-flight checklist requires the crew to activate the DFDR prior to engine start.

Note: When the crew contacted the KLC chief pilot on the second occasion which was approximately 2 hours after the event, they were reminded to secure the data on the CVR and DFDR. The Captain pulled the CVR CB, DFDR CB, QAR CB and the DFDR RVDT EXC CB and entered this information in the Aircraft Maintenance Log. After permission was granted by the Italian Investigator in charge Martinair Maintenance removed the QAR disk, DFDR and CVR at 16.20 the next day.

1.12. WRECKAGE AND IMPACT INFORMATION

N.A.

1.13. MEDICAL AND PATHOLOGICAL INFORMATION

N.A.

1.14. FIRE

N.A.

1.15. SURVIVAL ASPECTS

The cabin crew were interviewed about their observations during the flight, their perception of the seriousness of the event and how they coped with, or anticipated the possible scenarios such as emergency landing or on ground emergency.

The communication between the Captain and the CAs, the Captain and the passengers, the CAs and the passengers, and between the CAs themselves was also discussed.

Aspects such as cabin preparation, general knowledge about single engine aircraft performance and what indications (yellow flash, cabin floor vibration, etc.) would be worthwhile to communicate to the cockpit crew were also discussed.

The CA1 expressed the opinion that everything was taking much too long and that the aircraft should have been put on the ground as soon as possible.

The company AOM states that when an emergency arises directly after take-off (returning immediately for landing) or when an emergency arises during approach, a rapid evacuation after landing may be required. In the case when there is an emergency with time for preparation AOM 6.2.3 also states: *"Call CA 1 via the PAS, by the command CA 1 REPORT TO COCKPIT"*.

Guidelines for a passenger address are also mentioned in the AOM and including:

"Please remain seated, keep calm and follow cabin attendant's instructions carefully".

1.16. TESTS AND RESEARCH

1.16.1. Rolls-Royce investigation

After field investigation of the engines in Torino, immediately after the event, the engines were sent to Rolls-Royce East Kilbride Aero Engine facility in Scotland for strip inspection and investigation. During the initial investigation and stripping of the engines specialists from Martinair and KLC were present under the supervision of the ANSV Investigator-in -charge. The (remaining) fan blades from Engine No.1 were removed and after initial inspection they were sent to Rolls-Royce in Dahlewitz in Berlin and subsequently Rolls-Royce Derby in the UK for laboratory and other specialist assessment. Rolls-Royce produced their findings and analysis after concurrence with the other parties involved.

1.16.2. De-icing fluid

At 11.00 local time on the day of the incident, de-icing fluid samples were taken from SAGAT truck No.1 which was used to de-ice KL 1636.
Samples were taken from the tank and the nozzle.
The fluid temperature which was taken from a gauge on the truck was quoted as being 65ºC at the time of spraying.
Tests were conducted by the KLM laboratory on the samples of fluid on 20th of February 2002 with the following results:

Tank

- pH value of 7,3.
- Refractive Index of 1,393 at 20ºC.
- Viscosity of 3.900 mPa.s at 20ºC.

Nozzle

- pH value of 7,2.
- Refractive Index of 1,393 at 20ºC.
- Viscosity of 3.400 mPa.s at 20ºC.

The report conclusion stated that the sample from the vehicle tank showed a viscosity below the lower delivery limit. However, since the sample from the nozzle showed a viscosity well above the lower nozzle limit, this was acceptable as long as it was guaranteed that the viscosity of fluid from the nozzle would stay above the lower nozzle limit.

1.16.3. KLC simulator re-creation

In the absence of an animation program for the Fokker 70 a simulator program to re-create the event from the take-off roll to landing was constructed using information from the DFDR, ATC

tape transcript, ATC radar plot and actual aircraft weight and balance figures. All pilot actions, system alerts and failures, normal system operations and all radio transmissions were calculated along a time line scale.
Two Fokker 70 qualified pilots acted as Captain and first officer and performed all tasks on the 'cue' of a member of the investigating team who called all actions to be performed and read all radio transmissions from a pre-arranged '*script*' and also co-ordinated the timing of all these actions and events. In between instructions the two simulator pilots behaved as much as possible according to the standard company procedures.
A Fokker 70 qualified instructor operated the simulator and programmed all failures and alerts according to DFDR information. The instructor also ensured that the position of the simulator coincided with the actual position of the aircraft that was indicated on the ATC radar plot.
Another Fokker 70 co-pilot occupied the second jump seat to observe and take notes. The scenario was re-enacted several times and after the third time, the observing co-pilot replaced one of the simulator pilots in order to avoid over familiarity of these pilots with the scenario.
After each re-enactment several discussions took place between all parties present regarding the appearance of alert procedures on the MFDU, aircraft performance, possible actions and interpretations of the Captain and first officer etc.
The following results and observations were obtained.

- The fourteen second time interval between rotation and selection of gear up did not seem excessive considering the initial shock of the situation and comprehension of the event that was occurring. The actions of heading select, auto pilot engagement and then initial turn to follow the engine failure procedure, following the gear up selection, had to be performed in a crisp and decisive manner.
- The level 2 MASTER CAUTION double chime and amber flashing light generated by the dual autothrottle failure and finally presented at 400 feet, remained ON for an extended period of time and hence blocked visual and aural attention getters of subsequent alerts until it was cancelled by the flight crew just prior to the fuel asymmetry alert.
- After the auto pressurization failure, CAB PRESS CTL CHAN was presented on the left MFDU with the alert procedure for CAB PRESS CTL on the right MFDU. This was exactly as it had occurred in the aircraft, as stated by the first officer and came as a surprise to the investigators present in the simulator. It must be noted, however, that the simulator does not contain a Flight Warning Computer, but all faults are generated by a simulation computer. A

reproduction attempt on the incident aircraft did not show a mismatch between the alert, (left MFDU) and the procedure heading, (right MFDU); however, there may be a technical explanation for the mismatch under certain intermittent failure conditions, which would explain the reported observation.

- The fuel asymmetry warning which could not be pre-programmed coincided within seconds of the same time as it did in the actual aircraft.
- The N1 AND N2 engine vibration tapes of the engine No. 1 were presented on the right hand MFDU throughout the alert procedures.
- The simulator reached 6.000 feet 40 seconds earlier than the actual aircraft. The level off at 6.000 feet could be extended by 40 seconds in the simulator with a slight reduction of thrust on the left engine.
- In order to achieve all the tasks performed in the given time frames both pilots had to perform several tasks individually.

The simulation re-enactment was recorded on video which was made available to the investigation team for their analysis.

1.16.4. Comparable events

A similar event in some aspects, to that presented in this report occurred on December 27, 1991, at Gottrora (Sweden) in which a SAS MD-81 experienced severe damage on both engines due to clear-ice ingestion after take-off.
Findings, conclusions and recommendations that resulted from the accident investigation have been taken into consideration when analyzing facts and information regarding the KL1636 Fokker 70 incident.
The report of the SAS MD-81 accident in Stockholm in 1991 (Swedish Board of Accident Investigation Report C 1993:57, Case L-124/91) was used as a reference. The similarity of events on several issues made it worthwhile and even necessary to compare certain findings and analysis results.

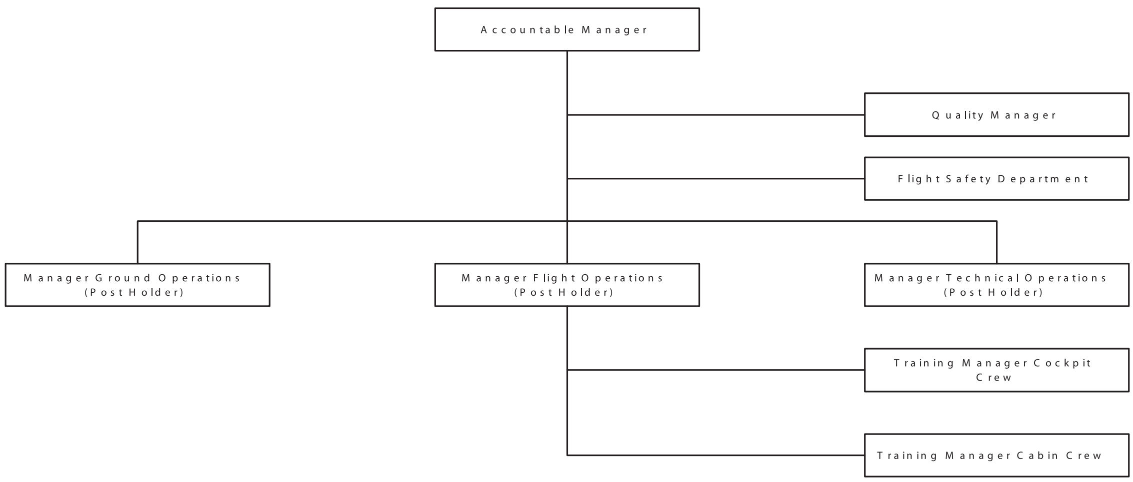
1.17. ORGANIZATIONAL AND MANAGEMENT INFORMATION

1.17.1. General

Since December 3rd 2001 KLM Cityhopper B.V. has been found competent by Civil Aviation Authority Netherlands to conduct Commercial Air Transport Operations and has satisfied the Operator Certification requirements prescribed in JAR-OPS 1.
Some relevant part from JAR-OPS 1 requirements are quoted in Appendix I.

1.17.2. KLC general

The following information is based on and quoted out of the KLM Cityhopper Basic Operations Manual (BOM) and KLC quality manual which were valid at the time of the incident.
The organizational Structure, related to JAR-OPS 1 requirements, is presented in the following diagram, which gives description, subordination, and reporting lines, which pertain to the safety of flight operations.



At the request of ANSV the Dutch Transport Safety Board - DTSB has conducted an analysis of the structure of the KLC Cityhopper.
These comments relate to the company structure and the responsibilities of the Postholders and Managers relevant to this report, they are described in Appendix I bis *KLC - General*.

1.17.3. KLC operating manuals (De-Icing/Anti-Icing Procedures)

The KLC Basic Operations Manual (BOM) 8.2.4 explains that *"clear ice may form on the upper wing surface with an outside temperature above freezing, upper wing skin temperature below*

freezing and precipitation or visible moisture present”. It is further stated that *“the upper wing skin temperature can be lower than the outside temperature due to radiation when the aircraft is parked overnight or when after a flight, cold fuel still remains in contact with the upper wing skin”*.
The general responsibility regarding de-icing/anti-icing on the ground is described as follows:
‘If frost or ice has formed on the lower wing surface tank area and the aircraft has been subject to precipitation conditions (rain, drizzle, fog) during its ground time or when there is otherwise doubt that clear ice has formed on the upper wing surface, then the upper surface has to be checked using a suitable means of access in order to detect the possible clear ice. ……..It must always be remembered that below a snow/slush layer there can be clear ice, which is very difficult to detect. There is a great risk that the undetected ice layer will separate from the wing during take-off roll or in the worst case during rotation, causing substantial lift loss and possible severe internal engine damage (aircraft with rear mounted engines)”.
“The pilot in command has the final responsibility for ensuring that wing leading edges and upper surfaces are free of frost, ice, snow or slush prior to departure and at take-off”.
At stations where no ground engineer is available the de-icing/anti-icing handling agent is responsible for the correct and complete de-icing / anti-icing treatment of the aircraft.
At stations where a ground engineer is available (as the pilot expected was available in Torino, according to the information reported in the Regional Operations Manual ROM - paragraph 3.5 “De-/anti-icing Procedures Outstations.”) *the ground engineer is responsible for the release of the aircraft free of frost, ice, snow or slash. He is also responsible for the correct and complete de-icing/anti-icing treatment of the aircraft.*
After completion of the de-icing treatment the aircraft should be thoroughly checked.
These checks should be carried out by the de-icing/anti-icing handling agent. (One of the checks includes rechecking the wing to ensure that all deposits of ice have been removed). A cautionary note adds*: In some cases the presence of (clear) ice on the upper wing surface can only be determined by touch.*
To release the aircraft for the flight, the ground engineer or Captain has to be assured that this check has been properly carried out.
Note: The KLC winterisation and the type qualification training program did not include any “hands on” training for the detection of clear ice.

In the company Regional Operations Manual (ROM) it was written that in Torino Type 2 Kilfrost ABC3 fluid 100%, 75%, 50% or 25% would be used for de-icing/anti-icing with 1 step operation or "2 step" operation (on request of the Captain).
It was further written that SAGAT would be the company performing the de-icing/anti-icing and that Alitalia would be the company inspecting after completion of the de-icing/anti-icing treatment (see table in Appendix L).
In the company AOM 2.5.1 the cold weather operation pre-flight check includes to check that the wings are clear of contamination and to beware that clear ice can be hidden below rain/moisture/snow on a cold soaked wing. It further states:
"As the Fokker 70 wing is critical for ice build-up a tactile check is required in certain circumstances. These checks may be performed by the flight crew, but normally are performed by a licensed ground engineer, not necessarily Fokker 70/100 licensed".
According to the flow chart reported in the AOM (see Appendix L), icing conditions are defined as when the OAT is between +6 °C and –25 °C inclusive and either:

- *visible moisture in the air (such as clouds, fog with visibility less than 1.500 meters, rain, drizzle, snow, sleet or ice crystals), or*
- *slush, ice or snow is present on the taxiways or runways, or*
- *the difference between the OAT and the dew point temperature is less than 3 degrees C. When icing exists a normal check for ice plus a tactile check should be done.*

The tactile (hands on) check is described as:

"Check the wing leading edges along the full wing span until the front spar, indicated by the black 'no step' line and perform a visual scan of the remaining upper wing surface. The tactile check must be done by touching the indicated area by bare (or surgical-glove protected) fingers to check for ice / frost / snow / slush contamination.
For this check, a platform with a minimum height of one meter is needed to reach the area".

Note: There was no (one meter high) platform readily available at Torino and there were no surgical gloves available either at the handling agent or on board the aircraft.

In the company AOM 1.12.1 - Visual ice detection aid – is reported as *“a black stripe is provided on the outboard wing to help checking the wing for ice contamination during flight and on the ground”*.

An internal company document known as Plane Facts Fokker 70 and titled Winter Operation was published in December 1998.

This document featured technical particulars of the Fokker 70 with respect to icing, operational guidelines and application of what was written in the BOM and the company AOM. The document had no official status and was not issued to all pilots who transferred to the Fokker 70 aircraft after 1998.

1.17.4. SAGAT Handling

SAGAT Handling, company fully owned by SAGAT S.p.A., (the company that handles Torino Caselle airport) and specifically addressed to provide handling services in the liberalized market starting from October 1st, 2001, was in charge of de/anti-ice operations at Torino airport.

The operations followed the same procedures previously referred to SAGAT S.p.A. and personnel involved had not changed since the previous winter season.

According to SAGAT handling management organization, the de/anti-ice operations are referred to the station manager on duty *“Capo scalo di servizio”,* who supervises all handling services on ramp, passengers boarding and related apron services.

With reference to the de/anti-ice operations, SAGAT Handling has stated in a note (n. 02/289) dated 27th December 2002, the following:

- that before the start of daily de-icing operation a refractive control is performed on the fluid of each de-icing truck to be used;

- all refractive data from the past seasons were recorded;
- during 2001-2002 season the controls were made, but the data was not recorded regularly due to a re-structuring and a re-allocations of jobs;
- personnel in charge of the de-icing operations have been regularly trained; the assessment of the training received has been recorded (results of the assessment were not attached);
- viscosity and refractive check on liquid stock station has been recorded.

For the 2002-2003 time period, SAGAT Handling stated that:

- current organization is confirmed;
- training records are continuously updated and collected in a personal folder (all check data

sheets are available) for each operator;

- daily refractive check is recorded on a “ad-hoc” booklet carried on board of each de/anti-ice truck;
- some improvements have been made on liquid stock station and others are in progress.

In 1999 SAGAT S.p.A. published a de-/anti-icing operation manual *(“Trattamento de-/anti-icing degli aeromobili”)* (see Appendix C) in which are detailed in Italian, the procedures to be followed for de-/anti-icing operations. SAGAT Handling operators are trained on the basis of the information contained in the manual. At paragraph 5.1 “*Procedure operative*”, it is reported that the responsibility of the de-/anti-icing operations lies with the aircraft operator, in particular the designated ground engineer or, in his absence, with the aircraft’s Captain *(“La responsabilità dell’erogazione è della compagnia aerea, in particolare nella persona del tecnico motorista e dove non presente, del comandante dell’aeromobile”).*

Moreover, in paragraph 5.2 of the icing manual it is explained how to spray the de-icing fluid on aircraft structure, with particular reference to the fuselage/wing joint area, where clear-ice is likely to form. At paragraph 5.4 *“Controlli finali prima della partenza”* (Final check before aircraft departure) it is specified that the clearance for aircraft departure after de-/anti-icing treatment is released by authorized personnel (from aircraft company or from authorized inspecting company).

The ground handling contract between SAGAT Handling and KLC, with regard to the de-/anti-icing procedures, did not conform to the standard IATA handling agreement specifications. De-icing was mentioned only in regard to the cost of this service.-

General procedures were referred to in the KLC station manual which was a direct copy of various sections of the BOM. KLC station manual did not contain reference to specific procedures or instructions relative to de-/anti-icing.

KLC stated that there was a verbal agreement with Alitalia regarding the post de-icing inspection. KLC claimed the agreement was that SAGAT Handling would inform Alitalia when de-icing would take place and that Alitalia would send a ground engineer to inspect the aircraft after de-icing was completed.

SAGAT Handling stated that there were neither verbal nor written instructions from KLC about this agreement.

Flight crews were not informed of the details of ground handling contracts or any obligations regarding monitoring the execution of these contracts.

1.17.5. ALITALIA

In accordance with the information reported in the KLC ROM valid at the time of the event, Alitalia was recorded as being the inspection company for the de-/anti-icing operation in Torino airport.
Alitalia Maintenance Quality Manager (*Divisione Ingegneria e Manutenzione)* was questioned about the contract with KLC regarding the de-icing inspection. His answers are summarized below.

- Alitalia was not the handling company performing inspection after de-/anti-icing and there wasn't any related contract with KLC, neither at the time of the audit (January 2001), nor at the time of the serious incident (February 2002).
- In 2001 and 2002 Alitalia personnel detached in Torino did not have any certification on Fokker 70.
- Alitalia personnel were not trained to perform de-icing inspection on the Fokker 70.

Alitalia Quality Manager also stated that there was neither a written contract nor verbal agreement regarding post de-icing inspection with KLC.

1.17.6. De-Icing /Anti-Icing Quality Control Pool (DAQCP)

JAR-OPS 1 requires airline operators to remain responsible as an operator for contracted services including audits and inspections.
To meet these requirements Swissair took the initiative to form the DAQCP in 1998 as a means or a tool to satisfy the JAR-OPS 1 requirement. At this moment there are 37 member airlines including KLC.
Participating airlines in the pool have mutually agreed upon terms and conditions to provide a De-Icing/Anti-Icing Quality control and inspecting service, compliant with JAR-OPS 1.035, at specific airports. In this agreement, a participating airline carrying out an audit at an airport is called *"the inspecting airline"*.
This inspecting airline applies the standards, reporting formats and inspection procedures as laid down in this agreement.
A steering group and a Chairman are elected by the pool members.
Each airline is assigned with a minimum of 5 airports/contractors per year and has a time inspecting window between October and March.
The results are sent to all participating operators, after which it is the operator's responsibility to

initiate corrective action if deemed necessary. The pool fulfils the JAR-OPS 1.035 requirement but the operating companies remain responsible for ensuring the de-icing and anti-icing is appropriate and safe for use on its aircraft.

1.17.7. SAGAT and ALITALIA audit reports

On behalf of the de-icing pool, DAQCP, KLC QA conducted a de-icing audit on SAGAT and Alitalia service for maintenance in Torino on the 22nd of January 2001.
The findings summary for SAGAT showed that:

- No personnel theoretical training tests carried out.
- No passing rates had been established (75%).
- Vehicle tanks not labelled for type/mix .
- Storage and filling ports not labelled for type/mix .
- The findings summary for Alitalia showed that:
- No valid signed contracts at the station.
- No de-icing procedure manuals were found for servicing CLH and KLC.
- No evidence of expiry dates for annual refresh training.
- No evidence of personnel theoretical tests.
- No passing rates had been established.

A letter was sent from KLC the following day to all the nominated DAQCP representatives advising them of the audit results.
A letter was also issued the following day to SAGAT advising them of the audit results. A reply from SAGAT was sent to KLC QA on Feb 15th 2001 advising that all findings would be rectified by June 2001.
A de-icing/anti-icing checklist was sent by the KLC ground handling manager to SAGAT on 27th November 2001. The details concerning the inspecting company were left blank.
In spite of this, Alitalia was still listed as the inspecting company in the KLC ROM, found on the aircraft the day of the incident by the investigator, 16th of February 2002.
The de-icing audit for 2001/2002 was not performed until March 2002 and was done by DAT (Delta Air Transport). Results from this audit revealed the same findings from the year before.

1.18. ADDITIONAL INFORMATION

1.18.1. Clear ice issue

Preliminary information regarding the serious incident was delivered to pilots, operators and Italian Civil Aviation Authority (ENAC) as follows:

- After the event in February 2002 KLC forwarded a Crew Bulletin to all Fokker 70 pilots warning them about the weather and operating conditions where clear ice is likely to form. Information regarding on how to perform the visual inspection when de-icing the aircraft and the applicability of economical fuel tanking were also detailed.
- In April 2002 ANSV forwarded a *"Messaggio di Allerta"* (Safety Alert Message) to ENAC (see Appendix M).
- In September 2002 Fokker sent a message to all Fokker 70/100 operators warning them on the importance of strict adherence to the *"clean aircraft concept*".

1.18.2. JAR-OPS 1 requirements

With reference to the interpretation of JAR-OPS 1, in relation to the responsibility for de-icing operations, questions on the following matters were forwarded to ENAC and Civil Aviation Authority of Netherlands (CAA NL), as the regulatory Authority in the State of Registration and of Operator of the aircraft.

a) The intended Postholder who is to be responsible for aircraft de-icing inspections.
b) The circumstances under which the intended Postholder may delegate the responsibility of above inspections to another Postholder.
c) The actions which are required of the intended Postholder, should the responsibility of de-icing be delegated to another Postholder and comments concerning ambiguity of JAR-OPS 1 in relation to de-icing and the difficulty of interpretation of JAR-OPS 1 on this matter.

The answers that were given are as follows:

a) In compliance with requirements of JAR-OPS 1.890(a)(1) and JAR-OPS 1 AMC OPS 1.890 (a)(1) (*Maintenance Responsibility*) CAA-NL holds the Postholder Maintenance responsible for the proper execution of the pre-flight inspection. AMC OPS 1.890(a)(1)1.f explicitly states that it must be ensured the aircraft surfaces must be free from ice, snow, sand, dust, etc… Under the responsibility of the Postholder Maintenance the Operator should publish guidance to maintenance, flight and contracted personnel regarding the performance of pre-flight inspections, defining the responsibilities and tasks in accordance with the requirements as set forward in AMC OPS 1.890(a)(1)3. The pre-flight inspections and the responsibilities should be defined in the operators Maintenance Management Exposition (MME) manual. De-icing operations (with specific reference to organizational and commercial aspects) as defined in JAR-OPS 1.175(i)(4) and further defined in ACJ OPS 1.175(i), do not fall under the competence of the Postholder Maintenance, but are under the competence of the Postholder Ground Operations.

b) The Postholder Maintenance, responsible for the technical aspects of the pre-flight inspections, should not delegate the responsibility for the pre-flight inspection, but he can delegate the specific tasks to pilots, maintenance personnel or contracted ground handling personnel. For contracting ground handling activities, including pre-flight and de-icing, the operator may make use of the IATA standard ground handling agreement as referred to in AMC OPS 1.895(d)4. The MME should be explicit in who is responsible for the execution of the pre-flight inspections. According to JAR-OPS 1.875(a) pre-flight inspections need not necessarily be carried out by the JAR-145 organisation.

c) With reference to the action requested from a responsible Postholder when such responsibility is delegated to another Postholder, the Civil Aviation Authority (CAA) of the Netherlands confirmed that the operator's Basic Operation Manual (BOM) and the MME should be explicit in who is responsible for performing de-icing activities. Usually the Postholder Ground Operations is responsible for such activities and for the contracting of such activities, but if such responsibility should be delegated to the Postholder Maintenance, then an adequate reference should be well defined in the MME.

The directive for executions of de-icing and pre-flight inspections is however, the responsibility of the Postholder Maintenance. None of such activities can be reassigned to contractors or personnel without the written consent and quality assessment by the Postholder Maintenance. See AMC OPS 1.890(a)(1)3. The contractor selection procedure as defined in the operators MME must be followed.

According to JAR-OPS 1.900(a) (1) and (2) these activities must be part of the quality monitoring programme of the operator. JAA Administrative & Guidance Material Section 4, Part Three, Temporary Guidance Leaflet (TGL) 21 gives the possibility to operators to take part in a quality inspection/audit pool. This TGL requires a written pool agreement and defines items to be addressed in this agreement.

In relation to de-icing and difficulty of interpretation of JAR-OPS 1, CAA NL stated that after studying JAR-OPS with respect to de-icing, the conclusion was that JAR-OPS provides regulations which may require more detail, but for the moment it does give an Authority means to check, and if necessary, correct on items as de-icing.

ENAC agreed on this interpretation and added that it is up to the operator to define in greater detail the responsibilities and the relationship between all parties involved in the de-icing process, in their own Operation manuals and in the MME.

Note: Company publications (manuals) are subject to approval by the Authorities.

CHAPTER II

ANALYSIS

2. ANALYSIS

2.1. CLEAR ICE FORMATION

Ice can form on the upper surface of the wing when precipitation comes into contact with this area and the surface temperature of the area is below zero. The rate of formation of ice and final thickness of the ice layer will be determined by the surface temperature of the wing, the outside temperature and the rate of precipitation. The appearance of such ice will be clear, glass-like, if both the OAT is above 0ºC and the precipitation (or condensation) is in liquid form.

When sub-zero temperature fuel is in contact with the upper surface of the wing then the wing surface temperature will also be below zero. The most likely areas for cold fuel induced ice formation are the wing root between the front and rear spars and any part of the wing that contains unused cold fuel in contact with the skin. As the thermal conductivity of fuel is much less than that of the wing structure, cold fuel induced ice formation is usually found at and near the more heavy structural elements, typically at the wing rear spar, and forward depending on the fuel level in the tank.

Before departure from AMS on the evening before the day of the incident, approximately 2.600 kg of fuel was added to each wing which already had approximately 1.200 kg of unused fuel. It is reasonable to assume that the 1.200 kg quantity of fuel was already at sub zero temperature due to the previous flight from Torino (rough calculations show –6ºC) (ref document provided by FS). The 2.600 kg of added fuel had a temperature of approximately 8,6ºC which could be calculated from the specific gravity value of 0,806 recorded on the fuel docket. Taking the mixing ratio of around 2:1, at best the fuel temperature in the tanks prior to departure would have been approximately 3ºC.

From TAT DFDR data it was calculated that during flight the fuel temperature would have dropped by approximately 13ºC which meant that the temperature in the tanks on arrival in Torino would have been approximately -10ºC.

Although it was not possible to establish which area of the wing would have been in contact with the specific amount of fuel that remained on board, it can be said that the area above the collector tank would have been in contact with the sub zero fuel for a period of time. The collector tanks are directly in line with the engine inlet area. No information was available about how long the fuel would remain in the collector tanks after the fuel pumps were turned off however, both wing tanks would have been approximately 70% full. It is assumed therefore that a substantial area of the wing surface area was at a sub zero temperature for a considerable period of time.

The outside air temperature of between 1ºC and 0ºC, during night stop, would have been favourable for the formation of clear ice. Given that the conditions immediately after engine shut down, were ‘ideal' for the formation of cold fuel induced ice, that is light rain and snow falling on cold soaked wings and that the wings would have remained cold for a long period of time, then it is probable that a substantial layer of ice formed and remained on the wings over night. But also, given the mixed nature of the precipitation, it is unlikely that it would be clear ice only. In this respect it is also possible that wet snow collected on the sides of the fuselage during the night, and slid down onto the wing roots when the aircraft skin and outside temperature rose.

The Captain's observation during the pre-flight inspection, of ice ridges 1,5 to 2 cm thick under the wing leading edges and 1 to 2 millimetres of slushy water and ice in small areas on top of the wings indicates that ice had formed on the wings during the night.

The presence of slush indicates that the ice was beginning to melt, probably due to the ambient temperature being above zero.

The Rolls-Royce technical report concluded that both engines had suffered soft body ingestion and specifically that the impacting body was ice. The size of the ice required to cause excessive fan blade distortion leading to its failure in engine No 2. was calculated to be in the order of 1,8 cm to 3,6 cm thick based upon a block of 30,5 cm x 30,5 cm and depending upon the orientation of the block. For engine No 1. the ice would have to have been 1,3 to 2,6 cm thick also depending upon orientation.

Several pieces of ice of various size were found immediately after the event on the runway close to the point of rotation of the aircraft. The largest pieces found were 10 cm by 10 cm by 1cm thick and of irregular shape. These pieces were also described as appearing like glass. This evidence supports the Rolls-Royce calculations as the pieces found on the runway would have been fragments of larger and thicker (given the elapsed time after the event) plates of ice.

Based upon the amount of fuel in the wing tanks, en-route temperatures during flight, the weather conditions upon arrival at Torino and during the night, the Captains observations during the pre flight inspection the following day, the Rolls-Royce technical report and the description of

the pieces of ice collected from the runway, it is concluded that a thick layer of (clear) ice formed on both wings of the aircraft whilst it was on the ground in Torino.
Further to this it is probable that the right wing 'collected' more ice as the westerly facing parking position would have protected the left wing to some extent from the prevailing light wind coming from the North, during the night.

2.2. ANALYSIS OF POWERPLANT

2.2.1. General

Analysis of the damage to both engines lead to the conclusion that the engines ingested (clear) ice. The failure of engine No.2 at the point of rotation was the result of the failure of one fan blade approximately 21 mm above the blade/disc line (see photograph 1, Appendix G). Analysis of the fracture showed that there was no evidence of a pre-existing crack. The blade had failed as a result of distortion to the blade aerofoil resulting in a very rapid forced rupture. Four other aero foils failed in overload from the trailing edge as a result of secondary engine damage. The nature of the distortion in terms of the impacting body was the result of soft body ingestion
The engine was shut down automatically due to the activation of the Emergency Shut-off Cock System (ESOC). The ESOC was triggered by shock loading as a result of the fan blade failure. After activation of the ESOC any action by the crew to retard (close) the fuel lever could not be made.
Engine failures due to FOD ingestion such as ice are more likely to affect both engines. Due to the independent activation of the ESOC system in the case of FOD ingestion it could be possible therefore for this system, under certain circumstances, to be activated (independently) on both engines. The investigation team considered the threat of a multiple engine failure in circumstances where the cause of the failure is generated by an external agent. With the input from Rolls Royce and Fokker Services it was finally concluded that the ESOC system only comes in when the engine is very badly damaged and, almost surely, not capable to continue to operate and to provide thrust[1].

[1] The broad band vibration limit as used in the design of the Engine Vibration Monitoring system is 1.5 inch/sec. From Rolls Royce information on the activation of the ESOC system a vibration level (or equivalent sudden shock loading) of 125 inch/sec. would be required to operate the system. So, that is more than a factor 80 away. Thus, it can be concluded that operation of the ESOC system as per its design, in itself does not in any way realistically add to the risk of a double engine in flight shutdown in conditions that might otherwise allow continued operation of at least one engine.

The distortion observed to the fan blades of engine No.1 causing vibration in the engine was also considered to be consistent with the ingestion of ice (see photograph 2, Appendix G).
Typical soft body ingestion could be bird, ice or tire.
There was no evidence of bird or tire or any traces of unusual material that resembled other less likely soft body type materials. The fact that ice pieces of various sizes were found near the rotation point on the runway led to the conclusion that the damage was caused by ice. The sizes of the largest sections of broken ice pieces were recorded as being approximately 10 cm x 10 cm x 1 cm.
The debris recovered from the runway near the rotation point consisted of metallic particles which was consistent with the fan blade material released from engine No.2 (see photograph 3, Appendix G).
After assessment of the nature of the impacting body, the Rolls-Royce corporate impact specialist concluded that the most likely impacting body was ice. Analyses showed that based on a block of ice (30,5 cm x 30,5 cm) and assuming the most critical orientation towards the engine inlet, the minimum thickness required to deform and result in the very rapid failure of the Low Pressure Fan Blade was 1,8 cm. If the ice plate were not in the most critical orientation then more likely the thickness would have to be in the order of 3,6 cm.
The amount of ice ingested was likely to have been significantly greater than that assessed by Rolls-Royce as the capability of the Tay engine at the time of certification.
Therefore the certification of the Tay engine, as far as ice ingestion, was not compromised.

2.2.2. Witness reports

A passenger, an Italian engineer, who was seated in the rear right hand section of the cabin stated that he saw an orange object fly over the wing which then hit the fuselage and moved backwards. After that he said he heard a loud bang.
The CA2, also seated in the rear of the aircraft, stated that she heard a very loud bang just after lift-off and she also noticed a yellow flame on the right side of the fuselage.
The possible reason for the mentioned yellow flame is the effect of an engine surge and the forward movement of the unstable combustion flame. The visual effect would have been enhanced by the fact that it was dark outside and the cabin lights were dimmed prior take-off.
The orange effect of the object flying backwards could have been caused by the object passing the right wing trailing edge flap fairing which is painted orange. The flap fairing is painted orange to alert ground crews and baggage handlers. The transparency of a plate of ice released

from the wing would have enhanced this visual effect.

2.2.3. Engine maintenance history

An extensive review of the maintenance history, for the last two years, taken from the aircraft logbook and from KLC records revealed that there were no significant engine maintenance activities carried out other than routine ones. No unusual maintenance activities were carried out immediately prior to the flight.

2.2.4. Autothrottle (AT) behavior when operating single engine

As stated earlier, the case of an SAS MD-81 accident was analysed; in December 1991 the aircraft took-off with ice on the wings. During lift-off the clear ice separated from the wings and was ingested by the engines. The ice caused damage to the engines that caused severe engine surging. The surges eventually destroyed the engines.
The surges were intensified by the activation of the Automatic Thrust Restoration System (ATRS) installed on the MD-81. In case of an engine failure on the MD 81, the ATRS will automatically increase thrust on the other engine. It will cancel the CLAMP or Throttle Hold mode during take-off and the thrust will automatically increase to G/A Thrust. Also, the MD 81 was equipped with an Automatic Reserve Thrust System (ARTS) which, in case of single engine failure, will ensure maximum take-off thrust on the remaining engine.
Engine surging is normally controlled by reducing thrust. As opposed to this, an increase in thrust will increase the severity of the surges. What was exceptional in the SAS case was that both engines were subjected to the same treatment with the result that both failed in the same way.
The right engine surged for 51 seconds before failing. That engine could have been used with reduced thrust. So, with sufficiently reduced thrust in the right engine and maintaining the existing (de-rated) take-off thrust in the left engine, probably the engines would have delivered sufficient thrust allowing for the aircraft to return for landing.
Comparing this information with the Torino serious incident it became clear that the authority of an AT system could play a significant role in engine behaviour and consequently to condition the capability of a FOD damaged engine to survive selected thrust demands.
AT systems control, Full Authority Digital Engine Control (FADEC) or mechanical speed governing systems may, after the system recognizes an engine failure or thrust loss, set a higher limit on the remaining engine. Interfaces between AT systems, selections made using an Auto Flight System and Modern Engine Controls manage all parameters in such manner that limitations and

acceleration requirements do not cause surges and/or stalls.
Such systems will not however adjust their set limitations or thrust demands when engines are damaged as was the case in the SAS MD-81 accident.
Although the F-70 is not equipped with similar systems (ATR/ARTS) as in the MD81, the use of AT after an engine failure is KLC standard procedure.
Specifically, after an engine failure the procedure recommended to disconnect the AT. After the failed engine has been secured, the AT could then be reconnected at the pilot's discretion. KLC standard operating procedures required the AT system to control the remaining engine. This may or may not lead to more abrupt thrust control changes than with manual operation, depending on the abnormal flight situation and the level of pilot training and experience in manual thrust control.
In the KL 1636 case the bracket holding the Throttle Lever Angle transducer failed and consequently both AT channels failed.
After the engine failure the flight was completed using manual thrust. Further operation of the thrust lever was influenced by the crew awareness that the aircraft was experiencing engine vibrations and the realisation that the remaining engine had triggered an engine vibration alert.
Although the aircraft manufacturer is working closely together with its power plant supplier during the development and certification of the aircraft, it is doubtful if the operator developing its company procedures is aware of all the consequences of these procedures.
During the investigation Fokker Services (FS) and Rolls-Royce (RR) were requested to indicate if they would recommend the use of AT during a single engine operation.
Rolls-Royce indicated that the engine performed well considering the circumstances. However, it was not possible, in this case, to predict without further technical analyses if aggressive accelerations required by the AT could have been sustained by the engine.
Based on Fokker Services response and with input from KLC advisors, the following was concluded.
The ATS on the Fokker 70 is designed without an automatic power reserve in case of an engine failure. Although the ATS thrust changes may sometimes be abrupt and fast, they are within the capabilities of an undamaged engine. When operating with one engine at low altitude and during configuration changes, thrust variations however can be large and more aggressive. Manual thrust selections made by an experienced pilot may be less aggressive and therefore may be preferable when operating a damaged engine.
However, as pilots normally operate with the ATS engaged, depending upon experience and training, they may not be familiar with the correct settings for manual thrust selection. In these

cases manual thrust would require more attention and therefore the use of ATS may reduce the pilot's workload.
Specific and regular training would therefore be required to gain and maintain sufficient manual thrust control experience.
At this point, it is a matter of striking the correct safety balance, which is not helped by rigid procedures, with respect to the use of ATS but it is best served with a free decision by the flight crew, who can assess the entire situation.
In view of these inputs and also considering the fact that, in this specific F-70 event, the vibration was not so much related to aggressive thrust lever movement but occurred during a stable *level* of thrust condition, it is concluded that there is enough reason to review the procedures and training techniques on how to identify and handle suspected engine damage, specifically in relation of the use of autothrottle.

2.2.5. Ignition logic

Engine No.2 fuel transfer tube was damaged as a secondary result of the accessory casing distortion. The same distortion also caused concern about the ignition logic of the F-70 in conjunction with the ESOC system.
The shock loading induced by the fan blade failure of engine No.2 and the subsequent deflection of the engine casings resulted in the tensioning of the cable and the ESOC valve being operated. Once the system has operated (and closed the fuel valve on the engine) the locking pin which locates into a slot cannot be reset. As a result the fuel lever in the cockpit will be blocked and cannot be moved to the shut position.
When suspecting severe engine damage, which is normally the case when the ESOC system activates, the KLC emergency procedure requires the crew to position the thrust lever to idle, shut the fuel lever, to pull the associated fire handle and to discharge one fire bottle.
The F-70 has two ignition systems per engine. Selections to operate the separate systems automatic (normal mode), continuously or to activate a relight are possible. When the system is operated in the normal mode, systems 1 and 2 will be activated whenever the fuel lever is in the open position and the Engine Multiplexer system senses an engine-out condition. System 1 is activated if the Engine Failure Sensing Unit (EFSU) senses an engine failure. In the Relight position, system 1 and 2 are activated irrespective of the fuel lever position. With the selector in normal, closing the fuel lever deactivates the ignition.
Pulling the fire handle will close the respective fire shut-off valves in the fuel and hydraulic sys-

tems and the Over Pressure and Shut-Off Valve (OP/SOV) in the bleed air system.
In this case the crew was not aware, nor trained to recognize and deal with a jammed fuel lever. If that would have been the case they might have concluded that the engine was severely damaged and adopted the consequent decisions.
After landing and vacating the runway, the crew decided to pull the fire handle and after parking it was noticed that the ignition was still activated. Due to the fuel lever jammed in the open position the ignition could only be stopped by pulling the associated circuit breaker.
The (ESOC) system is designed to keep an engine failure contained and to prevent disastrous secondary damage.
The severe engine damage procedure is designed to isolate the engine and to prevent a possible fire.
During the investigation it became apparent that the F-70 Ignition logic design did not consider the consequence of a jammed fuel lever after an ESOC system activation.
With an even more severe damage than in the KL 1636 case, assuming the transfer fuel tube was not just damaged but was actually leaking, the ignition would still have been activated, even after completion of the severe engine damage procedure.
Pulling the Fire handle, the fuel fire shutoff valve would effectively cut off any further fuel supply to the engine. However, it is recommended that a redesign should be considered or that crews are made aware of, and trained on how to deal with the possibility of the ignition system remaining active, with a fuel lever blocked in open position after the completion of the severe engine damage checklist.
Fokker Services has indicated that this will indeed be followed up in the Aircraft Operating Manual (AOM).

2.3. ANALYSIS OF EVENTS

2.3.1. Crew hand over

The Captain of the last inbound flight to Torino on February 15th 2001 reported to the investigation team, encountering icing conditions during the approach with snow changing to rain below 1.000 ft. This Captain recorded 5.080 kg of fuel remaining on board in the AFL.

In the company Aircraft Operations Manual (AOM 2.5.1) it was mentioned that economical tanking should not be applied in cases when a temperature/dew point spread was expected to be 2°C or less with an expected OAT of less than 10ºC. The explanation for this policy was given

as minimizing the need for an unnecessary de-/anti-icing treatment due to fuel induced icing. KL 1649 was however, dispatched with economical tanking.
In fact while company records showed that the restrictions for economical tanking were mostly observed for day return flights, the same restrictions were almost never observed for overnight stops. In the latter circumstances, as aircraft would most probably require de-/anti-icing the following morning in any case, the presumed benefits of not performing economical tanking were no longer valid.
The Captain of KL 1649 did not challenge the economical tanking. No matter what the reason was for agreeing to the final fuel uplift, the investigators feel that this Captain did not take into account the possibility of clear ice formation overnight, otherwise he would have alerted the morning crew with a message to that effect.
KLC did not publish any procedures or recommendations for crew hand over. This meant that if flight crews did not actually meet one another, as was the case with the KL 1649/KL 1636 handover, then no information would be passed on about previous flight conditions, etc,… unless the crew took it upon themselves to leave a note in the cockpit. This was done sometimes for example for technical matters relating to the aircraft. On the handover examined here, KL 1649 - KL 1636, there was no information left by the previous crew that would have alerted the Captain of KL 1636 to the possibility of clear ice formation during the night.
In the company Basic Operations Manual (BOM 8.2.4) it was explained that clear ice may form on the upper wing surfaces with an outside temperature above freezing, upper wing skin temperature below freezing and precipitation or visible moisture present.
It was further stated that the upper wing skin temperature can be lower than the outside temperature due to radiation when the aircraft is parked overnight or when after a flight, cold fuel still remains in contact with the upper wing skin.
Whilst this would appear to be the primary 'safety' reason for not applying economical tanking in these circumstances, this information was in fact 'disassociated' from the information contained within the company AOM by virtue of the fact that it was contained within a different company manual (BOM).
According to the company manuals, the link with economical tanking was made in regard to unnecessary de-icing and not directly with the possibility of clear ice formation.
This would have diluted the overall crew awareness of this phenomenon. Although specific mention was made in the BOM regarding radiation cooling and cold fuel remaining in the wings overnight, it is questionable whether this would have crossed the minds of the inbound crew of

KL 1649. This mindset could be linked to the fact that this crew would be off duty until the next afternoon.

2.3.2. Pre-flight inspection

During the pre-flight external inspection of the aircraft the Captain observed ice both underneath and on top of the wings and it was raining.

In the BOM the general responsibility regarding de-/anti-icing on the ground is described as: "*If frost or ice has formed on the lower wing surface tank area and the aircraft has been subject to precipitation conditions during its ground time or when there is otherwise doubt that clear ice has formed on the upper wing surface, the upper wing surface has to be checked using a suitable means of access in order to detect the possible clear ice*". Mention is also made that clear ice can only be detected by touch (tactile check).

This text indicates that a tactile check of the wings should have been performed because there was ice on the lower wing surface tank area and it was raining at the time.

Pre-departure check in BOM paragraph 4.1 states that: "*When clear-ice conditions exist a check for clear-ice has to be performed. Clear-ice is very difficult to detect as it is crystal clear and very smooth and can only be checked by a hand's on check (tactile)".*

The OAT was +2°C and dew point 0°C. According to the company AOM icing conditions were considered to exist; therefore the pilot had to follow the indication on the flow diagram reported in the AOM which in turn indicated that a tactile check was required.

The flow chart indicated "certain" circumstances when the wing should be checked. This was specifically intended to guide crews to check the wings for the possibility of ice when there was a concern, according to the company AOM and BOM that clear ice has formed. In other words as clear ice is very difficult to detect, "tactile check" is a precautionary action in the pre-flight check and in the after de-icing inspection to detect if wings are clean.

The Captain stated that he did not touch any part of the wing surfaces because he had already decided that the aircraft needed to be de-iced (from his observation of ice and slush on top of the wing). This would imply that he did not draw the association between ice on the wings and rain, with the possibility of clear ice accretion.

A handover information from the previous crew about the previous flight conditions and/or recognition of the fact that cold fuel had been in contact with a very cold upper wing surface during precipitation at night would probably have been sufficient to alert the Captain of KL 1636 to the possibility of clear ice formation. This however, was not the case.

In the company manuals several references were made to icing conditions and the consequential actions that are required. Reference was also made to (clear) icing conditions. It is felt however, that the crew did not completely understand the intent of the instructions contained within the manuals and that their understanding of the situation was limited by lack of any specific practical training.
It is also considered that either incorrect interpretation of the company AOM and BOM texts, or insufficient information collected regarding the previous flight history, or the ambiguous intent of the flow chart in the AOM, hampered the Captain from making important conclusions about the possibility of clear ice formation.
Further, however, the tactile check as described in the AOM is: "*to check the wing leading edges along the full wing span until the front spar, indicated by the black 'no step' line and perform a visual scan of the remaining upper wing surface"*.
If a tactile check had been performed as described above, the clear ice on the wing may not have been detected as it is most probable that the clear ice that was ingested by the engines had formed on the wing surface area aft of the black "no step" line. It is also debatable as to whether clear ice in these circumstances could have been detected without a proper device such as a scraping or tapping tool of some sort (a special type of scraper was developed by SAS after the MD 81 accident in December 1991). Also the method of performing a tactile check has not been adequately described.
The Captain did not specifically ask for an anti-ice treatment as he did not consider that the "hold over" concept was applicable; he also did not specify the percentage of mixture and the type of fluid to be used for de-icing, nor did the de-icing operator ask for any specific instruction. According to the AOM however, the criteria for icing conditions was defined as follows: OAT between +6°C and –25°C inclusive and visible moisture in the air (rain).
At the time of the pre-flight inspection, according to these criteria, icing conditions did exist. The company de-icing "hold over" tables, showed that no hold over was required for temperatures above zero, unless in presence of "freezing rain". Since on the day of the incident the rain was not "freezing rain" and since cold soaked wings were not taken into consideration the Captain could conclude, in view of the existing conditions, that the "hold over" procedure was not applicable in these circumstances and therefore that no anti-icing was required. The "hold over" criteria (persistence of the de-/anti-icing effect following the fluid application) is described in the AOM to take into account the time elapsed from engine start to start of take-off run.
According to the same "hold over" tables however, when rain is falling onto a cold soaked wing,

anti-icing must be performed with de-icing fluid type II 75% or better, in order to obtain sufficient holdover time for start up and taxi out to the runway. In the case of KL 1636, the aircraft was experiencing or had experienced rain on cold soaked wings and so de-icing should have been performed with at least Type II 75%. The fact that the Captain did not take the state of the wings into account as was mentioned in the “hold over” tables, is a further indication that he did not recognise the wings as being cold soaked.

In relation to wing ice accretion detection and avoidance, KLC company manuals referred to certain criteria, including the instruction to carry out tactile check during a pre-flight inspection, the observance of “hold over” tables applicable after anti-icing and the use of engine anti-ice. In this case the Captain drew the incorrect conclusion that he did not have to perform a tactile inspection of the wings because he had already observed ice on the wings. The Captain correctly decided to select Engine anti-ice “ON” during the take-off but he did not think that icing conditions existed related to the “hold over” criteria and hence his decision not to anti-ice the aircraft.

The Captain of KL 1636 was sensitive to a previous negative experience in another Italian airport when, as he stated, his aircraft had improperly been de-iced. Yet this sensitivity appeared to be only related to the outcome of the de-icing process itself and not to the capacity to recognize any possibility of clear ice build-up prior to the de-icing.

2.3.3. The de-icing operation

In the company regional operating manual (ROM) which was on board the aircraft, it was stated that Type II Kilfrost ABC 3 fluid would be used in either “1 step” or “2 step” operation to be specified by the Captain.

Further it was specified that SAGAT would be the company performing the de-icing operation and Alitalia would be the company inspecting after the de-icing operation.

This is the only information that the Captain had at his disposal in regard to the de-/anti-icing operation at Torino Caselle airport.

The Captain did not request a “2 step” spraying (de-/anti-icing) as he considered that it was only necessary to de-ice the aircraft.

He did however specify to the de-icing operator to spray the underside of the wings and the tail of the aircraft. The Captain would not have been aware that Meridiana was performing a “2 step” procedure.

The de-icing operator requested the Captain to *“control the result”*.

In SAGAT de-/anti-icing operation manual - “*Final check before aircraft departure*” – it is stated that the release of an aircraft for departure after de-/anti-icing treatment must be obtained from authorized personnel (from aircraft company or from authorized inspecting company). In essence, that the responsibility for the de-/anti-icing operations remained with the aircraft operator, in particular the designated ground engineer or, in his absence, with the aircraft's Captain. According to the de-icing operator, his request to *"control the result"* directed to the Captain, would have in essence related to the post de-icing inspection. The reply from the Captain "OK good" may have been interpreted as confirmation of this.

The Captain on the other hand could not recall any other conversation with the operator other than the request to spray the underside of the wings and the tail.

The fact that the Captain could not recall any part of this conversation with the de-icing operator could indicate that he did not comprehend the meaning of the request to "control the result". There is no certainty about the actual or intended meaning of the conversation between the Captain and the de-icing operator, however it can be concluded that there was a misunderstanding between them regarding the final inspection of the aircraft.

Visual inspection of the underside of the wings was sufficient to satisfy the Captain that the ice had been removed from the aircraft. He did not intend to perform an inspection for the correct execution of the de-icing operation since, to his knowledge, it would be conducted by Alitalia personnel. He performed this inspection because of his previous negative experience with quality of de-icing operation in another Italian airport. Yet this sensitivity appeared to be only related to the outcome of the de-icing process itself and not to the possibility to recognize any clear ice build-up prior to de-icing operation.

The Captain stated that according to the ROM Alitalia ground staff would perform the post de-icing inspection. The Captain, however, did not call for any Alitalia operator before de-icing, nor did he request any verbal or written report from Alitalia ground staff after the treatment confirming the airworthiness of the aircraft. There were no procedures or instructions from the company to this effect and as such the Captain could have assumed that Alitalia would have been summoned by SAGAT.

Alitalia did not inspect the aircraft because there was no agreement with KLC for post de-icing inspection and they were not asked to do so.

The receipt for the de-icing operation was handed to the Captain without the signature of the supervising agent. There was however no information available to the Captain from KLC, as to whether he had to specifically check signatures on such a receipt or if in fact that he had to request any such document. Unlike load sheets, for example, where specific items are required to be checked, there were no instructions regarding the receipts for de-icing. Also, there are no standard invoices for de-icing. Therefore, it is reasonable to assume that any receipt for the de-icing operation may have only been intended for keeping track of payment.

As mentioned before, the Captain did not request any specific type of fluid for the treatment and the aircraft was de-iced with Type II, 50 %. That fluid concentration was not suitable for anti-icing cold soaked wings in rain conditions. The temperature of the fluid at the gauge of the de-icing truck was reported to be 65ºC, but the actual temperature at the surface of the wing is unknown and therefore it is not possible to determine whether the fluid would have been 'hot' enough to remove clear ice.

PH value, refractive index and viscosity at the nozzle were all tested to be within limits for the type of fluid that was used for the de-icing operation. However, clear ice removal also depends upon the cross sectional area of the spray, the distance of the nozzle from the surface of the wing and the technique used during the spraying.

In order to deploy the correct technique it is also necessary that the de-icing operator is aware that clear ice is present. It is unlikely that a thick layer of clear ice may have formed on the wings after the spraying, but rather it is reasonable to believe that the clear ice already on the wings was not removed.

2.3.4. Take-off roll, rotation and initial climb-out

Engine indications and aircraft performance were described by the crew as being normal during the take-off roll.

The increase in fan vibration of engine No.1 and the sudden failure of engine No.2 at lift off suggests that both engines were affected by the same phenomena. Ice ingestion is the most likely cause as this is normally released from the wings during rotation and no other evidence of bird strike or other foreign object damage was found. Further to these 'glass like' pieces of ice were found on the runway immediately after the landing at the same position where the aircraft commenced its rotation.

The high vibration in engine No.2 resulted in failure of the bracket holder of the throttle lever angle transducer unit. The Captain stated that he was aware that he was flying with manual throttle and so he was therefore in complete control of the thrust setting on engine No.1. According to the DFDR there was a slight reduction in EPR on engine No.1 during the initial climb. This could have been caused by a reduction in the engine performance due to the damage or it may have been caused by a small movement of the thrust lever. In the simulator exercise it was noted

that the simulator reached 6.000 feet, 40 seconds before the actual aircraft. It was possible to match the actual aircraft performance with a very slight aft movement of the left throttle.
It may have been fortuitous that the autothrottle failed on KL 1636 (note however, that AT was already declutched, as per design, from about 80 kts in the take-off roll and thus when the engine failed).
In the SAS MD-81 event automatic thrust increase was activated as a result of the surging in both engines. It was also stated in the report on that accident that right hand engine could have been used with reduced thrust and if the left engine had remained at reduced thrust the aircraft would have been able to continue flying.
One of the reasons that KL 1636 did not suffer the same fate as SAS could have been due to the less aggressive movement of the throttle. The DFDR showed variations in vibration levels directly related to throttle movement. A more aggressive autothrottle movement might have adversely affected engine vibration.
However, given the fact that the AT was already declutched when the engine damage occurred, that Fokker Services has indicated that it is not necessarily so that manual thrust lever manipulation is always less aggressive than AT control, and also considering that a high level of engine vibration was not so much depending from thrust lever movement, but occurred (initially) at stable thrust level, further considering the workload reduction by AT in demanding situations, it is felt by the investigating team that, in similar situations, it shall be left to the flight crew whether or not to re-engage the AT.

2.3.5. Alert sequence and system behaviour

The crew of KL 1636 were trained to cope with an engine failure at V1. However, during training, failures are expected by the crew to occur and as such are anticipated.
In Torino the failure at V1 was sudden. In addition the Engine Failure (N-1) departure procedure required a right turn at 1.500 feet QNH and thrust control of the left engine had to be managed manually (also a normal situation with both engines operative until re-clutch of the AT). The KLC re-enactment of the crew's actions in the simulator indicated that they performed the aircraft manoeuvring and configuration changes (except for the late landing gear up selection) in a well organized and decisive manner.
The alert procedure for the engine failure did however present some problems. When the first officer selected the fuel lever to shut it moved only slightly before it jammed almost in the full open position. This created some confusion as the possibility of this scenario was not known to

the crew. This confusion is highlighted by the first officer's repeated attempts to close the fuel lever. In essence, one line of the alert procedure 'Fuel Lever Shut' had to be skipped.
Immediately following, the first officer was faced with a second dilemma. According to training performed in the simulator for this type of problem, indications of residual N1 and N2 rotation meant for them that there was no severe engine damage. His observation of N1 and N2 were in direct contradiction to the "kind of bang" that he had heard during rotation. As the N1 and N2 observation was a trained discipline and the "bang" was open to interpretation the crew were probably discouraged from pulling the fire handle. It was not written in any company documentation that the fire handle should be pulled in the event of the fuel lever not being able to be closed, even though this would seem to be a logical course of action.
Although not pulling the fire handle did not have any adverse consequences for this flight, the first officer was preoccupied by the status of the fuel lever and both the Captain and first officer were confused as to whether to pull the fire handle or not. Extra instructions in addition to the emergency checklist, more diverse examples of engine behaviour in the simulator during training and more complete explanation of the system behaviour would have helped the crew to overcome several of their uncertainties.
The autothrottle alert that was presented at 400 feet Radio Altitude was followed by a cabin pressurization control alert presented at 1.500 feet QNH. The latter alert which was confirmed by an overhead system fault light and a sense of pressure variation in the ears was stated by the first officer, as being a cabin pressure control channel fault on the left hand MFDU.
While the left MFDU showed the "level 1"alert message "CAB PRESS CTL CHAN" (malfunction of a control channel of cabin pressure system), the right MFDU showed the "level 2" alert message "CAB PRESS CTL" (cabin pressure system control malfunction).
This possible aircraft inconsistency also occurred in the simulator re-creation. It must be noted, however, that the simulator does not contain a Flight Warning Computer, as all faults are generated by a simulation computer.
A reproduction attempt on the incident did not show a mismatch between the alert and the procedure heading. It is therefore recommended to review the simulator software.
The procedure for the cabin pressurization control alert appeared on the right MFDU below the autothrottle fail procedure; however the real or perceived inconsistency between the message on the left screen and the procedure on the right screen also created confusion for the first officer.
The system of dealing with all the alert procedures presented on the MFDU, before referring to the emergency checklist, would have been an extremely cumbersome and time consuming way

of doing things in this case.
The MFDU Engine Fail alert procedure already required reference to the paper emergency checklist for the item *“single engine procedure, apply”*.
Then the MFDU alert procedures for the autothrottle failure and the Cabin Pressurization Control would have to be completed before reference could be made to the paper emergency checklist for all three procedures thus far presented. The first officer commented that he only checked the emergency checklist for the Cabin Pressure Control alert and he skipped the autothrottle checklist as the Captain had already announced that he would continue with manual throttle.
When the Fuel Asymmetry alert was presented on the left MFDU both pilots commented that they were surprised by this.
The Fuel Asymmetry alert is normally triggered for a 350 Kg asymmetry. It has been calculated that an unbalance of 160 Kg (in excess in the right tank) was already present at the beginning of the flight.
During the simulator re-enactment the Fuel Asymmetry alert occurred at the same time as it occurred in the aircraft which confirms the unbalance calculation of 160 Kg prior to lift-off.
The fact that the Fuel Asymmetry alert came as a surprise can be explained. The initial unbalance of 160 Kg. meant the time interval to the alert was approximately half the normal time interval that would usually be expected. In the absence of the initial unbalance, the normal execution of the single engine procedure, which includes selecting the fuel cross feed, would already be completed thus avoiding this alert altogether. In this case, however, at the time of the Fuel Asymmetry alert the single engine procedure had not yet been completed.
Engine No.1 vibration level went below limits (alert activation limit) 26 seconds after the Fuel Asymmetry alert appeared. Which was confirmed by the first officer when he reported the alert procedure for the vibration shown on the left MFDU with a white tag instead of an amber tag (the alert procedure will change from amber to white when the alert is no longer valid).
At that stage, the failures of the autothrottle and the Cabin Pressurization systems had been present for two minutes on the right MFDU and there was insufficient space to show the Engine Vibration High alert procedure, since the MFDU system logic would only allow its presentation upon completion of the procedures already displayed.
The statements received from the first officer were somehow contradictory and it is difficult to assess certain aspects of the course of events.

2.3.6. Crew Management

Historically the likelihood of an engine failure during lift-off is remote and although such an occurrence may come as a surprise to the flight crew, they are trained to perform certain essential actions. It is important to retract the landing gear immediately to obtain the best possible climb capability.

In the case of the failure of both engines on a twin-engine aircraft, a better option may be to leave the landing gear extended.

Certainly the landing gear should not be retracted without confirmation of a positive rate of climb.

During the KLC simulator re-creation it was felt (by the participants) that the 14 second time interval between rotation and gear selection did not 'seem' excessive considering the initial shock of the situation and comprehension of the event that was occurring. This impression was derived from the consideration of human factors.

Other members of the investigation team felt however that the gear should have been retracted more quickly and this opinion was driven from a more clinical or technical view point.

The delayed retraction of the landing gear, in this case, did however provide a valuable insight into the crew response. It was considered by the investigation team to suggest a review of the take-off engine failure procedure by KLC, to include a '*positive rate'* call by the PNF, to focus the attention of the crew to gear selection.

The crew co-ordination during and immediately after the engine failure was such that the Captain manoeuvred the aircraft while the first officer communicated the emergency situation with ATC and then performed the alert procedure. The demands of manoeuvring in the Torino Caselle terrain area, in combination with multiple failures, required the adoption of split cockpit duties (reduced cross check between pilots) different from the normal crew integration adopted for single malfunctions. In other words each pilot would have had very little opportunity to concentrate upon the tasks of the other. This factor was also demonstrated in the simulator re-creation.

The overall situation was however discussed between the Captain and the first officer. For example the crew decided together that holding at SIRLO was more desirable than the acceptance of radar vectors for an immediate return for landing.

The MASTER CAUTION light was left flashing after the dual autothrottle Fail alert was presented. This meant that both the visual and aural attention getter for the subsequent alerts including the Engine Vibration High alert were suppressed. A high workload situation can distract one's attention from other apparently less critical matters, however, cancellation of the warning in this case would have probably lead the crew to the conclusion about the source of the left engine vibration a lot sooner. A single chime would otherwise have sounded for the (VIB HIGH) alert.

Shortly after the vibration was traced to Engine No1, the Captain issued a MAYDAY call. ATC responded as they had done to the initial PAN PAN PAN call by offering the aircraft radar vectors for an immediate return to Torino. This offer was declined for the second time and it was not until approximately 10 minutes after the MAYDAY call that KL 1636 requested to return.

During the 10 minute time interval the crew went through the normal procedures and checklists in preparation for the approach and landing.

The Captain contacted the cabin attendant by interphone and informed her that it would be another 10 to 15 minutes before landing and he followed this with a public address to the passengers. The cabin crew did not have any face to face contact with the Captain or the first officer and they did not relay their concern about the vibration that they had been feeling in the cabin floor. This added information might have prompted the Captain into considering a quicker return than was currently being performed.

Even after the crew had curtailed some of the alert/emergency checklist procedures they were still burdened by a lengthy approach process including descent and approach checklists. It is felt that an immediate return checklist that could be activated upon the declaration of a MAYDAY would have helped the crew to land the aircraft far sooner than they did. It is also felt that the concept of the MAYDAY call was not fully understood by the crew.

ATC's interpretation of the MAYDAY was that of a request for immediate assistance which was offered in the form of radar vectors. This offer was turned down so in these circumstances if another aircraft had declared a MAYDAY then the priority would have shifted away from KL 1636.

This would have created a dilemma for the ATC. A clear understanding of the MAYDAY call would have meant that the crew would have accepted the immediate return and would have abbreviated their approach preparation even more.

2.3.7. Crew communication and survival aspects

During rotation both cabin attendants were immediately aware that something was wrong with the aircraft. Each of them also made some very important observations during the early stages of the flight namely the vibration of the cabin floor, the very loud 'bang' and the yellow flame outside the aircraft. However, this important information was not relayed to the cockpit.

The Captain contacted the CA1 by interphone approximately 8 minutes after lift off. This was the only communication between the cockpit and the cabin during the entire flight. The fact that the Captain did not request any information from the CA1 may have given her the impression that everything was known to the cockpit crew. However, had the information about the loud 'bang' and the vibration in the cabin floor been relayed to the cockpit at this time, the Captain would have probably assessed the critical nature of their situation much earlier.

According to the company AOM 6.2.3 it is stated that in circumstances such as returning immediately for landing, the CA 1 should be requested via the public address system to report the cockpit. It is not stated whether this should be in person or via the intercom.

When the Captain contacted the CA1 he only mentioned the problem of the right engine and that it would be another 10 to 15 minutes before landing. This is an indication that at this stage he was probably unaware of the problem with the left engine. The statement to the CA1 to *"expect a normal landing"* led her to conclude that it was not necessary to make any preparation for an "emergency" landing.

Given the critical nature of this situation it is felt by the investigation team that emergency preparations would have been desirable as the continued operation of the left engine was not necessarily guaranteed. The recurrence of vibration during the approach was even more severe than had been previously experienced. It is felt that following the MAYDAY call the cabin should have been prepared for an "emergency" landing.

The CA1 was particularly anxious that the flight was taking too long. Whilst she was not in a position to ask the Captain to *"speed things up"* and she was also probably reluctant to interrupt an already busy cockpit crew, it meant that her own level of anxiety would have increased with time. The increased level of anxiety would have affected the performance of her normal duties and would have certainly impacted on any extra duties that she may have been required to perform.

The Captain was unaware of the state of anxiety of the CA1 and an improved two-way communication might have helped to alleviate her anxiety.

The CA2 on the other hand did not appear to share the same level of anxiety as she stated that she conducted a mental revision of her training to prepare herself for any emergency situation.

After the MAYDAY call the Captain made a brief announcement to the passengers giving a short description of the situation and adding that any further question could be directed to the cabin attendants.

Although the Captain probably meant this in terms of information relating to further arrangements for the passengers and not to questions that may have been of a technical nature, this statement was considered to be undesirable and may have added even more stress to the cabin attendants who were in an already stressful situation. A better statement would have been to direct the passengers to follow all instructions from the cabin attendants. This would have elevated the authority (self esteem) of the cabin attendants and might have also sparked some initiative from them.

In the case of an emergency with time for preparation, the company AOM 6.2.3 also mentions some recommended text for the Captain's public address to the passengers including the statement to *"follow the cabin attendant's instructions carefully"* Although time and circumstances may preclude direct reference to this section of the AOM it is felt that the Captain did not consider the particular situation unfolding to fall into the definition of an "emergency" landing. This is also indicated by the fact that he told the CA1 to *"expect a normal landing"*.

The investigation team felt that within the industry generally, there should be more awareness and emphasis placed upon operation after an engine failure in a twin engine aircraft.

In the case of KL 1636 the crew were burdened by several other system failures and in such a case it is even more important to keep the overall situation in mind. It was left to the discretion of the crew to assess whether or not an immediate landing was required.

Although the decision to shorten the approach preparation procedures was eventually decided upon it is felt that the 'imbedded' training philosophy to complete all procedures and checklists in combination with a cumbersome combination of electronic and paper checklists led the crew into a pre-determined course of action for an excessively lengthy period of time.

The self initiated course of action did not come until 10 minutes after the MAYDAY call.

In this case the only remaining engine was damaged which created a very critical situation. It is considered that a practical approach rather than academic approach to failure management is highly desirable in cases such as KL 1636.

As such KLC should evaluate how the rigid use of procedures and checklists, in particular circumstances, may affect crew decision making.

2.4. ANALYSIS OF FLIGHT RECORDERS DATA

The lack of CVR data made the analysis of this investigation more difficult. Although the ATC audio tape provided some important information such as the content and timing of the emergency calls, a strong reliance had to be placed upon the Captain's and first officer's recollection of many other events. Hard evidence about when and how various procedures and checklists were performed as well as the crew's discussion and analysis of the situation would have added value to the analysis.

Data from the DFDR was used to verify when certain actions such as the selection of maximum continuous power, new airspeeds or new altitudes were performed. From the DFDR it was also possible to determine the exact time when each alert occurred.

However, the exact time when the VIB HI procedure for engine No. 1 was presented on the right MFDU could not be determined from DFDR data. While the DFDR helped to create a good "picture" of the flight without the CVR the human factor element was missing.

The simulator re-creation helped to give the investigators some idea about the human element. For example it was determined from the re-creation that the crew would have had many periods during which they would have had to work independently. The re-creation also demonstrated how decisive and important an immediate action by the crew would have been and also the overall complexity of the multiple failures was made more apparent.

There is no doubt however that the analysis of this event would have been far more comprehensive had the CVR data been available.

As this particular CVR only records on a continuous 30 minute loop, information from the first minutes of the flight would not have been available. Given that the airborne time was 29 minutes and that the aircraft taxied for a several minutes after landing and that there were some further checklists performed in the parking position, even if the crew had taken immediate action to pull the CVR circuit breakers, the most crucial moments during the initial stages of the flight would not have been recorded.

The CVR was later tested and found to be serviceable and no interface deficiencies were detected between the equipment and the aircraft itself. It was therefore concluded that since the fuel lever remained jammed in the open position, the CVR recorded a "silent" cockpit up until the Captain pulled the circuit breakers some 2 hours after the event.

2.5. ANALYSIS OF ORGANIZATIONAL AND MANAGEMENT FACTORS

At the request of ANSV the Dutch Transport Safety Board - DTSB has conducted an analysis of the structure of the KLC Cityhopper. The following paragraphs describe the resource management, the organizational climate and other aspects of the company structure and are reported below.

2.5.1. KLC - Organisation and Management

The organisational preconditions that could lead to this serious incident were difficult to analyse. Contradicting statements in combination with the fact that just prior the KL 1636 serious incident two important managers were succeeded by two newly appointed managers, created large amounts of conflicting information.

KLC's Management structure complies with the JAR-OPS requirements and has been organized in a rather flat organization scheme (see paragraph 1.17.2).

This organization structure with direct lines between the Accountable Manager and his/her Postholders has the advantage that no filtering process, which could cause information to be contaminated, will take place. A clear and concise information exchange could be the result.

The flat organizational structure may give the writer of the organization description in the Basic Operations Manual, the challenge to clearly distinguish the duties and responsibilities between the different Postholders.

In a flat organizational structure an overlap of duties and responsibilities could complicate the decision process and create the potential for ”somebody else will take care of it” attitude or even promote a blame culture within the company. A potential problem or uncertainty concerning decision development could 'float' within the company for a considerable time.

When there is no clarity and common sharing of objectives among Postholders, as it has been observed by the DTSB, some overlap of duties and responsibilities may rise.

Assumptions, such as another Postholder has (probably) corrected the problem, could be a result of unclear duties and responsibilities. An unclear or overlapping division of responsibilities will negate the advantages of a flat organizational structure.

Experience has shown that the longer a potential problem or complication 'floats' the less effort is made to correct the situation.

When the problem remains dormant it becomes something that the company gets used too. This, in combination with overlapping responsibilities, could aggravate the situation and finally this potential (safety) problem establishes itself as a fixed and accepted anomaly within the company.

According to the organizational JAR-OPS criteria, a Postholder should only approach the Accountable Manager if he is convinced that the communication/negotiation process with another Postholder will not lead to a satisfactory resolution.

Clear distinction between commercial and safety related issues should be recognized and realized by the Postholders when they decide to use the direct link to the Accountable Manager.

Any reluctance to report directly to the Accountable manager, when deemed necessary, could hamper a direct flow of information.
The accuracy and scope of information that is supplied to the Accountable Manager is directly affected by the communication reliability and understanding between the Postholders. If for whatever reason the information flow is restricted or is inaccurate, then it is not possible for the Accountable Manager to initiate adequate corrective action.
On the other hand the Accountable Manager should have the ability and even instinct to discriminate signals pointing directly or indirectly to flight safety issues. He should be able to identify 'gaps' at the middle management level and has the authority to demand explanation and set deadlines to fix a problem.
The JAR-OPS 1 basic organization scheme has placed the QA (Quality Assurance) department as an independent control function to signal to the Accountable Manager any potential problem with the Postholders and between the Postholders and the Accountable Manager. That is exactly why JAR-OPS intended this line to be separate from the Postholder communication lines and thus direct to the Accountable Manager.
In a JAR-OPS organization, if there is an ineffective Postholder group that lacks an internal communication and alerting system and the QA Manager is not able to value the input of available information, then his controlling capacity over the system becomes degraded and could even work as counterproductive in the management process.

2.5.1.1. Resource Management

Just prior the time of the serious incident KLC's operation was expanding. KLC is a regional airline and often operates from regional airports which have a different infrastructure than the main international airports.
When the de-icing operation (performing and inspecting) was transferred from the responsibility of a qualified AMT (Aircraft Maintenance Technical) to ground handling, the DAQCP was formed to monitor the performance of the contracted ground handling companies.
To reduce the burden and costs of inspecting all of its out-stations, KLC joined the DAQCP. This inspection pool meant that the regional airlines were able to share the costs of the ground handling company audit inspections.
It could be that if there is only one contractor available at a station and that contractor does not meet the DAQCP audit requirements, then the airport was not suitable for de-icing operations.
Participation in the Pool could be interpreted as a safe-guard and best defence against less pro-

ficient contractors. Results of the DAQCP audit performed in March 2002 however revealed the same results as the previous year with no corrective actions having been taken by SAGAT despite a commitment to do so.
The QA manager at the time was also a DAQCP inspector. He was known to be very eager on de-icing issues and a strong supporter of the DAQCP. In the company some viewed his intense interest a “hobby”. His successor started as an assistant QA manager in November 2001 and was also a DAQCP inspector. He was appointed as QA manager in April 2002 after the serious incident in February 2002.
According to JAR-OPS 1 requirements 1.890(a)(1) and JAR-OPS 1 AMC OPS 1.890 (a)(1) (Maintenance Responsibility) at the time of the event, the Maintenance Postholder (Technical Postholder) was supposed to be responsible for the proper execution of the pre-flight inspection and post de-icing inspections. None of these activities could be reassigned to other Postholders without specific instructions or adequate quality control. The MME did not contain any specific instructions and the Post-Holder Technical (Maintenance) did not verify if the Post-Holder Ground Handling was able to fulfil the technical aspects of the de/anti-icing operation.
According to CAA NL, none of these responsibilities could be reassigned to contractors or personnel without the written consent and quality assessment by the Postholder Maintenance. The appropriate document where the transfer of responsibilities with regard to de-icing should be explained is the MME. No references regarding this matter were found in the KLC MME.

In spite of the above JAR-OPS 1 requirements the responsibilities as described in KLC’s BOM prior to the serious incident showed that de-icing operation responsibilities were shared between the Manager Ground Operations (MGO), the Manager Flight Operations (MFO).

2.5.1.2. Organizational Climate

The financial assets were allocated to the MGO who was also responsible for the contents of the de-icing contracts. The relationship between quality of service (which also affects flight safety in this case) versus budget was complicated and required an open and two-way communication between the MFO and QA Manager.
The QA Manager initially noticed, while spot-checking the ROM, that the type of de-icing fluid had been changed in Torino. At the same time he also noticed that Alitalia was mentioned as the inspecting company, whilst he knew that there was no written contract between KLC and Alitalia. He alerted the MGO and the MFO and received a reply from both of them that it would

be corrected. However, a contract with Alitalia did not eventuate and information regarding Alitalia was not removed from the ROM.

Although the QA Manager noticed several times that his signals did not have the desired impact he expected, he took no further action as he anticipated that next audit would be sufficient to correct the situation.

The Accountable Manager on the other hand was aware of de-icing problems but expressed that these were so vast in number that it was difficult to decide which one had more importance. Lack of effective communication and feedback between the Postholders also made the identification of the most serious issues more difficult.

The Accountable Manager believed that the QA Manager had a rather naive approach but at the same felt confident that each Postholder would accept their own responsibilities.

The investigation led to the conclusion that the QA Manager did not understand the message that he had to relay to the Accountable Manager. It was a message that should not have been related to the (missing) de-icing procedures issues in Torino only, in respect of the de-icing inspection contract, but one that would have alerted the Accountable to the confusion existing regarding the Postholders and their inaction and overlapping of competences and responsibilities in Torino.

The implications of the lack of post de-icing contract and the non compliance with JAR-OPS 1 requirements were not fully appreciated by the QA Manager as it was belief that the Captain had final responsibility for the flight irrespective of all other issues.

The MFO had the responsibility to define standards for the performance, training and quality of ground handling activities. As mentioned it could be reasonable to expect that the struggle between the MGO and the MFO could be intense as both try to meet their individual responsibilities. After analyses of the information obtained during the interviews, the previous MFO did not feel that he was effectively involved in the process of negotiation of ground handling contracts. He felt that there was no clear allocation where 'the buck would stop' if audits or other signals showed that a problem became persistent within the company.

On the other hand, the MGO had to cope with an expanding company, a diversity of contractors, a diversity of cultures, varying standards experienced on several regional airports and a strict budget control.

It seemed that the previous QA Manager expressed his concern related to the de-icing issue so vigorously and so often that it became almost annoying to all other managers. It could have been possible that there was an over-saturation on the quantity of concerns expressed by the previous

QA Manager. In essence therefore he was not taken seriously on this matter. This contaminated the importance of the signals produced by the previous QA manager and the problem started to settle in. Mixed with the sometimes troubled conflict of interests between the MGO and the previous MFO, these were the pre-conditions to get the problem 'floating'.

The previous MFO was interviewed after he left the company and he stated that he felt that the internal communication between the Postholders and the QA Manager could have been more effective. He described it as frustrating to work with an overlap of responsibilities, especially in the area of ground operations. The result was an almost 'lethargic' reaction after continuous conflicts with the MGO. It was felt by the previous MFO that when he expressed concern about ground handling issues the MGO would react with the statement that it would be fixed contractually. The previous MFO felt he had an awkward relationship with the MGO and he often noticed a difference between interests and commercial purpose and goals.

An expanding company, an awkward relationship between the previous MFO and the MGO and a QA Manager not taken seriously on his concern of the de-icing issues were the climate in which a new MFO was appointed.

The new MFO, who worked previously as a technical pilot, was appointed on the 7^{th} of November 2001. There was a period of two months of lead-time together with the previous MFO. The previous MFO felt that the handover was performed in an appropriate way. During the handover period the new MFO sat in on all meetings and was introduced to all outstanding issues. The new MFO stated that he felt that there had not been a formal or official hand-over of all existing safety issues. The MFO job-description" to define standards for the quality and contents of flight preparation and ground handling activities", was not interpreted by him as a direct responsibility in regard of the ground handling activities. After the new MFO was appointed the QA Manager noticed that the closure rate of outstanding recommendations was slower. At the time of the serious incident the company was developing a Quality Manual that was not yet completed.

The Flight Safety Manager (FSM) who manages a Risk Assessment Team (RAT) was at the receiving end of the reports coming from the aircrew. Crews who experienced complications in regard of the de-icing issues would inform the FSM via an ASR. After research it showed that reports were received on unsatisfactory de-icing operations. The flight safety manager was not invited to any management meetings. The FSM was aware of the QA Manager's warnings regarding de-icing and without any other information it could have been interpreted that the QA Manager had 'control' of the matter.

2.5.1.3. Operational process

Corporate decisions are influenced by distinct and independent information sources and should be based on reliable, factual and relevant data.

If management requires increased operational tempo and flexibility, due to expansion, then it is imperative to ensure that the Postholders, Quality Manager and the FSM are suitably qualified and capable and that they are supported by sufficient numbers of staff members.

When a company is expanding it becomes more vulnerable and more difficult to control. Added challenges, such as operating from an increasing number of new regional airports, creates even more pressure. The company was apparently becoming aware of the threat being created as the initiative to develop an improved quality manual was taken.

At the time of the incident KLC's organization structure met all JAR-OPS 1 requirements.

With regard with de-icing issues, corporate decisions and the Accountable Manager's supervisory role was influenced by the information flow from the Postholders and the Quality Manager. The Postholders responsibility for de-icing inspection process was not assigned in accordance of JAR-OPS 1 requirements.

With a misplaced trust in the DAQCP, a non effective approach to management from the QA Manager, a MGO who considered verbal contracts to be adequate and a Maintenance Postholder who did not comply with his own JAR-OPS 1 responsibility, and an MFO who encountered several frustrations when dealing with the MGO it is not difficult to understand that the numerous and complex de-icing issues would have been difficult to sort out.

2.5.2. KLC de-anti icing procedures

The BOM, ROM and AOM were the KLC publications in which de-icing procedures were described as well as the related activities. From a general point of view the information related to de-icing could be considered satisfactory; however, some information did not match the agreement set between KLC and the handling and inspecting company in Torino.

In the BOM it was reported that the "handling agent would carry out the checks after de-/anti-icing treatment". This statement was in disagreement with the information contained in SAGAT (handling agent) manual, which stated that the responsibility for checking the aircraft after treatment, prior to release for flight, lies with the operator.

In the contract between SAGAT and KLC there was no reference to the procedure for checking the aircraft after the treatment.

The ground handling contract between SAGAT and KLC did not conform exactly to the standard IATA handling agreement specifications. De-icing was mentioned only in regard to the cost of this service. General procedures were referred to in the station manual which was a direct copy of some sections of the BOM.

KLC stated that there was a verbal agreement regarding the post de-icing inspection. The agreement was that SAGAT would inform Alitalia that de-icing would take place and that Alitalia would then send a ground engineer to inspect the aircraft after de-icing was completed. There were no written instructions about this agreement. This is in contrast with the requirements of JAR-OPS 1 AMC OPS 1.035 in which it is clearly defined in paragraph 5.1.2 that "*A written agreement should exist between the operator and the sub-contractor clearly defining the safety related services and quality to be provided*".

Flight crews were not informed of the details of ground handling contracts or any obligations regarding monitoring the execution of these contracts.

In the BOM it was reported that clear ice on the wing upper surface can only be detected by touch. This statement is correct, however there were no suitable means available to flight crew at Torino (e.g. ladder, surgical gloves) to be used in order to carry out this inspection nor was the handling agent aware about the possibility to make available such tools. In our case, should the Captain have decided to check the wing upper surface by touch, he would not have any "suitable means" or suitable tools readily available.

In the ROM is clearly reported that in Torino Caselle, Alitalia was the inspecting company after de-icing. This information was incorrect. At the time prior and after the incident, according to the information gathered during the investigation, there was no written agreement with Alitalia. KLC and Alitalia had a difference of opinion about the existence of a verbal agreement. Even though the lack of a written agreement was highlighted during the de-icing audit in 2001 as a non-conformance, no actions were taken by KLC at any management level to correct the situation.

In the company AOM the full implication of icing conditions was not clear. Icing conditions referred only to the use of engine anti-icing and wing anti-icing for take-off. The tactile check only referred to the wing leading edge along the full win span and there were no instructions for tactile checks to detect the possibility of clear ice formation on the wing upper surface area above the fuel collector tank area.

2.6. JAR-OPS REQUIREMENTS

In relation to de-icing and difficulty of interpretation of JAR-OPS 1, CAA NL and ENAC stated that after studying JAR-OPS with respect to de-icing, JAR-OPS regulations, as they are currently written, they are not ambiguous and contain enough information on how and what an operator needs to arrange for de/anti-icing. Each JAR-OPS operator when using sub-contractors needs to arrange these services contractually and remains responsible for the quality and safety of the services.

It is noted that most services defined under ground handling which can be outsourced to sub-contractors are not regulated and there is no requirement for sub-contractor compliance. There is no JAR “Ground Handling Operations” for sub-contractors.

Also, safety critical functions within certain ground handling services are not licensed by Aviation Authorities even when ICAO standards exist. It therefore remains the responsibility of each individual JAR-OPS operator to make separate arrangements to ensure that sub-contractors are qualified and properly trained, procedures are up to date and available and that standards are maintained.

At out stations control and oversight of quality and safety of services is far more difficult and complex.

Therefore a European / International approach, in terms of regulated international safety standards for ground handling companies, is considered necessary.

CHAPTER III

CONCLUSIONS

3. CONCLUSIONS

3.1. EVIDENCES - FINDINGS

1. The pilots and cabin crew were qualified to perform the flight.
2. Aircraft Certificate of Registration and Airworthiness were valid and the aircraft was airworthy.
3. Company procedures on economical fuel tanking were not applied, thus the aircraft departed from Amsterdam with 'round trip' fuel and did not require fuel uplift prior to departure from Torino Caselle.
4. A mixture of clear ice and other types of ice formed on the upper surfaces of the wings during the night stop (overnight).
5. The Captain did not link the weather conditions and the previous flight history with the possibility of clear ice formation.
6. The Captain did not receive any information regarding the previous flight history.
7. The operating company's instructions, procedures and equipment were insufficient for ensuring the discovery and removal of clear ice.
8. The (clear) ice on the upper surface of the wings was not discovered during the pre-flight check.
9. The Captain asked the de-icing operator to de-ice the aircraft including the underside of the wings and the tail. The Captain did not request anti-icing and did not specify the type and the percentage of de-icing fluid to be used.
10. The de-icing operator did not ask the Captain to specify the de-icing fluid type and percentage.
11. According to company de-icing and hold over tables a minimum of Type II 75% fluid was required to be sprayed as a second step anti-icing treatment for the conditions of rain on cold soaked wings.

12. The aircraft was sprayed with Type II fluid 50%.
13. The de-icing operation carried out before the flight did not remove the (clear) ice from the upper surface of the wings.
14. According to the company ROM, Alitalia was recorded as being the inspecting company for de-icing at Torino Caselle airport.
15. In the SAGAT de-/anti-icing operation manual - "Final check before aircraft departure" it is stated (*translated from Italian*) that the aircraft must be released by authorized personnel (from a/c company or from authorized inspecting company) after de-/anti-icing treatment has been performed.
16. There was misunderstanding between the Captain and the de-icing operator regarding the final inspection of the aircraft.
17. The Captain performed a visual inspection of the underside of both wings after de-icing was completed.
18. The (clear) ice on the upper surface of the wings was not discovered after the de-icing treatment was performed.
19. The flight crews were not informed about the procedures that were agreed between KLC and SAGAT regarding the de-icing operation.
20. The de-icing invoice that was handed to the Captain did not have a signature for company inspecting.
21. At lift off the (clear) ice separated from the wings and was ingested by both engines; this occurrence caused the right engine to fail (the engine was shut down due to activation of the Emergency Shut-Off Cock system – ESOC) and the left engine to develop high fan vibration.
22. The crew issued a PAN PAN PAN call 30 seconds after lift-off followed by a MAY DAY call 7 minutes after lift-off. The Captain did not accept radar vectoring for an immediate return that was offered by ATC on both these occasions.
23. Visual and aural attention getters for several alerts were suppressed due to the flight crew not having cancelled the MASTER CAUTION.
24. The crew had to cope with several system failures during a critical phase of flight.
25. The ENG VIB HI alert is a "level 1"alert and the attention getters are suppressed when a MASTER CAUTION is not cancelled. The left hand MFDU will present the alert however the procedure does not appear on the right hand MFDU until there is sufficient space available.

26. The ENG VIB HI alert is not upgraded in circumstances when the other engine has failed.
27. Company training regarding residual N1 and N2 rotation on the failed engine led the crew to believe that the engine had not suffered severe damage.
28. The Captain and First Officer were not aware of the severe engine No. 2 damage and therefore did not follow the Engine Fire / Severe Damage checklist.
29. The crew did not pull the fire handle (in accordance with the engine fire / severe damage checklist) at the time of the engine failure.
30. The fuel valve on the engine was closed by the ESOC system and the fire handle would have closed the fuel fire shutoff valve on the wing rear spar.
31. The ignition system remained active after completion of the severe engine damage checklist until the crew pulled the circuit breakers for the system.
32. The fuel lever could not be shut after the activation of the ESOC system and the crew was confused by this phenomenon.
33. The ESOC system is an independent, mechanically activated system.
34. The crew did not immediately recognise the high engine vibration in Engine No1 due to the occurrence of several other system failures and due to the fact that the MASTER CAUTION was not cancelled.
35. The Captain decided to commence the approach at Torino approximately 10 minutes after the MAY DAY call was made.
36. Despite the decision by the crew to curtail some of the alert / emergency checklist procedures the aircraft remained airborne for 28 minutes and 20 seconds.
37. Communications between flight and cabin crew during the emergency were considered not adequate to cope with the situation. Cabin crew was aware of excessive vibration in the cabin but they did not report it to the flight crew. The flight crew did not request information from the cabin crew.
38. The Captain did not request for the cabin to be prepared for the possibility of an emergency landing or on ground emergency.
39. Although the remaining engine performed well considering the circumstances, it is not possible to predict without further technical analyses, if aggressive accelerations could have been sustained by the engine.

40. The most critical stage of the incident would not be on the available CVR recorded tape due to the fact that it was limited to 30 minutes recording time.
41. KLC was JAR-OPS 1 certified since December 2001.
42. The responsibilities (as described in Company's BOM) regarding de-anti-icing operations were shared between the Manager Ground Operations (MGO), Manager Flight Operations (MFO).
43. The Manager of Technical Operations was not directly involved in the de-icing process. (The QA Manager only communicated to the MFO and MGO).
44. The Postholders responsibility for de-icing inspection process was not assigned in accordance of JAR-OPS 1 requirements.
45. The Flight Safety Manager was not included in any company management meetings.
46. The MME did not clearly specify any references to the de-icing technical standards or procedures with regard to transfer of responsibilities.
47. The Postholder Technical (Maintenance) did not verify if the Postholder Ground Handling was able to fulfil the technical aspects of the de-/anti-icing operation.
48. Information concerning recognition, detection and removal of clear ice in the Company (BOM, ROM, and AOM) publications was considered insufficient and confusing for ensuring the discovery and removal of clear ice.
49. General procedures were referred to in the KLC station manual which was a direct copy of various sections of the BOM. There was no reference to specific procedures or instructions in the station manual.
50. The ROM incorrectly stated that Alitalia was the inspecting company for KLC in Torino.
51. KLC did not have a contract for an inspecting company in Torino. This was highlighted during the de-icing audit in 2001 as a non-conformance.
52. No actions were taken by KLC at any management level to correct the non-conformance.
53. KLC did not publish any specific de-/anti-icing instructions to SAGAT Handling regarding de-/anti-icing inspection.
54. The ground handling contract between KLC and SAGAT did not conform to the standard IATA handling agreement specifications.

55. During the DAQCP audit in January 2001 it was highlighted that there wasn't any valid signed contract with a company in charge for the de-/anti-icing inspection. This non-conformance was mentioned to the MFO and MGO by the QA Manager; however the company ROM was not amended.
56. DAQCP and KLC internal de-icing audit follow-up was not effective; non-conformances that were discovered were not correctly addressed within the company management.
57. The DAQCP does not have any sanction possibilities.
58. KLC's Quality System regarding the de-icing process was ineffective. The feedback system did not ensure that necessary corrective actions were both identified and carried out in a timely manner.
59. The SAGAT manual for de-/anti-icing operations ("Trattamento De-/anti-icing degli aeromobili") is published in Italian only.
60. Most of the services defined under ground handling which can be outsourced to sub-contractors are not regulated by JAR OPS.
61. Safety critical functions within ground handling are not licensed by aviation Authorities even when ICAO standards exist.

3.2. IMMEDIATE CAUSES

The primary cause of the event was the ingestion of ice by both engines which caused the right engine to fail completely and the left engine to develop high fan vibration.

3.3. SYSTEMIC CAUSES

From the evidence gathered during the investigation and the analyses made, the following contributing factors were identified:

1. The company's procedures on economical fuel tanking were not applied.
2. Information regarding icing and weather conditions was not available from the previous flight.
3. Lack of a procedure for the transfer of information for aircraft/crew hand over.
4. Both inbound and outbound crew did not draw the conclusion that the wings were cold

soaked and so the formation of clear ice was not suspected.

5. Clear ice was not detected on the upper surface of the wings.
6. Clear ice was not removed from the upper surface of the wings.
7. After the de-icing operation a tactile check was not performed to check for the removal of all ice from the wings.
8. The company's information regarding the recognition and detection of clear ice was inadequate and confusing.
9. The company's facilities, equipment and procedures were inadequate for the detection of clear ice.
10. The crew was not aware that there was no de-/anti-icing inspecting company available in Torino for KLC.
11. The confusion and the overlapping responsibilities of the Postholders and their inaction with respect to the repeated warnings from the Quality Manager with relation to de-icing.
12. The company's quality system was ineffective with regard to de-icing operations.

CHAPTER IV

SAFETY RECOMMENDATIONS

4. SAFETY RECOMMENDATIONS

4.1. Recommendation ANSV–27/140–1/I/04

Recommendation to be addressed to ENAC and CAA-Netherlands, through the DTSB:
That European / International Aviation Authorities establish international safety standards and procedures for ground handling companies.

4.2. Recommendation ANSV–28/140–2/I/04

Recommendations to be addressed to CAA-Netherlands, through the DTSB.

a) To the address of KLM Cityhopper

1. That KLC clearly define Postholder responsibilities with respect to icing operations and assign an order of priority to these responsibilities.
2. That KLC review and modify all ground handling contracts to conform to industry recognised agreement specifications.
3. That KLC involve the FSM in Postholder management team meetings when those meetings include flight safety related subjects.
4. That KLC use this report to asses the effectiveness of its current quality assurance system.
5. That KLC incorporate cockpit/cabin communication and highlight the importance of such communication in joint CRM recurrent training sessions.
6. That KLC establish clear instructions and crew understanding as to when the cabin should be prepared for an emergency landing.
7. That KLC review and expand its training with regard to engine failure recognition, severe engine damage indications and the information regarding residual N1 and N2 rotation.
8. That KLC review crew hand over procedures and the information that should be exchanged between inbound and outbound crew and that crew should be trained to recognise when and what information should be passed on.

9. That KLC consider defining flight crew emergency management priorities to eliminate hindrance by rigid procedures and/or training induced inflexibility.
10. That KLC review the company's instructions, procedures, training and information reported in the relevant publications (BOM, ROM, AOM) related to detection and removal of clear ice.
11. That KLC provide 'hands on' training to all crew regarding the detection of clear ice.
12. That KLC provide suitable equipment to enable crews to detect the presence of clear ice.
13. That KLC review the effectiveness of the DAQCP.
14. That KLC specify and inform all crew of their responsibilities regarding the execution of the duties that are performed by ground handling companies.
15. That KLC ensure adherence to fuelling policies in conjunction with crew judgement.
16. That KLC consider the installation of CVRs which have 2 hour recording capability on all their aircraft.
17. That KLC arrange verification of the Fokker 70 simulators for the correct indication of the cabin pressurization control alerts.

b) To the address of Fokker Services

1. That Fokker Services informs all operators regarding the complexities associated with severe engine damage and in particular the possibility of a jammed fuel lever.
2. That Fokker Services considers including information in the Aircraft Operating Manual to recommend crew to bypass unnecessary preparations in cases when an immediate return must be made to ensure survival.
3. That Fokker Services in cooperation with Rolls-Royce review the procedures and training techniques on how to identify and handle suspected engine damage and the use of autothrottle with an engine which has suspected damage.
4. That Fokker Services in cooperation with Rolls-Royce review the ignition system logic, and how to deal with the possibility of the ignition system remaining active after completion of the severe engine damage checklist with a fuel lever blocked in the open position.
5. That Fokker Services review the technical and operational aspects of the alert priority for the ENG HI VIB alert in cases when the other engine is non-operational.

4.3. Recommendation ANSV–29/140–3/I/04

Recommendation to be addressed to ENAC.

That Handling Companies publish the operating de-anti icing manual (normally published in Italian) also in English.

LIST OF APPENDICES

APPENDIX A: Torino Caselle aerodrome layout.

APPENDIX B: Torino Caselle Metar information.

APPENDIX C: SAGAT de-icing document.

APPENDIX D: Torino Runway 36 standard instrument departure and ILS approach chart.

APPENDIX E: DFDR engines parameters plotting and Fokker 70/100 instrument panel.

APPENDIX F: ATC radio communications transcript and radar plot.

APPENDIX G: PH-KZH engines and debris photos.

APPENDIX H: Runway inspection statement.

APPENDIX I: JAR-OPS 1 requirements.

APPENDIX I bis: KLC - General.

APPENDIX L: KLC ROM de-/anti-icing Procedures Outstations, KLC AOM de-/anti-icing decision flow chart.

APPENDIX M: ANSV – "Messaggio di allerta" Safety Alert Message , KLC crew bulletin Fokker 70, Fokker 70/100 All Operators Message.

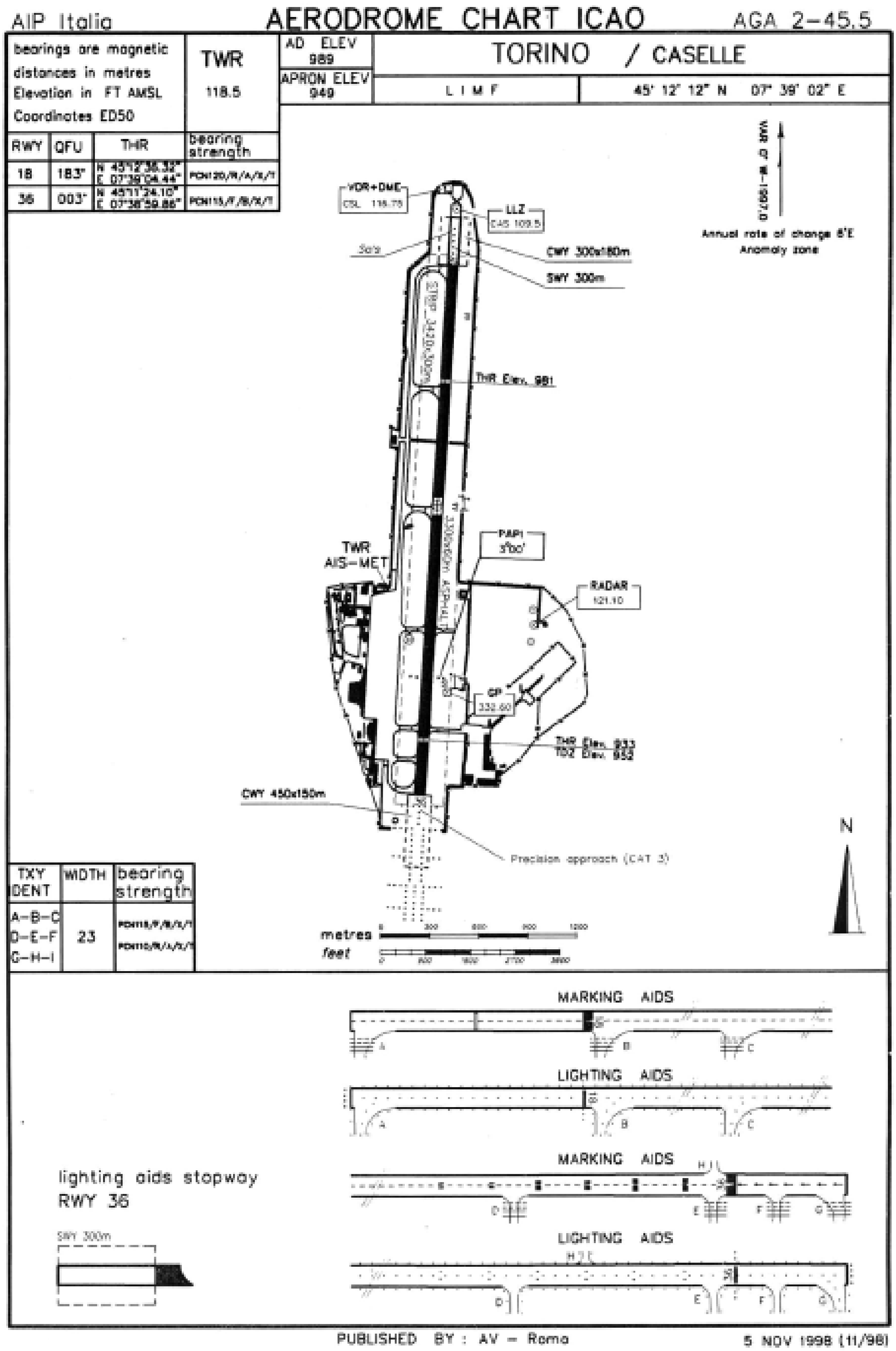
APPENDIX N: KLC/SAGAT ground handling agreement.

APPENDIX O: KLC Quality Audit to Alitalia De-/Anti-icing.

APPENDIX P: Fuel density vs Temperature plot.

APPENDIX Q: Fokker Services answers to the Flight Warning Logic with respect to Cabin Pressure alerts.

The attachments included are copies of original documents made available to ANSV through various sources. In these documents the privacy of all individuals involved in the event has been safeguarded, as indicated in Legislative Decree of February the 25th 1999, n. 66.


AIP Italia
AERODROME CHART ICAO
AGA 2-45.5
bearings are magnetic
distances in metres
Elevation in FT AMSL
Coordinates ED50
TWR
118.5
AD ELEV
989
APRON ELEV
949
TORINO / CASELLE
L I M F
45° 12' 12" N 07° 39' 02" E
RWY
QFU
THR
bearing strength
18
183°
N 45°12'36.32"
E 07°39'04.44"
PCN120/R/A/X/T
36
003°
N 45°11'24.10"
E 07°38'59.86"
PCN115/F/B/X/T
VOR+DME
LLZ
CWY 300x180m
SWY 300m
THR Elev. 981
TWR
AIS-MET
PAPI
3°00'
RADAR
121.10
GP
332.60
THR Elev. 933
TDZ Elev. 952
CWY 450x150m
Precision approach (CAT 3)
Annual rate of change 6'E
Anomaly zone
N
TXY IDENT
WIDTH
bearing strength
A-B-C
D-E-F
G-H-I
23
metres
feet
MARKING AIDS
LIGHTING AIDS
MARKING AIDS
LIGHTING AIDS
lighting aids stopway
RWY 36
SWY 300m
PUBLISHED BY : AV - Roma
5 NOV 1998 (11/98)

Aerodromes used by International Civil Aviation

1 **CITY / Aerodrome: TORINO/Caselle**

2 **Reference Point:**
Lat. 45°12'04"N Long. 07°39'00"E

3 **Distance and direction from city:**
8 NM NNW

4 **Elevation:**
See AD chart

5 **Aerodrome reference temperature:**
27.3° C

6 **Magnetic variation:**
See AD chart

7 **Transition altitude:**
6000 FT

8 **Operation hours:**
H24

9 **Aerodrome Operator:**
S.A.G.A.T.

Administrative Authority:
Ministero dei
Trasporti e Navigazione - D.G.A.C.

10 **Postal address:**
Aeroporto «Città di Torino»
10072 Caselle Torinese

11 **Telegraphic addresses:**

- **Autorità Amministrativa**
  AFTN: LIMFYD
  Commerciale: 220693 LIMFYD
- **Esercente**
  SITA: TRNKOXH
  Commerciale: 220246 S.A.G.A.T.
- **Assistenza al Volo**
  AFTN: LIMFZT
  Commerciale: 225100 LIMFZT

12 **Telephone numbers:**

- **D.G.A.C.**
  TEL 011/4704058 - 4701625
  FAX 011/4704320 - 5676418
- **S.A.G.A.T.**
  TEL 011/5676213 - 5676207 - 5676452
  FAX 011/5676421 - 5676424
- **AIR BP ITALIA S.p.A.**
  TEL 011/4704622

13 **Overnight accomodation:**
Caselle (KM 2), Borgaro (KM 4), Ciriè (KM 6).

14 **Restaurant accomodation:**

SELF - SERVICE 160 seats HR:
1200-1530 / 1830-2115 (1100-1430 / 1730-2015)
RESTAURANT 100 seats HR:
1200-1500 / 1830-2130 (1100-1400 / 1730-2030)

15 **Medical facilities:**
First aid treatment - Medical assistance-Ambulances - Hospitals in Ciriè (KM 8), Torino (KM 15).

16 **Transportation available:**
Bus from / to Torino 0515/2230 (0415/2130)
Bus from / to Aosta 0500/2015 (0400/1915)
Taxi - Car rentals.

17 **Cargo handling facilities:**
Available without limitations

18 **Fuel grades:**
JET A1 - AVGAS 100LL

19 **Oil grades:**
MOBIL JET OIL II - ESSO OIL

20 **Oxygen and related servicing:**
NIL

21 **Refuelling facilities and limitations:**
- HR JET A1: (*)
  AGIP: 0500/2300 (0400/2200)
  MOBIL: 0600/1900 (0500/1800)
- HR AVGAS: (*)
  MON: 1200/1700 (1100/1600)
  TUE/SAT: 0600/1700 (0500/1600)

(*) Other hours O/R 3 hours PN WI HR.

- HR AIR BP ITALIA S.p.A.:
  JET A1 - AVGAS 100LL HR 0500/2100 (0400/2000).
  Other hours O/R 2 hours PN WI HR.

22 **Hangar space available for visiting ACFT:**
Hangars for General Aviation ACFT only. Hangar space available to be checked with S.A.G.A.T.

23 **Repair facilities normally available:**
ALENIA: MON/FRI 0830/1730 (0730/1630)
TEL 011/9961326 - TELEX 210095 ALFLT

24 **Crash equipment:**
Protection level: 8th ICAO Category

25 **Seasonal availability:**
All year

26 **Local flying restrictions:**
Training flights on the field are subject to MAINT works on maneuvering area. Permission must be requested to AD Civil Aviation Authority submitting SKED FLT 10 days PN required except for home based ACFT with MAX TKOF weight greater than 4 tons and for home based HEL OPR to / from HEL ALA.

27 **Pre-flight altimeter check point(s) and elevation:**
See AD chart;

INS: See parking area chart.

28 METEOROLOGICAL DATA

Mean daily maximum and minimum temperatures (C)

Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maximum	5.2	8.0	12.4	16.7	21.1	24.5	27.3	26.3	22.7	17.2	10.8	6.6
Minimum	-3.9	-2.2	1.6	5.4	9.8	13.8	15.9	15.2	12.4	6.4	1.9	-2.3

Monthly mean pressure in hectopascal (HPA)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
	1017.8	1015.4	1015.3	1013.2	1014.2	1014.4	1014.3	1014.2	1016.7	1016.6	1016.9	1017.3

29 **Slopes (RWY, SWY, CWY):** See AOC. Transverse: from W to E: RWY 1% - CWY 18/36: 0,5%.

30 **Physical characteristics:** See AD chart.

31 **Movement areas:** See AD chart.

Helicopter alighting area:
- Dimensions: M25 x 25
- strength: PCN 90/F/B/Y/U
- surface: flexible in bituminous conglomerate.

VISUAL GROUND AIDS

32 **Taxiing guidance system:** See AD chart

33 **Visual aids to location:** ABN revolving white/green alternating light.

34 **Indicators and ground signalling devices:** See AD chart.

35 **Lighting aids:**

See AD chart.
- RCL RWY 18/36: spaced 15 M

36 **Emergency lights:** Light gun

37 **Obstruction marking and lighting:** See AOC and IAL.

38 **Marking aids:** See AD chart.

39 **Obstructions in approach and take-off areas:**See AOC.

Declared Distances:

RWY	TORA M	ASDA M	TODA M	LDA M
36	3300	3600	3600	2950
18	3300	3300	3750	2575

AIP Italia — AIRCRAFT PARKING DOCKING CHART — AGA 2-45.7

bearings are magnetic distances in metres Elevation in FT AMSL Coordinates ED50	TWR 118.5	AD ELEV 969 APRON ELEV 946	TORINO / CASELLE L I M F — 07°39'02" E 45°12'12" N

APRON

lighting	bearing strength
Edge: Orange	Surface: Flexible in conglomerate bituminous and semirigid with antikerosene treatment Strength: PCN117/F/B/X/T PCN110/R/A/X/T

POINTS ON PARKING AREA

STANDS	N	E
A09	45°11'38.82"	7°38'44.99"
A10	45°11'36.96"	7°38'44.87"
A11	45°11'35.09"	7°38'44.75"
A12	45°11'33.23"	7°38'44.64"
A13	45°11'31.36"	7°38'44.52"
A14	45°11'29.49"	7°38'44.40"
A15	45°11'28.25"	7°38'47.71"
A16	45°11'26.94"	7°38'47.62"
A17	45°11'25.63"	7°38'47.54"
A18	45°11'24.32"	7°38'47.46"
A19	45°11'23.01"	7°38'47.38"
A20	45°11'21.69"	7°38'47.29"
A21	45°11'20.39"	7°38'47.21"
B05	45°11'27.29"	7°38'47.55"
B06	45°11'24.96"	7°38'47.40"
B07	45°11'22.57"	7°38'47.25"
B08	45°11'20.17"	7°38'47.10"
C2	45°11'40.85"	7°38'45.79"
C3	45°11'42.50"	7°38'45.10"
C4	45°11'44.16"	7°38'46.00"
C5	45°11'45.81"	7°38'46.11"
C6	45°11'47.46"	7°38'46.21"
C7	45°11'49.11"	7°38'46.32"
C8	45°11'50.76"	7°38'46.43"
X1	45°11'51.10"	7°38'48.40"
X2	45°11'47.38"	7°38'48.17"
X3	45°11'43.62"	7°38'47.93"
Y1	45°11'52.55"	7°38'48.92"
Y2	45°11'51.24"	7°38'48.83"
Y3	45°11'48.84"	7°38'48.68"
Y4	45°11'47.52"	7°38'48.60"
Y5	45°11'45.12"	7°38'48.45"
Y6	45°11'43.81"	7°38'48.37"

RMK:

1) C2 : C8 POWER IN–POWER OUT
Y1 : Y6 PWER IN – POWER OUT
X1 : X3 POWER IN – POWER OUT
A09 : A21 POWER IN – PUSH BACK
B05 : B08 POWER IN – PUSH BACK

2) A, C and X stands marking provided with a yellow continuous line.
B and Y stands markings provided with an orange continuous line.

3) liaise with CTN and request follow-me assistance in case of uncertainty.

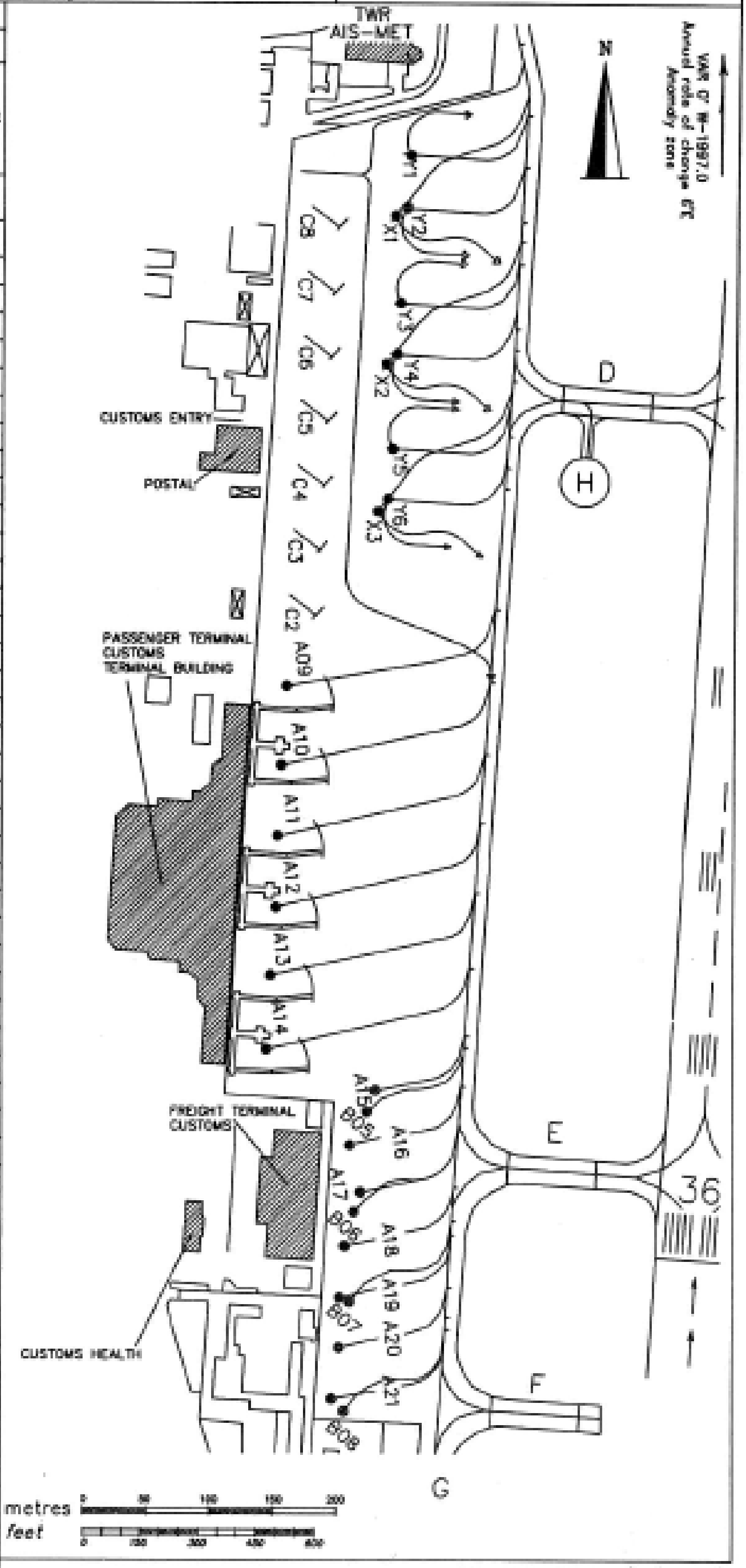
4) during cat II OPS follow-me avbl on request.

5) during cat III OPS acft moving FM/TO parking stands TO/FM manoeuvring area must be led by follow-me car

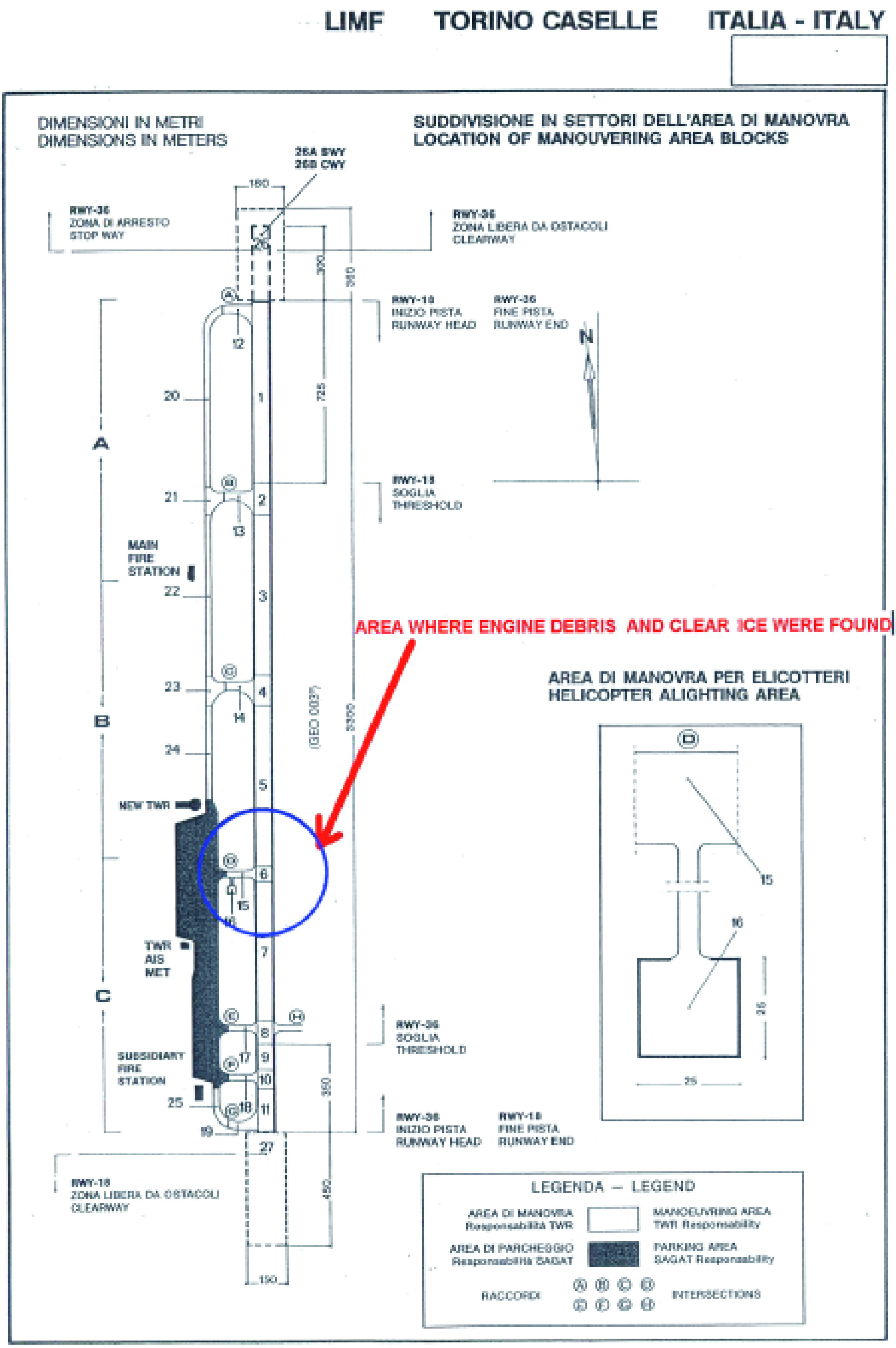
6) push back OPS must be coordinated with SAGAT handling and carried out under marshaller instruction, Freq 131.90 MHZ AVBL for coordination purposes.

7) STANDS– A09–A10–A11–A12–A13–A14 have bridges and Docking System provided(ACFT type allowed BA146:B747)

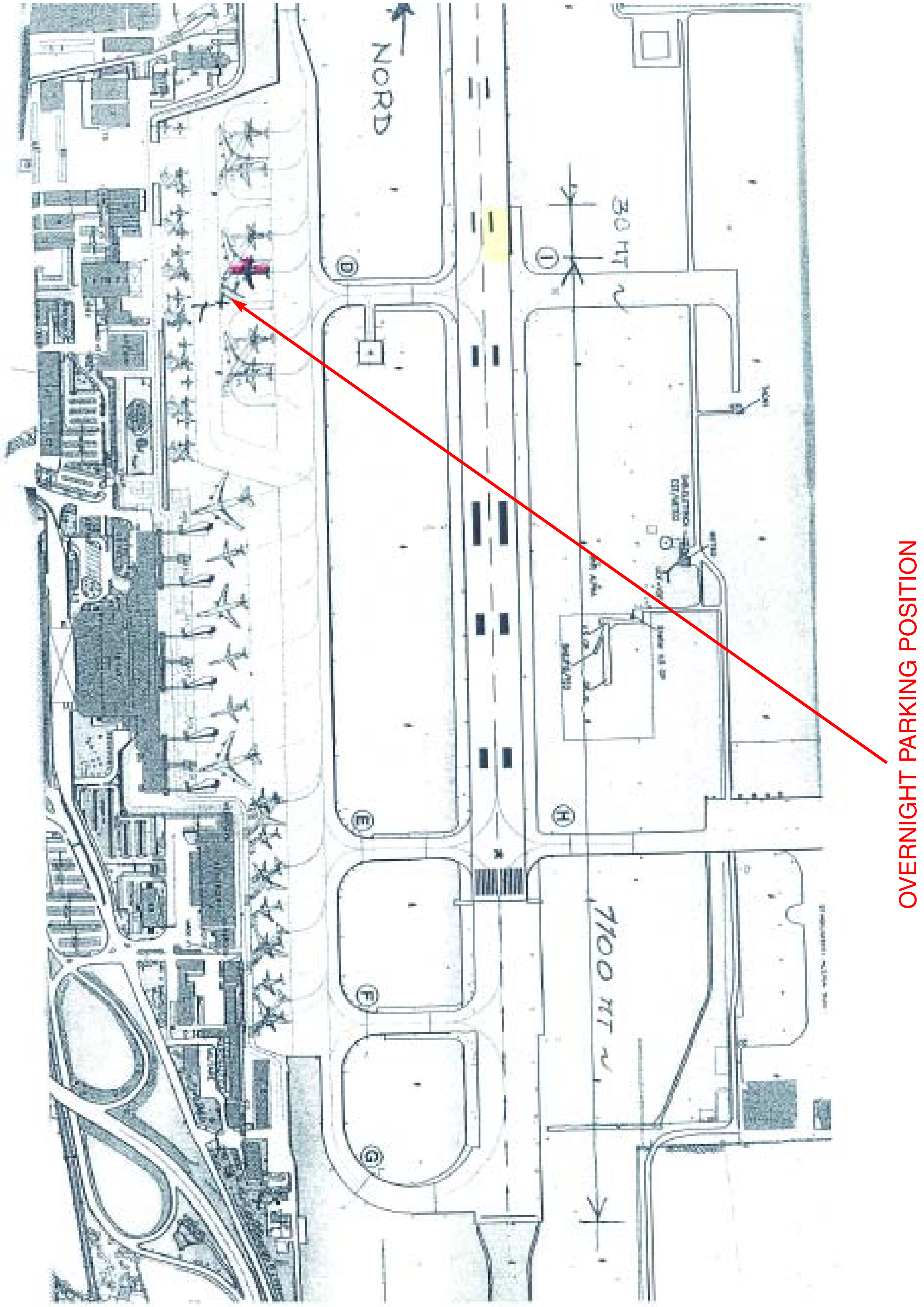
8) GENERAL AVIATION if parking brake is engaged the P.I.C. his agent must be immediately contactable



PUBLISHED BY: AV – Roma — 25 JAN 2001 (1/2001)



LIMF TORINO CASELLE ITALIA - ITALY
DIMENSIONI IN METRI
DIMENSIONS IN METERS
SUDDIVISIONE IN SETTORI DELL'AREA DI MANOVRA
LOCATION OF MANOUVERING AREA BLOCKS
RWY-36 ZONA DI ARRESTO STOP WAY
RWY-36 ZONA LIBERA DA OSTACOLI CLEARWAY
RWY-18 INIZIO PISTA RUNWAY HEAD
RWY-36 FINE PISTA RUNWAY END
RWY-18 SOGLIA THRESHOLD
MAIN FIRE STATION
AREA WHERE ENGINE DEBRIS AND CLEAR ICE WERE FOUND
AREA DI MANOVRA PER ELICOTTERI
HELICOPTER ALIGHTING AREA
NEW TWR
TWR AIS MET
SUBSIDIARY FIRE STATION
RWY-36 SOGLIA THRESHOLD
RWY-36 INIZIO PISTA RUNWAY HEAD
RWY-18 FINE PISTA RUNWAY END
RWY-18 ZONA LIBERA DA OSTACOLI CLEARWAY
LEGENDA — LEGEND
AREA DI MANOVRA Responsabilità TWR
MANOEUVRING AREA TWR Responsability
AREA DI PARCHEGGIO Responsabilità SAGAT
PARKING AREA SAGAT Responsability
RACCORDI
INTERSECTIONS


NORD
30 mt
7100 mt
D
E
F
G
H
I
OVERNIGHT PARKING POSITION

AEROPORTO DI: TORINO

02/02/18 08:31:37

STAMPA DEL FILE BOLLETTINI METAR SU FLOPPY STORICO

2002/02/15 11:20 BOLLETTINO EMESSO
LIMF 151120Z 06010KT 4000 RA BR SCT003 OVC010 04/02 Q1021=

2002/02/15 11:50 BOLLETTINO EMESSO
LIMF 151150Z 03009KT 4000 RA BR SCT003 OVC010 03/02 Q1021=

2002/02/15 12:20 BOLLETTINO EMESSO
LIMF 151220Z 01009KT 4000 RASN BR BKN003 OVC010 02/01 Q1021=

2002/02/15 12:50 BOLLETTINO EMESSO
LIMF 151250Z 33006KT 1600 SN BR BKN003 OVC010 00/M01 Q1021=

2002/02/15 13:20 BOLLETTINO EMESSO
LIMF 151320Z 33004KT 1500 SN BR BKN003 OVC010 00/M01 Q1021=

2002/02/15 13:50 BOLLETTINO EMESSO
LIMF 151350Z 31007KT 1600 SN BR BKN003 OVC010 00/M01 Q1021=

2002/02/15 14:20 BOLLETTINO EMESSO
LIMF 151420Z 33007KT 1600 SN BR BKN003 OVC010 00/M01 Q1021 RSG
36590295=

2002/02/15 14:50 BOLLETTINO EMESSO
LIMF 151450Z 31007KT 2500 RASN BR BKN005 OVC015 00/M01 Q1021 RSG
36590295=

2002/02/15 15:20 BOLLETTINO EMESSO
LIMF 151520Z 31007KT 2500 RA BR BKN005 OVC015 01/M01 Q1021
RSG36590295=

2002/02/15 15:50 BOLLETTINO EMESSO
LIMF 151550Z 35006KT 2500 RA BR BKN005 OVC015 01/00 Q1021 RSG
36590295=

2002/02/15 16:20 BOLLETTINO EMESSO
LIMF 151620Z 35006KT 4000 RA BR BKN006 OVC017 01/00 Q1021 RSG 36
CLEAR=

2002/02/15 16:50 BOLLETTINO EMESSO
LIMF 151650Z 36008KT 7000 RA SCT010 OVC035 02/00 Q1020=

2002/02/15 17:20 BOLLETTINO EMESSO
LIMF 151720Z 33006KT 7000 RA SCT008 OVC030 02/01 Q1021=

2002/02/15 17:50 BOLLETTINO EMESSO
LIMF 151750Z VRB03KT 7000 RA SCT008 OVC030 02/00 Q1021=

2002/02/15 18:20 BOLLETTINO EMESSO
LIMF 151820Z VRB02KT 6000 RA SCT008 OVC030 01/00 Q1021=

2002/02/15 18:50 BOLLETTINO EMESSO
LIMF 151850Z VRB03KT 7000 RA SCT008 OVC030 02/01 Q1021=

AEROPORTO DI: TORINO

02/02/18 08:31:43

2002/02/15 19:20 BOLLETTINO EMESSO

LIMF 151920Z VRB02KT 7000 RA SCT008 OVC030 02/01 Q1021=

2002/02/15 19:50 BOLLETTINO NON EMESSO

METAR LIMF 2000Z 070 04KT R36/P1500M RA SCT008 OVC030 02/00 Q1021

2002/02/15 20:20 BOLLETTINO EMESSO

LIMF 152020Z 05004KT 7000 -RA SCT008 OVC020 02/00 Q1022=

2002/02/15 20:50 BOLLETTINO EMESSO

LIMF 152050Z 36004KT 7000 -RA SCT008 OVC020 01/00 Q1022=

2002/02/15 21:20 BOLLETTINO NON EMESSO

METAR LIMF 2120Z 330 04KT R36/P1500M -RA SCT008 OVC020 00/M01 Q1022

2002/02/15 21:50 BOLLETTINO EMESSO

LIMF 152150Z 28006KT 6000 RASN SCT006 OVC022 01/M01 Q1022=

2002/02/15 22:20 BOLLETTINO EMESSO

LIMF 152220Z 25006KT 6000 RASN SCT004 OVC015 01/00 Q1022=

2002/02/15 22:50 BOLLETTINO EMESSO

LIMF 152250Z VRB03KT 7000 RASN SCT004 OVC015 01/M01 Q1022=

2002/02/15 23:20 BOLLETTINO EMESSO

LIMF 152320Z VRB02KT 7000 RASN SCT004 OVC015 01/M01 Q1022=

2002/02/15 23:50 BOLLETTINO EMESSO

LIMF 152350Z VRB02KT 5000 SN BR SCT004 OVC015 00/M01 Q1022=

2002/02/16 00:20 BOLLETTINO EMESSO

LIMF 160020Z VRB03KT 5000 SN BR SCT004 OVC015 00/M01 Q1022=

2002/02/16 00:50 BOLLETTINO EMESSO

LIMF 160050Z AUTO VRB03KT //// // ///013 00/M01 Q1022=

2002/02/16 01:20 BOLLETTINO EMESSO

LIMF 160120Z VRB03KT 5000 RA BR SCT004 OVC015 00/M01 Q1022=

2002/02/16 01:50 BOLLETTINO EMESSO

LIMF 160150Z 34004KT 5000 RA BR SCT004 OVC015 00/M01 Q1022=

2002/02/16 02:20 BOLLETTINO EMESSO

LIMF 160220Z VRB03KT 6000 RA SCT005 OVC018 01/M01 Q1022=

2002/02/16 02:50 BOLLETTINO EMESSO

LIMF 160250Z 30008KT 6000 SCT005 OVC018 01/M01 Q1022=

2002/02/16 03:20 BOLLETTINO EMESSO

LIMF 160320Z 31006KT 6000 -RA SCT005 OVC018 01/00 Q1022=

2002/02/16 03:50 BOLLETTINO EMESSO

LIMF 160350Z 30007KT 6000 -RA SCT005 OVC018 01/00 Q1022=

AEROPORTO DI: TORINO

02/02/18 08:31:46

2002/02/16 04:20 BOLLETTINO EMESSO
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2002/02/16 04:50 BOLLETTINO EMESSO
LIMF 160450Z VRB03KT 6000 RA SCT005 OVC018 01/00 Q1022=

2002/02/16 05:20 BOLLETTINO EMESSO
LIMF 160520Z 01006KT 7000 RA SCT007 OVC018 02/00 Q1022=

2002/02/16 05:50 BOLLETTINO EMESSO
LIMF 160550Z 04004KT 7000 RA SCT007 OVC018 02/00 Q1022=

2002/02/16 06:20 BOLLETTINO EMESSO
LIMF 160620Z VRB02KT 6000 RA SCT005 OVC018 01/00 Q1023=

2002/02/16 06:50 BOLLETTINO EMESSO
LIMF 160650Z VRB02KT 6000 RA SCT005 OVC018 01/00 Q1023=

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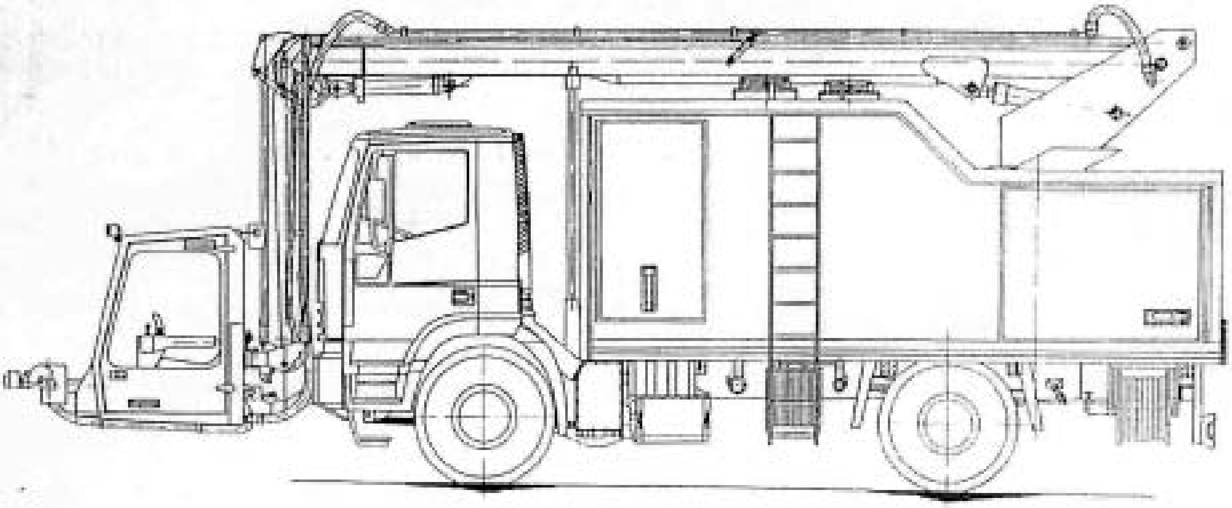
SAGAT

AEROPORTO CITTA' DI TORINO

TRATTAMENTO DE/ANTI-ICING DEGLI AEROMOBILI



Direzione Operativa – Traffico

1ª Edizione 11 giugno 1999

DE ICING MANUAL

5. PROCEDURE OPERATIVE EROGAZIONE DEL LIQUIDO DE/ANTIICING, IMPIANTO DI STOCCAGGIO E TRATTAMENTO DEI LIQUIDI.

5.1. PROCEDURE OPERATIVE

La responsabilità dell'erogazione è della Compagnia aerea, in particolare nella persona del tecnico motorista e dove non presente, del comandante dell'aeromobile.
La richiesta per il trattamento de-icing, di quali parti trattare e della percentuale di diluizione acqua/liquido viene fatta dal Responsabile Tecnico della Compagnia all'addetto rampa il quale a sua volta inoltrerà tale richiesta al Responsabile di Linea Piazzale che ha il compito di dare la priorità del trattamento de-icing agli aeromobili secondo lo schedulato di partenza o degli eventuali slots.

5.2. EROGAZIONE DEL LIQUIDO DE-ICING

N.B. la temperatura del fluido miscelato all'uscita dell'uscita dell'ugello deve essere di almeno 60°C.
Normalmente l'erogazione del liquido deve essere a pioggia per evitare inutili sprechi e coprire così con l'erogazione, una maggior superficie.
Il getto va solamente usato per lo snevamento (quando si eroga solamente acqua), oppure quando sull'ala, in particolare al suo congiungimento con la carlinga, si noti la presenza di uno strato di ghiaccio superiore ai 3 mm. In quella zona spesso c'è una formazione di ghiaccio trasparente, alla quale è necessario prestare particolare attenzione durante l'erogazione del liquido de-icing. In tal modo la pressione del getto forerà il ghiaccio e, grazie alla trasmissione della temperatura del liquido, si avrà lo scorrimento del medesimo sotto la crosta di ghiaccio che a sua volta si staccherà.
Per quanto inerente all'erogazione del liquido de icing sulle ali ed i piani orizzontali di coda è necessario iniziare dall'estremità verso il congiungimento con la fusoliera (così facendo, il liquido inizierà a colare sghiacciando la parte successiva), e dalla parte anteriore verso quella posteriore (evitando di far finire il liquido all'interno del pannello dei flaps nel quale potrebbe impedirne il movimento o ghiacciare).
L'erogazione dello stabilizzatore di direzione (timone) deve essere iniziata dall'estremità superiore, verso quella inferiore, dirigendo l'erogazione il più orizzontalmente possibile.
Sulla fusoliera dell'aeromobile, il liquido deve sempre essere erogato a pioggia, per evitare colature sugli oblò e sui vetri della cabina di pilotaggio. Il liquido a lungo andare potrebbe corrodere le guarnizioni dei vetri con gravi ripercussioni sulla pressurizzazione dell'aeromobile.

DE ICING MANUAL

ATTENZIONE: bisogna evitare di erogare il liquido nei motori, nell'uscita APU, nelle prese d'aria ed in tutti quegli interstizi (ad esempio l'attacco dei flaps e del timone, in tubi pitot e sonde) nei quali il liquido depositandosi potrebbe

comprometterne la funzione. E' necessario evitare di erogare il liquido sul "naso" dell'aeromobile, perché durante il decollo verrebbe spinto sui vetri della cabina di pilotaggio, con conseguente riduzione della visibilità.

5.3. MODALITA' DI EROGAZIONE

Per un corretto trattamento de-icing, bisogna iniziare dalla parte sinistra dell'aeromobile posizionandosi con il mezzo posteriormente all'ala, iniziando dall'estremità della stessa sino al congiungimento con la fusoliera, erogano il liquido de-icing a pioggia coprendo con l'erogazione prima la parte anteriore e poi la posteriore. È necessario ricordarsi che per gli aeromobili con l'ala "alta" (tipo ATR42, BA146, F27, ecc.), quando si eroga il de-icing, bisogna trattare anche la parte sopra la carlinga, ossia dove si congiungono le due ali.
Può venir richiesto anche il trattamento de-icing sotto le ali; in questo caso, bisogna abbassarsi completamente con il braccio del cestello ed iniziare il trattamento de-icing, facendo attenzione a coprire con l'erogazione l'intera superficie dell'ala soprattutto la parte congiungimento con la fusoliera.
Successivamente si passa ai piani di coda. Posizionarsi con il mezzo de-icing posteriormente e parallelamente ai piani di coda. Così facendo, si può iniziare l'erogazione dall'estremità del piano di coda di sinistra, terminando l'estremità di quello di destra.
Per quanto riguarda l'erogazione, i piani di coda vanno trattati con particolare cautela a causa del differente materiale di costruzione rispetto alle ali.
Terminati i piani di coda, si passa a trattare l'ala di destra dell'aeromobile; posizionarsi con il mezzo de-icing frontalmente all'ala ed iniziare il trattamento come per l'ala di sinistra.
Per quanto riguarda il trattamento de-icing della carlinga, bisogna iniziare qualche metro prima della porta dell'aeromobile verso le ali e proseguire sino alla fine dello stesso. La carlinga va trattata prima delle ali.
Se richiesto, il trattamento de-icing può riguardare anche le eliche, in questo caso, erogare il de-icing dall'alto verso il basso, posizionandosi con il cestello sopra l'elica stessa per evitare che il liquido all'interno del motore.

5.4. CONTROLLI FINALI PRIMA DELLA PARTENZA

Nessun aereo può considerarsi pronto alla partenza in condizioni di ghiaccio o dopo aver effettuato de/anti-icing, senza aver prima ricevuto un controllo finale da una persona responsabile e autorizzata. (omissis)

SAGAT
TURIN AIRPORT

OPERAZIONI ANTIGHIACCIO
SNEVAMENTO - SGHIACCIAMENTO
SNOWING - ANTI- DEICING OPERATIONS

N° 1582

LIQUIDO: KILFROST ABC – 3 TYPE II
LIQUID:

ATTREZZATURA: DI10 SAFEAERO N. 1
EQUIPMENT:

COMPAGNIA *AIRLINE*	KLM	DATA *DATE*	1 6 0 2 0 2
N° VOLO *FLIGHT NUMBER*	K L 1 6 3 6	SIGLA A/M *REG. MARKS*	P H K Z H
INIZIO OPERAZIONI *START OPERATIONS*	0 6 5 5	FINE *END*	0 7 1 0

MISCELA: 5 0 %
MIXTURE:

QUANTITÀ LIQUIDO PURO EROGATO DA ADDEBITARE 413
QUANTITY OF SPRAIED PURE LIQUID TO BE DEBITED

L' OPERATORE SAGAT
SAGAT OPERATOR

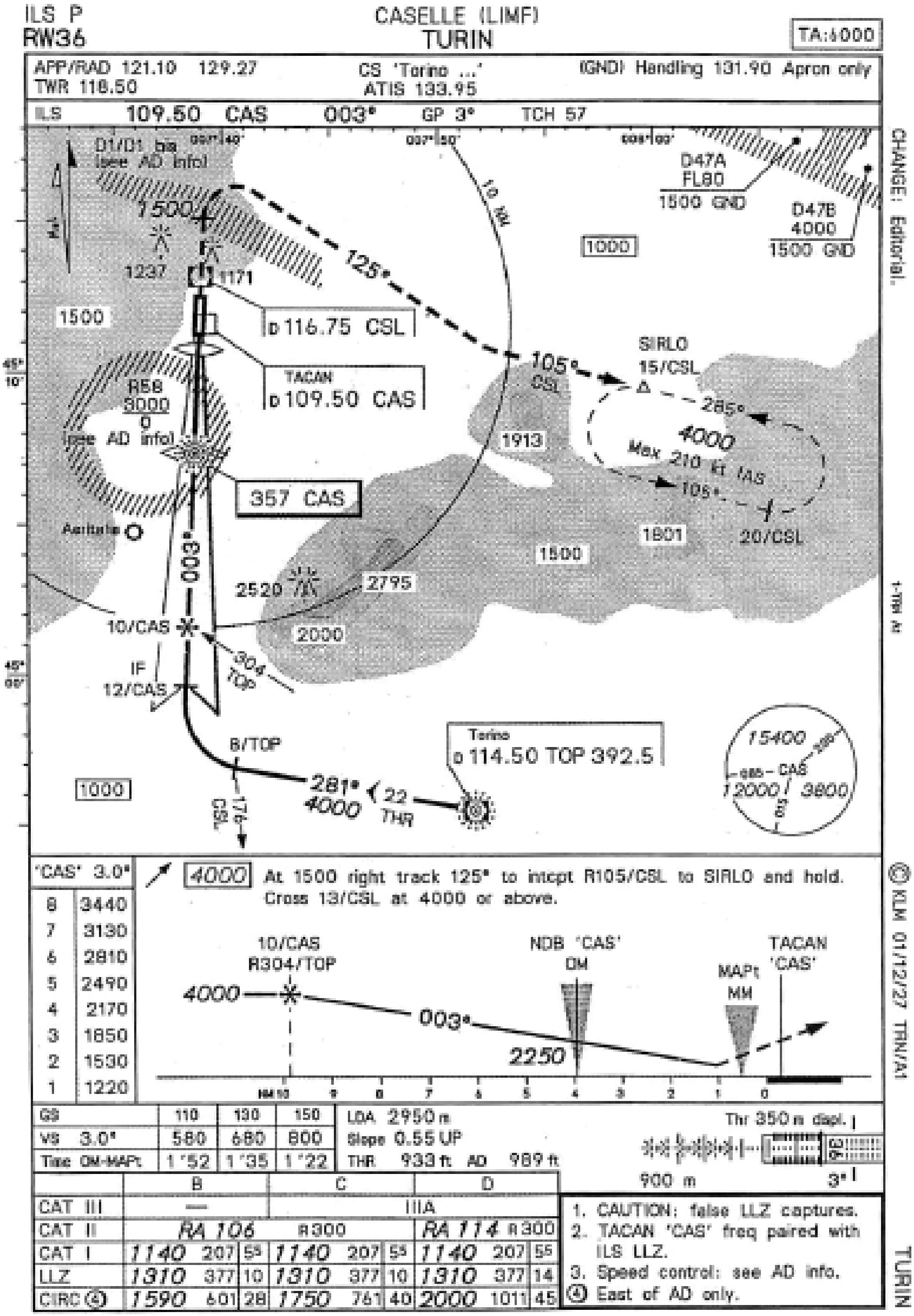
IL SUPERVISORE SAGAT
SAGAT SUPERVISOR

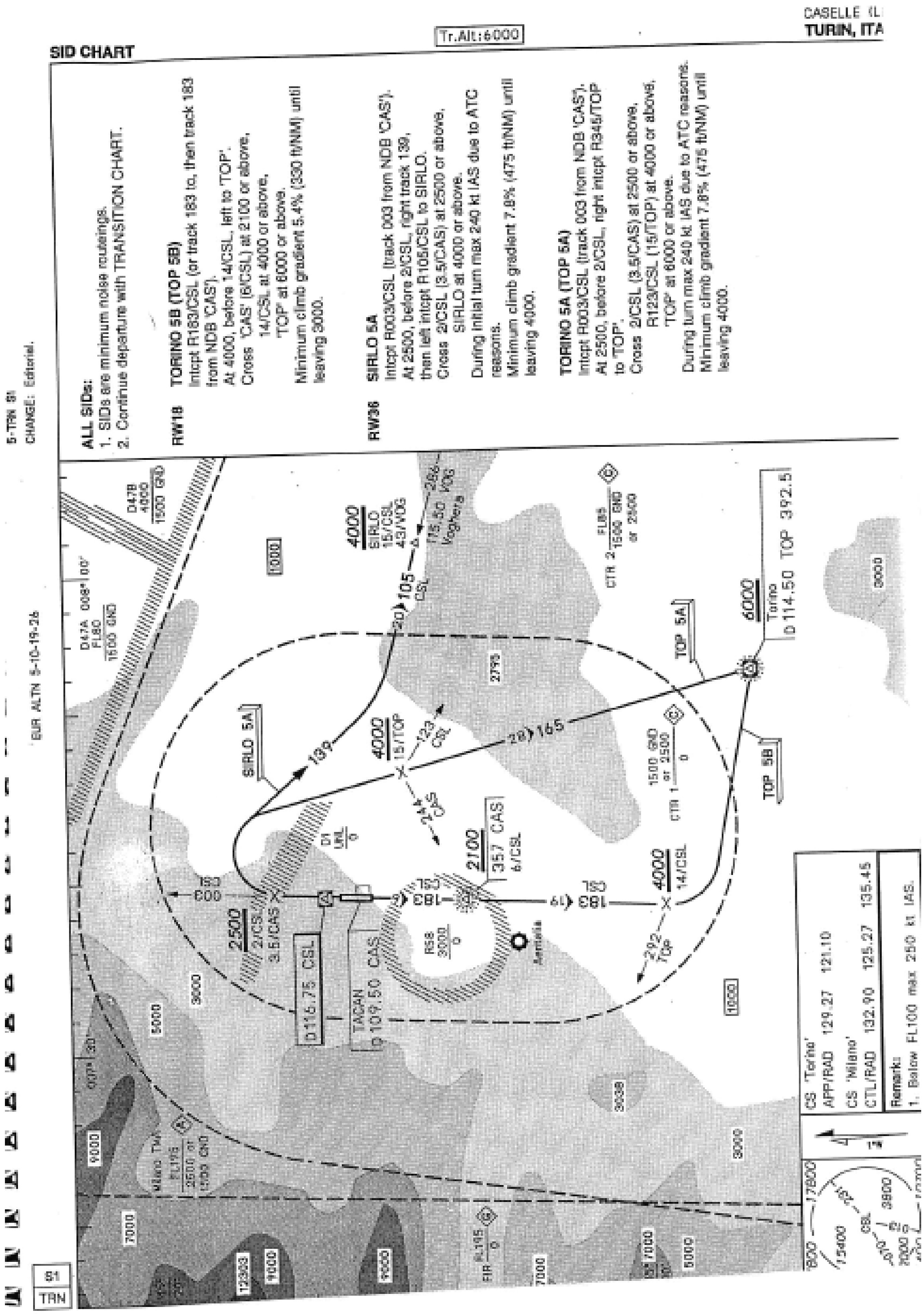
L' OPERAZIONE E' STATA EFFETTUATA SU RICHIESTA/ISTRUZIONE E RESPONSABILITA' DELLA COMPAGNIA AEREA, ANCHE IN RELAZIONE ALLA MISCELA USATA ED ALLA QUANTITA' DI LIQUIDO EROGATA.
TREATMENT HAS BEEN SUPPLIED ON REQUEST/INSTRUCTIONS AND CONTROL OF THE AIRLINE, MIXTURE AND QUANTITY OF SPRAYED FLUID INCLUDED.

IL TECNICO RESPONSABILE DEL VOLO O IL COMANDANTE
ASSIGNED GROUND ENGINEER OR CAPTAIN IN COMMAND

COPIA FATTURAZIO

Tip. StampArt Torino - Mod. 135-12-98


ILS P
RW36
CASELLE (LIMF)
TURIN
TA:6000
APP/RAD 121.10 129.27
TWR 118.50
CS 'Torino ...'
ATIS 133.95
(GND) Handling 131.90 Apron only
ILS 109.50 CAS 003° GP 3° TCH 57
D1/D1 bis (see AD info)
1500
1237
1171
D 116.75 CSL
TACAN
D 109.50 CAS
R58 3000 0 (see AD info)
357 CAS
Aeritalia
003°
10/CAS
IF 12/CAS
304 TOP
8/TOP
176 CSL
281° 4000
22 THR
Torino
D 114.50 TOP 392.5
125°
10 NM
105° CSL
SIRLO 15/CSL
285°
4000
Max 210 kt IAS
105°
20/CSL
D47A FL80 1500 GND
D47B 4000 1500 GND
1000
1913
1801
1500
2520
2795
2000
1000
15400
12000
3800
CHANGE: Editorial.
'CAS' 3.0°
8 3440
7 3130
6 2810
5 2490
4 2170
3 1850
2 1530
1 1220
4000 At 1500 right track 125° to intcpt R105/CSL to SIRLO and hold. Cross 13/CSL at 4000 or above.
10/CAS R304/TOP
NDB 'CAS' OM
MAPt MM
TACAN 'CAS'
4000
003°
2250
GS 110 130 150
VS 3.0° 580 680 800
Time OM-MAPt 1'52 1'35 1'22
LDA 2950 m
Slope 0.55 UP
THR 933 ft AD 989 ft
Thr 350 m displ.
900 m
3°
B C D
CAT III — IIIA
CAT II RA 106 R300 RA 114 R300
CAT I 1140 207 55 1140 207 55 1140 207 55
LLZ 1310 377 10 1310 377 10 1310 377 14
CIRC ④ 1590 601 28 1750 761 40 2000 1011 45
1. CAUTION: false LLZ captures.
2. TACAN 'CAS' freq paired with ILS LLZ.
3. Speed control: see AD info.
④ East of AD only.
© KLM 01/12/27 TRN/A1
TURIN


CASELLE (L
TURIN, ITA
Tr.Alt:6000
SID CHART
5-TRN S1
CHANGE: Editorial.
EUR ALTN 5-10-19-26
S1
TRN
ALL SIDs:
1. SIDs are minimum noise routeings.
2. Continue departure with TRANSITION CHART.
RW18
TORINO 5B (TOP 5B)
Intcpt R183/CSL (or track 183 to, then track 183 from NDB 'CAS').
At 4000, before 14/CSL, left to 'TOP'.
Cross 'CAS' (6/CSL) at 2100 or above,
14/CSL at 4000 or above,
'TOP' at 6000 or above.
Minimum climb gradient 5.4% (330 ft/NM) until leaving 3000.
RW36
SIRLO 5A
Intcpt R003/CSL (track 003 from NDB 'CAS').
At 2500, before 2/CSL, right track 139, then left intcpt R105/CSL to SIRLO.
Cross 2/CSL (3.5/CAS) at 2500 or above,
SIRLO at 4000 or above.
During initial turn max 240 kt IAS due to ATC reasons.
Minimum climb gradient 7.8% (475 ft/NM) until leaving 4000.
TORINO 5A (TOP 5A)
Intcpt R003/CSL (track 003 from NDB 'CAS').
At 2500, before 2/CSL, right intcpt R345/TOP to 'TOP'.
Cross 2/CSL (3.5/CAS) at 2500 or above,
R123/CSL (15/TOP) at 4000 or above,
'TOP' at 6000 or above.
During turn max 240 kt IAS due to ATC reasons.
Minimum climb gradient 7.8% (475 ft/NM) until leaving 4000.
D47A 008° 00'
FL80
1500 GND
D47B
4000
1500 GND
Milano TMA
FL195
2500 or
1500 GND
FIR FL195
D116.75 CSL
TACAN
D 109.50 CAS
2500
2/CSL
3.5/CAS
SIRLO 5A
139
D1
UNL
0
4000
15/TOP
244
CAS
123
CSL
4000
SIRLO
15/CSL
43/VOG
105
CSL
115.50 VOG
Voghera
RS8
3000
0
2100
357 CAS
6/CSL
Aeritalia
183
CSL
165
4000
14/CSL
292
TOP
1500 GND
or 2500
0
CTR 1
CTR 2
FL85
1500 GND
or 2500
TOP 5A
TOP 5B
6000
Torino
D 114.50 TOP 392.5
9000
7000
5000
3000
12303
1000
2795
3038
CS 'Torino'
APP/RAD 129.27 121.10
CS 'Milano'
CTL/RAD 132.90 125.27 135.45
Remark:
1. Below FL100 max 250 kt IAS.

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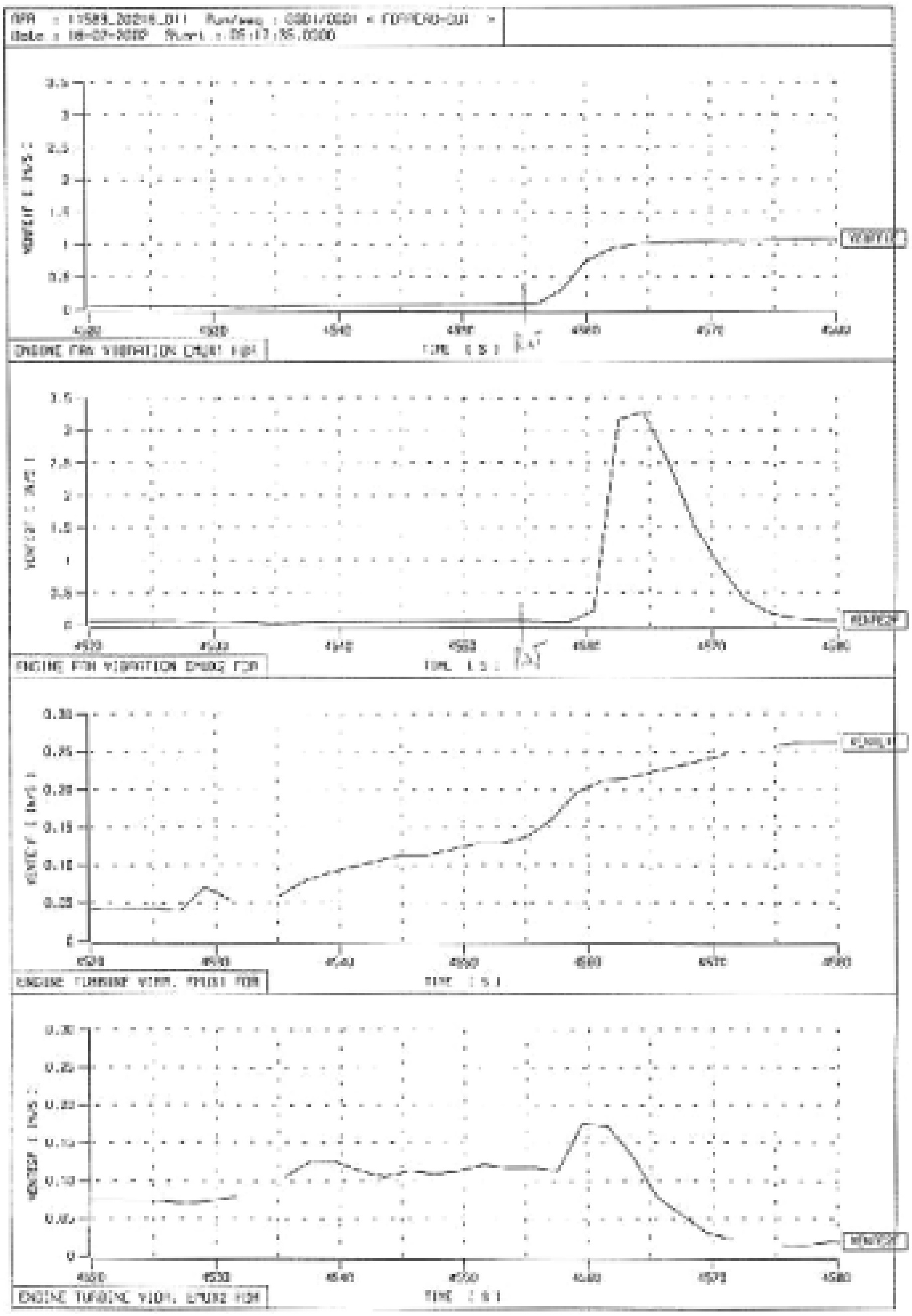

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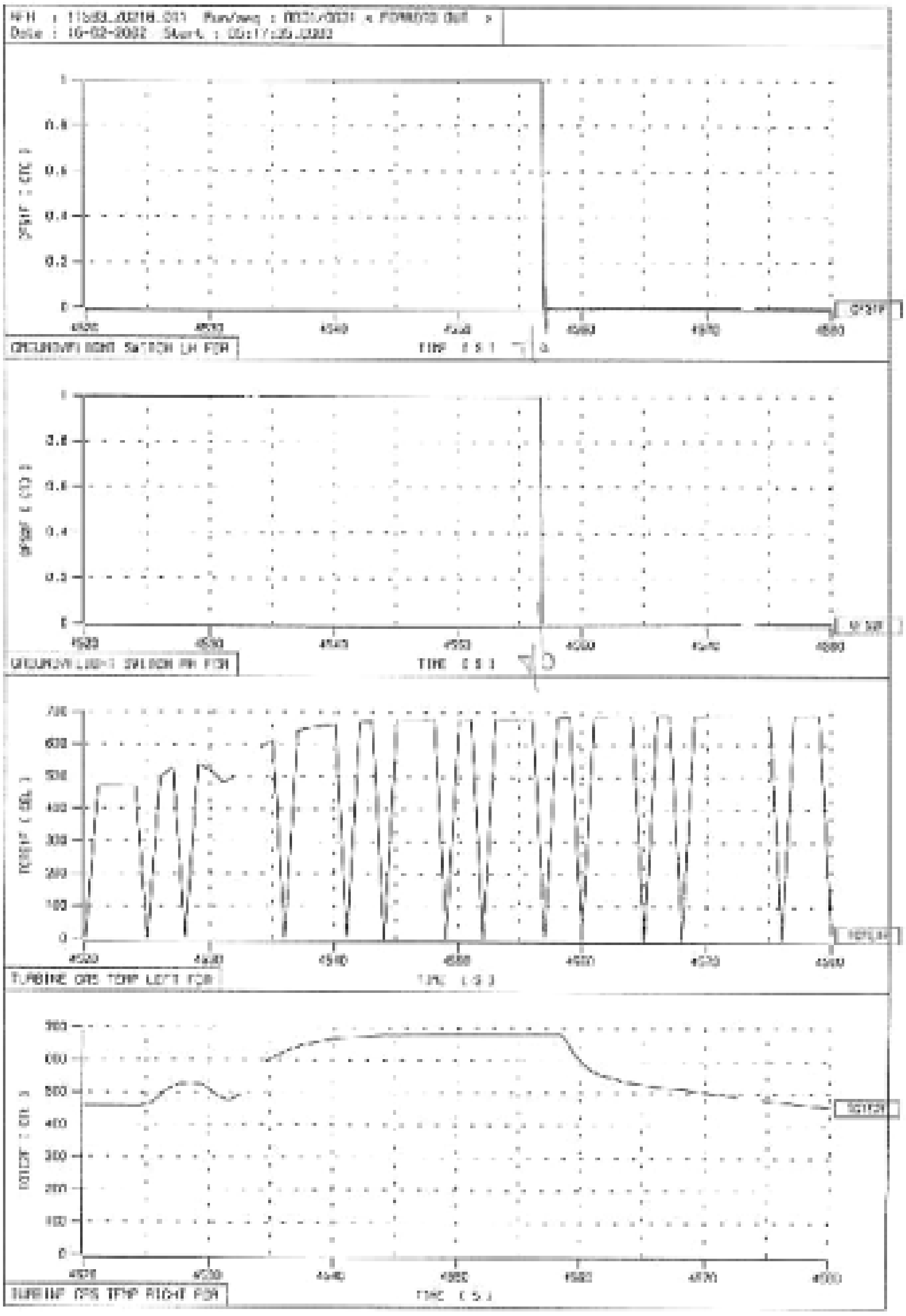

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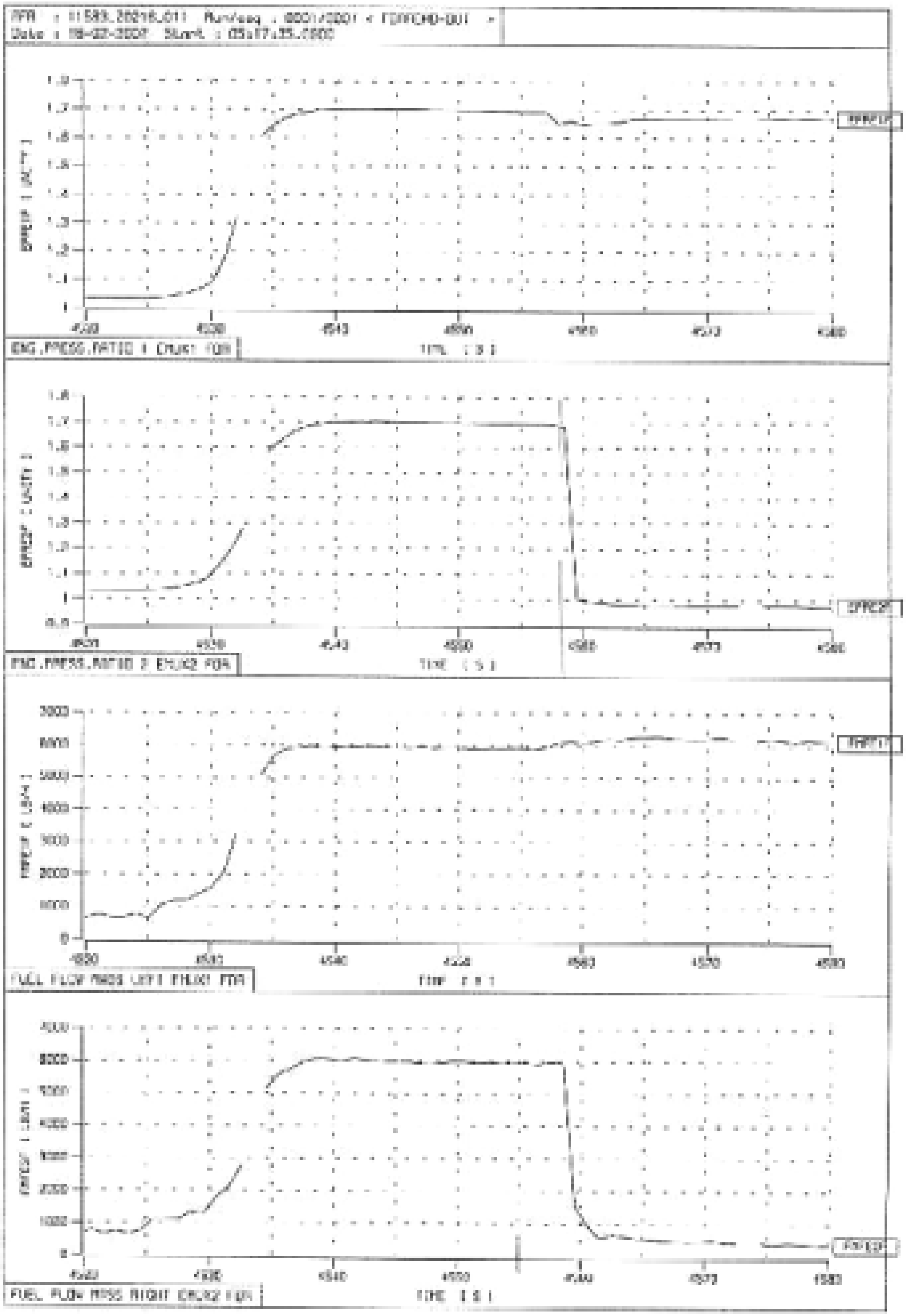

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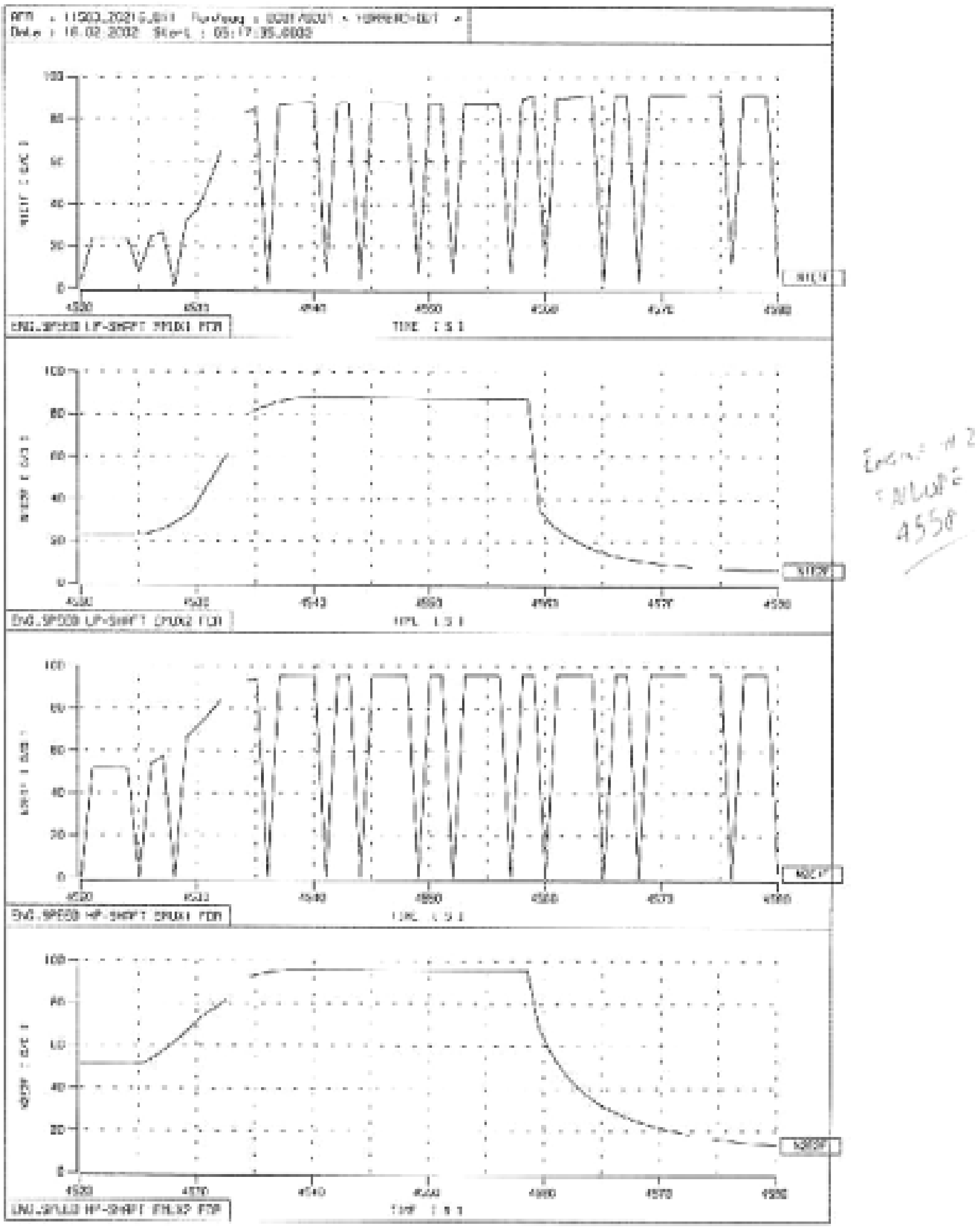

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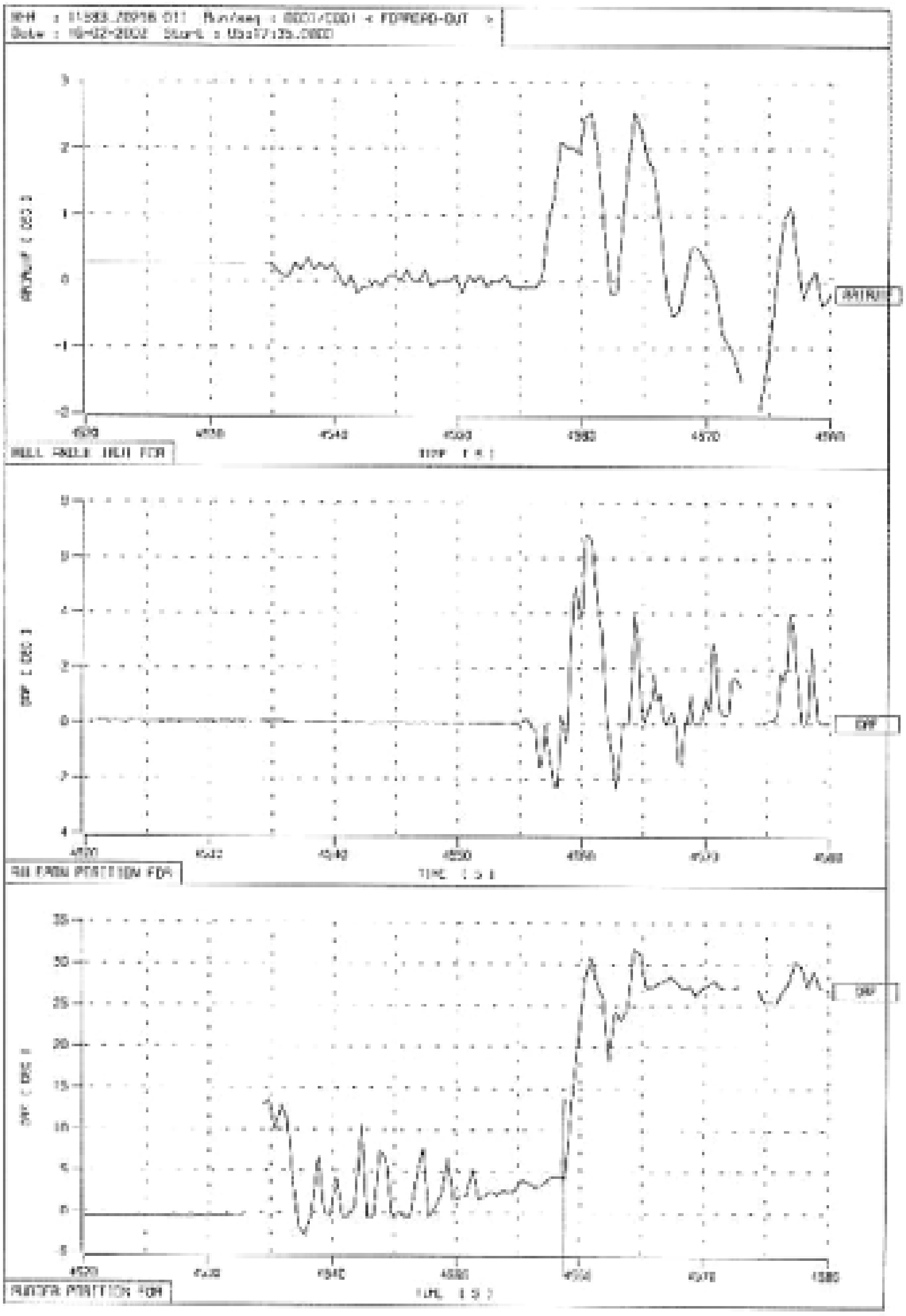

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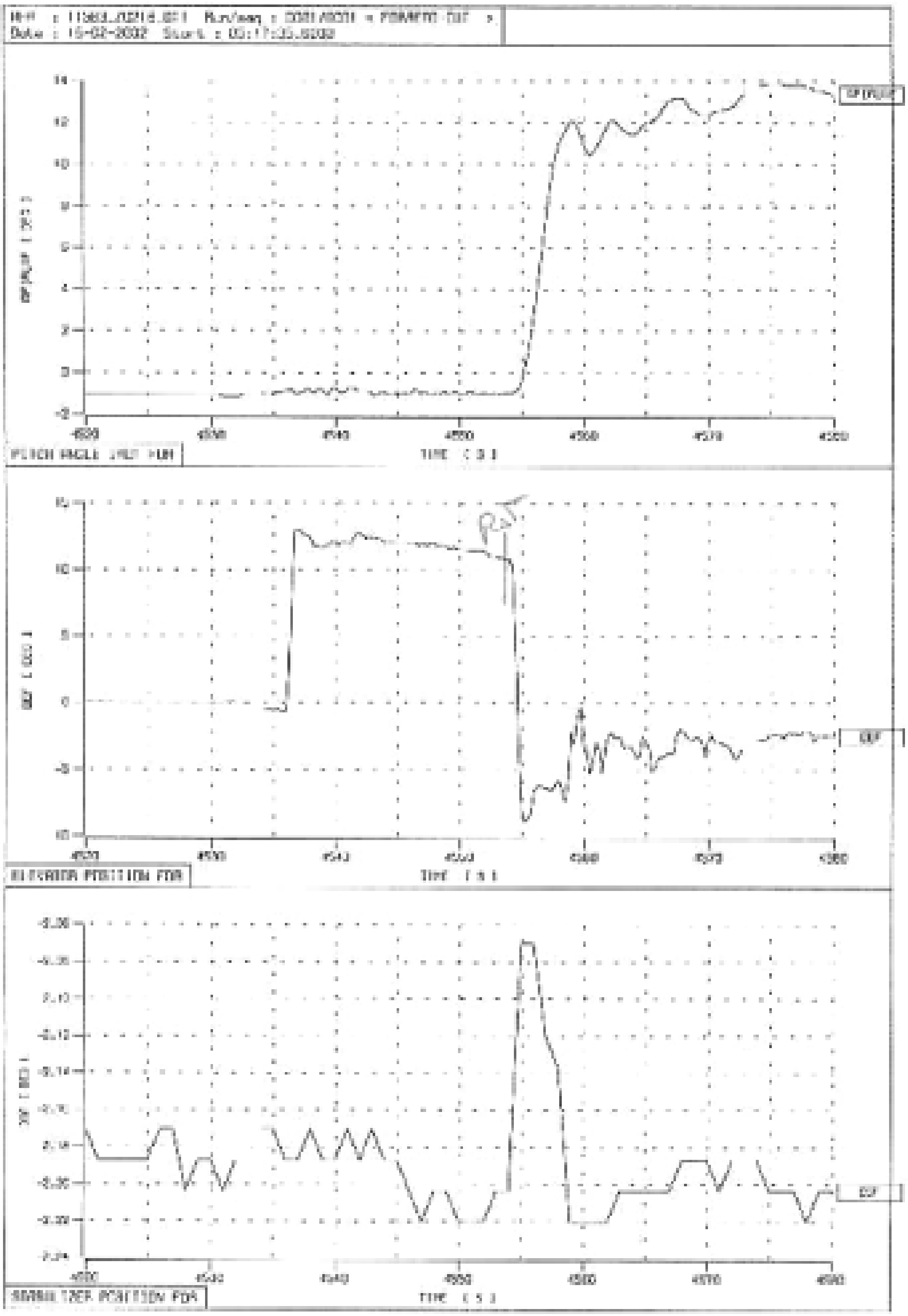

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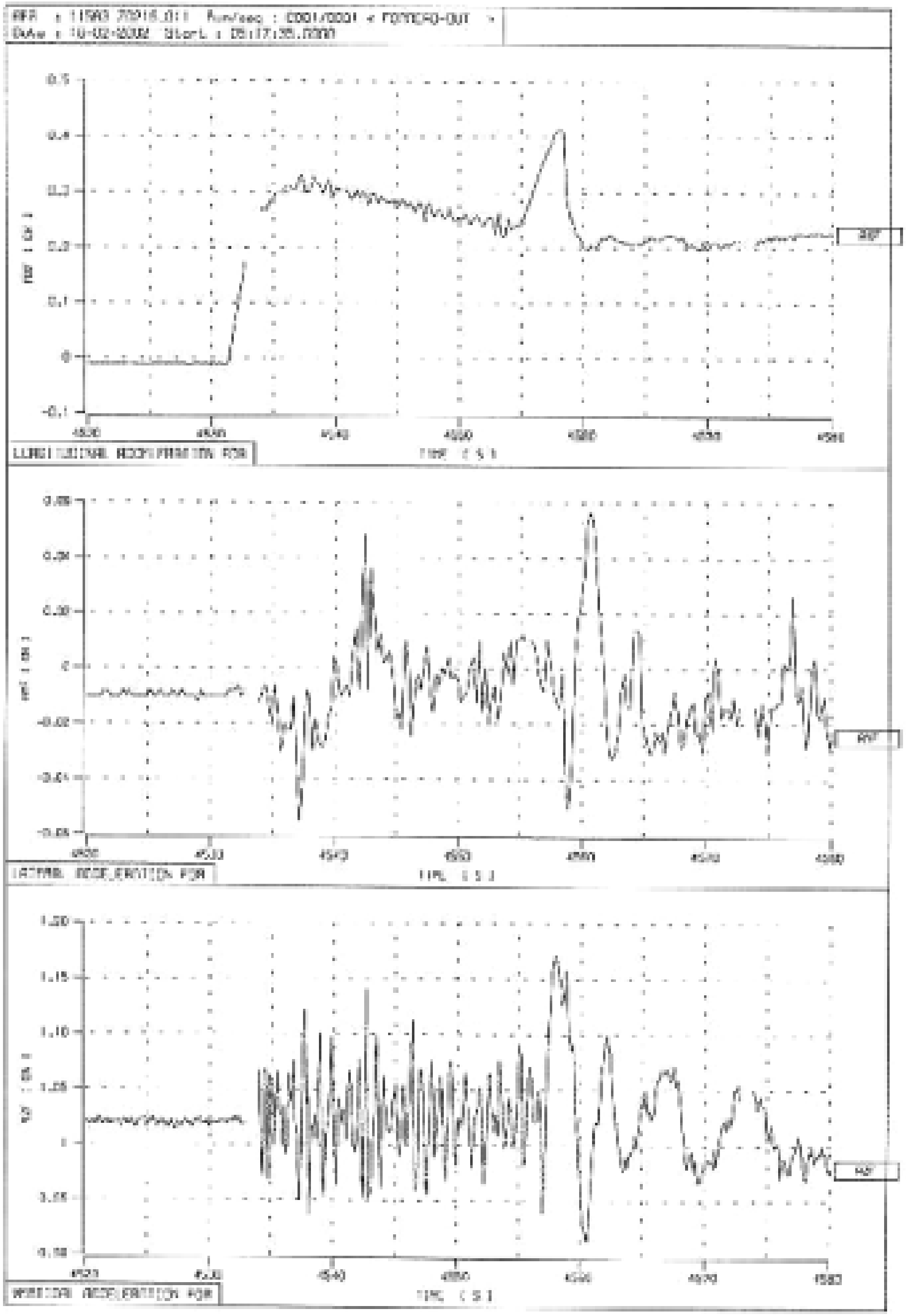

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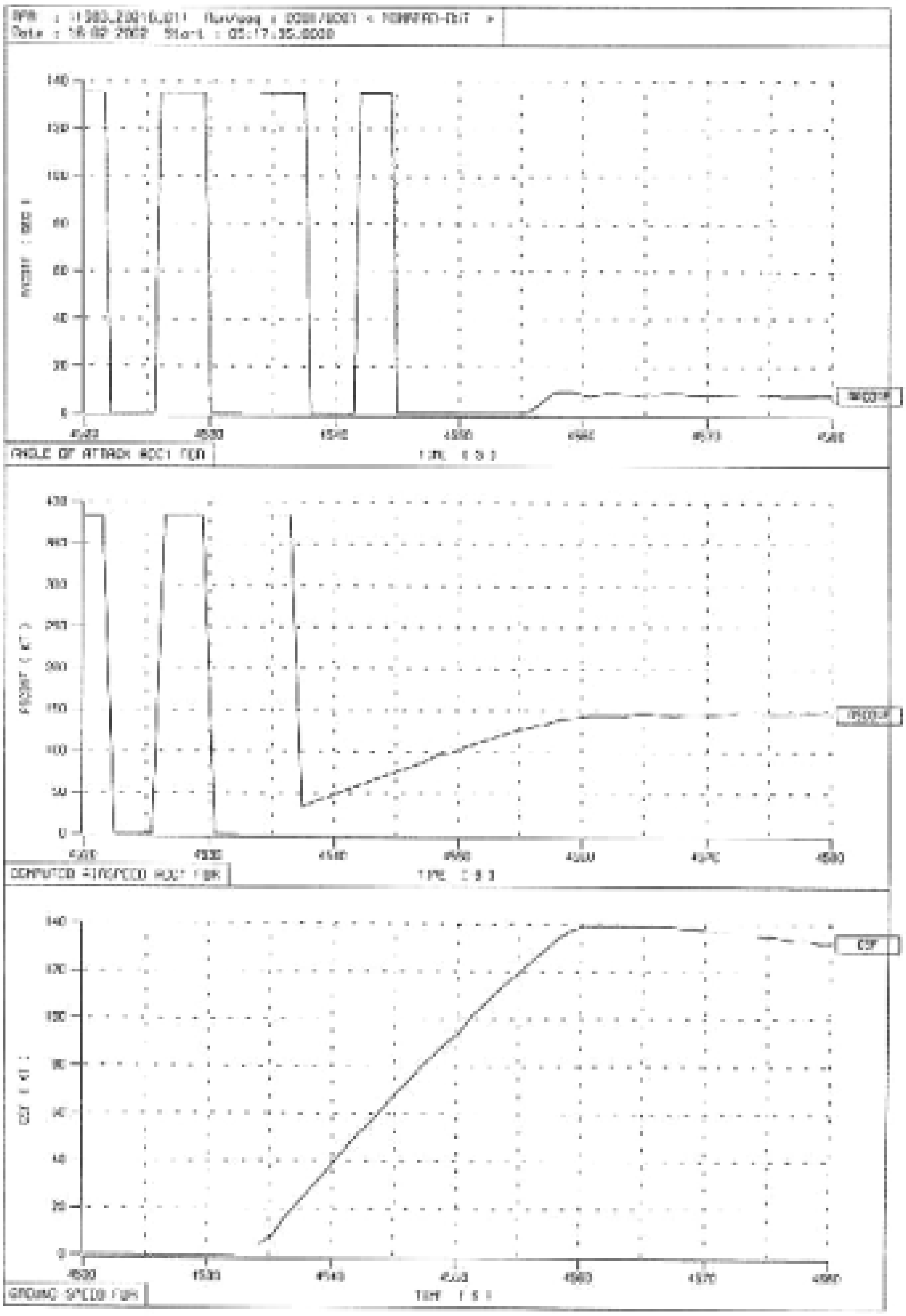

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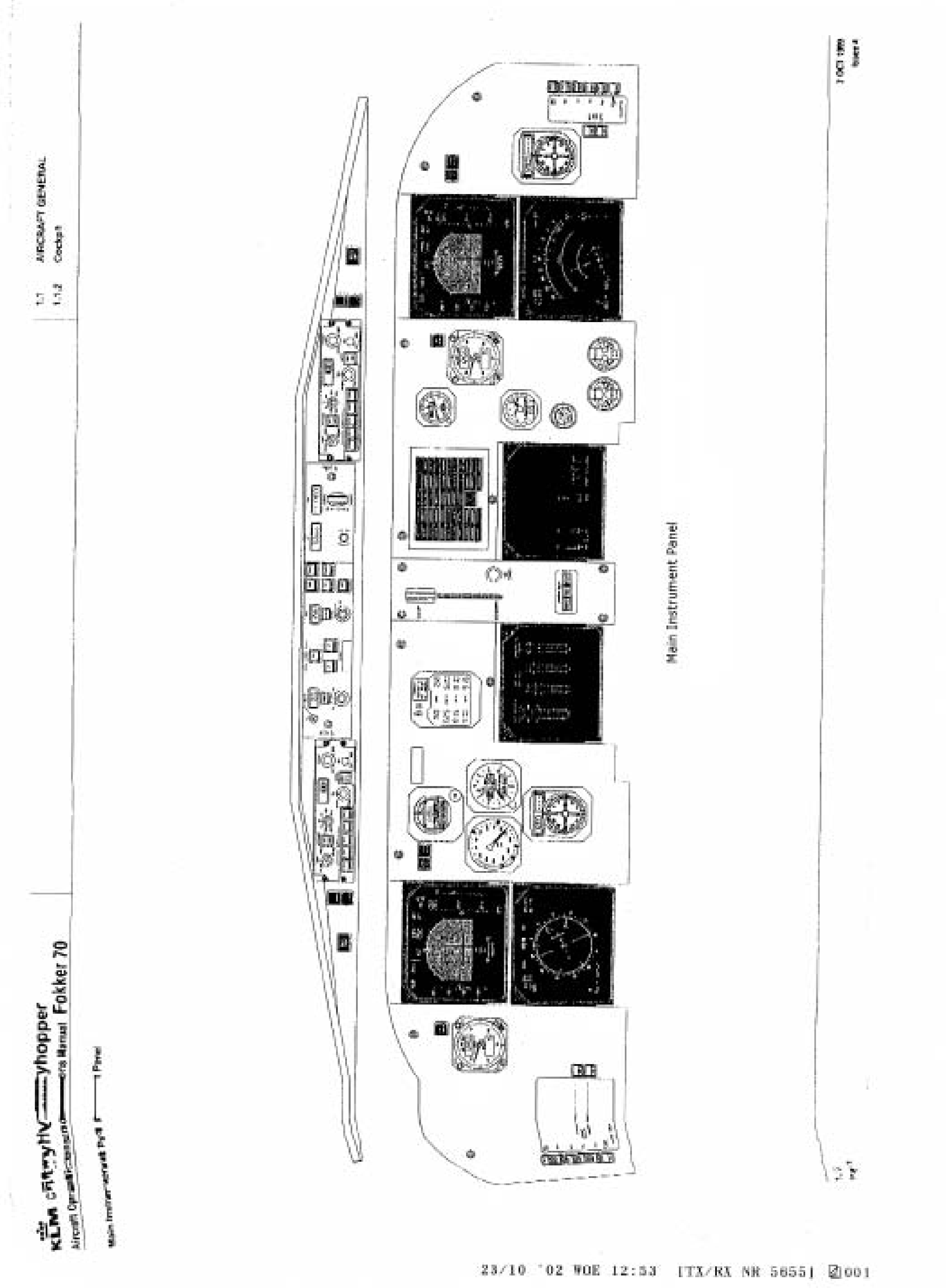
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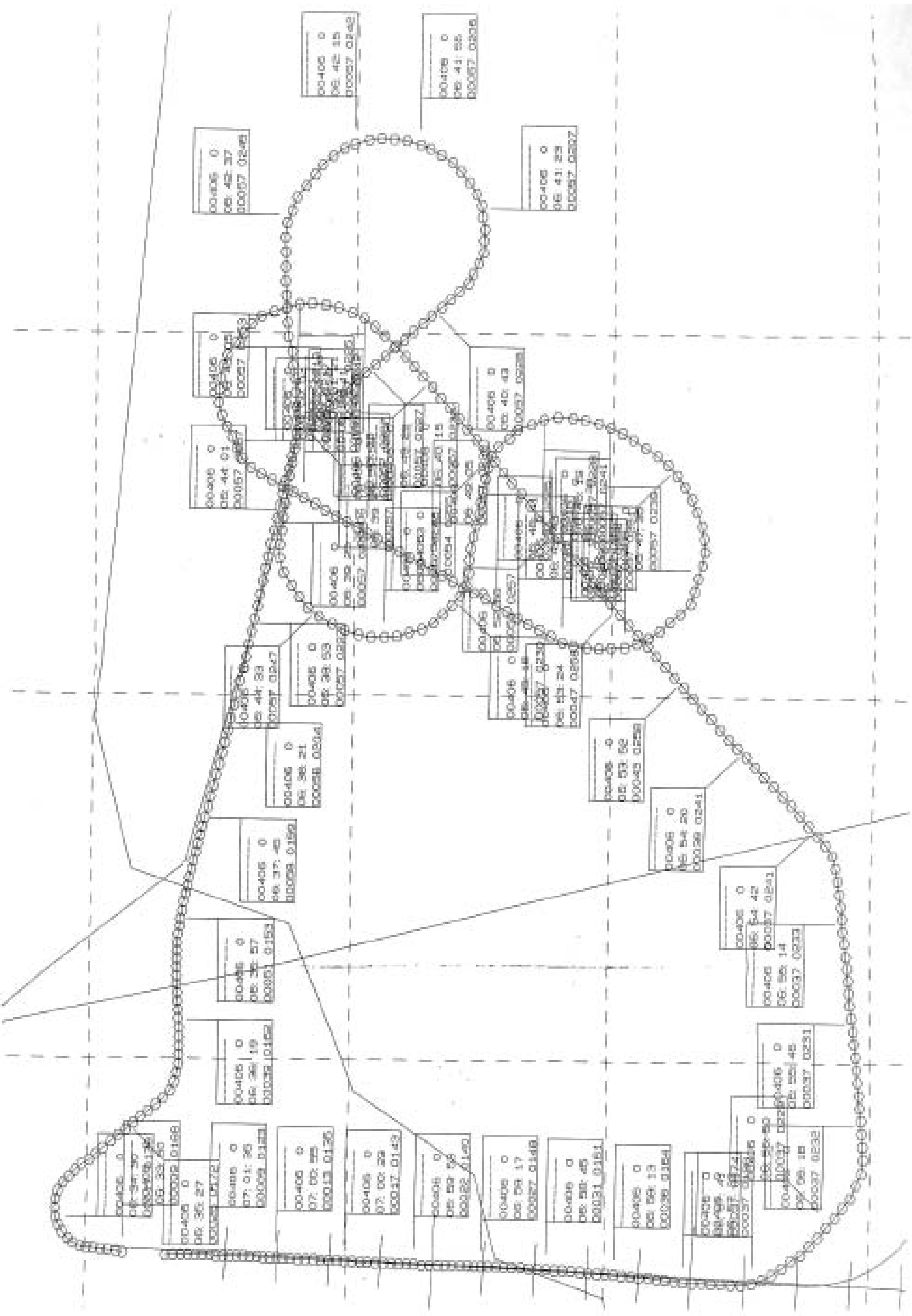
1.1.2 Cockpit
Fokker 70
Main Instrument Panel
23/10 '02 WOE 12:53 [TX/RX NR 5655] 001



ENAV S.p.A. CAV TORINO

STRALCIO COMUNICAZIONI T/B/T TRA KLM1636 E TWR / RDR DEL GIORNO 16/02/02 ORE 0610/Z

06,10'20''

KLM - KLM 1636 request start up.

TWR - KLM1636 stand by ,your slot just expired we are going to request an extention to the flow management to Milano .

KLM - Ok thank you very much KLM 1636

06,17'20''

KLM - KLM1636, do you have any idea Sir.how much long it will be ?

TWR - 1636, just now a new SLOT for you, 40' (four –zero), time check 17 start up approuved according to your new SOLT,just send a ready message i'm waiting for an improvement, monitor on this frequence.

KLM - Ok start up is approuved slot 40 stand by KLM1636

06,25'50''

KLM - KLM1636 request taxy

TWR - KLM1636 taxy holding point rwy36, report ready to copy A.T.C.

KLM - Holding point 36 KLM1636

06,26'53''

KLM - KLM1636 reday to copy

TWR - 1636 cleared to AMSTERDAM via SIRLO 5A MATOG 7M, climb initially FL 120 squawk 0406

KLM – SIRLO 5A departure , MATOG 7M FL120 squawk 0406 KLM1636

TWR - KLM1636 clearence correct report ready

06,28'40''

KLM - klm 1636 approaching holding point 36 ,ready for departure.

TWR - KLM1636 line up and wait RWY36

KLM - Line up and wait 36 KLM1636

06,33'00''

TWR - KLM 1636 cleared for take off 36, wind calm

KLM - Cleared for take off 36 KLM1636

06,34'18''

TWR - KLM 1636 Torino

KLM - PAN PAN – PAN PAN – PAN PAN we have an engine failure steearing on the right setting on….. to track 110

TWR - Contact 129,27

KLM - We stay on this frequency klm1636 ?

TWR - Negative , 129,27

KLM - 129,27 klm1636

06,36'24''

RDR - KLM1636 Torino RDR

KLM - Stand by KLM1636

06,36'58''

KLM - KLM1636 we had an engine failure we continue to 6000ft and we join the hold over SIRLO

RDR - Roger , do you need RADAR assistance for come back in field?

KLM - We want to come back to Torino

RDR - KLM 1636 you are under RDR control, turn right heading 180 vectoring for final 36.

KLM - First we like to continue to the SIRLO holding to give some time to prepare for the return to Torino

RDR - Roger , call me back when you want come back.

KLM - I call you back when we are in the SIRLO holding KLM1636

06,40'40''

KLM - MAY DAY ,MAY DAY, MAY DAY KLM1636 presently holding and we when will reday, we would like to return to Torino and we would like emergency services standing by Sir.

RDR - KLM1636 Torino you are under RDR control turn right heading 240 vectoring for

the approach 36

KLM - Grates , we like to remain in the hold this states and when we are ready , will call you

RDR - Roger

06,50'10''

KLM - KLM1636 request RDR vectors for ILS approach 36

TWR - KLM 1636 continue right turn, heading 230 vectoring ILS approach 36,report if able right turn or left turn .

KLM - Steering on the right heading 230 KLM1636

06,51'02''

RDR - KLM 1636 have you got meteo information ?

KLM - No can you give us last meteo information

RDR - Rwy in use 36 wind 040°3kts,visibility 6km, moderate rain SCT 500ft OVC 1800ft

TT01 TD00 QFE 990

KLM - The QNH ?

RDR - QNH 1023, report ready to start descend.

KLM - QNH 1023 and we are ready to start descend.

RDR - KLM 1636 descend 4000FT on QNH 1023.

KLM - Descend 4000ft on QNH 1023 KLM1636

06,52'28''

RDR - KLM1636 about 28MN to run to the field , your position is 16 NM south est of the field .

KLM - Copied KLM1636

06.54'30''

RDR - KLM 1636 Torino turn right 270 for base.

KLM - Right 270 for base KLM1636

06,56'05''

RDR - KLM 1636 turn right heading 320

KLM - Right heading 320 KLM1636

06,56'20''

KLM - We are cleared to the approach KLM1636?

RDR - KLM1636 continue right turn on heading 330, cleared to intercept ILS , report on the LOC

KLM - Heading 330 and cleared ILS KLM1636.

06,57'32''

RDR - KLM1636 cleared for the approach 10NM from touch down report O.M.

KLM - Report O.M. 1636

07,00'00''

KLM - 1636 O.M.

RDR - KLM 1636 cleared to land wind 050° 3 knots

KLM - Cleared to land 36 KLM1636

07,02'19''

RDR - KLM 1636 on the ground 02 to the left to vocate the rwy , report emergency terminated

KLM - To the left to vacate KLM1636

07.04'12''

RDR - KLM1636 switch with the TWR 118,5 good by

KLM - 118,5 thank you 1636.

07,04'32"

KLM - TWR buon giorno KLM1636 just vacated 36 we like to stand for a wile to complete all the procedure .

TWR - Roger do you need any kind of assistence?

KLM - No for the moment no thank you KLM1636

TWR - Roger call me back when ready to procede with your taxy.

KLM - Copied KLM1636.

07,09'52"

KLM - TWR KLM1636.

TWR - Go ahead Sir.

KLM - 1636 we are ready to taxy and if it's possible we would like assistence to follow us the fire equipment it's fine

TWR - Roger, continue your taxy on your left and the follow me is coming and

fire……(incomprensibile)…to the parking area.

KLM - Roger KLM1636

07,24'41"

TWR - KLM1636 Torino

07,24'53"

TWR - KLM1636 Torino

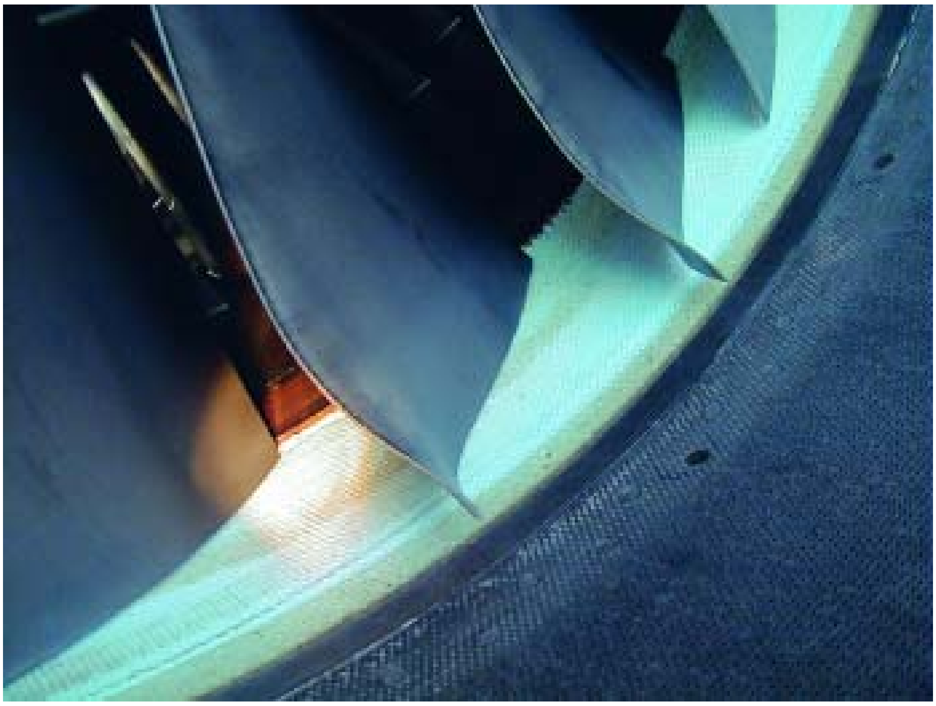
KLM - No replay

07,35'00 - Fine emergenza

Photo 1

RH Engine.

Photo 2



LH Engine.

Photo 3

RH Engine debris.

Enclosure "2" to the Doc.Ref. 02/290

DECLARATION

SUBJECT: FLIGHT KL 1663 EMERGENCY
COLLECTION OF DETRITUS

The writer , on duty for the Service of Airport air-side conditions control from 06.00 to 14.00 L.T. of the day february 16th, 2002, declares that:

- After the emergency landing of KLM flight, charged by local Aviation Authority Office (Civil Aviation Direction-Traffic Control Office), he went on the runway in order to collect eventual object/detritus connected to the failure of KLM a/c and in order to clean the runway surface
- During the job he found on runway 36, east side in respect of center line, between taxi way connection "D" and "C", several metallic detritus seemingly referable to a/c and several ice patches
- He collected metallic pieces and he didn't collect ice pieces, because not being a specified target of the search
- Ice pieces appeared like glass, clear and compact presenting different front dimension and similar thickness of about 10 mm; the biggest front dimensions were 10 cm x 10 cm with irregular border

Note
The presence of ice patches wasn't immediately put in evidence being not the primary target for which he had been charged.
After successive meditation , he advised his service responsible
who requested a written declaration in order to specify events and circumstances referred to ice pieces.
Upon my honour

Caselle Torinese, february 20th, 2002

APPENDIX I

JAR-OPS 1 selected requirements

ACJ/AMC/IEM C – *Operator Certification and Supervision*
IEM OPS 1.175 *the management organisation of an AOC holder*

1. Function and purpose

1.1 The safe conduct of air operations is achieved by an operator and an Authority working in harmony towards a common aim. The functions of the two bodies are different, well defined, but complementary. In essence, the operator complies with the standards set through putting in place a sound and competent management structure. The Authority working within a framework of law (statutes), sets and monitors the standards expected from operators.

2 Responsibilities of Management

2.1 The responsibilities of management related to JAR-OPS Part 1 should include at least the following five main functions:

a. Determination of the operator's flight safety policy
b. Allocation of responsibilities and duties and issuing instructions to individuals, sufficient for implementation of company policy and the maintenance of safety standards
c. Monitoring of flight safety standards
d. Recording and analysis of any deviations from company standards and ensuring corrective action
e. Evaluating the safety record of the company in order to avoid the development of undesirable trends

JAR-OPS 1.175: **sect. 1** *The Operator must certify the Authority that:*

- *Its organisation and management are suitable and properly matched to the scale and scope of the operation; and*
- *Procedures for the supervision of operations have been defined*
- *The operator must have nominated an accountable manager acceptable to the Authority who has corporate authority for ensuring that all operations and maintenance activities can be financed and carried out to the standard required by the Authority*
- *The operator must have nominated post holders, acceptable to the Authority, who are responsible for management and supervision of the following areas:*

1. *Flight Operations*
2. *The maintenance system*
3. *Crew training*
4. *Ground Operations*

1

In Appendix 2 to JAR-OPS 1.175, concerning *The management and organisation of an AOC holder:*
(ii) An operator contracting other organisation to provide certain services, retains responsibility for the maintenance of proper standards. In such circumstances, a nominated post holder must be given the task of ensuring that any contractor employed meets requirements standards.

According to **JAR-OPS 1.035** an operator shall establish one Quality System and designate one Quality Manager to monitor compliance with, and the adequacy of, procedures required to ensure safe operational practises and airworthy aeroplanes. Compliance monitoring must include a feed-back system to the Accountable Manager to ensure corrective action as necessary.

At 1.035 **section 2** paragraph 5.1 *"Sub-Contractors", operators may decide to sub-contract out certain activities to external agencies for the provisions of services related to areas such as:*

a. *Ground De-icing/Anti-icing.*
b. *Maintenance.*
c. ………
d. ………
e. ………
f. ………

At par. 5.1.2 it is also reported that *"The ultimate responsibility for the product or service provided by the sub-contractor always remains with the operator. A written agreement should exist between the operator and the sub-contractor clearly defining the safety related services and quality to be provided. The sub-contractor's safety related activities relevant to the agreement should be included in the operator's Quality Assurance Programme.*

AMC OPS 1.890 (a)
Maintenance Responsibility

………
3 *An operator should establish adequate co-ordination between flight operations and maintenance to ensure that both will receive all information on the condition of the aircraft necessary to enable both to perform their tasks.*

AMC OPS 1.890 (a) (1)
Maintenance Responsibility

1 *With regard to the pre-flight inspection it is intended to mean all of the actions necessary to ensure that the aeroplane is fit to make the intended flight. This should typically include but are not necessarily limited to:*

………………
f *That all the aeroplane's external surfaces and engines are free from ice, snow, sand, dust etc.*

IEM OPS 1.890 (a)(1)
Maintenance Responsibility

2

See JAR-OPS 1.890(a)(1)
The fact that the performance of pre flight inspections is an Operator's maintenance responsibility does not necessarily means that such personnel performing pre-flight inspection tasks report to the Nominated Post Holder for Maintenance, but that the Nominated postholder for Maintenance is responsible for determining the content of the pre flight inspection and setting the qualification standard of the involved personnel. In addition, compliance with the qualification standard should be monitored by the Operator's Quality System.

AMC OPS 1.900
Quality System
See JAR-OPS 1.900

……………………

2 *The feedback part of the system should address who is required to rectify discrepancies and non compliance in each particular case and the procedure to be followed if rectification is not completed within appropriate timescales. The procedure should lead to the Accountable Manager specified in JAR-OPS 1.175(h).*

IEM OPS 1.900
Quality System
See JAR-OPS 1.900
The primary purpose of the Quality System is to monitor compliance with the approved procedures specified in an Operator's Maintenance Management Exposition to ensure compliance with Subpart M and thereby ensure the maintenance aspects of the operational safety of the aeroplanes. In particular, this part of the Quality System provides a monitor of the effectiveness of maintenance, reference JAR-OPS 1.890, and should include a feedback system to ensure that the corrective actions are both identified and carried out in a timely manner.

According **JAR-OPS 1.037** *an operator shall establish an accident prevention and flight safety programme, which may be integrated with the Quality system, including:*

- *Programmes to achieve and maintain risk awareness by all persons involved in operations; and*
- *An occurrence reporting scheme to enable the collation and assessment of relevant incident and accident reports in order to identify adverse trends or to address deficiencies in the interests of flight safety. The scheme shall protect the identity of the reporter and include the possibility that reports may be submitted anonymously; and*
- *Evaluation of relevant information relating to incidents and accidents and the promulgation of related information, but not the attribution of blame; and*
- *The appointment of a person accountable for managing the programme*
- *Proposals for corrective action resulting from the accident prevention and flight safety programme shall be the responsibility of the person accountable for managing the programme.*

3

- *The effectiveness of changes resulting from proposals for corrective action identified by the accident and flight safety programme shall be monitored by the Quality Manager.*

4

SUBPART C – OPERATOR CERTIFICATION AND SUPERVISION

JAR–OPS 1.175 General rules for Air Operator Certification

Note 1: Appendix 1 to this paragraph specifies the contents and conditions of the AOC.

Note 2: Appendix 2 to this paragraph specifies the management and organisation requirements.

(a) An operator shall not operate an aeroplane for the purpose of commercial air transportation otherwise than under, and in accordance with, the terms and conditions of an Air Operator Certificate (AOC).

(b) An applicant for an AOC, or variation of an AOC, shall allow the Authority to examine all safety aspects of the proposed operation.

(c) An applicant for an AOC must:

(1) Not hold an AOC issued by another Authority unless specifically approved by the Authorities concerned;

(2) Have his principal place of business and, if any, his registered office located in the State responsible for issuing the AOC; (See IEM OPS 1.175(c)(2));

(3) Have registered the aeroplanes which are to be operated under the AOC in the State responsible for issuing the AOC; and

(4) Satisfy the Authority that he is able to conduct safe operations.

(d) Notwithstanding sub-paragraph (c)(3) above, an operator may operate, with the mutual agreement of the Authority issuing the AOC and another Authority, aeroplanes registered on the national register of the second-named Authority.

(e) An operator shall grant the Authority access to his organisation and aeroplanes and shall ensure that, with respect to maintenance, access is granted to any associated JAR–145 maintenance organisation, to determine continued compliance with JAR–OPS.

(f) An AOC will be varied, suspended or revoked if the Authority is no longer satisfied that the operator can maintain safe operations.

(g) The operator must [ ] [satisfy the Authority that]:

[(1) Its organisation and management are suitable and properly matched to the scale and scope of the operation; and

(2) Procedures for the supervision of operations have been defined.]

(h) The operator must have nominated an accountable manager acceptable to the Authority

JAR-OPS 1.175(h) (continued)

who has corporate authority for ensuring that all operations and maintenance activities can be financed and carried out to the standard required by the Authority. [(See ACJ OPS 1.035)]

(i) The operator must have nominated post holders, acceptable to the Authority, who are responsible [for the management and supervision of the following areas.]

(1) Flight operations;

(2) The maintenance system;

(3) Crew training; and

(4) Ground operations.

[(See ACJ OPS 1.175(i))]

[(j) A Person may hold more than one of the nominated posts if acceptable to the Authority but, for operators who employ 21 or more full time staff, a minimum of two persons are required to cover the four areas of responsibility. (See ACJ OPS 1.175(j) & (k).)

(k) For operators who employ 20 or less full time staff, one or more of the nominated posts may be filled by the accountable manager if acceptable to the Authority. (See ACJ OPS 1.175(j) & (k).)]

[(l)] The operator must ensure that every flight is conducted in accordance with the provisions of the Operations Manual.

[(m)] The operator must arrange appropriate ground handling facilities to ensure the safe handling of its flights.

[(n)] The operator must ensure that its aeroplanes are equipped and its crews are qualified, as required for the area and type of operation.

[(o)] The operator must comply with the maintenance requirements, in accordance with Subpart M, for all aeroplanes operated under the terms of its AOC.

[(p)] The operator must provide the Authority with a copy of the Operations Manual, as specified in Subpart P and all amendments or revisions to it.

[(q)] The operator must maintain operational support facilities at the main operating base, appropriate for the area and type of operation.

[Ch. 1, 01.03.98; Amdt. 3, 01.12.01]

SUBPART M – AEROPLANE MAINTENANCE

JAR–OPS 1.875 General
(See IEM OPS 1.875)

(a) An operator shall not operate an aeroplane unless it is maintained and released to service by an organisation appropriately approved/accepted in accordance with JAR–145 except that pre-flight inspections need not necessarily be carried out by the JAR–145 organisation.

(b) This Subpart prescribes aeroplane maintenance requirements needed to comply with the operator certification requirements in JAR–OPS 1.180.

JAR–OPS 1.880 Terminology

The following definitions from JAR–145 shall apply to this Subpart:

(a) *Preflight inspection* – means the inspection carried out before flight to ensure that the aeroplane is fit for the intended flight. It does not include defect rectification.

(b) *Approved standard* – means a manufacturing/design/maintenance/quality standard approved by the Authority.

(c) *Approved by the Authority* – means approved by the Authority directly or in accordance with a procedure approved by the Authority.

JAR–OPS 1.885 Application for and approval of the operator's maintenance system

(a) For the approval of the maintenance system, an applicant for the initial issue, variation and renewal of an AOC shall submit the documents specified in JAR–OPS 1.185(b). (See IEM OPS 1.885(a).)

(b) An applicant for the initial issue, variation and renewal of an AOC who meets the requirements of this Subpart, in conjunction with an appropriate JAR–145 approved/accepted maintenance organisation's exposition, is entitled to approval of the maintenance system by the Authority. (See IEM OPS 1.885(b).)

Note: Detailed requirements are given in JAR–OPS 1.180(a)(3) and 1.180(b), and JAR–OPS 1.185.

JAR–OPS 1.890 Maintenance responsibility

(a) An operator shall ensure the airworthiness of the aeroplane and the serviceability of both operational and emergency equipment by (See AMC OPS 1.890(a)):

(1) The accomplishment of preflight inspections (See AMC OPS 1.890(a)(1));

(2) The rectification to an approved standard of any defect and damage affecting safe operation, taking into account the minimum equipment list and configuration deviation list if available for the aeroplane type [(See AMC OPS 1.890(a)(2));]

(3) The accomplishment of all maintenance in accordance with the approved operator's aeroplane maintenance programme [specified in JAR–OPS 1.910 (See AMC OPS 1.890(a)(3));]

(4) The analysis of the effectiveness of the operator's approved aeroplane maintenance programme (See AMC OPS 1.890(a)(4));

(5) The accomplishment of any operational directive, airworthiness directive and any other continued airworthiness requirement made mandatory by the Authority. Until formal adoption of JAR–39, the operator must comply with the current national aviation [regulations (See IEM OPS 1.890(A)(5)); and]

(6) The accomplishment of modifications in accordance with an approved standard and, for non-mandatory modifications, the establishment of an embodiment policy. (See AMC OPS 1.890(a)(6).)

(b) An operator shall ensure that the Certificate of Airworthiness for each aeroplane operated remains valid in respect of:

(1) The requirements in sub-paragraph (a) above;

(2) Any calendar expiry date specified in the Certificate; and

(3) Any other maintenance condition specified in the Certificate.

(c) The requirements specified in sub-paragraph (a) above must be performed in accordance with procedures acceptable to the Authority.

ACJ/AMC/IEM C – OPERATOR CERTIFICATION & SUPERVISION

IEM OPS 1.175
The management organisation of an AOC holder
See JAR-OPS 1.175(g)-(o)

1 Function and Purpose

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c. Monitoring of flight safety standards;

d. Recording and analysis of any deviations from company standards and ensuring corrective action;

e. Evaluating the safety record of the company in order to avoid the development of undesirable trends.

IEM OPS 1.175(c)(2)
Principal place of business
See JAR-OPS 1.175(c)(2)

1 JAR-OPS 1.175(c)(2) requires an operator to have his principal place of business located in the State responsible for issuing the AOC.

2 In order to ensure proper jurisdiction by that State over the operator, the term 'principal place of business' is interpreted as meaning the State in which the administrative headquarters and the operator's financial, operational and maintenance management are based.

[Ch. 1, 01.03.98]

[ACJ OPS 1.175(i)
Nominated Postholders – Competence
See JAR-OPS 1.175(i)

1. General. Nominated Postholders should, in the normal way, be expected to satisfy the Authority that they possess the appropriate experience and licensing requirements which are listed in paragraphs 2 to 6 below. In particular cases, and exceptionally, the Authority may accept a nomination which does not meet the requirements in full but, in this circumstance, the nominee should be able to demonstrate experience which the Authority will accept as being comparable and also the ability to perform effectively the functions associated with the post and with the scale of the operation.

2. Nominated postholders should have:

2.1 Practical experience and expertise in the application of aviation safety standards and safe operating practices;

2.2 Comprehensive knowledge of:

a. JAR-OPS and any associated requirements and procedures;

b. The AOC holder's Operations Specifications;]

ACJ OPS 1.175(i) (continued)

[c. The need for, and content of, the relevant parts of the AOC holder's Operations Manual;

2.3 Familiarity with Quality Systems;

2.4 Appropriate management experience in a comparable organisation; and

2.5 Five years relevant work experience of which at least two years should be from the aeronautical industry in an appropriate position.

3. Flight Operations. The nominated postholder or his deputy should hold a valid Flight Crew Licence appropriate to the type of operation conducted under the AOC in accordance with the following:

3.1 If the AOC includes aeroplanes certificated for a minimum crew of 2 pilots - An Airline Transport Pilot's Licence issued or validated by a JAA Member State:

3.2 If the AOC is limited to aeroplanes certificated for a minimum crew of 1 pilot - A Commercial Pilot's Licence, and if appropriate to the operation, an Instrument Rating issued or validated by a JAA Member State.

4. Maintenance System. The nominated postholder should possess the following:

4.1 Relevant engineering degree, or aircraft maintenance technician with additional education acceptable to the Authority. 'Relevant engineering degree' means an engineering degree from Aeronautical, Mechanical, Electrical, Electronic, Avionic or other studies relevant to the maintenance of aircraft/aircraft components.

4.2 Thorough familiarity with the organisation's Maintenance Management Exposition.

4.3 Knowledge of the relevant type(s) of aircraft.

4.4 Knowledge of maintenance methods.

5. Crew Training. The nominated postholder or his deputy should be a current Type Rating Instructor on a type/class operated under the AOC.

5.1 The nominated Postholder should have a thorough knowledge of the AOC holder's crew training concept for Flight Crew and for Cabin Crew when relevant.

6. Ground Operations. The nominated postholder should have a thorough knowledge of the AOC holder's ground operations concept.]

[Amdt. 3, 01.12.01]

[ACJ OPS 1.175(j)
Combination of nominated postholder's responsibilities
See JAR-OPS 1.175(j)

1. The acceptability of a single person holding several posts, possibly in combination with being the accountable manager as well, will depend upon the nature and scale of the operation. The two main areas of concern are competence and an individual's capacity to meet his responsibilities.

2. As regards competence in the different areas of responsibility, there should not be any difference from the requirements applicable to persons holding only one post.

3. The capacity of an individual to meet his responsibilities will primarily be dependent upon the scale of the operation. However the complexity of the organisation or of the operation may prevent, or limit, combinations of posts which may be acceptable in other circumstances.

4. In most circumstances, the responsibilities of a nominated postholder will rest with a single individual. However, in the area of ground operations, it may be acceptable for these responsibilities to be split, provided that the responsibilities of each individual concerned are clearly defined.]

IEM OPS 1.895(c)
Maintenance Management
See JAR-OPS 1.895(c)

This paragraph only applies to contracted maintenance and therefore does not affect situations where the JAR 145 approved/accepted Organisation and the Operator are the same organisation.

[Amdt. 2, 01.07.00]

AMC OPS 1.895(d)
Maintenance Management
See JAR-OPS 1.895(d)

1 Where an operator is not approved to JAR-145 or an operator's maintenance organisation is an independent organisation, a contract should be agreed between the operator and the JAR-145 Approved Maintenance Organisation that specifies, in detail, the work to be performed by the JAR-145 Approved Maintenance Organisation.

2 Both the specification of work and the assignment of responsibilities should be clear, unambiguous and sufficiently detailed to ensure that no misunderstanding should arise between the parties concerned (operator, maintenance organisation and the Authority) that could result in a situation where work that has a bearing on the airworthiness or serviceability of aircraft is not or will not be properly performed.

3 Special attention should be paid to procedures and responsibilities to ensure that all maintenance work is performed, service bulletins are analysed and decisions taken on accomplishment, airworthiness directives are completed on time and that all work, including non-mandatory modifications is carried out to approved data and to the latest standards.

4 For the actual lay out of the contract the IATA Standard Ground Handling Agreement [may be used as a basis, but this does not preclude the Authority from ensuring that the content of the contract is acceptable to them, and especially that the contract allows the Operator to properly exercise its maintenance responsibility. Those parts of a contract that] have no bearing on the technical or operational aspects of airworthiness are outside the scope of this paragraph.

[Amdt. 2, 01.07.00]

AMC OPS 1.895(e)
Maintenance Management
See JAR - OPS 1.895(e)

1 In the case of a contract with an organisation that is not JAR 145 approved/accepted, the Operator's Maintenance Management Exposition should include appropriate procedures to ensure that all this contracted maintenance is ultimately performed on time by JAR 145 approved/accepted organisations in accordance with data acceptable to the Authority. In particular the Quality System procedures should place great emphasis on monitoring compliance with the above. The list of JAR 145 approved/accepted contractors, or a reference to this list, should be included in the Operator's Maintenance Management Exposition.

2 Such a maintenance arrangement does not absolve the Operator from its overall Maintenance responsibility. Specifically, in order to accept the maintenance arrangement, the Authority should be satisfied that such an arrangement allows the Operator to ensure full compliance with JAR-OPS 1.890 Maintenance Responsibility.

[Amdt. 2, 01.07.00]

Appendix I bis

1. ORGANIZATIONAL AND MANAGEMENT INFORMATION

1.1. General

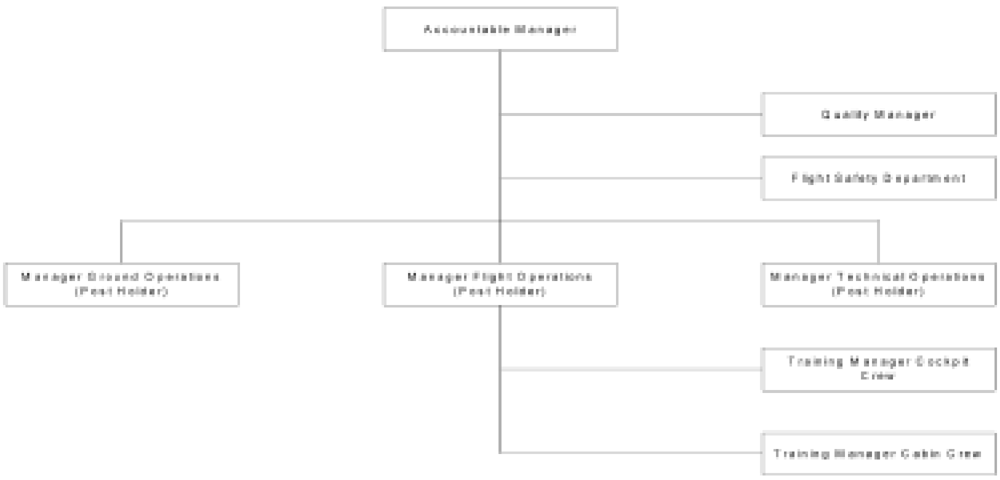
Since December 3rd 2001 KLM Cityhopper B.V. has been found competent by Civil Aviation Authority Netherlands to conduct Commercial Air Transport Operations and has satisfied the Operator Certification requirements prescribed in JAR-OPS 1.

Note: Some relevant part from JAR-OPS 1 requirements are quoted in Appendix I.

1.2. KLC general

The following information is based on and quoted out of the KLM Cityhopper Basic Operations Manual (BOM) and KLC quality manual which were valid at the time of the incident.

The organizational Structure, related to JAR-OPS 1 requirements, is presented in the following diagram, which gives description, subordination, and reporting lines, which pertain to the safety of flight operations



1

1.3. Accountable Manager

The Managing Director has been nominated as JAR-OPS 1 Accountable Manager. He/she has the ultimate authority for ensuring that all operations and maintenance activities can be and are carried out to the standard required by the Civil Aviation Authorities.

The Accountable Manager has corporate responsibility regarding the Air Operator Certificate (AOC). He/she shall maintain an adequate organization including procedures applicable in case of absence of nominated Postholders.

1.4. Quality Manager

The purpose of KLC's Quality system is to ensure that the management activities within KLC result in safe and airworthy operation of all aircraft, while complying with the requirements of JAR-OPS. An independent Quality Assurance (QA) Manager is responsible for monitoring the continued compliance of KLC with JAR-OPS requirements by performing an audit program. In case a non-conformance is observed, the QA Manager will ensure that remedial actions aimed at eliminating the root cause of the non-conformance are defined. KLC's Basic Operations Manual (BOM) states that execution of the Quality policy, including the incorporation of required remedial actions is definitely not the sole responsibility of the QA Manager but of the complete management team of KLC.

The QA manager of KLC:

• reports directly to the Managing Director of KLC who also performs the function of JAR-OPS Accountable Manager;

• has an independent position within KLC and has full access to all relevant activities and information regarding KLC and its subcontractors. On matters which have a relation with JAR-OPS the QA Manager will be involved in the decision making process.

To achieve the objectives a Quality Assurance Program has been developed.

The QA Manager:

2

• ensures that remedial actions are taken by the responsible manager(s) when non-conformances with the requirements are observed;

• monitors JAR-OPS requirements and performs an audit program to assure conformity;

• coordinates periodic liaison with the authorities in order to keep the authorities updated with KLC's situation with respect to the JAR-OPS requirements;

• is obliged to keep himself informed about the future developments in relation to JAR-OPS regulations;

• will, with respect to the subcontracted activities, ensure that the QA requirements are correctly included in the contract. The QA manager will also audit the contractor to ensure compliance with the contracted tasks and responsibilities;

• besides auditing, he/she also has the possibility to inspect, either within the company or the subcontractor, to verify whether established procedures and (training) requirements are followed and if necessary corrected;

• will in principle review all relevant subjects annually.

1.5. Flight Safety Manager

The Flight Safety Manager can report directly to the Accountable Manager.

The Flight Safety Manager:

- monitors and enhances flight safety within KLC;
- uses the British Airways Safety Information System (BASIS) as a documenting and classifying system for air safety reports and then uses this data to generate trend analysis;
- assigns risk classifications to all safety related incidents;
- represents KLC in incident and accident investigations initiated by the local authorities;
- conducts Safety Incident Investigations (situation 16th March, 2002);
- provides safety information to management and operational staff;
- has the authority to initiate safety incident investigations;
- advises the Accountable Manager and the Manager Flight Operations independently and free of implications to his/her position on flight safety related subjects;

- will coordinate, in cooperation with the Manager Flight Operations, Chief Pilots or Technical Pilot representatives, the required operational and technical follow-up.

The Flight Safety Manager has direct access to all flight safety reports and has the responsibility to identify potential safety related issues. For instance, trends or specific safety threats should trigger the Flight Safety Manager to address the problem directly to the manager of flight operations.

Within KLC the Flight Safety Manager (FSM) can also report directly to the Accountable Manager regarding flight safety issues as he/she is the head of an autonomous department. The FSM had regular meetings with the Accountable Manager but did not attend any management meetings where other Postholders were present. The QA Manager has no sanction possibilities, and therefore should have access to the Accountable Manager in the case when it is considered that there has not been an adequate response to a problem by the Flight Safety Manager or the Postholders.

Note: The Quality System is completely independent of the flight safety program. The QA Manager has direct access to all BASIS flight safety incident reports and subsequent follow-up. The QA Manager will periodically audit the flight safety program.

1.6. Manager Technical Department [Postholder]

The manager Technical Department has been nominated as JAR-OPS Postholder Maintenance.

The manager Technical Department has been delegated the following responsibilities:

- ensuring the maintenance and relevant equipment of the aircraft, engines and components is according to the regulations of JAR-OPS1, JAR 145 and applicable local lows and regulations;
- ensuring the availability of the required number of well qualified maintenance staff;
- issuance, distribution and maintenance of KLC Cityhopper's Maintenance Management Exposition (MME).

Based on the above mentioned general responsibilities and the duties allocated to the Manager Technical Department he shall:

- ensure that quality standards are developed to a level to comply with or exceed the actual airworthiness requirements;

4

- ensure that engineering and maintenance is organized in agreement with the safety and efficiency standard as required by KLC Cityhopper's Management Team and JAR-OPS 1;
- ensure that procedures are available for execution for all described tasks according to the MME;
- ensure that the maintenance of KLM Cityhopper's aircraft is performed according with the KLM Cityhopper MME;
- ensure that the aircraft are equipped for the area and type of operation required;
- ensure that the resources, materials and tools are available in sufficient quantity and quality.

The responsibility with regard to de-icing and anti-icing contractual arrangements was given to the Postholder Ground Handling. The MME did not clearly specify any references to the de-icing technical standards or procedures with regard to transfer of responsibilities.

At the same time the Post-Holder Technical (Maintenance) did not verify if the Post-Holder Ground Handling was able to fulfil the technical aspects of the de/anti-icing operation.

1.7 Manager Flight Operations [Postholder]

The Manager Flight Operations has been nominated as JAR-OPS 1 Postholder Flight Operations and he/she reports directly to the Managing Director (Accountable Manager).

The Manager Flight Operations has the following staff reporting directly to him/her:

- Chief Pilots.
- Training Manager Cockpit Crew.
- Manager Cabin Staff.
- Flight Support Manager.
- Manager Flight Technical Department.

The Manager Flight Operations:

- is responsible to ensure safe and efficient conduct of all KLC flights in accordance with the regulations of JAR-OPS 1 and applicable local laws and regulations;

- ensures the availability of the required number of well qualified cockpit and cabin crew to perform the flights;
- issues and distributes KLC Operation Manuals.

Note: Specifically in relation to ground handling activities the following duty is described

The Manager Flight Operations defines standards for the quality and contents of flight preparation and ground handling activities performed and the relevant training requirements for ground operations staff involved.

The Manager of Flight Operations stated that he had not been informed about any threat to safety regarding the de-icing/anti-icing contract in Turin. He had however seen the results of the KLC internal de-icing audit of January 14th 2002 which stated that there were no valid contracts available for inspection after de-icing/ anti-icing services for Turin. It was published in the company Regional Operation Manual [ROM] that Alitalia would inspect the de-icing/anti-icing operation performed by SAGAT.

It is also company policy that the Manager Flight Operations will inform the flight planners in relation to the current fuel tanking policies. He stated however, that it had become 'custom' to fuel the last flight of the day to Turin with enough fuel to return to Amsterdam the next morning.

The Manager of Flight Operations was appointed to this position on 7th November 2001. There was a 2 month '*hand over*' period during which the new MFO worked directly alongside the previous MFO. The newly appointed MFO stated that he was not informed about any outstanding safety issues.

The previous Manager Flight Operations stated that every audit regarding de-icing had shown short comings for a number of years. He described a certain company attitude of '*boy crying wolf*' to the quality manager's repeated warnings about de-icing. He also stated that the contents of the ground handling contracts were not shared with him.

1.8 Manager Ground Operations [Postholder]

The Manager Ground Operations guards a safe and efficient ground handling process for all KLC flights in accordance with the JAR-OPS 1, applicable local laws and regulations.

The Manager Ground Operations:

6

- will ensure that JAR-OPS 1 and local laws and regulations are adhered to in the procedures and proposed procedures through participation and representation of KLC at the Airline Operators Committees at Schiphol as well as the out stations to which KLC operates;
- is responsible for negotiations and final KLC ground handling contracts at Schiphol as well the out stations;
- issues and distributes parts of the KLC Station Manual;
- is responsible for the training of KLC ground handling staff;
- has the authority to hire, train and/or discharge ground operations personnel and to contract ground handling activities outside the KLC organization.

The ground handling manager produces contracts for de-icing based upon specifications of fluid types provided by the KLC technical department, and procedures provided by the aircraft certificate holder.

The contract is not shown to any other managers within KLC unless there is a discrepancy such as the de-icing agent saying that it will not do the final inspection after de-icing.

1.9 Sub-contractors to KLC

When KLC is using sub–contractors, the responsibility for quality of the product or service remains with KLC. KLC and the sub-contractors shall have clearly defined written agreements stating the responsibilities, authorizations and quality standards.

KLC:

- will ensure that the sub-contractor has the necessary authorization/approval, the resources and competence to undertake the task;
- will, if the contract activity exceeds the sub-contractor's authorization/approval,

  ensure that the sub-contractor takes account of such additional requirements;
- uses the IATA Ground Handling Manual to define the activities and responsibility of the sub-contractor.

1.10 KLC Audit Procedures

Before the 1st of January each year the QA Manager issues a QA Program, which gives an overview of the scope and planned dates of all internal and external audits, to be performed in the coming year.

Results are documented in an audit report. The minimum contents of a report include the observed non-conformances as well as the conclusions reached.

For every non-conformance the QA Manager determines whether it is a non-compliance with clearly defined procedures or a non-conformance in which the procedures/standards are not sufficiently described or are outdated.

The audit analysis will indicate the direct/indirect impact of the non-conformance on safety and quality. When this analysis shows that the non-conformance has a serious adverse effect, it could be necessary to suspend the activity until compliance has been restored.

The analysis shall indicate the origin or root cause of the non-conformance.

Before the audit report is finalized, the findings are discussed with the Postholder who is responsible for the audited process. In case of conflicting opinions, the QA manager has the final authority with respect to the approval of the audit report.

If considered necessary by the QA Manager, follow up audits are scheduled to ensure that the required corrective actions have been taken and that they are effective.

It is the responsible manager's task to define and, in a suitable time frame implement the required corrective actions in a manner acceptable to the QA manager.

Any possible dispute arising from the required corrective action will, in the first instance, be handled by the Accountable Manager.

If necessary, the QA Manager has direct access to the Accountable Manager, who holds the final responsibility for setting priorities and allocating resources for performing the required corrective actions.

The corrective action will be documented in a Corrective Action Report.

The QA Manager shall verify incorporation of the corrective action, as well as its effectiveness. If the action is unsatisfactory or inadequate a new corrective action report will be submitted.

The QA Manager holds a record of all outstanding corrective actions and will report the status and progress periodically (at least quarterly) to the Accountable Manager.

KLC categorizes the findings/non-conformity as follows:

- Level 1: Items directly affecting airworthiness, flight safety or non-compliance which require immediate corrective action and to report to the QA Manager within a preset period.
- Level 2: Items which affect the continuing approval of the organization and require corrective action to the satisfaction of the QA Manager/Auditor within a longer period than for Level 1 but not more than approximately 60 days.
- Level 3: Items of a general nature included for completeness and information.

KLM cityhopper
ROUTE OPERATIONS MANUAL
Part 2 - Regional

3. IRREGULARITIES AND ADDITIONAL INFORMATION
3.5 De-/Anti-icing Procedures Outstations

					COMP Performing	COMP Inspecting	Heater
Turin, TRN	Type 2	Killfrost ABC3	1 + 2 Step*	100-75-50-25	S.A.G.A.T.	Alitalia	Yes
Venice, VCE	Type 2	Killfrost ABC3	1 + 2 Step	100-50-10	S.A.V.E.	Alitalia	Yes
Vienna, VIE	Type 4	Killfrost ABCS	1 + 2 Step	100-75-50-25	Vienna Airport	KLM/TT	Yes
Zurich, ZRH	Type 2	Killfrost ABC3	2 Step	100-75-25	Swissair Technics	Swissair Technics	Yes
	Type 4	Killfrost ABCS	2 Step	100-75-25	Swissair Technics	Swissair Technics	

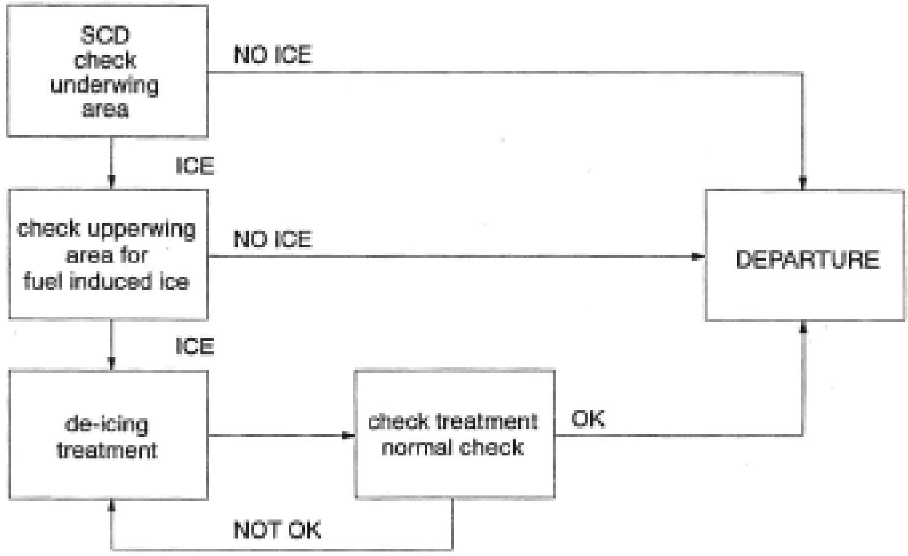
* = on request of captain

** = visual inspection only

2 Source: SPL/ZD 21 FEB 2002 Issue 7

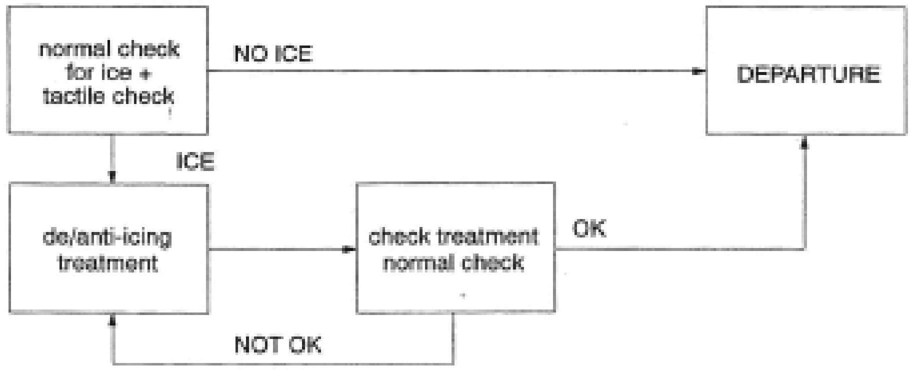
4. DE-/ANTI-ICING DECISION FLOW CHART

NO ICING CONDITIONS (paragraph 1)

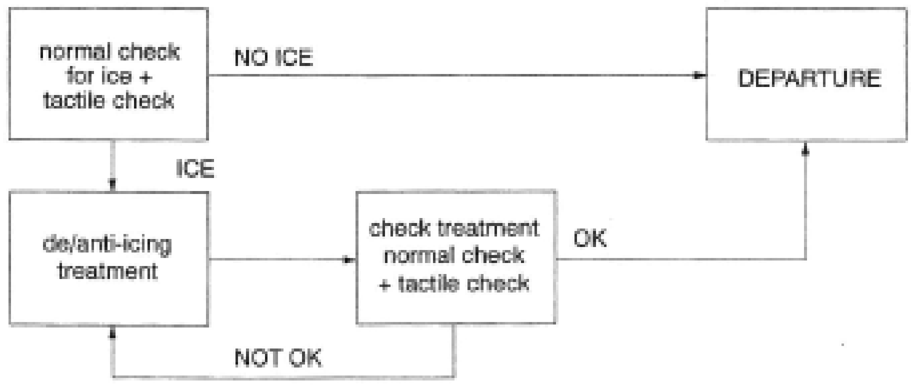


ICING CONDITIONS (paragraph 1)

GWLEHS
fully serviceable



GWLEHS U/S
(recommended with APU-air not available)



7.3 Hold-over Time Table for ISO Type 2

WEATHER CONDITIONS											Hold-over time in hours:minutes for given anti-icing code		
OAT (°C)	Frost	Freezing Fog		Snowfall		Freezing Drizzle		Freezing Rain ①	Rain on cold soaked wings				
	Light / Moderate	Light	Moderate	Light	Moderate	Light ②	Moderate	Light	Light	Moderate	ISO Type 2/100	ISO Type 2/75	ISO Type 2/50
Above 0	*										12:00	6:00	4:00
		*									1:30	1:00	0:30
			*								0:35	0:25	0:15
				*							0:55	0:40	0:15
					*						0:20	0:15	0:05
						*					0:55	0:45	0:15
							*				0:30	0:20	0:05
								*			0:15	0:10	0:05
									*		0:40	0:25	
										*	0:05	0:05	
0 thru -3	*										8:00	5:00	3:00
		*									1:30	1:00	0:30
			*								0:35	0:25	0:15
				*							0:45	0:30	0:15
					*						0:20	0:15	0:05
						*					0:55	0:45	0:15
							*				0:30	0:20	0:05
								*			0:15	0:10	0:05
Below -3 thru -14	*										8:00	5:00	
		*									1:05	0:55	
			*								0:20	0:20	
				*							0:35	0:25	
					*						0:15	0:15	
						*					③ 0:45	③ 0:30	
							*				③ 0:15	③ 0:15	
								*			③ 0:10	③ 0:10	
Below -14 thru -25	*										8:00		
		*									0:20		
			*								0:15		
				*							0:30		
					*						0:15		

① Fokker 50: Take-off **NOT** permitted in freezing rain conditions.

② Fokker 50: For light freezing drizzle apply hold-over time for moderate freezing drizzle.

③ Do not use below -10°C.

Hold-over time: The estimated time an anti-icing fluid will prevent frost, ice, snow or slush to form or accumulate on the protected surfaces of an aircraft under **average** weather conditions. When snow/ice starts to accumulate (surface turns white) the effective hold-over time has ended. Given times are **maximum** times!

CAUTION: Heavy precipitation, high air moisture, high wind velocity and jet-blast may cause a degradation of the protective film; as a result the hold-over time will be shortened. The hold-over time will also be shortened when temperature of fuel in wing tanks is 10°C (or more) ***lower*** *than OAT.*

KLM cityhopper

KUYPERS
SPL/NK 1513

ALL FOKKER 70 PILOTS
CREWBULLETIN FOKKER 70
001-02

classificatie/classification
uw referte/your ref.
uw datum/your date

telefoon/telephone
onze referte/our ref.
onze datum/our date
telefax

SPL/ZN/TV
22 february 2002
020-6493023
020-6497140

onderwerp/subject **DE– AND ANTI ICING PROCEDURES**

On feb 16 a KLC Fokker 70 sustained major damage to the RH engine and minor damage to the LH engine shortly after lift-off. Investigations by the authorities and by KLC are being performed.

Initial indications are that we can not rule out the possibility of clear ice on the wings to be contributary to this event. We would like to stress these are early indications, and definitely not the outcome of any of the investigations. Since both engines sustained damage, the following measures are in effect untill the investigations give us an indication of what happened.

1 The policy of tanking economical fuel as described in AOM 3.2.2/1 will also be applicable on aircraft going on nightstop. (*to reduce the possibility of clear ice forming after landing*)

2 Significant deposits of clear ice can form, in the vicinity of the fuel tanks, on wing upper surfaces as well as under wing. Aircraft are most vulnerable to this type of build-up when:
- Wing temperatures are below 0 °C (eg due to cold soaked fuel)
- Ambient temperatures are between –2 °C and +15 °C
- Precipitation occurs when the aircraft is on the ground
- Ice or ice ridges are present on lower surface of either wing

This type of ice formation is extremely difficult to detect. Therefore, when the above conditions prevail, or when there is otherwise any indication that clear ice may be present, a hands-on (tactile) check shall be performed of the upper wing area including the trailing edge, between the fuselage and 5 mtr outboard of the fuselage. This tactile check is required specifically to detect clear ice, and must be performed even where a decision has already been made to de-ice the aircraft.

3 If clear ice is detected, it shall be removed using hot fluid. After removal, the area shall be checked to be free of clear ice with a hands-on (tactile) check. Only after it has been confirmed the area is free of clear ice, the normal de- and anti-icing treatment of the entire aircraft shall commence.

Chief Pilot F-70

KLM Cityhopper B.V.
Postbus 7700, 1117 ZL Luchthaven Schiphol
P.O. Box 7700, 1117 ZL Schiphol Airport, The Netherlands

AGENZIA NAZIONALE PER LA SICUREZZA DEL VOLO

(istituita con decreto legislativo 25 febbraio 1999, n. 66)
Via A. Benigni, 53 – 00156 Roma - Italia
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tel. +39 0682078219-0682078200, fax +39 068273672

Prot. n. 395/INV/140-35/02
Roma, 9.4.2002

Al Presidente dell'ENAC
Dott. Alfredo Roma

e p.c. Alla Divisione sicurezza volo
dell'ENAC
Att.ne Com.te Silvano Imparato

Oggetto: inconveniente grave occorso in data 16.2.2002 sull'aeroporto di Torino Caselle all'aeromobile tipo Fokker 70, marche PH-KZH - MESSAGGIO DI ALLERTA.

Nel mese di febbraio 2002 un aeromobile Fokker 70, in partenza da uno scalo nazionale, dopo aver effettuato la procedura di sghiacciamento aeromobile *(de-anti ice)* in condizioni meteorologiche caratterizzate da elevata umidità e temperatura esterna prossima allo zero, in decollo, dopo la rotazione (*lift off*), subiva un'avaria grave al motore destro e danni al sinistro.

Nonostante l'investigazione tecnica da parte di questa Agenzia sia tuttora in corso, dalle prime risultanze tecniche non si può escludere la possibilità che la causa principale dell'inconveniente grave di cui all'oggetto sia rappresentata dal ghiaccio vetrone (*clear ice)* formatosi sul dorso delle ali.

In considerazione dell'analogia fra l'evento considerato e l'incidente occorso all'aeromobile DC-9-81 SAS in decollo dall'aeroporto Arlanda di Stoccolma il 27 dicembre 1991, nonostante la stagione fredda stia volgendo al termine ed in attesa della conclusione dell'inchiesta, si ritiene opportuno invitare codesto Ente a valutare l'opportunità di richiamare agli operatori nazionali alcuni aspetti operativi relativi alla formazione di ghiaccio vetrone sulle ali.

Formazioni significative di ghiaccio vetrone si possono creare sulla parte superiore delle ali, in prossimità dei serbatoi carburante, accompagnate da brina o ghiaccio nella corrispondente superficie inferiore dell'ala stessa.

Il fenomeno si manifesta *al suolo*, con maggiore probabilità, se sono presenti la seguenti condizioni:

- temperatura delle ali inferiore a 0°C (es. dovuto alle basse temperature alle quali il carburante è stato esposto durante la crociera);
- temperatura ambientale fra –2°C e +15°C;
- presenza di precipitazioni quali pioggia o neve durante la sosta dell'aeromobile.

La presenza di ghiaccio vetrone è estremamente difficile da identificare a vista.

Se si presentano le condizioni sopra dette oppure si notano formazioni di ghiaccio e/o brina sulla superficie inferiore dell'ala, si impone un controllo con mano (*tactile check*) da parte di personale appositamente qualificato o del comandante responsabile del volo. Il controllo dovrà interessare la parte superiore dell'ala, particolarmente in corrispondenza dei serbatoi alari.

Qualora venga riscontrata la presenza di ghiaccio vetrone, esso dovrà essere rimosso con fluido caldo. Dopo l'applicazione, l'area interessata dovrà essere controllata nuovamente a mano e solo dopo aver accertato che essa sia libera da ghiaccio, il normale trattamento antighiaccio (*anti ice*) potrà essere effettuato prendendo come riferimento per il calcolo della durata di "*hold over time*" l'orario di inizio del trattamento *anti ice*.

L'Agenzia resta a disposizione per ogni ulteriore informazione e chiarimento.

Si resta in attesa di ricevere un cortese cenno di riscontro in merito agli eventuali provvedimenti intrapresi da codesto Ente.

Il Presidente
(Prof. Bruno Franchi)

Draft Fokker 70/100 All Operators Message

Dated: September xx, 2002

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Ref. No. :TS02.5zzzz
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Subject: **Fokker 70 – Engine damage during Take-Off, update #2**

Introduction

Further to our previous All Operator Messages on this subject (AOF100-087 and -088), this message is to inform you about the progress of the investigation into an occurrence with a Fokker 70 aircraft in which both engines were damaged during take off.

Investigation update

The investigation is continuing under the direction of the local authorities. No conclusions have been drawn yet, but the perception is that conditions were indeed favorable for the formation of wing upper surface (clear) ice. No evidence has been provided to Fokker Services so far that would point clearly to a cause of the engine damage other than ingestion of ice released from the inner wing upper surfaces during the take-off/rotation. If confirmed, this would constitute the first ever report of (dual) engine ice FOD due to ingestion of inner wing upper surface (clear) ice on the Fokker jet fleet (F28 series, all marks) in about 15 million flight cycles.

Whereas clear ice may occur on any aircraft type, the possibility of ingestion of (clear) ice released from the inner wing upper surface on principle exists only on aircraft types with aft-fuselage mounted engines. However, service experience on the Fokker jet fleet in this respect is quite favorable in comparison with some other aircraft types with aft fuselage mounted engines. This is presumably due to differences particularly in engine inlet location relative to the wing root and in the characteristics of the fuel storage and transfer system.
It is rather unclear yet which specific circumstances would have made the subject case different.

The subject early-morning take off was the first of the day after an overnight stay at an out-station of about 10 hours. The aircraft reportedly arrived with some 5 tons of fuel remaining in the wing tanks (center tank empty), enough for the next flight (economic tankering policy). It is estimated that the average fuel temperature after the flight would have been about minus 12 deg C, and that with such a fuel quantity the cold fuel would determine the temperature of (most of) the inner wing upper surface for some hours after arrival. Reported weather conditions during the night were rainy, temporarily rain/snow, temperatures varying between 0 and plus 2 deg C, dewpoint 0 to minus 1 deg C, light wind. It is also estimated that under these conditions the average fuel temperature just prior to take off would have been close to 0 deg C.
Before take off, the pilot in command reportedly determined that a de-icing treatment was needed, indicated by the presence of ice-ridges on the wing <u>lower</u> surface. De-icing was reportedly done using Type II 50/50 fluid. It is not known so far to what extent the wing <u>upper</u> surface was checked or examined for the presence of (clear) ice, both before and after the applied de-icing. However, it has been reported that "as

far as possible without using a ladder, 1 to 2 millimeters of slushy water and ice in small areas on top of the wing and slush on the trailing edge of the left wing" were observed.
By not refueling prior to this flight, the distinct advantage of the F28 series (all marks) fuel storage and transfer system, with fuel running through inner wing upper surface top hat stringers, was not utilized. This advantage is the possibility to influence the temperature of the inner wing upper surface by the added fuel (when this fuel temperature is above 0 deg C) and thus either melt frozen deposits or reduce adherence to facilitate removal during de-icing.

Action

In view of the above mentioned preliminary investigation results Fokker Services would like to re-emphasize the importance of strict adherence to the clean aircraft concept as detailed in the AFM, AOM and AMM procedures. Whereas over the years more and more attention was drawn to the potential hazardous lift loss effects of wing leading edge ice, this occurrence may be seen as a reminder to all of us that the danger of ice

- is not limited to wing leading edge and lift loss effects,
- requires continuous awareness of flight and ground crew.

For that reason it is recommended to once more review not only your own company's procedures, including those related to economic fuel tanking, but also those of third party organisations to which you may have possibly outsourced ground handling and de-/anti-icing activities. Fokker Services will undertake a similar exercise to determine whether the AFM, AOM and AMM procedures can be further optimized.

STANDARD GROUND HANDLING AGREEMENT
SIMPLIFIED PROCEDURE

ANNEX B.1.0 : Location (s), agreed services, facilities and charges to the Standard Ground Handling Agreement (SGHA) of April 1998

between: **KLM CITYHOPPER B.V. (KLC)**

having its principal office at:
Wallaardt Sacrestraat 10, Schiphol-Oost
P.O. BOX 7700
1117 ZL Schiphol
The Netherlands

hereinafter referred to as "the Carrier"

and: **SAGAT S.p.A. Turin Airport**

having its principal office at:
Aeroporto "Città di Torino"
Starda San Maurizio, 12
10072 Caselle Torinese (TO)
Italy

hereinafter referred to as "the Handling Company".

This Annex	B.1.0
for the location:	Turin (TRN)
is valid from:	01.01.2000
is valid until:	31.12.2002
and replaces:	none

PREAMBLE:
This Annex B is prepared in accordance with the E.U. directive 96/67 introduced in Italy through the law decree 18/99.
This Annex B is prepared in accordance with the simplified procedure whereby the Carrier and the Handling Company agree that the terms of the Main Agreement and the Annex A of the Standard Ground Handling Agreement (SGHA) of April 1998 as published by the International Air Transport Association shall be part of this agreement as if such terms were repeated here in full. By signing this Annex B, the parties confirm that they are familiar with the aforementioned Main Agreement and Annex A.

1.3.2 BASIC HANDLING CHARGES

All prices hereunder are fixed during the validity of this agreement B.1.0.

(a) *DAYFLIGHT WITH F70 AIRCRAFT*

YEAR	*PRICE*
2000	
2001	
2002	

(b) *OVERNIGHT PACKAGE WITH F70 A/C*

YEAR	*PRICE*
2000	
2001	
2002	

(b.1) de-icing equipment free of charge. Liquid at cost;
(b.2) no extra charges will be made for one morning departure before 07H00 local time.

These prices do not include:
⇒ Any charges , fee , or taxes imposed or levied by the Airport, Customs or other Authorities against the Carrier or the Handling Company in connection with the provision of services herein by the Handling Company or in connection with the Carrier's flights .
⇒ Expenses incurred in connection with stopover and transfer of passengers and with the handling of passengers for interrupted, delayed or cancelled flights.
Such charges, fees, taxes or other expenses as outlined above shall be borne ultimately by the Carrier.
⇒ Cute implementation and utilisation. Training will be implemented at Carrier's cost.

1.3.3 EXTRA HANDLING SERVICES CHARGES

The following services are not included in the above mentioned package and are charged additionally:

- ✓ De-icing full cost for daily operation and included in the night package excluded liquid
- ✓ Push Back and Loading Bridge

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To:

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Copies to: DAQCP – Pool Members

From:

Date: 23 January 2001

Nbr Pages: 1

Subject: De-/Anti-icing Audit on 22 January 2001

Dear Mr.

First I want to take this opportunity to thank you and your staff for the cooperation and assistance given to me during my audit at your facilities.
The positive and constructive approach to the inspection was very much appreciated.

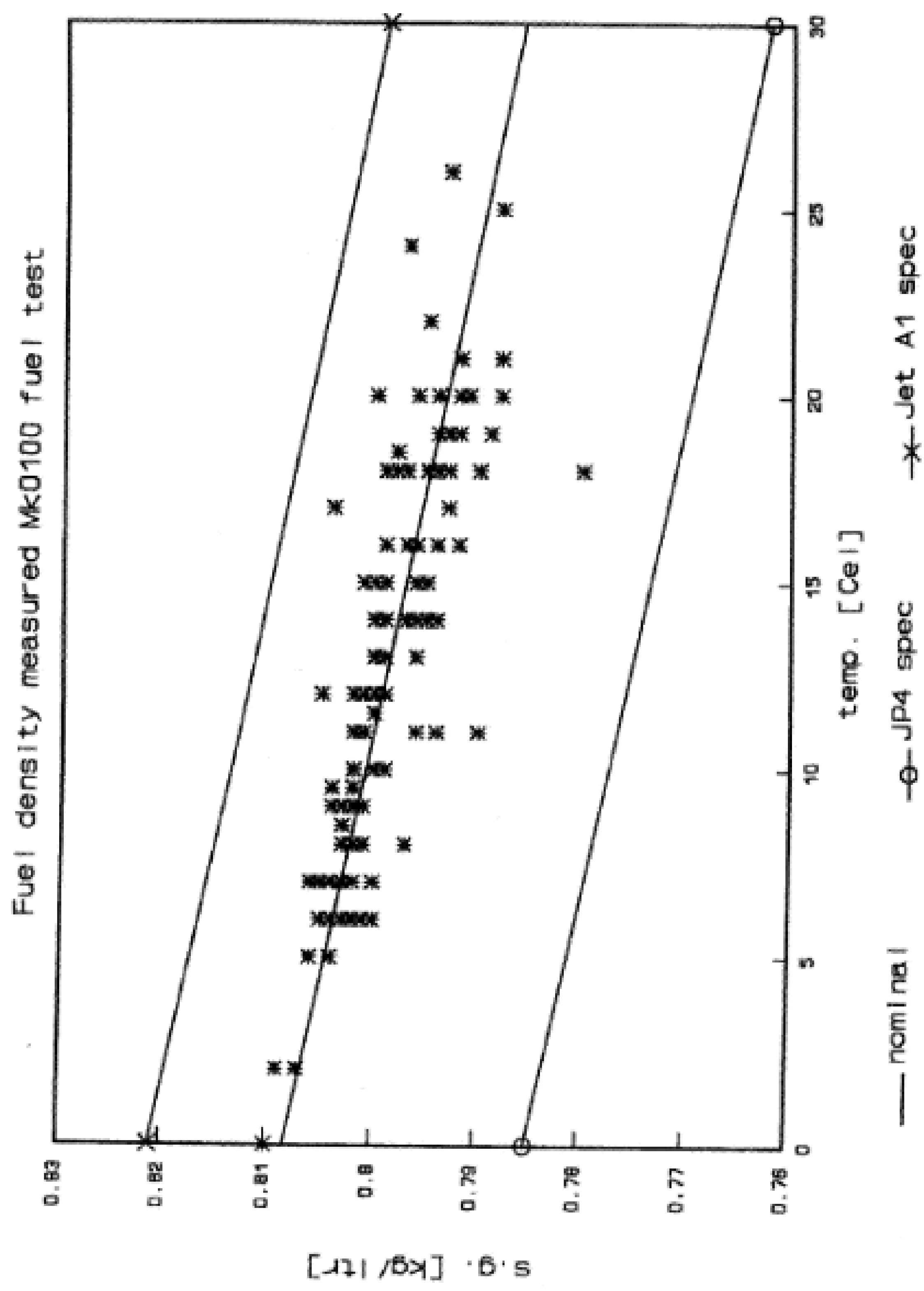
The inspection was conducted to fulfill our authority regulations (JAR-OPS) which require periodical inspections of companies providing De-/Anti-icing services. This inspection was performed on behalf of AF – DAT – KLC – LH.

The subsequent listed findings were made at the inspection, which require a remedial action:

1. No valid signed contracts could be shown
2. No De-icing procedure manuals available from CLH & KLC.
3. No evedence annual refresh for expiry dates.
4. No theoretical test has been given.
5. No training passing rates of 75 % are established.

We kindly request you written response **within 14 days** detailing your corrective action or comments to the Items.

Kind Regards



Graph 3.4.2-1; Fuel Densities measured during fuel tests

Cabin Pressure alerts Turin

Draft KL 1613 ANALYSIS

Quote:
The auto throttle alert that was presented at 400 feet was followed by a cabin pressurization control alert presented at 1,500 feet. The latter alert which was confirmed by an overhead system fault light and a sense of pressure variation in the ears was however, presented as a cabin pressure control channel fault on the left hand MFDU. This inconsistency also occurred in the simulator re-creation. The procedure for the cabin pressurization control alert appeared on the right MFDU below the auto throttle fail procedure, however the inconsistency between the message on the left screen and the procedure on the right screen also created confusion for the first officer.
Unquote.

Interpretation:
1. A cabin pressurization control alert was presented at 1,500 feet, with a local fault light on the overhead panel.
2. A cabin pressure control channel fault appeared on the left hand MFDU.
3. The procedure for the cabin pressurization control alert appeared on the right MFDU.
4. The mentioned mismatch is a mismatch between the alert (CAB PRESS CTL CHAN) on the left hand MFDU and the header of the procedure on the right hand MFDU (CAB PRESS CTL).

Flight Warning Logic

The Flight Warning System (FWS) contains two cabin pressure controller alerts:

1. CAB PRESS CTL CHAN
   This level 1 alert indicates that one of the two cabin pressure controllers has a fault. This alert does not have a procedure and the local fault light on the overhead panel will <u>not</u> illuminate.
   The alert condition for this alert is:
   - cabin pressure control single channel fault AND
   - not cabin pressure ctl dual fault AND
   - not AC bus 2 off AND
   - time delay 1 second

2. CAB PRESS CTL
   This level 2 alert indicates that both cabin presser controllers have faults. Since automatic cabin pressure control is lost the crew receives a procedure to manually control the cabin pressure. The fault will also illuminate the local fault light on the pressurization control panel on the overhead panel.
   The alert condition for this alert is:
   - cabin press ctl dual channel fault AND
   - not essential AC bus off AND
   - not essential DC bus off AND
   - time delay 1 second

Aircraft 11583 is equipped with a single cabin pressure controller. In this configuration both the single channel fault and the dual fault are generated at the same moment. The FWS logic prevents annunciation of the single channel failure when at the same time the dual failure condition is active.

Maintenance information

According to information received from Martinair the aircraft had several cabin pressure controller faults during the days preceding the Turin incident. According to the same source the alerts were presented as CAB PRESS CTL CHAN. After replacement of an intermittently opening circuit breaker in the FWC single/dual pressure control channel logic the problem was solved.
Note: When the circuit breaker is opened the dual fault signal to the FWC is interrupted. If in this condition the pressure controller alert becomes active then the fault will be annunciated as a CAB PRESS CTL CHAN alert.

Attempts to get the above verbally received information in writing failed due to the availability of only limited information from the Martinair maintenance computer system.

On aircraft verification

Due to this discussion it was decided to generate a CAB PRESS CTL alert and a CAB PRESS CTL CHAN alert on the incident aircraft. The test revealed that the FWS worked as advertised.

- The CAB PRESS CTL alert was a level 2 alert and was presented with the correct procedure (including heading)
- The CAB PRESS CTL CHAN alert was a level 1 alert and was presented without procedure (Note: this required 'misleading' the FWC single/dual pressure control channel logic to let it believe the aircraft pressure controller was configured with a two pressure controls).

Centralized Fault Display Unit (CFDU)

The CFDU only stored the CAB PRESS CTL alert and not the CAB PRESS CTL CHAN alert. If the CAB PRESS CTL CHAN alert would have been generated by the FWC then this alert should also have been stored in the CFDU.

Discussion

According to the draft KLC report there was a mismatch between the alert and the procedure heading. This behavior would also have been visible on the simulator. It must however be noted that the simulator does not contain a Flight Warning Computer, but all faults are generated by a simulation computer. It can be questioned whether the simulator acts like the real aircraft.

The alert that was generated during the incident flight was most likely the CAB PRESS CTL alert (level 2). This is supported by:

- The presence of a local fault light on the pressurization control panel
- The presence of a cabin pressure control related procedure
- The CFDU memory

A mismatch between the alert and the procedure heading could not be reproduced on the incident aircraft. Therefore two possible causes remain:

1. The crew knew that the aircraft had a history of CAB PRESS CTL CHAN alerts, but received during the incident flight the CAB PRESS CTL alert and associated procedure.
2. The reportedly intermittently opening circuit breaker has the potential effect that due to timing the FWC and pressurization control system, momentary behaved as if it were a dual channel system.

In view of the reported mismatch on the simulator it is recommended to review the simulator software at this point.