TRANSPORTATION SAFETY BUREAU

FINAL REPORT

2011-120-4P
SERIOUS INCIDENT

BUDAPEST
17 JUNE 2011

ATR42-500
YR-ATG

The sole objective of the technical investigation is to reveal the causes and circumstances of aviation accidents, incidents or irregularities and to initiate the necessary technical measures and make recommendations in order to prevent similar cases in the future. It is not the purpose of this activity to apportion blame or liability.

INTRODUCTION

This investigation was carried out on the basis of

- Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC,
- Act XCVII of 1995 on aviation,
- Annex 13 identified in the Appendix of Act XLVI. of 2007 on the declaration of the annexes of the Convention on International Civil Aviation signed in Chicago on 7th December 1944,
- Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents (hereinafter referred to as Kbvt.),
- MET Decree 123/2005 (XII. 29.) on the regulations of the technical investigation of aviation accidents, incidents and irregularities,
- Act CXL of 2004 on the general rules of administrative authority procedure and service when Kbvt. is not applicable.

The competence of the Transportation Safety Bureau of Hungary is based on Government Decree 278/2006 (XII. 23.).

Under the aforementioned regulations

- The Transportation Safety Bureau of Hungary shall investigate aviation accidents and serious aviation incidents.
- The Transportation Safety Bureau of Hungary may investigate aviation incidents and irregularities which - in its judgment - would have resulted in accidents in other circumstances.
- The Transportation Safety Bureau of Hungary is independent of any person or body whose interest conflict with the functions of the investigating body.
- In addition to the aforementioned laws, the Transportation Safety Bureau applies the ICAO DOC 6920 Manual of Aircraft Accident Investigation.
- This Final Report shall not be binding, nor shall an appeal be lodged against it.

No conflict of interest has arisen in connection with any member of the investigating committee. Persons participating in the technical investigation shall not act as experts in other procedures concerning the same case.

The IC shall safe keep the data having come to their knowledge in the course of the technical investigation. Furthermore the IC shall not be obliged to make the data – regarding which the owner of the data could have refused the disclosure of the data pursuant to the relevant act – available to other authorities.

This Final Report

was based on the draft final report prepared by the IC and sent to all affected parties (as stipulated by the relevant regulation) for comments.

DEFINITIONS AND ABBREVIATIONS

ADC	Aerodrome Controller
AIB Denmark	Accident Investigation Board Denmark
ANSV	Agenzia Nazionale per la Sicurezza del Volo
ATPL	Airline Transport Pilot Licence
BUD	IATA code for Budapest Liszt Ferenc International Airport
CAVOK	Ceiling and Visibility OK
CIAS	Civil Aviation Safety Investigation and Analysis Center (Romania)
CPL	Commercial Pilot Licence
EASA	European Aviation Safety Agency
GPWS	Ground Proximity Warning System
HCF	High Cycle Fatigue
IATA	International Air Transport Association (of airlines)
IC	Investigating Committee
ICAO	International Civil Aviation Organization (of states)
inch (”)	a unit of length; 1 inch equals 25.4 mm
Kbvt.	Act CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents
knot (kts)	a unit of speed; one knot equals one nautical mile (1.852 km) per hour
LHBP	ICAO code for Budapest Liszt Ferenc International Airport
LROP	ICAO code for Bucharest Otopeni International Airport
MAYDAY	an emergency procedure word used internationally as a distress signal in radio communications
MET	Ministry of Economy and Transport (Gazdasági és Közlekedési Minisztérium, GKM)
MTCW	Ministry of Transport, Communications and Water (Közlekedési, Hírközlési és Vízügyi Minisztérium, KHVM)
NTA AD	National Transport Authority, Aviation Directorate (Hungary)
OTP	IATA code for Bucharest Otopeni International Airport
PA	Passenger Address system

PT1/PT2	Power Turbine 1st/2nd stage
PWC	Pratt & Whitney Canada
QFE	barometric pressure measured at location („Query: Field Elevation”)
QNH	barometric pressure adjusted to sea level („Query: Nautical Height”)
RKI	Airport Disaster Response Directorate (Budapest)
SB	Service Bulletin
TAROM	TAROM Romanian Air Transport, the national air carrier of Romania
TAWS	Terrain Awareness and Warning System
TC	Transport Canada
TCAS	Traffic Alert and Collision Avoidance System
TSB	Transportation Safety Bureau (of Hungary)
TSB Canada	Transportation Safety Board of Canada
UTC	Coordinated Universal Time

BRIEF DESCRIPTION OF THE OCCURRENCE

Occurrence category		serious incident
Aircraft	**class**	fixed wing aircraft
	manufacturer	AVIONS DE TRANSPORT REGIONAL
	type	ATR42-500
	registration	YR-ATG
	operator	TAROM
Occurrence	**date and time (UTC)**	17 June 2011, 17:22
	location	Budapest
Time zone used in the report		UTC

Reports and notifications

The occurrence was reported to the dispatcher of the TSB at 17:27 (UTC) on 17 June 2011 by the dispatcher of the HungaroControl Plc.

TSB dispatcher:

– reported the occurrence to NTA AD at 17:36 (UTC) on 17 June 2011,

– sent Notifications on 17 and 18 June 2011 to the following interested parties:

- State of Operator (Romania);
- State of Manufacturer (France);
- State of Engine Manufacturer (Canada);
- Italy (as the problematic engine was owned by an Italian repair facility);
- EASA;
- ICAO;
- The European Commission.

Investigating committee

The Director-General of the TSB assigned the following Investigating Committee (hereinafter referred to as IC) for the investigation of the serious incident on 17 June 2011:

Investigator-in-Charge (IIC)	Mr. György HÁY	investigator
IC member	Mr. László STORCZER	investigator
IC member	Mr. János ESZES	investigator
IC member	Mr. András KOVÁCS	field technician

Mr. Storczer's and Mr. Eszes' employment by TSB was terminated during the investigation.

Overview of the investigation process

The field technician of TSB arrived at the aircraft shortly after landing and made photographs of the on-board documentation of the aircraft. as well as of the aircraft itself.

Upon request, TAROM and CIAS provided operation-related documentation and the FDR data. HungaroControl, RKI and Budapest Airport Plc provided the recorded radio traffic related to the occurrence. The IC also obtained the Fire Chief's report and the recorded taxi and approach radar information. A TAROM engineering team removed the defective engine from the aircraft under TSB supervision. TSB took the engine under custody and arranged its transportation and shop inspection at the Avio Company, Pomigliano d'Arco, near Naples, Italy. There the engine (Fig. 1) was disassembled and inspected under TSB supervision and all interested parties present. The PT1 roror assembly was removed and sent to Pratt&Whitney Canada for further laboratory inspection under TSB Canada supervision. The inspection determined that the turbine blade fracture was caused by material defect and subsequent fatigue crack.

Fig. 1: Engine removal from the aircraft

In the course of the investigation the IC was informed of two other serious incidents – very similar in nature - being investigated by AIB Denmark and ANSV. The three concerned investigating organisations conducted a joint meeting organised by ANSV in Rome in February 2012 where it was decided to take co-operated action and issue five immediate safety recommendations. The three investigating organisations sent their official letters with identical text of the safety recommendations to the addressees on the same day, 26 July 2012 (see 1.18 for details).

Transport Canada, the addressee for safety recommendations BA2011-120-4P-2A and BA2011-120-4P-3A, responded on 26 September 2012 to TSB Canada, For administrative reasons, TSB HU received this response only on 16 May 2013 (see 4.3.1).

EASA, the addressee for safety recommendations BA2011-120-4P-4A and BA2011-120-4P-5A, responded to TSB HU on 8 January 2014 and 10 April 2014 respectively (see 4.3.2 and 4.3.3).

A short summary of the occurrence

The ATR42-500 aircaft (registration YR-ATG, operated by TAROM) took off from runway 31L of Budapest Liszt Ferenc International Airport for Bucharest (as flight ROT234) at 17:21 UTC on 17 June 2011. The flight crew noticed the failure, flameout and fire of RH engine 11 seconds after rotation. The flight crew acted in accordance with the emergency checklist and declared MAYDAY while making a turn with the intention to land. The passengers panicked when they noticed the smoke in the cabin and the flaming engine through the window. The pilots received clearance for the tower and landed on runway 13L, 3 minutes after takeoff. The engine fire was put off in flight. The aircraft exited the runway and stopped on a taxiway where the captain ordered emergency evacuation of the aircraft. One passenger had medical problems due to the emergency situation and required medical assistance. The aircraft was checked by the fire brigade and then towed to the apron (Fig. 2).

Fig. 2: The aircraft on the apron

The affected engine was removed from the aircraft and shipped to an authorised engine repair facility for disassembly. The power turbine disk assemblies were taken to the engine manufacturer for analysis. The inspections revealed that the engine failure was caused by a broken turbine blade. The blade defect itself was a consequence of microshrinkage porosity and subsequent fatigue crack. The remaining damages were consequential.

In the course of the investigation the IC received information on two other occurrences similar in nature and conditions – aircraft type, engine type, occurrence – that took place in 2011 and one more from 2013. ANSV, AIB Denmark and TSB HU issued five immediate safety recommendations – with agreed text – concerning turbine blade inspections during manufacturing and on-board documentation related to in-flight emergency situations. The IC recommends to issue a safety recommendation – upon closure of the investigation - on training and equipment modification with regard to the Passenger Address system of the affected aircraft type.

1. FACTUAL INFORMATION

1.1 History of the flight

The ATR42-500 aircaft (registration YR-ATG, operated by TAROM) took off from runway 31L of Budapest Liszt Ferenc International Airport for Bucharest (as flight ROT234) at 17:21 UTC on 17 June 2011. The flight crew noticed engine noise from the RH engine typical for engine stall while at around 1100 feet. (Engine stall is an oscillation of air mass and air pressure throughout the compressor that can lead to disruption of air flow, unstable operation or flameout.)

Soon after having reduced engine thrust to flight idle, the flight crew received low engine oil pressure warning followed by an engine fire warning.

The pilots immediately responded in accordance with the emergency checklist items (memory items) for the case of engine fire. The propeller of the stopped engine was feathered. The pilots declared emergency by reporting MAYDAY and engine fire. At the same time they requested landing, first to runway 31L, which was soon changed to 13L. The latter request was immediately granted by ADC controller.

The tower alerted the airport fire brigade at 17:22. The vehicles of Central Base and Cloud Base were standing by on taxiways A5 and A9 respectively. The ICAO Rescue Fire-Fighting (RFF) category for the other runway (runway 31L) was temporarily reduced to 7; the departing and arriving flights were notified on this change by the ATC.

The aircraft made a tight right turn while the First Officer initiated both fire extinguishing systems for the RH engine and managed to put out the fire in the engine nacelle. Some passengers panicked when they noticed the smoke in the cabin and the flaming RH engine through the windows.

The cabin crew instructed the passengers to take their seats and to fasten their seatbelts, however, the Passenger Address system at this time was already blocked (see **1.18.2**).

The aircraft landed on runway 13L at 17:25 with a landing speed of 115 knots between the taxiways K and Z. After intensive braking it left the runway through taxiway X and stopped at the intersection of taxiways X and A8 at 17:27. The captain ordered emergency evacuation that was completed without incident. The fire vehicles that followed the aircraft on the runway and on taxiway A9 arrived 30 seconds after stopping and took positions. There was no need for action because the engine fire was put out in flight. The fire crew scanned the engine nacelle with an infrared camera and determined that there was no fire inside. The site commander, however, ordered the cooling of the wheel brakes (with fans), because they became very hot due to intensive braking.

The evacuated passengers were summoned near taxiway A8; fortunately no one was injured. One passenger - a woman - had complaints due to the stressful landing and was taken to the medical room of Terminal 1 by an ambulance car. She was examined, treated and released upon her own request. The other passengers were taken to the terminal by bus. The towing of the aircraft to the apron started at 18:03.

1.2 Injuries

Injury	Crew		Passengers	Other
	Flight Crew	Cabin Crew		
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	1	0
None	2	2	34	

The minor injury in the above table refers to the passenger with stress-induced complaints.

1.3 Damage to aircraft

The Power Turbine of the RH engine (engine No.2) (Fig. 3), the exhaust pipe and the engine nacelle (Fig. 4) sustained heavy damage.

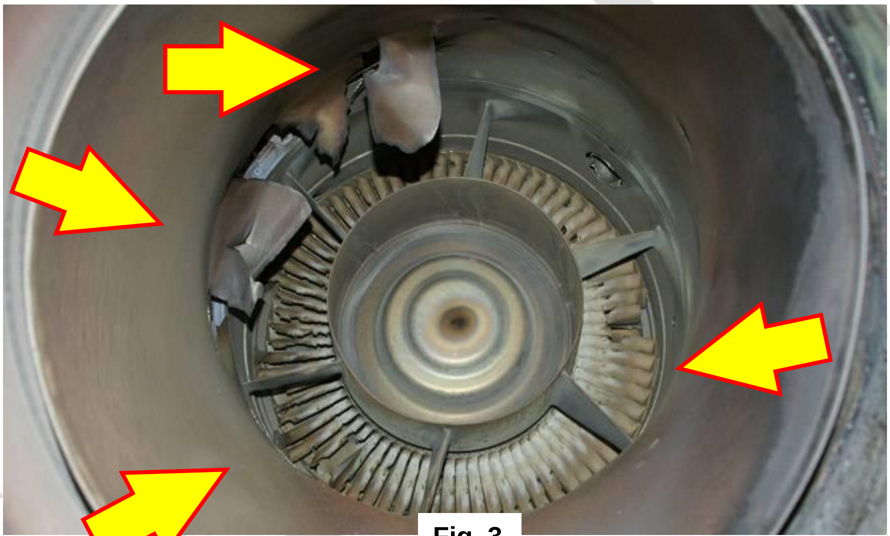


Fig. 3

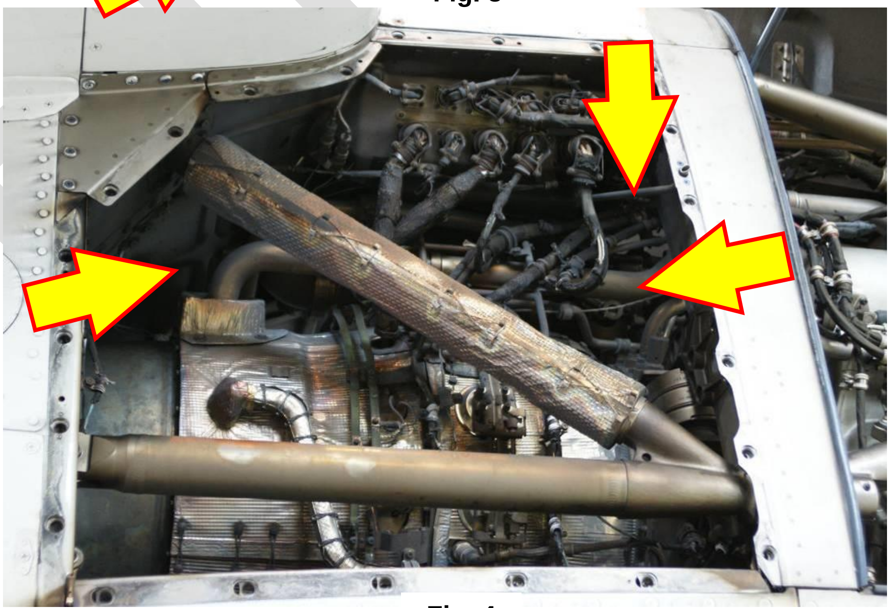


Fig. 4

1.4 Other damage

The IC had no knowledge of any other damage.

1.5 Information on personnel

1.5.1 Captain

Age, nationality, gender		54, Romanian male
Licence data	**Type**	ATPL
	Professional valid until	10 AUG 2011
	Medical valid until	07 AUG 2011
	Ratings	Captain, ATR72/42
Flying experience, hours	**Total**	14,685 hrs
	On the type	3,407 hrs
	As Captain	3,217 óra
	in the previous 28 days	118 hrs
	in the previous 7 days	38 hrs
Types flown		ATR72, ATR42
Role at the time of the occurrence		Pilot Flying
Rest time in the previous 48 hours		36 hrs

1.5.2 First Officer

Age, nationality, gender		31, Romanian male
Licence data	**Type**	CPL
	Professional valid until	13 JUL 2011
	Medical valid until	03 SEP 2011
	Ratings	First Officer, ATR72/42
Flying experience, hours	**Total**	1,368 hrs
	On the type	1,080 hrs
	As Captain	67 hrs
	in the previous 28 days	14 hrs
Role at the time of the occurrence		Pilot Monitoring
Rest time in the previous 48 hours		48 hrs (2 days off)

1.5.4 Chief Flight Attendant, Purser

Age, nationality, gender		39, Romanian female
Licence data	**Type**	flight attendant
	Professional valid until	23 MAY 2012
	Type ratings	ATR72/42, A318, B737
Rest time in the previous 48 hours		more than 12 hrs
Flying experience, hours	**Total**	10,232 hrs
	On type	1,172 hrs
	As Purser	5,123 hrs
	As Purser, on type	991 hrs

1.6 Aircraft data

1.6.1. General

Aircraft class	fixed wing
Manufacturer	AVIONS DE TRANSPORT REGIONAL, France
Type	ATR42-500
Date of manufacturing	08 DEC 1999
Serial number	605
Registration	YR-ATG
State of Registry	Romania
Owner	TAROM
Operator	TAROM
Call sign during the affected flight	ROT234

1.6.2. Airworthiness

Airworthiness certificate	**Serial**	143
	Date of issue	12 JUN 2011
	Valid until	24 JUN 2012
	Last review	12 JUN 2011
	Restrictions	none

1.6.3. Engine data

Class	**turboprop**	
Type	PW127E	
Manufacturer	PRATT & WHITNEY CANADA	
Position on aircraft	No.1	No.2
Serial number	not relevant	AK0004
Date of installation	not relevant	24 MAR 2011
	hours/ cycles flown	
Since manufacturing	not relevant	20,279 hrs / 20,857
Since last overhaul	not relevant	5,463 hrs / 5,859
Since last periodic check	not relevant	435 hrs / 422

The subject engine belongs to the Pratt & Whitney Canada PW100 turboprop engine family. It has three coaxial and mechanically independent shafts. The first shaft and a low pressure radial compressor is driven by a single-stage low pressure turbine. The second shaft and a high pressure radial compressor is driven by a single-stage high pressure turbine. The third shaft – that drives the propeller through the main gearbox - is driven by a two-stage power turbine. See Fig. 5 and 6.

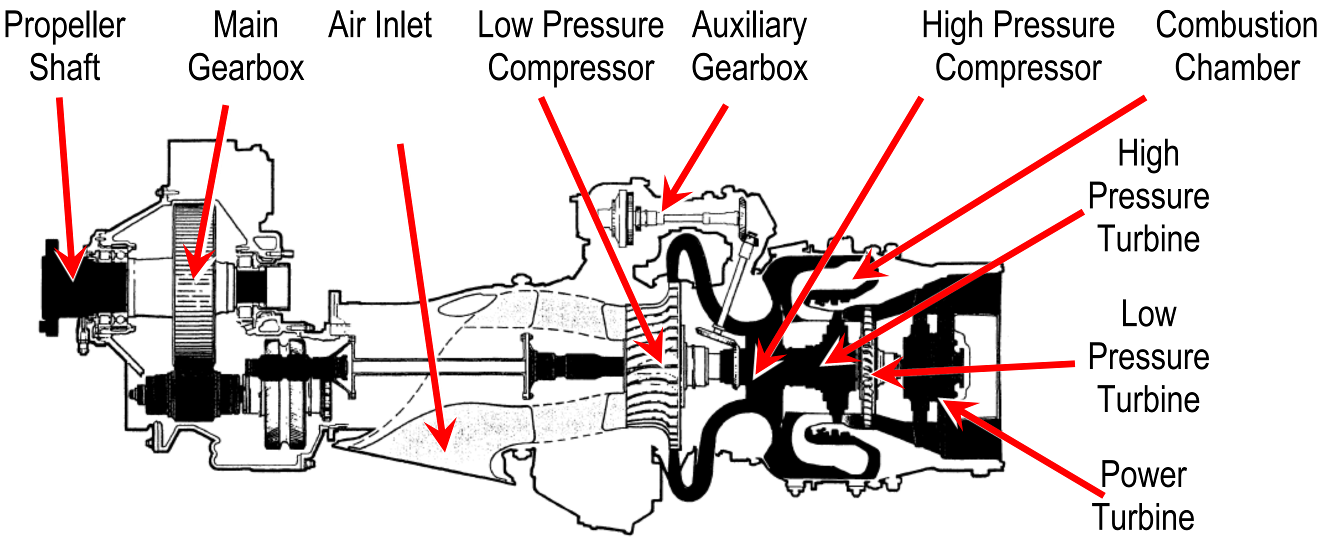


Fig. 5-6: Pratt & Whitney Canada PW127E engine

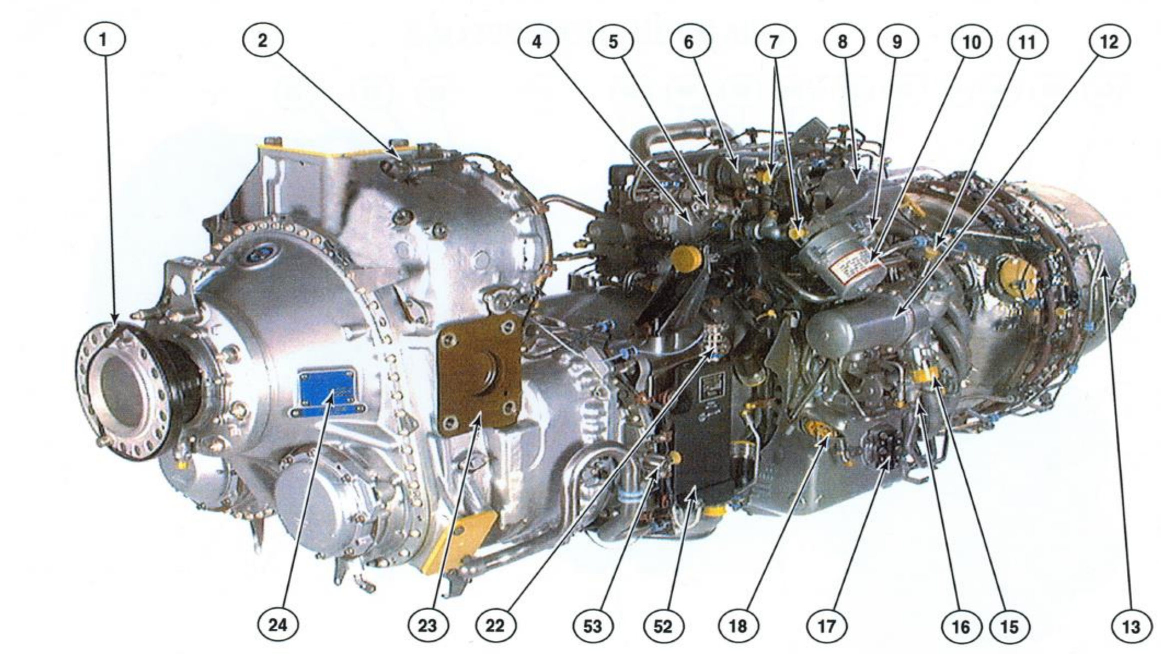


Fig. 6: Pratt & Whitney Canada PW127E engine and accessories

1) Propeller Shaft	9) Fuel inlet	17) Oil level sight glass
2) NP Pulse pickup probe	10) Low pressure fuel filter	18) Oil tank filler cap
4) Mechanical fuel control	11) Main oil filter impending bypass indicator	22) Characterization plugs
5) Power lever	12) Main oil filter	23) Mounting pad
6) High pressure fuel filter	13) No. 6 and 7 oil pressure tube	24) Reduction gearbox module data plate
7) Fuel filters impending bypass indicators	15) Oil inlet	52) Auto feather unit
8) Fuel heater	16) Oil pressure regulating valve	53) Torque sensor

The affected engine was manufactured in May 1996 by Pratt & Whitney Canada. It was first installed on an ATR72-200 aircraft (registration N425MJ, operator: American Eagle) on 18 October 1996 as No.1 (LH) engine. Later it was operated on a number of other aircraft. Prior to its installation onto the accident aircraft it was on a Yangon Airways (Burma) aircraft. Upon termination of the lease agreement the engine was inspected and repaired by Avio (Italy) on 01 March 2011. The engine output was reduced from 1953 kW to 1876 kW (conversion from PW127F to PW127E). The engine then was sealed and stored. On 24 March 2011 the engine was leased to TAROM and installed on the YR-ATG aircraft.

1.6.4. Propeller data

Class	constant speed, electronically controlled, 6-blade composite propeller	
Type	HS568F	
Manufacturer	Hamilton/Ratier Figeac	
Position	1	2
Serial number	not relevant	FR980652
	hours / cycles flown	
Since manufacturing	not relevant	20,281 hrs / 20,859
Since last overhaul	not relevant	5,465 hrs / 5,861

1.6.5 Loading data

Aircraft load and balance data had no effect on the course of the events therefore their analysis was not required.

1.6.6 Failure statistics

According to the information provided by the aircraft manufacturer ATR the accumulated flight performance of aircaft types equipped with PW127 class engines (ATR42 and ATR72) is approximately 7,234,000 hours to date of the occurrence. There were nine known cases of engine flameout, forced shutdown or power loss due to turbine blade fracture. Out of the here-mentioned nine cases four failures included the fracture of the oil pipe that lubricates bearings 6 and 7 (as in the investigated case). Out of these four, in three cases engine fire and fire extinguishing action took place. Out of these three, in two cases the fire caused damage to the engine and/or its surroundings.

1.6.7 On-board warning systems

The aircraft was equipped with a transponder, Traffic Alert and Collision Avoidance System (TCAS), Ground Proximity Warning System (GPWS) and Terrain Awareness and Warning System (TAWS). The engines were equipped with a twin-loop fire protection system. This system monitors the inside of the engine nacelles and warns the pilots if there is an abnormally high value or a rapid increase in the air temperature. The system functioned as intended during the occurrence.

1.7 Meteorological data

The weather on the day of the occurrence was a typical summer day with no precipitation and moderate Westerly wind. There was no weather phenomenon to

affect normal air operations. Visibility was 35-40 km, cloud base was over 5000 feet therefore CAVOK conditions persisted.
Air temperature at runway level was 25 degrees Celsius, dew point 15 degrees Celsius. Air pressure values were as follows: QFE 998 hPa, QNH 1014 hPa.

Wind measured near 31L threshold at the time of takeoff was 11 knots from 250°. Average wind for the previous 2 minutes for the same location was 9 knots with 12 kn gusts from 280°, deviation less than ±30°.

Wind measured near 13L threshold at the time of landing was 11 knots from 265°, it had a 7-knot tailwind and 8-knot crosswind component. Average wind for the previous 2 minutes for the same location was 11 knots with 14-knot gusts from 260° that had an effect of a 7-9 knot tailwind.

1.8 Aids to navigation

The aircraft was equipped with standard navigational instruments and they functioned normally. They had no effect on the course of events therefore their analysis was not required.

1.9 Communication

The land-based and the on-board communication equipment functioned normally.

According to the purser’s testimony, when she noticed the engine fire she tried to call the cockpit by pressing the PA system’s EMER button but the pilots did not answer because they were busy with the handling of the engine failure/fire and the preparation for emergency landing. The purser then attempted to instruct the passengers to take their seats but was unable to use the PA system (the EMER button was flashing).

By design the PA system gives priority to EMER calls if the handset is lifted and the EMER button is pressed. A relay keeps the call active until either someone in the cockpit answers the call or press the RESET button on the PA panel of the cockpit. The EMER (priority) call can also be cancelled from the passenger cabin by putting the handset back to its cradle. Upon resetting the EMER call, the PA system returns to standby and the cabin crew can address the passengers by pressing the PA button.

1.10 Aerodrome information

The takeoff and the emergency landing took place at Budapest Liszt Ferenc International Airport, ICAO code LHBP, IATA code BUD, GPS coordinates: N47º26’22” E019º15’43”. Runways: 31L (3,010 m) and 31R (3,707 m), surface: concrete. At the time of the occurrence the ICAO Rescue Fire-Fighting (RFF) category was 9 for both runways.

The airport of destination was Bucharest Otopeni (LROP / OTP).

1.11 Flight recorders

The aircraft was equipped with a flight data recorder listed in the type certificate.

Flight Data Recorder	**Manufacturer**	L3 Communications
	Type	F1000
	Serial number	01630
	Number of recorded parametres	26
	Location of readout	TAROM, Bucharest
	Location and status of the equipment on aircraft	position of installation, operative

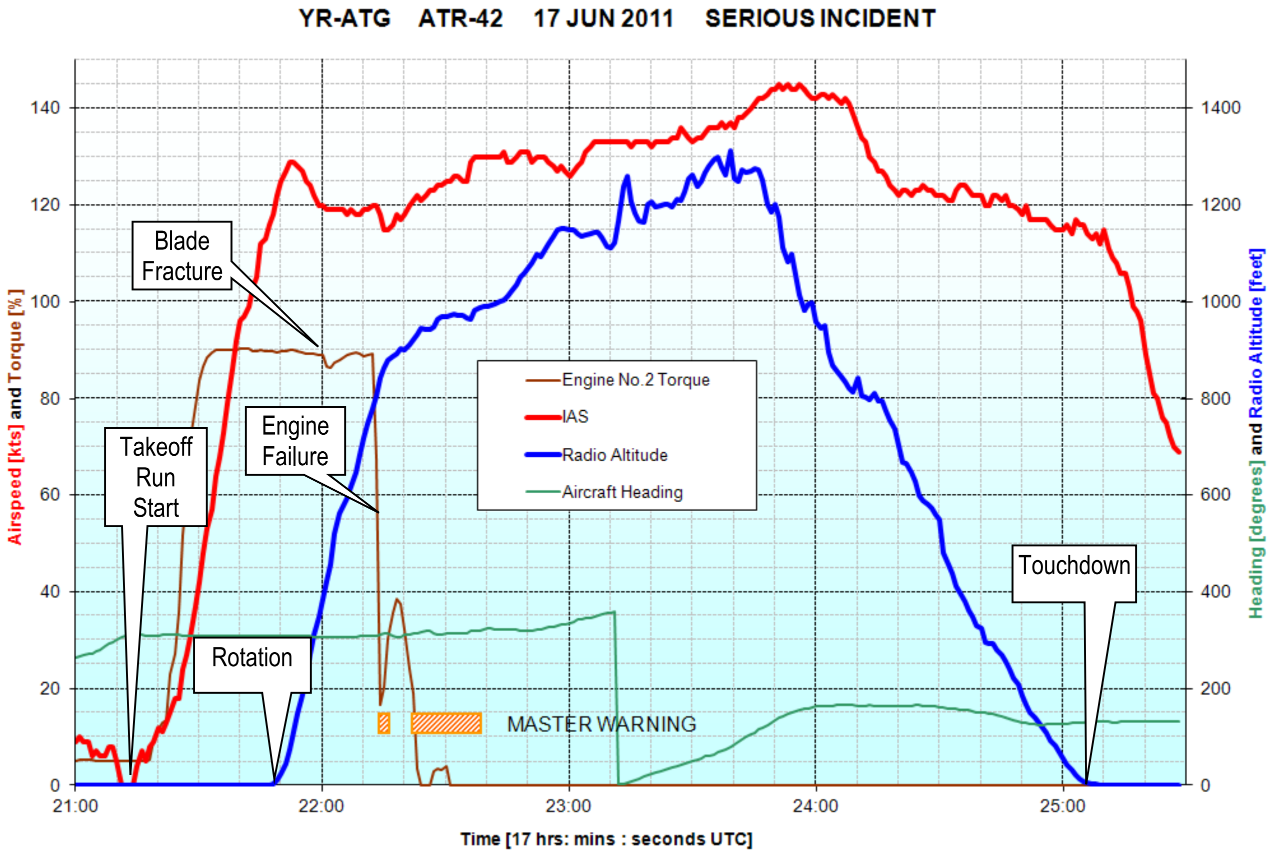


Fig. 7: Main parametres shown for the full duration of the flight

The occurrence flight parametres were downloaded from the FDR and analysed. Fig. 7 shows a selected set of parametres for the duration of the flight. It can be determined that the first sign that something was wrong in engine No.2 was a momentary drop of torque, 42 seconds after the start of takeoff run and 11 seconds after rotation. Another 12 seconds later turbine RPM, propeller RPM and torque went to steep fall. Torque dropped to zero in 2 seconds while the propeller stopped in 19 seconds. The gas generator section of the engine stopped another 10 seconds later. The low oil pressure warning came in for 2 seconds when the torque first dropped, followed by the engine fire warning 6 seconds later. It is remarkable how quickly the flight crew reacted to the low oil pressure warning: they started to reduce thrust on engine No.2 two seconds after the warning (see Fig. 8, black line, PLA_2).

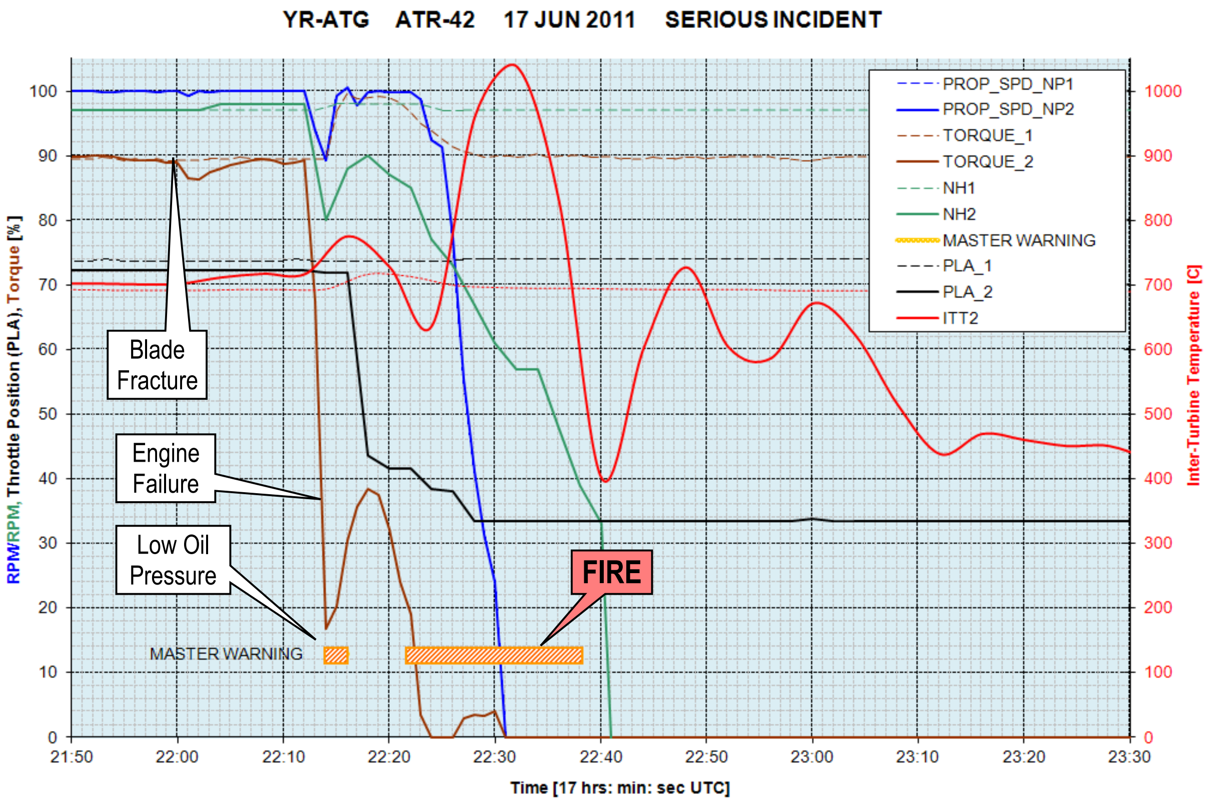


Fig. 8: Main engine parametres at the time of failure

1.12 Wreckage and impact information

There was no wreckage.

1.13 Medical and pathological information

The IC does not have information on the crew's psychophysical condition prior or during the flight.

Medical forensics examination

Not applicable.

1.14 Fire

As a result of major failure of engine No.2 a fire developed in the engine nacelle. The fire protection system triggered a fire warning to which the flight crew responded and successfully put out the fire with the built-in fire extinguishing system. The fire caused considerable damage near the turbine section but was confined to the inside of the nacelle (see Fig. 3 and 4).

1.15 Survival aspects

The flight crew successfully put out the fire in the No.2 engine nacelle with the built-in fire extinguishing system before landing. The fast and successful fire suppression was a result of the quick response of the flight crew as well as of the fact that the failed engine stopped thus cutting off the supply of the lubricating oil that fueled the fire through the damaged oil pipes.

RKI was notified at 17:22. The firefighter vehicles of Central and Cloud Bases arrived at the runway 13L at 17:25, providing immediately available firefighting and rescue support.

The aircraft taxied to the intersection of taxiways X and A8 (see Fig. 9) where the captain ordered emergency evacuation. There was no physical injury. Only one passenger - who was affected by the stress of the situation - needed medical assistance.

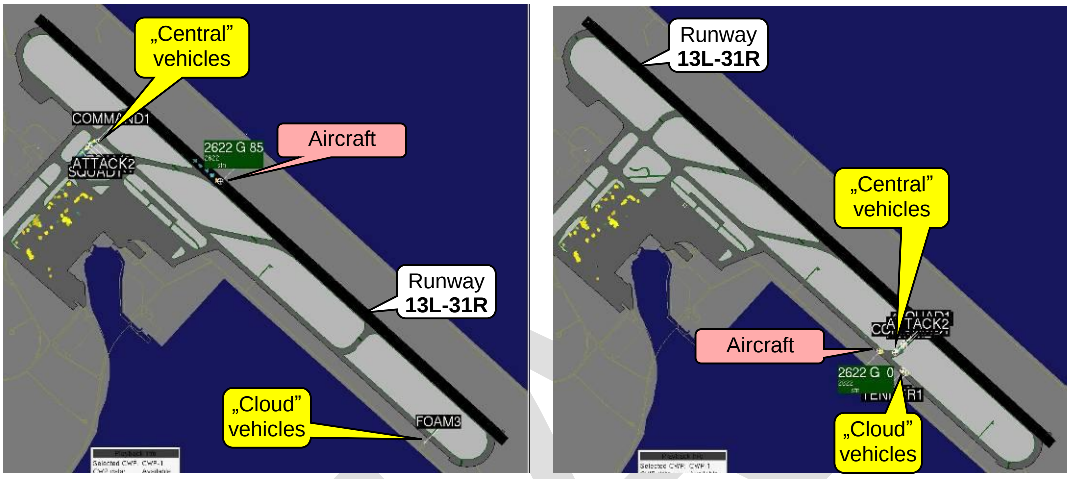


Fig. 9: Position of the RKI vehicles at the time of landing and stopping as shown on Advanced Surface Movement Guidance & Control System (A-SMGCC) screen

1.16 Test and research

The failed engine was removed from aircraft and shipped to the premises of maintenance and repair company Avio at Pomigliano d'Arco, Italy, near Naples. The engine teardown and inspection took place on 13 July 2011 in presence of representatives from all concerned parties (Fig. 10). Upon request of the IC the power turbine rotor disk assembly was removed and shipped to the manufacturer for further examination.

1.16.1 Engine teardown and inspection

Fig. 10: Engine inspection prior to disassembly at Avio, 13 July 2011

Findings during engine inspection:

- Fire damage on wiring and near turbine section (at a number of places).
- Mass fracture of Power Turbine 2nd stage (PT2) blades.
- Radially displaced oil pipes (supply, drain, ventilation) of bearings 6-7.
- Broken ventilation pipe of bearing 4.
- Oil level normal (1 mark below Full).
- Main and return line oil filters blocked (blockage indicators out).
- Dirty turbine chip indicator.
- Clean gearbox chip indicator.
- Chip on the low pressure rotor RPM sensor.
- Gas generator section rotors rotate freely.
- Power Turbine seized.

Findings during engine teardown:

- **PT2 rotor** (Fig. 11, RH photo): Impact damage on all blades. Scratching marks on the frontal surface of the rotor.
- **PT2 stator**: Damaged leading edges on vanes. Heavy damage on the outer areas of Stage 2 near 10 and 4 o'clock as well as of Stage 1 near 4 o'clock.
- **PT1 rotor** (Fig. 11, LH photo): Two missing blades (No. 41 and 47).
- **Joing housing of bearings 6-7** (Part No.: 3111633-01): Damaged seal. The conical end part of radial oil pipes found in the bearing housing, broken.
- **Radial oil pipes of bearings 6-7** (3 pipes) (Part No.: 3111243-01): Broken (see above)

Fig. 11: Power Turbine Stage 1 and Stage 2 rotor disks

1.16.2 Laboratory examination of PT1 rotor disk assembly (at the manufacturer)

PT1, blade No.41

A close-up photo (Fig. 12) shows the surface of the fracture. The High Cycle Fatigue (HCF) affected area is highlighted. (The rest of the damage was caused by tensile overload.)

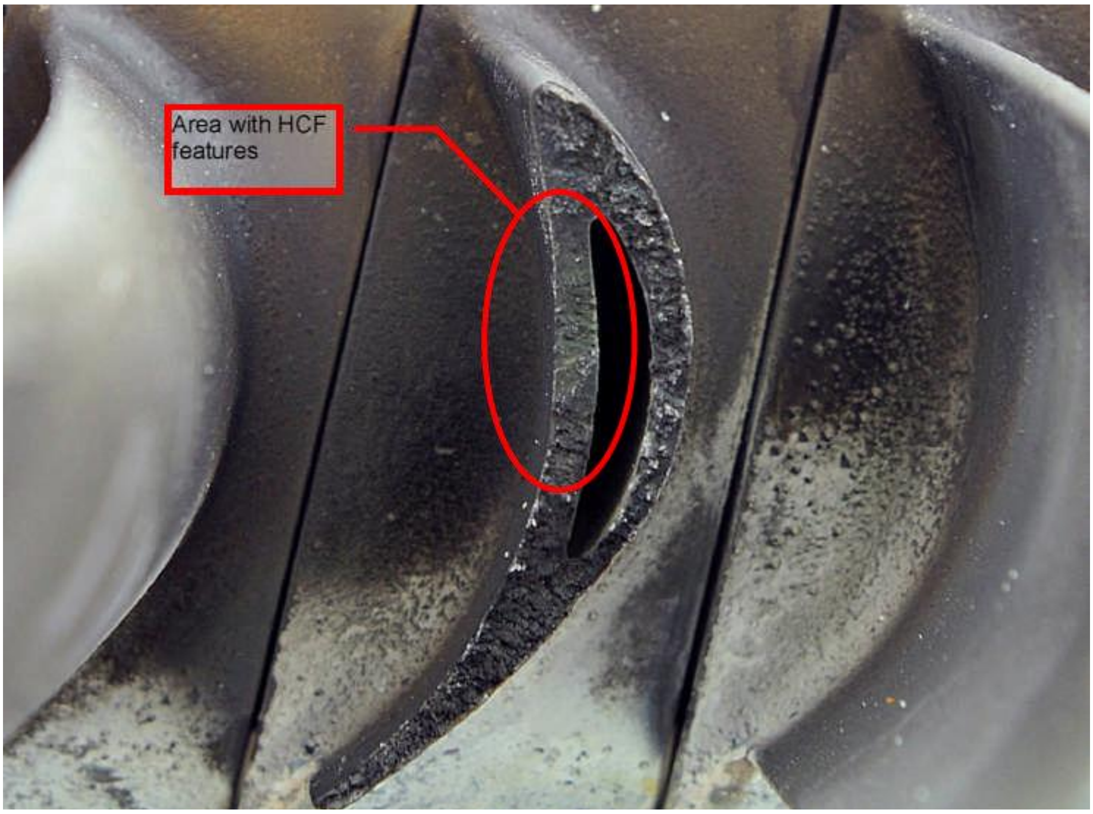


Fig. 12 (source: Pratt & Whitney Canada report No. 11GS00021)

A photo taken with a scanning electron microscope (SEM) shows a more detailed view of the HCF area (Fig. 13). The yellow arrow indicates the location of the material defect from where the fatigue crack started to develop while the narrow red arrows show the directions of the propagation of the crack.

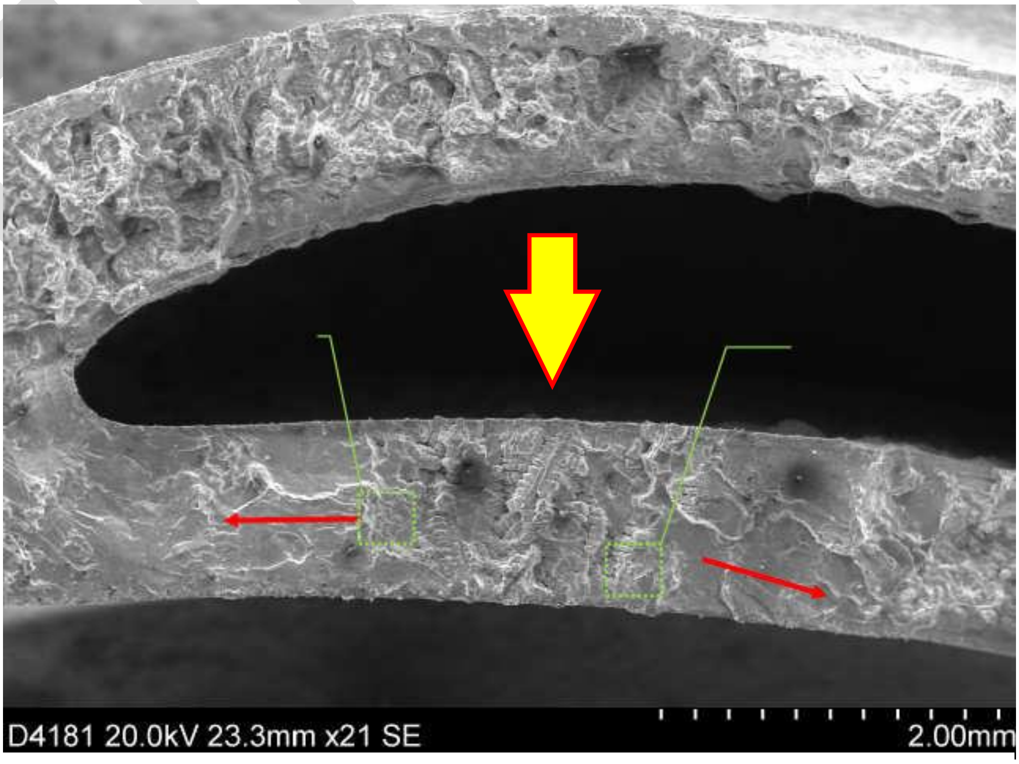


Fig. 13 (source: Pratt & Whitney Canada report No. 11GS00021)

A higher resolution SEM photo (Fig. 14) shows the details of the material defect (a microshrinkage porosity).

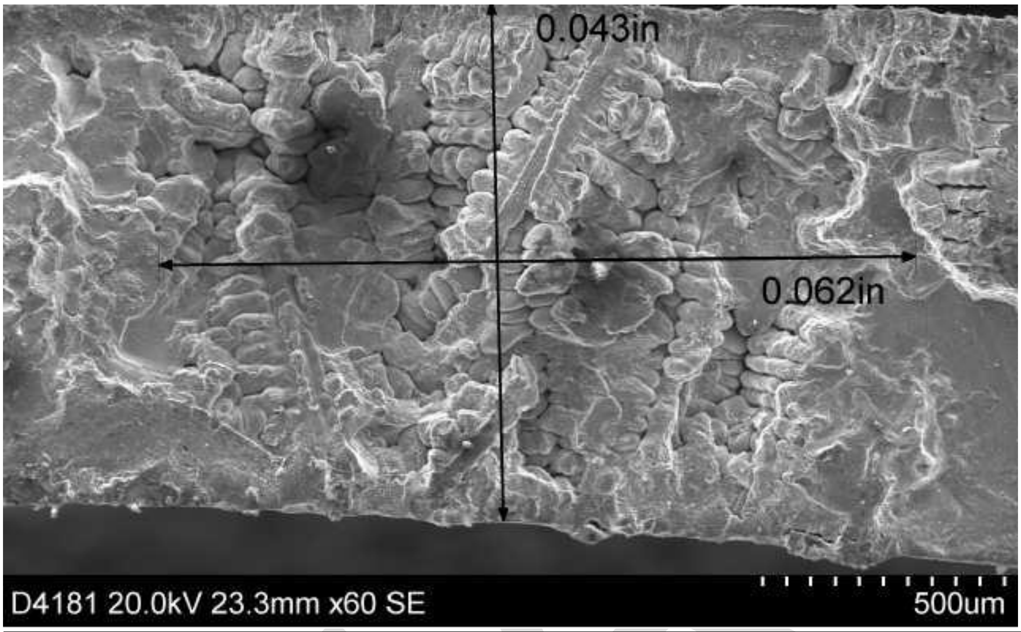


Fig. 14 (source: Pratt & Whitney Canada report No. 11GS00021)

PT1, blade No.41

A close-up photo (Fig. 15) shows the surface of the fracture. The High Cycle Fatigue affected area is highlighted. (The rest of the damage was caused by tensile overload.)

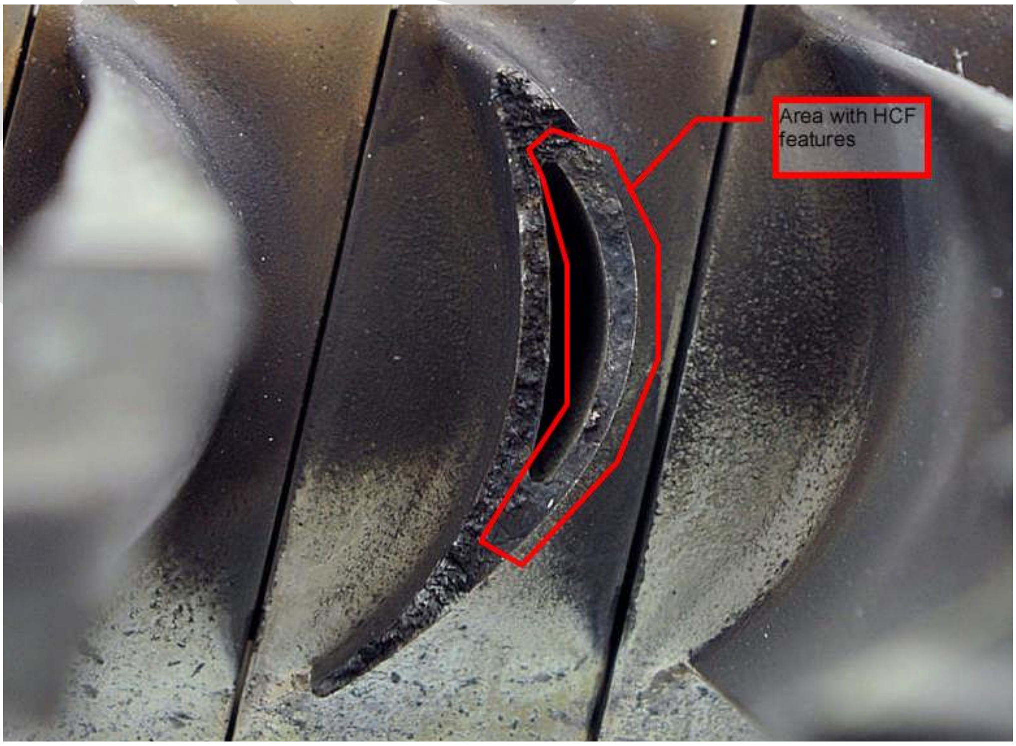


Fig. 15 (source: Pratt & Whitney Canada report No. 11GS00021)

Fig. 16 shows material defects and the propagation of the fatigue crack.

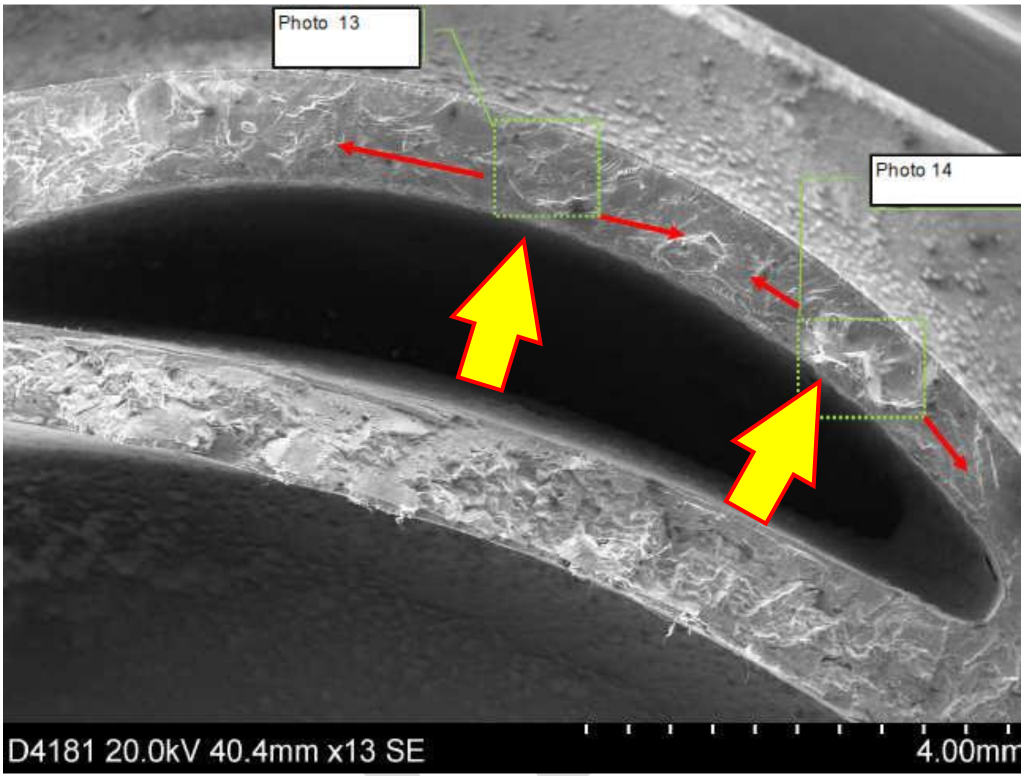


Fig. 16 (source: Pratt & Whitney Canada report No. 11GS00021)

Findings during the examination of turbine blades:

1. Turbine blades No.41 and 47 of PT1 were fractured due to fatigue caused by hidden material defect. Probably the failure process was started by the fracture of blade No.47 because it had a longer fatigue crack.
2. On the concave surface of blade No.41, 0.32” above blade platform there is a material defect (size 0.062”x0.040”). A crack developed from here towards both leading and trailing edge of the blade. The blade fractured when the length of the crack reached 0.25”. Since the broken blade is missing, it was impossible to determine whether the hidden material defect could have been revealed by X-ray inspection. The X-ray photos taken at the time of manufacturing of the blade were not available (they were discarded when their obligatory storage period expired).
3. On the convex surface of blade No.47, 0.20” above blade platform there are two areas of material defect from where fatigue cracks developed. One of these areas contain a number of defects (sized 0.001” – 0.003”) while the other one has only one (size: 0.012”x0.005”). Fatigue cracks started from these areas propagated towards the leading and trailing edges, then merged and continued to advance. The blade fractured when the length of the crack reached 0.625”. Since the broken blade is missing, it was impossible to determine whether the hidden material defect could have been revealed by X-ray inspection. The X-ray photos taken at the time of manufacturing of the blade were not available (they were discarded when their obligatory storage period expired).
4. Metallographic analysis revealed that the blades were not exposed to extreme high temperatures near the fracture area. According to the results of chemical analysis the material composition was in line with design values.

5. Microstructure evaluation performed on blade No.40 revealed that the blade had been exposed to extreme high temperature, 0.70” above blade platform. Based on material structure it is most probable that the exposition took place after manufacturing.
6. The turbine blades of PT2 were damaged by debris from PT1.

1.17 Organisational and management information

Not applicable.

1.18 Additional information

1.18.1 Similar occurrences that took place after the subject occurrence

During the investigation of the subject serious incident the IC was informed of two similar occurrences. These occurrences were investigated by ANSV and AIB Denmark.

– An ATR72-212A aircraft, registration OY-CIM, equipped with two PW127 engines took off from Copenhagen Kastrup (EKCH) on 13 September 2011. Near 130 feet above ground the LH engine triggered low oil pressure and high turbine temperature warnings, while smoke was present in the cockpit and the passenger cabin. At 750 feet the flight crew received fire warning for the LH engine. Sequentially, both fire agents were discharged and the fire was extinguished successfully. The pilots decided to return to Kastrup and successfully landed after 5 minutes of flying.

– An ATR72-212A aircraft, registration I-ADCC, equipped with two PW127 engines took off from Firenze Peretola (LIRQ) in a bleed-off configuration on 3 October 2011. Near 400 feet above ground the pilots received a short low oil pressure for Engine No.1 (LH engine) warning that disappeared. The pilots considered the warning as faulty indication but shortly another warning followed about engine fire, and at the same time smoke entered the cockpit and the cabin. The pilots stopped the engine, followed the emergency checklist for engine fire, and landed on the departure airport.

The IC wishes to mention a third occurrence similar to the above ones. An ATR-72-500 aircraft operated by Swiftair took off from Madrid for Vigo on 24 June 2013. Shortly after takeoff the LH engine (PW127F) triggered a fire warning. The pilots put out the fire using both agents, and landed successfully on the departure airport, with 69 passengers and 4 crewmembers on board. As of the date of this document, the investigation of the Madrid occurrence was still in progress but according to the interim report issued by the Spanish authorities the engine failure was caused by turbine blade fracture.

1.18.2 Findings regarding the operation of the aircraft's PA system

Fig. 17: The rearward PA station

During the emergency landing the Chief Flight Attendant (Purser) initiated an emergency call to the cockpit from the rearward PA station (see Fig. 17) by lifting the handset and pressing the EMER button. When pushed, the EMER button blocks the other buttons of the station including the PA button. The blockage is released when the call is answered or cancelled from the cockpit, or the handset of the station is replaced to the cradle.

1.18.3 Common characteristics of the three occurrences investigated by the competent authorities

ANSV and AIB Denmark launched investigations concerning the serious incidents described under **1.18.1**. The two safety investigating authorities and TSB HU held a joint meeting in February 2012 at ANSV premises where representatives of the concerned manufacturers, operators and respective safety investigating authorities were also present. In the course of the meeting the representatives came to the following conclusions:

- All three investigated events took place during initial climb.
- In all three cases the engine failure started with a blade fracture in PT1. As a result, PT1 became imbalanced, and the subsequent damages were a consequence of the imbalance as follows: the turbine bearing housing (for bearings 6-7) gets damaged - the oil pipes break - the oil spills onto the hot turbine housing sections - fire develops.
- In all three cases the turbine blades fractured due to fatigue crack caused by hidden material defect (microshrinkage porosity).
- The engine manufacturer modified the X-ray inspection technology of the maufactured turbine blades in April 2008 in order to reduce the probability of future defects. The updated method introduces an additional X-ray photo of the blade taken of the most critical part of the blade called the core pocket. Moreover, all previous X-ray photos were re-evaluated and 68 blades were issued a limited service life (via SB 21766).
- The subject engine statistics show 28 PT blade fracture events between 2005-2011 (with most having occurred between 2008-2009) therefore the fatigue fracture of PT1 blades cannot be considered as discrete failure. There is no provable direct correlation between the probability of failure and the service life.

The failures took place in random intervals and the cause was microshrinkage porosity formed during manufacturing.

- There were instances of blade fracture due to fatigue with new PT1 blades manufactured after implementing the improved X-Ray inspection, although at the moment they only have accumulated a limited number of cycles.
- As of the date of this document, there is no robust POD (Probability of Detection) study available and the minimum casting defect able to promote the crack growth is unknown.
- As of the date of this document, there is no sufficient statistical data that would prove the efficiency of the advanced testing introduced in 2008.
- In all three cases the direct cause of the event was a major mechanical failure. The flight crews, however, initially were not aware of the true nature of the problem and handled it as in-flight fire. The investigations revealed that the emergency procedures in effect at the time of the events were not always unequivocal, especially if taking into consideration their frequent and numerous modifications. The available regulations, inparticular EU-OPS 1.130 do not provide clear guidance on how quickly and in what way the operators shall apply those modifications to the air operating manuals that are not issued in the form of an Airworthiness Directive.
- The Temporary Revision of the "engine fire at take-off" emergency procedure of the ATR flight operating manual approved in November 2011 introduced a large number of further memory items. The increasing number of memory items seems to reflect a general trend; however, careful consideration should be given to the potential negative effects of the consequent build-up of the crew workload.
- The ATR emergency procedure (air conditioning smoke) did not direct the flight crew's decision making on how to remove smoke from the cockpit and cabin if smoke persisted. Comparing to similar aircraft types (Saab 340, Fokker 50 and Dash 8), differences were noted and it was found that the ATR smoke emergency procedures seemed not to be sufficient if smoke was persisting and cockpit/passenger cabin ventilation was required.

1.19 Useful or effective investigation techniques

The investigation did not require techniques differing from the traditional approach.

2. ANALYSIS

2.1. Engine failure

Based on the available information the IC determined the most probable sequence of events that resulted in the failure of the engine and to the engine fire, as follows:

2.1.1 Power Turbine Stage 1 rotor blade fracture

Based on the findings of the laboratory inspection (see **1.16.2**) two turbine blades of the 1st stage (blades No.41 and No.47) fractured due to fatigue. The expert analysis gives a greater probability to a scenario where blade No.47 broke off first, based on the fact that the fatigue crack length in blade No.47 was more than twice the length of the crack in blade No.41. The cracks propagated from hidden material defects.

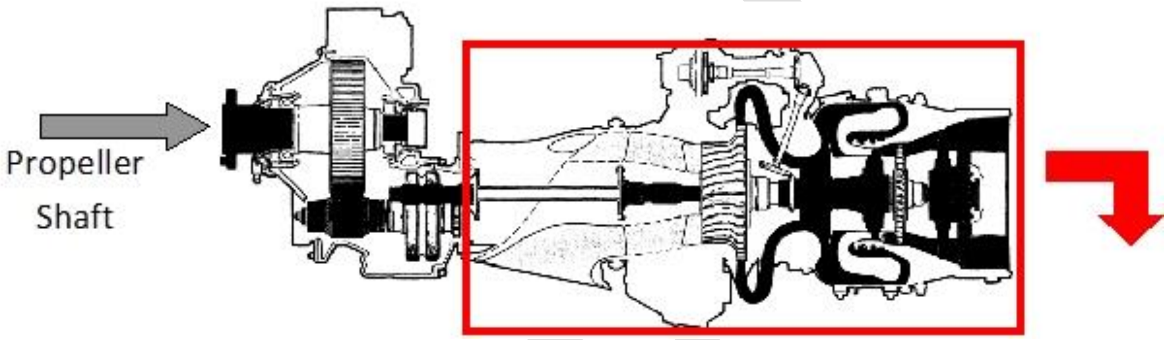


Fig. 18: PW127E engine schematics

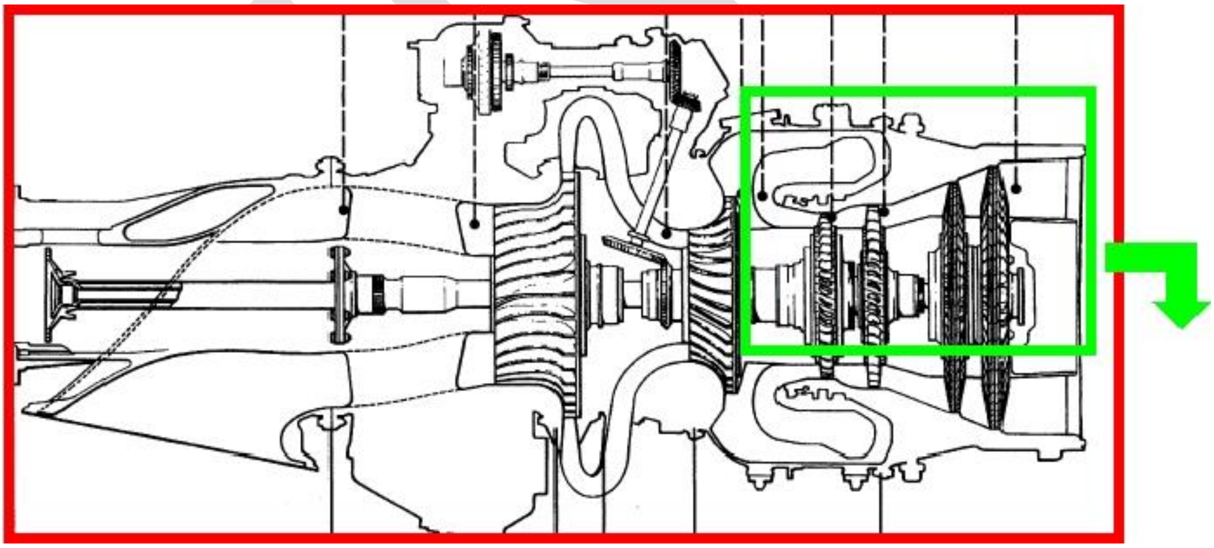


Fig. 19: PW127E engine stages

2.1.2 Engine damage sequence

1) Blade 47 (and possibly blade 41) in PT1 of RH engine break off. The broken blades damage the other blades of the PT1.
2) Consequential damage to PT2 due to debris moving downstream.
3) The whole Power Turbine becomes imbalanced.
4) Consequential imbalance of the low pressure turbine rotor.
5) The low pressure turbine rotor comes in contact with the housing of bearings 6-7 near the labyrinth seal area.
6) The shaft rotates the bearing housing along the axis of rotation.
7) Due to the above rotation the bearing housing radial oil pipes gets sheared.
8) Due to the broken supply oil pipe the engine oil pressure drops.
9) The engine oil spills into the engine nacelle.
10) The spilled oil comes in contact with hot engine parts and catches fire.

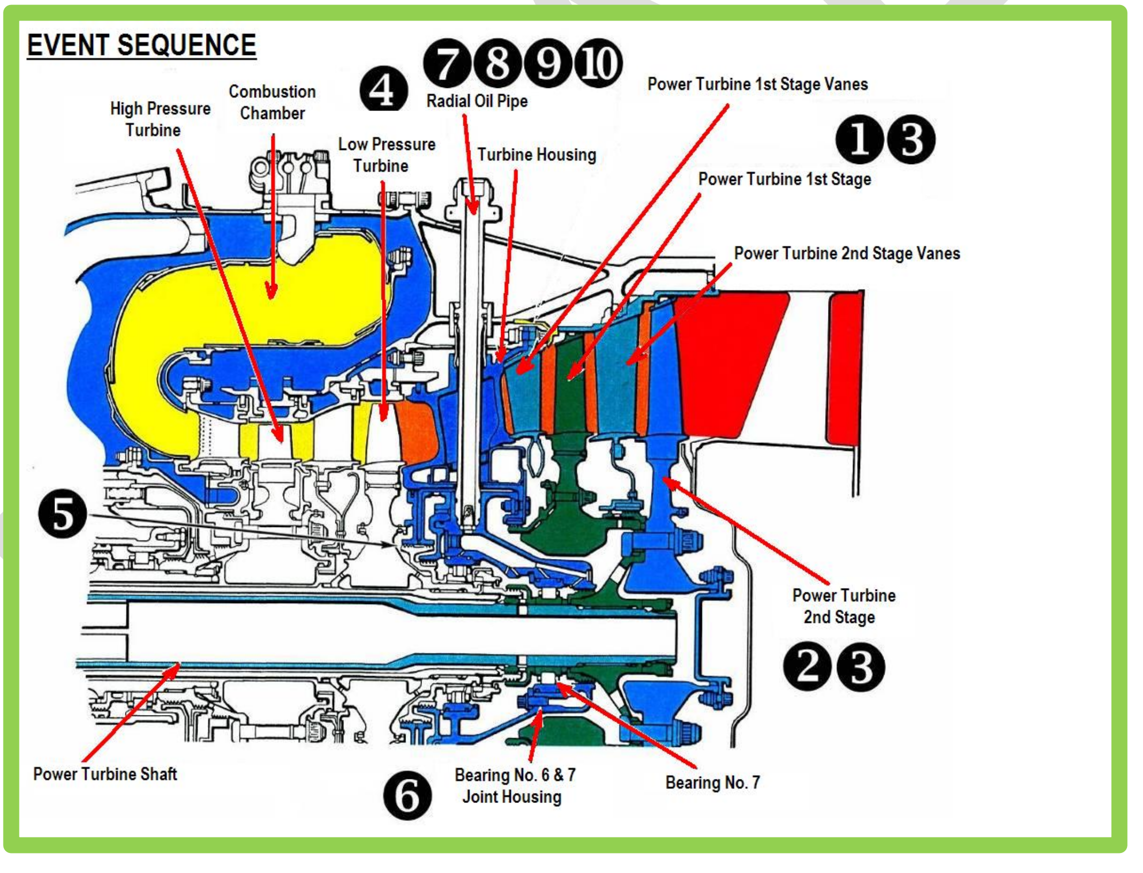


Fig. 20: Engine damage sequence (illustration for description in 2.1.2)

2.2. Problems with the operation of Passenger Address system

The cabin crew was unable to use the PA system during the emergency landing and the evacuation because the system remained blocked after pressing the EMER button. The pilots did not respond to the call because they were busy with the engine fire extinguishment and the emergency landing, and the purser – probably due to stress and because she urgently needed to use the PA system to calm down and instruct the passengers – did not reset the system by replacing the handset to the cradle.

3. CONCLUSIONS

3.1 Factual findings

The flight crew possessed the required certificates, authorizations and ratings as well as necessary experience. The flight was conducted in accordance with the relevant regulations in effect.

The aircraft was suitable for the flight and carried a valid airworthiness certificate. According to the maintenance documentation the aircraft was equipped with all necessary instruments and equipment, and was maintained in accordance with the relevant regulations and approved procedures.
Aircraft mass and balance was between the set limits.
The aircraft carried fuel of adequate quality and quantity.

After takeoff from Budapest two blades in PT1 of the RH engine fractured.

As a result, the turbine rotor disk assembly became imbalanced and excessive vibration developed.

Due to vibration the low pressure turbine shaft seized and moved the housing of bearings 6-7. The rotating housing broke the three radial oil pipes.

The spilled oil came in contact with hot engine parts and caught fire.

The engine fire protection system sent a warning to the cockpit. The flight crew activated the built-in fire extinguishing agents and successfully put out the fire inside the nacelle. At the same time the flight crew decided to return to the departure airport and made an emergency landing on runway 13L.

The RKI units arrived at the runway in 3 minutes after receiving alert.

The aircraft left the runway through a taxiway, stopped and the captain ordered emergency evacuation.

The Passenger Address system was not available for the cabin crew during the emergency landing and evacuation.

The IC did not find any information that would suggest problems regarding the air traffic control, airport operations or regular/line maintenance.

The IC received information about two other serious incidents in 2011, similar in character, with same aircraft type and engine type.

The subject engine statistics show 28 PT blade fracture events between 2005-2011 (with most having occurred between 2008-2009).

The engine manufacturer introduced an advanced post-manufacture testing of the turbine blades in 2008.

As of the date of this document, there is no sufficient data that would prove the efficiency of the advanced testing.

The Operation Manual for ATR42/72 aircraft has no items for smoke removal from the cabin.

The aircraft manufacturer introduced 3 changes within 14 months in the emergency procedures for ATR42 for engine fire and serious engine damage.

3.2 Factual findings that can directly be linked to the occurrence

Based on the available information the IC determined that the event had the following provable causes:

- The first step in the chain of events leading to engine failure was a Power Turbine Stage 1 blade fracture. The fracture was caused by a fatigue crack originated from a hidden material defect (microshrinkage porosity).
- The fractured blade inflicted damage to the downstream parts of the engine.
- The direct cause of the engine fire was the fracture of the oil pipes of bearings 6-7 and subsequent spilling of oil onto hot engine parts. The tubes were damaged when the bearings housing was rotated by the seized shaft.

4. SAFETY RECOMMENDATIONS

4.1 Recommendations issued during the investigation

Transportation Safety Bureau issued the following safety recommendations on 26 June 2012 while the investigation was still in progress:

BA2011-120-4P-1A *Investigations revealed that the emergency procedure (air conditioning smoke) did not direct the flight crew's decision making on how to remove smoke from the cockpit and cabin if smoke persisted. Comparing to similar aircraft types (Saab 340, Fokker 50 and Dash 8), differences were noted and it was found that the ATR smoke emergency procedures seemed not to be sufficient if smoke was persisting and cockpit/passenger cabin ventilation was required.*

Although in the serious incidents on subject this finding was not considered as a contributing factor, however, whether or not a similar incident takes place shortly after takeoff or at any altitude, no ATR smoke removal emergency procedure seemed to be at the disposal of a flight crew. For that reason, the signing investigation authorities regarded this finding as a flight safety issue, which needed further consideration.

> **TSB recommends to EASA to review the emergency procedures on ATR aircraft in order to ensure efficient removal of persisting smoke and appropriate cockpit/passenger cabin ventilation.**

The IC believes that the acceptance and implementation of the recommendation would enable the ATR crews to react to future cases more effectively – following proper guidance and training - when smoke is persisting and cockpit/passenger cabin ventilation is required.

BA2011-120-4P-2A *Fatigue failure of PT1 rotor blade was found a recurrent failure on this engine, with a total of at least 28 events already due to this root cause in the timeframe 2005-2011, with a peak in 2008-2009. As a consequence, in April 2008 the engine manufacturer improved the X-Ray inspection on the new blades by introducing an additional view specifically to be taken in the area of interest (core pocket). In addition, all retained X-Ray films were reviewed and 68 blades were limited in terms of service life in accordance with SB 21766.*

Furthermore, a previous recommendation was issued in 2010 by ASC-Taiwan as a result of a similar event occurred during take-off at Magong airport on 11 Feb 2009, requiring "to incorporate measures to efficiently detect the shrinkage porosity which beyond maximum allowable limits".

However, the recurrence of the failure in a wide range of accumulated cycles/flight hours shows that time to rupture cannot be predicted and it is mainly dependant on the size of the original shrinkage porosity. So, all other blades currently in service could be potentially affected by the same kind of deferred fatigue failure when a defect, not revealed at the first and only check for blades manufactured before 2007 or not detected at the second check in case of blades manufactured between 2007 and 2008, is big enough to propagate a crack.

> **TSB recommends to Transport Canada to consider the need to early withdraw from service the PT1 rotor blades manufactured before the introduction of NDT improvement or, alternatively, to urgently introduce a one shot X-Ray inspection on all those blades having accumulated a number of cycles beyond a limit to be established (e.g. 2000), specifically focused on the pocket area to exclude the presence of a fatigue crack.**

The IC believes that the acceptance and implementation of the recommendation would reduce the risk of similar or more serious occurrences caused by turbine blades that carry hidden core pocket area deficiencies large enough to allow for crack development.

BA2011-120-4P-3A *One more fatigue breakage was observed on new PT1 blades manufactured after implementing the improved X-Ray inspection, although at the moment they only have accumulated a limited number of cycles. In effect, in absence of a robust POD (Probability of Detection) study and with no knowledge of the minimum casting defect able to promote the crack growth, it seems there is still some uncertainty on the effective improvement achieved in terms of reliability of the parts.*

The significant increase in rejection rate at production, being only limited to 2011, at the moment cannot be considered as a proof of the effectiveness of the modifications introduced since 2008.

> **Taking into account the high volume of PT1 rotor blade production, TSB recommends to Transport Canada to consider the opportunity to introduce in production, at least as a temporary measure, an additional Computed Tomography check on a representative sample of blades in order to gain confidence on the effective improvement achieved through the review of the X-Ray methodology implemented in 2008.**

The IC believes that the acceptance and implementation of the recommendation would allow for a statistical proof for (or against) the effectivity of the improved X-ray procedure.

BA2011-120-4P-4A *All events were due to a severe mechanical damage and occurred at initial climb, although not necessarily immediately recognized as such by the crews and treated as an in-flight fire at a following stage.*

The investigation highlighted an uncertainty on the emergency procedure in force at the time of the event, considering the several amendments issued and ongoing on this subject.

Examination of the existing documentation, namely the EU-OPS 1.130, seems not able to clarify in mandatory terms the timeframe and the procedures to achieve the effective operator compliance on this item when the AFM modification is not accompanied by a dedicated AD.

> **TSB recommends to EASA to consider the need to harmonize the procedures, or to review the existing documentation as necessary, in order to establish in all cases a time limit within which to make effective in the AFM owned by operators the amendments approved by EASA.**

The IC believes that the acceptance and implementation of the recommendation would make it easier for the operators to track changes in air operating manuals.

BA2011-120-4P-5A *ATR AFM Temporary Revision of the "engine fire at take-off" emergency procedure approved in Nov. 2011 introduced a large number of further memory items.*

The increasing number of memory items seems to reflect a general trend in the implementation or review of the emergency procedures; however, it seems highly desirable that a careful consideration take place on the potential negative effects of the consequent build-up of the crew workload.

In this case, in addition to a delay of the shutoff action on the affected engine, it may potentially cause an area of hazard taking into consideration the criticality of the phase of flight.

TSB recommends to EASA to promote an internal debate (e.g.: dedicated working group, workshop, etc.) to carefully evaluate the pros and cons of a continuously increasing of memory items introduced in the implementation or review of the emergency procedure, mainly when to be applied in a critical phase of flight.

The IC believes that the acceptance and implementation of the recommendation would result in emergency procedures with optimized „memory items" as far as their number and complexity are concerned, especially in chapters relevant for the critical phases of flight.

4.2 Recommendations issued after the investigation

Transportation Safety Bureau issues the following post-investigation safety recommendation:

BA2011-120-4P-6 *The IC determined during the investigation that the cabin crew was not able to use the Passenger Address (PA) system during the preparation to emergency landing, the landing and the evacuation while it would have been necessary to calm down the passengers and to pass instructions. The PA system was blocked when a cabin crew member tried to call the cockpit by pressing the „EMER" button but received no reply. The blocking could have been released by replacing the handset back to its holder.*

TSB recommends to EASA to consider a modification of the Passenger Address system on ATR aircraft and all other aircraft equipped with similar passenger address systems that it allows release of „EMER" blocking with the PA button (situated next to the „EMER" button) or in other suitable way.

As a temporary measure until the above recommendation is implemented, TSB recommends to EASA to apply changes in the Cabin Crew Operating Manuals of the affected aircraft types in order to direct the attention of cabin crew members with more emphasis to the possibility of PA blocking release by replacing the handset back to its holder.

The IC believes that the acceptance and implementation of the recommendation would ensure enhanced robustness of PA system fuctioning on ATR cabin and, as a result, cabin crews would be able to handle emergency situations more effectively.

4.3 Actions taken during the investigation

4.3.1 Transport Canada reply (26 Sep 2012)

Transport Canada (TC) agrees that the removal of 2005-2008 batch PT1 blades from service will help mitigate the problem of premature blade fracture due to micro porosity on PW127 engines. Pratt&Whitney Canada (P&WC) in-service data has demonstrated since the introduction of the improved X-ray inspection methodology in April 2008, over 133,000 blades have been produced and, in PW127 application, these blades have incurred an estimated 6 million engine hours with only one confirmed blade fracture due to porosity (1.7e mínusz a hetediken per flight hour). P&WC is in the process of revising the existing blade casting inspection process and in early 2013 plan to introduce Digital X-ray technology to improve the acuity of inspection X-ray films.

P&WC will soon be releasing (SB 21823-Sept 2012) where a onetime inspection of the in-service affected PT1 blades will be mandated through a Transport Canada Airworthiness Directive. The inspection will be carried out using the post 2008 X-ray inspection methodology, for data has shown this method to be twice as effective as the pre 2008 process. Transport Canada is confident that the proposed inspection, rather than replacement of affected blades, will achieve the same level of safety with a reduced burden to operators.

Transport Canada believes that the given range of running times accumulated prior to these fractures; a mandatory onetime X-ray inspection of all in-service 2005-2008 batch PT1 blades would be more effective than the inspection of only some time-limited blades, as recommended. Additionally P&WC will establish a recommended soft-time replacement of PT1 blades at a time that would coincide with or near 2nd engine overhaul.

P&WC has also identified a number of operators believed to be at increased level of risk for blade fracture due to a combination of operating environment, PT blade service times and operational experience. P&WC is working closely with these operators to refresh their PW100 engines with new blades.

4.3.2 EASA reply (8 Jan 2014)

Recommendation (BA2011-120-4P-4A):

TSB recommends to EASA to consider the need to harmonize the procedures, or to review the existing documentation as necessary, in order to establish in all cases a time limit within which to make effective in the AFM owned by operators the amendments approved by EASA.

Reply:

The Agency understands that the intention of the Safety Recommendation is to establish a time limit for operators to apply changes in the aircraft flight manual (AFM) as provided to them by the manufacturers.
This Safety Recommendation is being considered within the framework of rulemaking tasks RMT.0516 and RMT.0517 'Updating Authority Requirements (Part-ARO) and Organisational Requirements (Part-ORO)', which were launched on 16 Sep 2013 with the publication of the associated Terms of Reference.
Status: Closed- partial agreement.

4.3.3 EASA reply (10 April 2014)

Recommendation (BA2011-120-4P-5A):

TSB recommends to EASA to promote an internal debate (e.g.: dedicated working group, workshop, etc.) to carefully evaluate the pros and cons of a continuously increasing of memory items introduced in the implementation or review of the emergency procedure, mainly when to be applied in a critical phase of flight.

Reply:

EASA promoted an internal debate with reference to the main aspect of the safety recommendation and in addition a specific study was conducted called "Checklist Memory Items", which has been published on EASA research web page. As reported in such study, an assessment of the available literature, in combination with the views of EASA experts and in addition to the feedback received from members of the European Human Factors Advisory Group, would suggest that memory items are not increasing either in terms of the number of items within the checklist itself or the number of checklists themselves. The advent of new technologies has resulted in a reduction and in a better management of the memory items within checklists as compared to older aircraft. As an example, with the introduction of Electronic Centralised Aircraft Monitor (ECAM) and Engine Indicating and Crew Alerting System (EICAS) the crew can easily monitor aircraft functions and system failures. In such systems messages detailing failures, lists of the procedures to correct the problem are provided to the crew that can instantly assess the situation and decide on the actions to be taken. They are designed to ease the crew workload in critical phase of flight, as well as in abnormal and emergency situations.
Status: Closed – Partially agreement.

Budapest, „ 11 „ January 2016

György HÁY
IIC

András KOVÁCS
IC member

APPENDICES

Appendix 1: ATR42 Emergency Checklist - Engine Fire
Appendix 2: ATR42 Flight Crew Operating Manual - Fire Detection
Appendix 3: ATR42 Flight Crew Operating Manual - Engine Fire Extinguishing System
Appendix 4: ATR42 Passenger Address System

NOTE:
This document is the translation of the Hungarian version of the draft report. Although efforts have been made to translate it as accurately as possible, discrepancies may occur. In this case, the Hungarian is the authentic, official version.

Appendix 1: ATR42 Emergency Checklist - Engine Fire

ATR 42-400/500	EMERGENCY	1.02	
		DEC 07	001

R

IN FLIGHT ENG FIRE OR SEVERE MECHANICAL DAMAGE

PL affected side .... FI
CL affected side .... FTR THEN FUEL SO
FIRE HANDLE affected side .... PULL
● **After 10 seconds**
FIRST AGENT affected side .... DISCH
■ **If fire after further 30 seconds**
SECOND AGENT affected side .... DISCH

LAND ASAP
SINGLE ENG OPERATION procedure (2.04) .... APPLY

ON GROUND ENG FIRE OR SEVERE MECHANICAL DAMAGE

PL 1 + 2 .... GI / REVERSE AS RQD
● **When aircraft stopped**
PARKING BRAKE .... ENGAGE
CL 1 + 2 .... FTR THEN FUEL SO
FIRE HANDLE affected side .... PULL
FIRST AGENT affected side .... DISCH
■ **If fire after further 30 seconds**
SECOND AGENT affected side .... DISCH

■ **If evacuation required**
ON GROUND EMER EVACUATION procedure (1.02) ... APPLY

ON GROUND EMER EVACUATION

AIRCRAFT / PARKING BRAKE .... STOP / ENGAGE
ATC (VHF 1) .... NOTIFY
CL 1 + 2 .... FTR THEN FUEL SO
MIN CAB LIGHT .... ON
CABIN CREW (PA) .... NOTIFY
FIRE HANDLES 1 + 2 .... PULL
AGENTS .... AS RQD
ENG START ROTARY SELECTOR .... OFF / START ABORT
FUEL PUMPS 1 + 2 .... OFF
EVACUATION (PA) .... INITIATE
● **Before leaving aircraft**
BAT .... OFF

Appendix 2: ATR42 Flight Crew Operating Manual - Fire Detection

ATR F.C.O.M.	FIRE PROTECTION	1.08.10		
		P 1	001	
	GENERAL			NOV 98

AA

10.1 DESCRIPTION

The fire protection system is provided in order to ensure :

- Detection for :
  - each engine fire
  - right nacelle overheat (on ground only)
  - each cargo compartment and toilets smoke
  - avionics compartment smoke
- Extinguishing for :
  - each engine
  - cockpit, cabin and each cargo compartment
  - toilets waste bin

ENGINE FIRE DETECTION SYSTEM

Each engine is equipped with a fire detection system which consists of :

- Two identical detection loops (A and B) mounted in parallel.
- A fire detection control unit.

The detection principle is based on the variation of resistance and capacitance of the detection cable (fire signal). If there is only a change in resistance, associated loop will be declared failed by the fire detection control unit (fault signal).

Red ENG. FIRE illuminates on CAP in case of :

- Fire signal detected by both loops A and B or,
- Fire signal detected by one of the 2 loops if the other one is selected OFF.

Appendix 3: ATR42 Flight Crew Operating Manual - Engine Fire Extinguishing System

ATR F.C.O.M.	FIRE PROTECTION	1.08.10		
		P 2	001	
	GENERAL			NOV 97

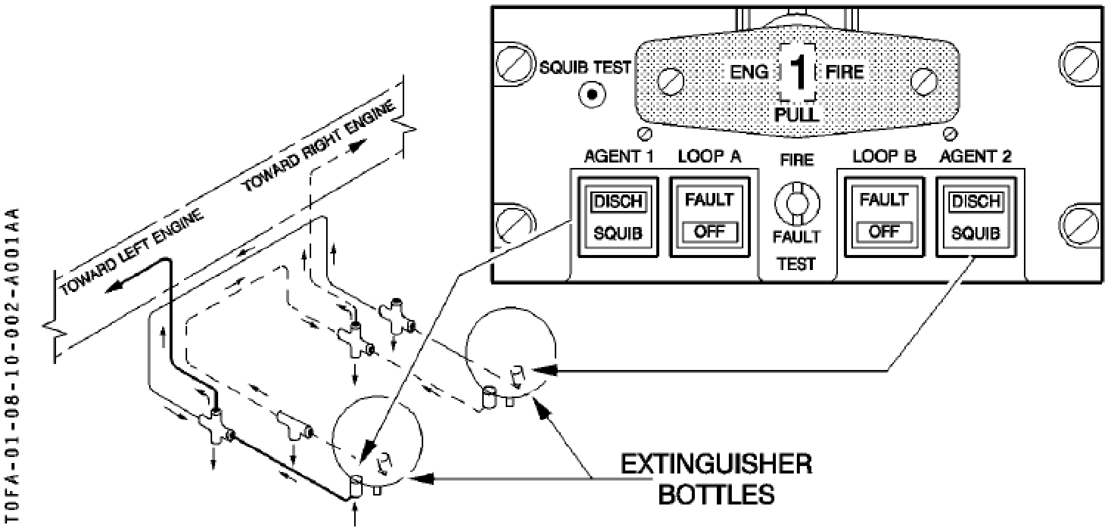
AA

R **AVIONICS SMOKE DETECTION** (See schematic 1.03.30 p. 3)

R The avionics extract air duct is provided with a smoke detection device, linked to the
R CCAS. Smoke detection between the avionics compartment and the extract fan
R activates a "ELEC SMK" red alert on CAP.

ENGINE FIRE EXTINGUISHING SYSTEM

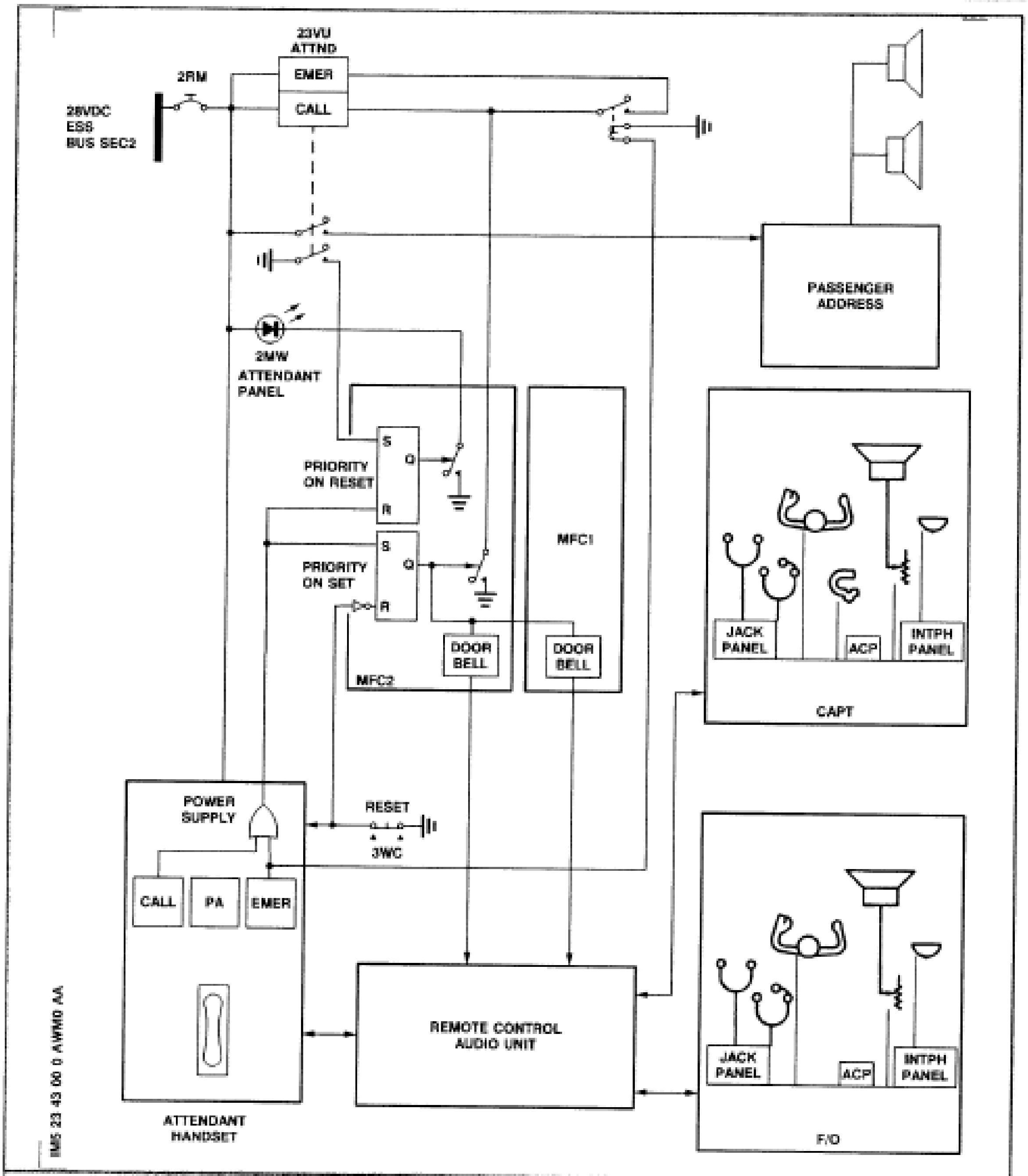
It includes two extinguishers bottles which may be used for engine n° 1 or engine n° 2. They are located on each side of the fuselage. Dual squibs are installed in the discharge heads on each bottle. For fire extinguishing, the squibs are ignited by depressing the correcponding illuminated AGENT pb on the ENG FIRE panel.
The extinguishing agent (freon or halon) is pressurized by nitrogen.



Appendix 4: ATR42 Passenger Address System

Customer : RO Type : ATR42-500 Rev. Date : Jul 01/11	Manual: AMMDO Selected effectivity: 507-507

23-43 : CABIN AND FLIGHT CREW CALL SYSTEM



23-43-00-002
Cabin and Flight Crew Call System - Block Diagram
** ON A/C ALL