MINISTRY OF
NATIONAL DEVELOPMENT
TRANSPORTATION SAFETY
BUREAU OF HUNGARY

FINAL REPORT

2014-230-4P
Incident

Budapest
11 June 2014

Boeing 737-600
TS-IOK

FINAL REPORT

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

NOTE: This document is the translation of the Hungarian version of the final 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.

INTRODUCTION

This investigation was carried out by Transportation Safety Bureau, Hungary 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.),
- Decree № 123/2005. (XII. 29.) of the Ministry of Economy and Transport on the rules of technical investigation of aviation accidents and incidents and other occurrences,
- Decree № 70/2015 (XII.1) of the Ministry of National Development on the technical investigation of aviation accidents and incidents, as well as on the detailed investigation for operators, and,
- In absence of other relevant regulation in the Kbvt., in accordance with Act CXL of 2004 on the general rules of administrative authority procedure and service.

The competence of the Transportation Safety Bureau of Hungary is based on Government Decree № 278/2006 (XII. 23.), and, as from 01 September 2016, on Government Decree № 230/2016. (VII.29.) 23) on assignment of a transportation safety organisation and on the dissolution of Transportation Safety Bureau with legal succession.

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 judgement - would have resulted in accidents in other circumstances.
- The Transportation Safety Bureau of Hungary is independent of any person or entity which may have interests conflicting with the tasks of the investigating organisation.
- In addition to the aforementioned laws, the ICAO Doc 9756 and the ICAO DOC 6920 Manual of Aircraft Accident Investigation are also applicable.
- This Final Report shall not be binding, nor shall an appeal be lodged against it.

Incompatibility did not stand against the members of the IC. The persons participating in the technical investigation did not act as experts in other procedures concerning the same case and shall not do so in the future.

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 its disclosure pursuant to the relevant act – available for other authorities.

FINAL REPORT

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FINAL REPORT

DEFINITIONS AND ABBREVIATIONS

31L	31 Left: Left hand side runway heading 305 - 315 degrees
A-SMGCS	Advanced Surface Movement Guidance and Control System
ADC	Aerodrome Controller
APP	Approach
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
°C	Degree Celsius (temperature value according to the 100-degree temperature scale)
CFM International	Joint venture between GE Aviation (USA) & Snecma (France)
knot	British and US unit of speed (= 1 n.mile/hour ≈ 1.85 km/h)
EASA	European Aviation Safety Agency
EGT	Exhaust Gas Temperature
FADEC	Full Authority Digital Engine Control
Fire equipment	Fire trucks or other devices used to extinguish fire
GKM	Ministry of Economy and Transport
GRC	Ground Controller
hPa	Hectopascal –SI unit of pressure (1 hPa = 100 Pa [N/m^2])
IC	Investigating Committee
ICAO	International Civil Aviation Organization
Kbvt.	At CLXXXIV of 2005 on the technical investigation of aviation, railway and marine accidents and incidents (hereinafter referred to as „Kbvt.")
KHVM	Ministry of Transport, Communications and Water Management
MCDU	Multifunctional Control Display Unit
ME/IR	Multi-Engine / Instrument Rating
MHz	Megahertz: SI unit of frequency (1MHz=10^6Hz)
N1 and N2	Rpm of the low-pressure (N1) and high-pressure (N2) rotating parts of the turbojet / turbofan engine
NTA AA	National Transport Authority, Aviation Authority (Hungary)
NTSB	National Transportation Safety Board (investigating entity in the USA)
TRE / SFE	Type Rating Examiner / Synthetic Flight Examiner
TRI / SFI	Type Rating Instructor / Synthetic Flight Instructor
TSB	Transportation Safety Bureau of Hungary
UTC	Universal Time (Coordinated): (Where otherwise not stated, all times in this Report are given in UTC.)
Z	indicates that the time it follows is given in UTC (e.g.16:21Z)

FINAL REPORT

Figure 1: *The aircraft towed back to its stand as seen by the IC upon arrival*

Figure 2: *Aircraft instrument displays after the engines were turned off.*

SUMMARY OF THE OCCURRENCE

Occurrence category		incident
Aircraft	**Class**	Land aircraft equipped with engine
	Manufacturer	The Boeing Co.
	Type	737-600
	Registration mark	TS-IOK
	Operator	Tunis Air
Occurrence	**Date and time (UTC)**	10 June 2014, 16:30
	Location	Budapest Liszt Ferenc International Airport

The aircraft was damaged in the incident.

Reports and notifications

The occurrence was reported to the duty service of Transportation Safety Bureau of Hungary (hereinafter referred to as "TSB") by the responsible officer of the airport on 10 June 2014 at 18: 35 hours.

The duty service of TSB

– informed the person on duty of NTA AA on 10 June 2014, at 18:42 hours.

– notified the investigating organisation of the country of the operator (Tunisia) on 13 June 2014.

– notified the investigating organisation of the country of the manufacturer (USA) on 12 June 2014.

– notified the investigating organisation of another country involved (France) on 12 June 2014.

Investigating Committee

On 10 June 2014, the Director General of TSB assigned the following investigating committee (hereinafter referred to as "the IC") to investigate the occurrence:

Investigator in Charge	György HÁY	Investigator
Member	Gábor TORVAJI	Investigator
Member	László BOGÁR	On-site investigation technician

Overview of the investigation process

The IC visited the scene after the incident. They viewed the aircraft and the malfunctioned engine, took photos of the aircraft, the engine, as well as the documents of the aircraft, the flight, and the crew. They notified the affected Tunisian (operation), US (aircraft manufacturer), and French (engine manufacturer) authorities and the EASA. They downloaded and safeguarded the information from the flight data recorder of the aircraft. They obtained the audio and video records related to the event from the air traffic control. They requested the reports on the event from Airport Fire Service and from Airside Management DAM Service, as well as the documents of the engine check and engine replacement in Budapest. After checking the malfunctioned engine, the IC obtained the investigations results from Lufthansa Technik and CFM, the engine manufacturer. The IC asked for and received help from BEA and NTSB, the French and US accident investigating organisations with the evaluation of the flight data recorder of the aircraft. The IC made all effort to find the broken turbine blade parts which had left through the tail pipe within the range of the event, but they failed.

The IC accepted the comments received to the Draft Report, and prepared the Final Report.

FINAL REPORT

Short summary of the occurrence

On 10 June 2014, the type Boeing 737-600 aircraft with registration mark TS-IOK of Tunisair airline started on Runway 31L, Budapest Liszt Ferenc International Airport, to perform its Budapest – Monastir flight №.TU4671. During the take-off run, at a speed of 28 knots, take-off was aborted due to severe malfunction of the left side engine №1. During the check of the aircraft, molten metal debris was found in the tail pipe of the malfunctioned engine. (Figure 3) The FMC screen showed “EGT HOT START” along with the take-off time. (Figure 2) In addition, an engine start fault indication is shown on the Center Display Unit EGT indication section. The flight was cancelled, the engine was replaced and taken to the Hamburg site of Lufthansa Technik AG for check and repair. During disassembly and check performed with the technical support of CFM, the manufacturer of the engine, it turned out that the cause of malfunction of the engine type CFM56-7B22 was the breakage of a blade of the rotating part of the high pressure turbine. The breakage was caused by a fatigue crack starting out from the inner wall of the cavity at the root of the blade. An oxidation blister was found at the starting point of the crack. According to information from the engine manufacturer, the problem of this kind of breakage of the affected blade type had been familiar to them before and that they have already eliminated that problem by modifying the blade design.

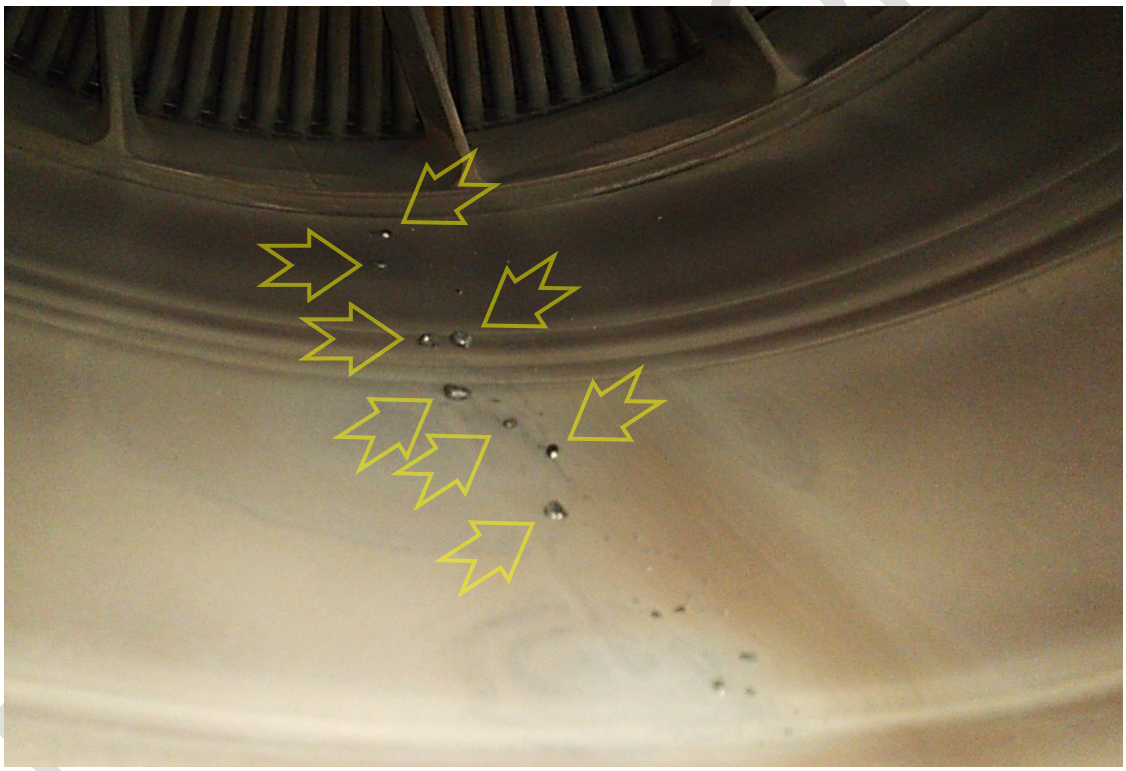

Figure 3: *Molten metal in the tail pipe of the Engine №1 after the event*

1. FACTUAL INFORMATION

1.1 History of the flight

On 10 06 2014, at 16:12 hours, the type Boeing 737-600 aircraft with registration mark TS-IOK, preparing to perform its Budapest – Monastir flight №TU4671 of Tunisair airline reported (on the 121.9 MHz frequency) from Stand №34 to the GRC controller that they were ready to take off. The air traffic controller communicated the ATC clearance, and after successful readback he approved backtrack and engine startup. At 16:16 hours, the aircraft requested and received clearance to taxi to Holding Point A2 to Runway 31L. At 16:19 hours, the GRC sent the aircraft over to ADR 118.1 MHz frequency. At 16:20 hours, ADC issued clearance to the aircraft to line up Runway 31L. At 16:21 hours, the aircraft was cleared to take off and to change to APP 129.7 MHz frequency.

The pilots released the wheel brakes, then powered up the engines to the required take-off value by gradually pushing the throttles forward, and started the take-off run. When the engines were running up, the crew perceived a loud bang and then strong vibration. The instruments showed a drastic increase in the exhaust gas temperature (EGT) leaving the left side Engine №1. Fifteen seconds after the power up was started, the take-off was aborted, the throttles of the engines were set to idle thrust, and the aircraft was braked and stopped using the wheel brakes. The aircraft achieved a maximum speed of 28 knots during the aborted take-off, and covered a distance of ca. 350 m.

Figure 4: *The moment of the malfunction as recorded by a surveillance camera*

At 16:22 hours, practically simultaneously with the stopping of the aircraft, the crew reported the ADC (at the 118.1 MHz frequency) the engine malfunction and the abortion of the take-off. Detecting smoke above the aircraft, the ADR declared „Aircraft Related Incident" alert, and closed Runway 13R/31L. Other aircrews were also notified of the alert of the fire service. The first fire trucks of the Airport Fire Service arrived at the scene within three minutes. Their intervention was not needed, however, because the smoke had dissipated in the meantime, and the thermographic camera showed no extremely high temperatures in the brakes or engines. As some of the fire trucks were reserved, the fire crew commander temporarily (till

16:41) reduced the firefighting category of Runway 13R/31L (which continued work) from 9 to 7.

The pilots turned the other engine off too, upon command from the fire chief. The passengers were evacuated on the runway, using a passenger stair towed to the scene, and then carried by buses to the transit area of Terminal 2B. During the inspection of the aircraft, molten metal debris was found in the tail pipe of the malfunctioned engine, while the MCDU screen showed the engine-start fault message "EGT HOT START" with the take-off time. Between 17:20 and 17:30 hours, the aircraft was towed from Runway 31L to Stand №223. The „Aircraft Related Incident" alert was cancelled at 17:31, with giving notification to those involved. After checking it for obstacles and contamination, Runway 13R/31L was reopened for traffic at 17:39.

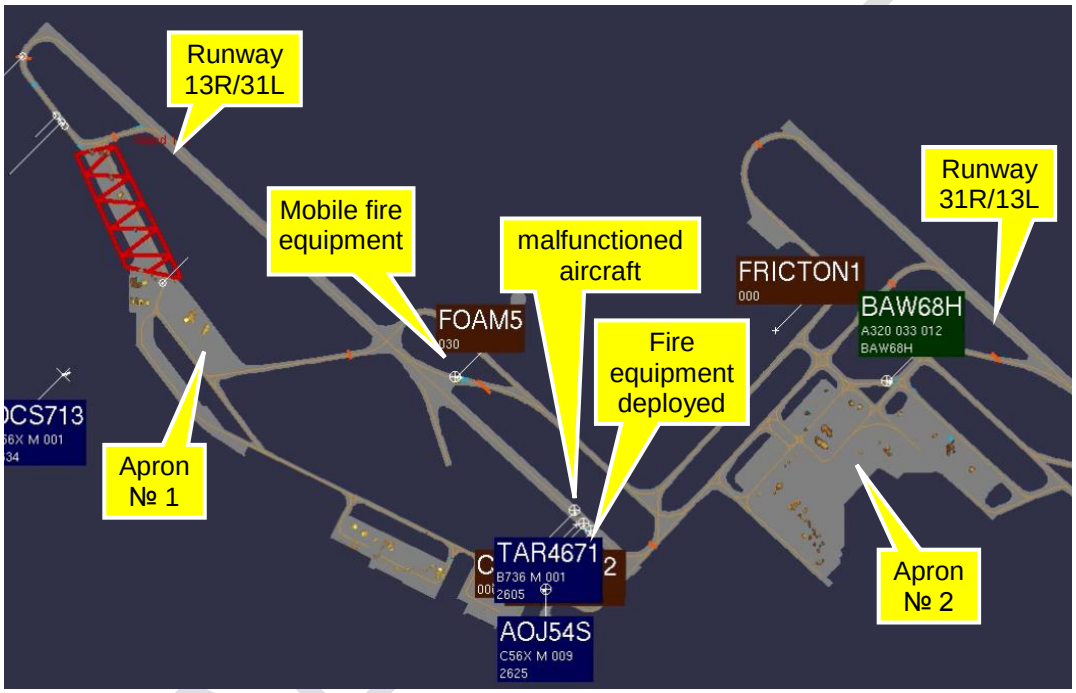

Figure 5: *Deployment of the airport services to the malfunctioned aircraft as recorded by the A-SMGCS system*

The engine was inspected at the stand by the experts of a local maintenance organization assigned by the operator, and then operator's experts sent to the scene. The noise and light effect accompanying the malfunction of the engine, as well as the molten metal debris found in the tail pipe indicated some inner damage to the engine. Confirming this, the boroscopic examination showed that the high pressure turbine of the engine was damaged seriously. According to recorded and evaluated data, the temperature of the gas leaving the engine exceeded 780 °C, and the vibration of the high pressure rotating part exceeded the critical value 4. Finally, a decision was made to replace the engine.

1.2 Personal injuries

Injuries	Crew		Passengers	Other people
	Flight	Cabin		
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	5	84	

1.3 Damage to aircraft

Engine №1 of the aircraft on the left was seriously damaged and had to be replaced.

Figure 6: *An image of the damaged high-pressure turbine, taken during the boroscopic examination performed on the day after the occurrence.*

1.4 Other damage

The IC received no information on other damage during the period of the technical investigation.

1.5 Crew information

1.5.1 Data of the Pilot in Command

Age, nationality, gender		59 years old, Tunisian, male
Licence data	**Type**	ATPL(A)
	Professional valid until	30 April 2015
	Certificates	ME / IR
	Ratings	TRI / SFI TRE / SFE
	Aircraft types flown	B727, B737
Flying experience, hours	**Total**	17 520 hours
	In the previous 90 days	69 hours 15 minutes
	In the previous 7 days	6 hours 50 minutes
	In the previous 24 hours	0 hours
	On the type, total	11 570 hours
Rest time	**in the previous 48 hours**	39 hours
Time in service		9 hours

FINAL REPORT

1.5.2 Data of the First Officer

Age, nationality, gender		32 years old, Tunisian, male
Licence data	**Type**	CPL(A)
	Professional valid until	30 April 2015
	Certificates	ME / IR
	Ratings	-
	Aircraft types flown	B737
Flying experience, hours	**Total**	3 475
	In the previous 90 days	107 hours 10 minutes
	In the previous 7 days	5 hours 25 minutes
	In the previous 24 hours	0 hours
	On the type, total	3 300 hours
Rest time	**in the previous 48 hours**	48 hours
Time in service		0 hours

1.6 Aircraft data

1.6.1. General

Class		Land aircraft equipped with engine
Manufacturer		Boeing
Type/subtype (type number)		B737-600
Serial number		29496
Registration mark		TS-IOK
State of registry		Tunisia
Since manufacturing	**Hours flown**	37 227 hours
	Number of landings	20 118

1.6.2. Airworthiness

It had no impact on the course of events, so this parameter requires no detailed analysis.

1.6.3. Aircraft engine data

Class	Turbofan engine	
Type	CFM56-7B22	
Manufacturer	CFM International	
Position on aircraft	Engine №1	Engine №2
Serial number	874693	-
	Hours/ cycles flown	
Since manufacturing	30 402 hours / 16 459 cycles	-

1.6.4. Propeller data

The affected engines have no propellers.

FINAL REPORT

1.6.5 Loading data

The aircraft loading data had no impact on the course of events, so this parameter requires no detailed analysis.

1.6.6 Description of the defective system, equipment data

The CFM56-7B turbofan jet engine is a product of the CFM International Company founded as a 50%-50% joint venture of the French Snecma and the American General Electric in 1974. In this co-operation, SNECMA (now Safran Aircraft Engines since May 2016) is responsible for manufacturing the fan, the low pressure compressor stage, and the low pressure turbine. General Electric manufactures the high pressure compressor, the combustion chamber, and the high pressure turbine stage. Each partner assembles complete engines independently.

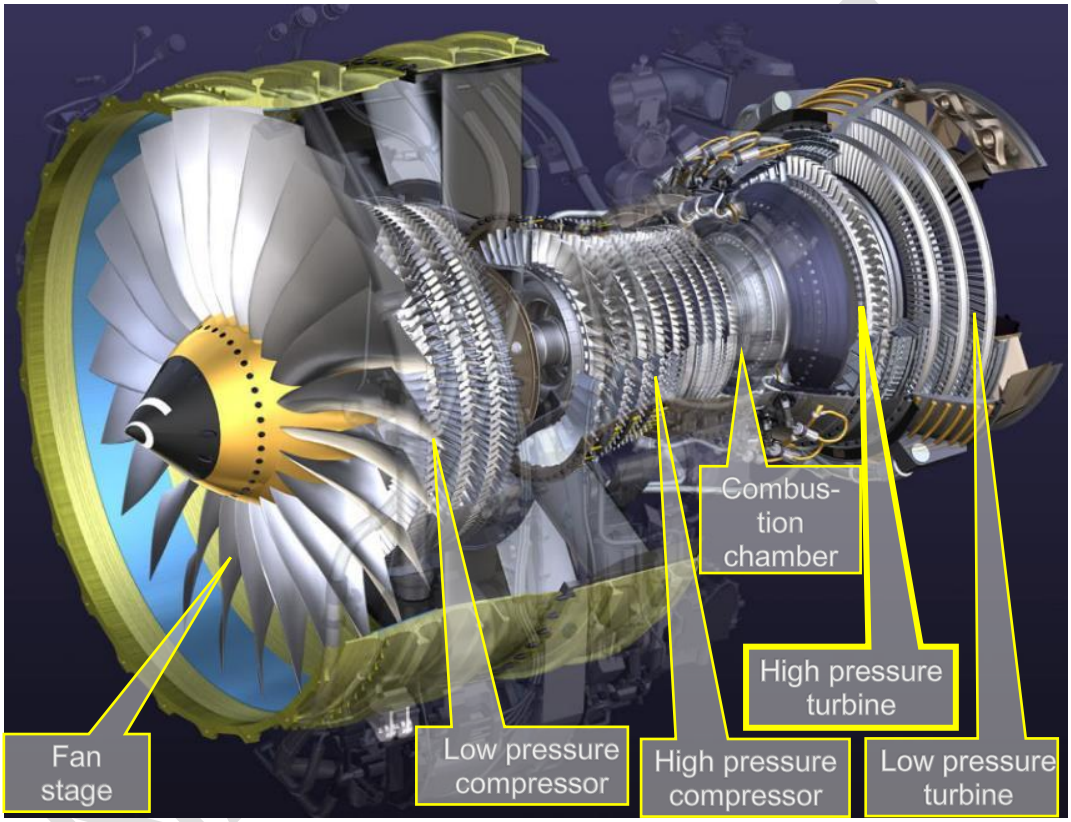

Figure 7: *Cutaway view of the CFM56-7B engine (WordPress: Solid Mechanic)*

CFM56-7 is a coaxial, high bypass (turbofan) gas turbine engine with axial flow. Its compressor consists of two parts. One is a three stage low pressure compressor and the other is a nine stage high pressure compressor. Its combustion chamber is annular type; the turbine has one high pressure stage and four low pressure stages; the former drives the high pressure compressor while the latter drives the turbofan and the low pressure compressor. The blades of the high pressure turbine contain cavities: the cooling air coming from the high pressure compressor flows through the cavities.

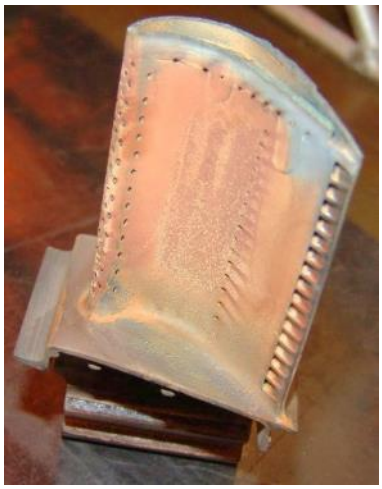

Figure 8: *CFM56-7B high pressure turbine blade*

Engine disassembly revealed two HPT blades which had separated in the shank area and exhibit-

ed fractographic evidence of fatigue. In both cases the fatigue had started from the internal wall of the cavity. At both HPT blades the area of origin of the fatigue cracking was situated along both the convex and concave wall of the cavity. Oxidation blisters were found near the point of origin of the cracks in the inner surface of the aforesaid cavities.

The malfunction of the engine was triggered by the fatigue fracture of a blade of the rotating part of the high pressure turbine, which took place during take-off in Budapest when the power of the engines was increased. The fracture of one blade soon led to the fracture of several other blades, strong vibration of the high pressure rotating part, engine surge, and finally to massive overheating of the turbine stages and complete engine shutoff. The liberated parts of the blades were broken into small pieces and exited the engine through the tail pipe as tiny fragments.

Name of malfunctioned equipment / part	High pressure turbine blade
Location of installation	High pressure turbine of Engine №1
Type	2002M52P09
Manufacturer	CFM International
Serial number	484U4/957W1
Hours / Cycles flown	34 381 hours / 18 538 cycles

1.6.7 Onboard warning systems

The aircraft was equipped with MCDU. After the occurrence, regarding Engine №1, the system contained the message “EGT HOT START” with the date and time of the interruption of the start, ”10 JUN 14 16:21Z”, as shown in Figure 9.

Figure 9 *message after the occurrence*

According to information from the engine manufacturer (received via NTSB), the content of the message comes from the FADEC device of the affected engine. The message is generated by an increase of the EGT gas temperature over 725 °C combined with a simultaneous low N2 rpm value, regardless of whether the trend of rpm change shows increase or decrease.

1.7 Meteorological data

The occurrence took place during daytime, in good visibility conditions, with no weather phenomena worth mentioning. The weather report valid at the time of the occurrence was as follows:

METAR LHBP 101600Z 31008KT 270V350 CAVOK 34/11 Q1016 NOSIG=

(*Budapest Liszt Ferenc International Airport, Day 10, 16:00 UTC, wind direction: 310 degrees, wind speed: 8 knots; the wind direction fluctuates between 270 and 350 degrees; excellent ceiling and visibility; temperature: 34°C, dew point: 11°C, QNH: 1016 hPa, no significant change is expected*).

The weather conditions had no significant effect on the course of events, so no further details are needed.

1.8 Aids to navigation

The aids to navigation had no effect on the course of events, so they need not be discussed in detail.

1.9 Communication

The equipment items indicated in the type certificate were installed in the aircraft; the IC added no comment and received no comment relevant to such items. Also, the IC added no comment and received no comment relevant to ground based equipment, such equipment proved to be fit for the task. (See detailed description of the communication between the flight crew and the air traffic management services in Section **1.1**.)

1.10 Airport information

The aborted take-off took place at Budapest Liszt Ferenc International Airport on 10 June 2016, at 16:21 hours. The scheduled destination was Monastir Habib Bourguiba International Airport. The airport affected in the occurrence had a valid operation certificate. The airport parameters had no effect on the course of events, so they need not be discussed in detail.

1.11 Flight recorders

The required recording systems of both the air traffic control and the aircraft were operable and the recorded data was suitable for evaluation.

FINAL REPORT

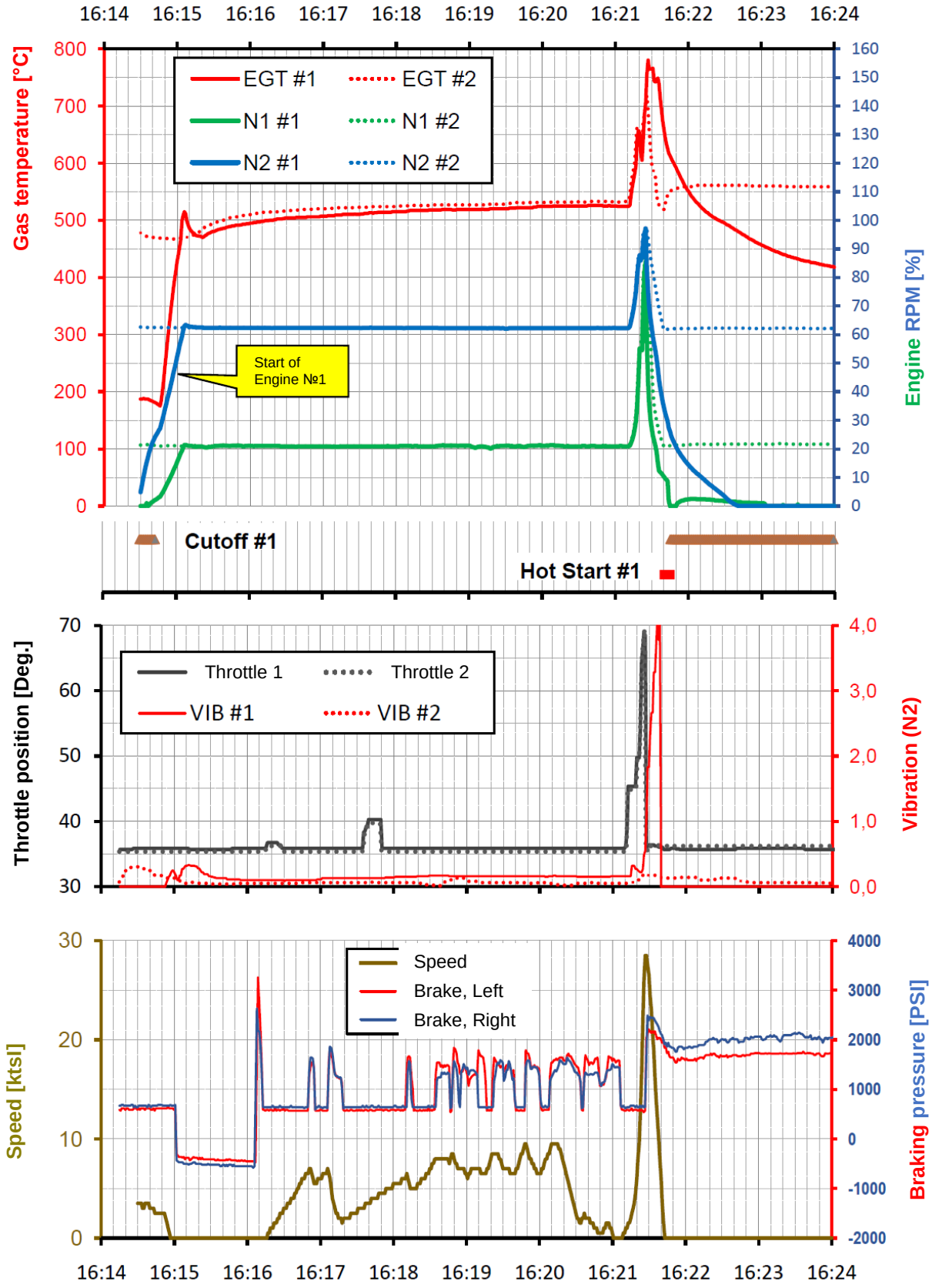

Figure 10: *Flight recorder information from engine start till the abortion of the take-off*

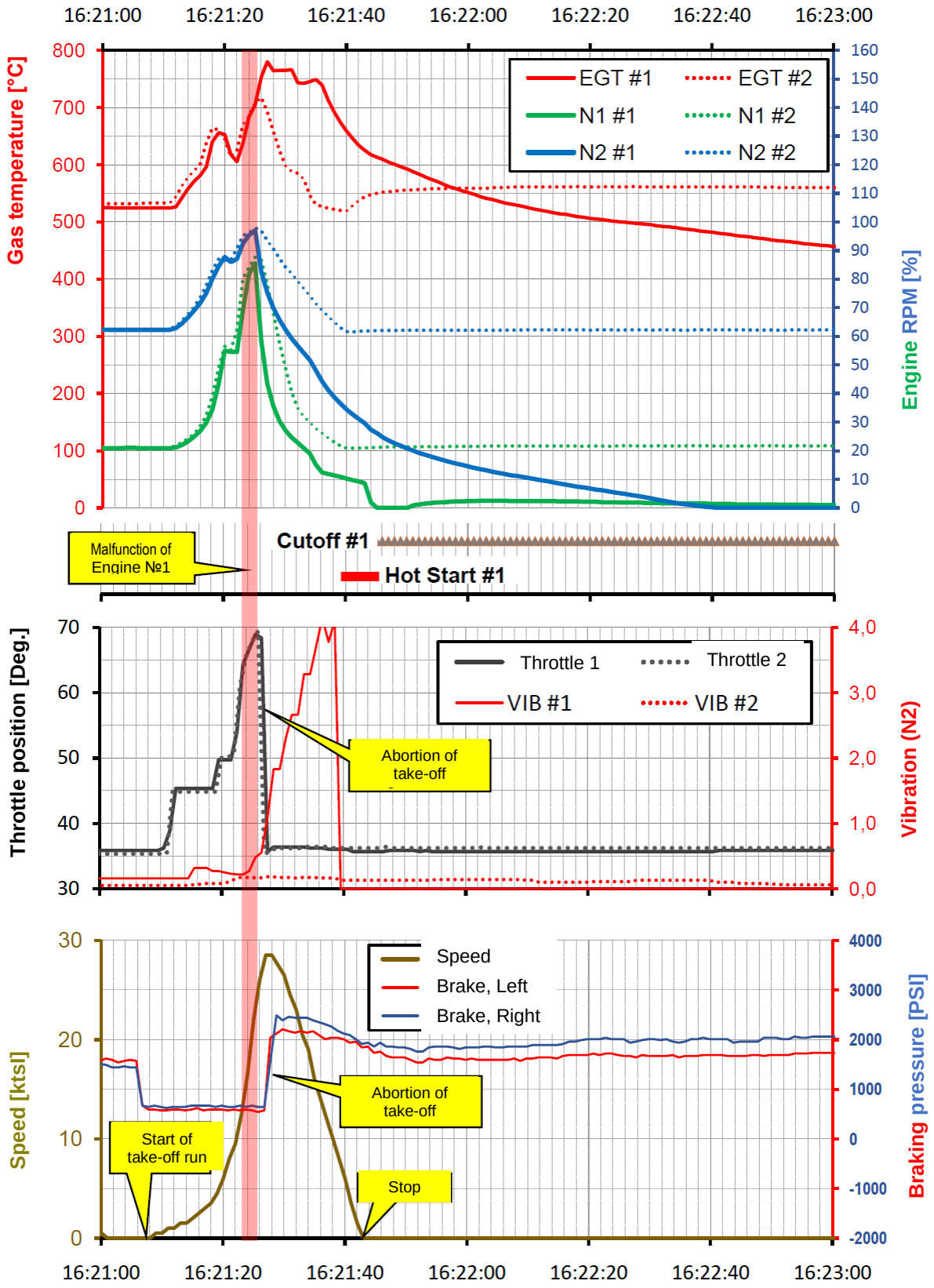

Figure 11: *Flight recorder information from the start of take-off till the abortion of the take-off*

The flight recorder started recording automatically at 16:14:14 when Engine №2 was started. Until the beginning of the take-off run, the recorded data show the picture of a routine start, from the engine start to taxiing to the runway. When starting take-off (at 16:21:07), the pilots released the wheel brakes, and five seconds later (at 16:21:12) they began to increase engine power by pushing the throttles forward. The rpm values of the engines were still increasing when Engine №1 malfunctioned (at 16:21:25). At that moment, the rpm values (N2) of the high pressure rotating parts of Engines №1 and №2 were 86% and 88%, respectively, and the respective rpm values (N1) of the low pressure rotating parts were 97% and 98%, and the temperatures of exhaust gas were 705°C and 707°C, respectively. Hearing the noise accompanied to the malfunction, the pilots began to withdraw the throttles of the engines which reached the idle position at 16:21:27-28. At 16:21:28, i.e. three seconds after the noise, the wheel brakes were already working full blast. The aircraft stopped at the runway at 16:21:43, after 15 seconds of deceleration.

The thrust of Engine №2 (right side) began to decrease as an effect of releasing the throttle, and reached its idle value at 16:21:40. The rpm of the high pressure rotating part of the malfunctioned engine began to decrease at 16:21:25, i.e. already before the throttles were used, and it fell below the idle value in five seconds (at 16:21:30). The low pressure rotating part, which has fairly higher moment of inertia, took three more seconds (16:21:33) to decelerate below its idle value. The temperature of the exhaust gas from Engine №1 increased two more seconds after the malfunction had occurred, and it reached 780°C at 16:21:27. Then it remained above 725°C for 10 seconds (until 16:21:37), while the rpm value of the high pressure rotating part of Engine №1 decreased to 41%. The fault message “EGT HOT START” appeared at 16:21:40, and lasted till 16:21:46, i.e. for six seconds. The pilots shut Engine №1 off, using the cutout switch, at 16:21:45.

1.12 Wreckage and impact information

The incident generated no wreckage.

1.13 Data of the medical investigations

There was no evidence to prove that any physiological factor or other obstruction influenced the crew’s ability to act.

1.14 Fire

There was no fire in relation to this event.

1.15 Chances of survival

No person was injured. After visually perceiving the interruption of the start and the smoke over the aircraft, the ADC immediately declared “Aircraft Related Incident” alert, and closed Runway 13R/31L. The first fire trucks of the Airport Fire Service arrived at the scene within three minutes. Their intervention was not needed, because the smoke had dissipated in the meantime, and the thermographic camera showed no dangerously high temperatures in the brakes or engines. The fire crew commander ordered the flight crew to shut the other engine off, too. The passengers were evacuated onto the runway through a stairway towed to the scene, and transported by buses to the transit area of Terminal 2B.

FINAL REPORT

According to the report in relation to the event written by Airport Fire Service, the proficient handling of the event was hindered by several difficulties:

- One of the fire trucks (Foam 2) was not available due to repair;
- A fire truck (Foam 7) was only ready to go with 15-minute delay due to difficulty to start.
- The same fire truck entered Taxiway B2 without clearance, and conflicted with an aircraft (SLD363) taxiing in the opposite direction.
- Vehicles (Tender 1 and Attack 2) with capabilities not complying with the ICAO standards were also needed to secure the aircraft.
- The self-protection (ground-spraying) system of certain fire vehicles could only work with forced operation but, due to lack of adequate number of operating personnel, it would have been difficult to use in case of necessity.

Figure 12: *Deployment of airport services as recorded by the A-SMGCS system*

1.16 Tests and research

Tests or research was not performed or initiated by the IC other than inspection of the engine at the repair shop.

1.17 Organisational and management information

The parameters of the competent organizations had no effect on the event therefore they need not be discussed in detail.

1.18 Additional information

No substantial additional information was made available to the IC, and the IC do not wish to publish information other than the factual findings described above.

1.19 Useful or effective investigation techniques

The investigation required no techniques differing from the standard procedures.

FINAL

2. ANALYSIS

2.1 Engine malfunction

The inspection performed by Lufthansa Technik with technical support from CFM, the manufacturer, found that the signs of fatigue break were seen in two blades of the high pressure turbine of the malfunctioned engine. The fatigue cracks leading to breakage started out and spread from the inner walls of the cavity inside the turbine blades. Very probably, crack formation was supported by the oxidation blisters found in the material of the turbine blade near the points of origin of the cracks.

The unexpected engine malfunction occurring during the attempted take-off at Budapest Liszt Ferenc International Airport on 10 June 2014 was caused by breakage of one of the two turbine blades mentioned above. The chain of events leading to breakage of the other blade and other damages to the engine was started by that breakage. It is not possible to find out which of the two blades weakened by fatigue cracks broke first because the broken off parts (wearing the signs of collisions) of the blades were not found.

The fatigue breakage of a blade of the rotating part of the high pressure turbine led to breakage of several other blades, strong vibration of the rotating part becoming unbalanced, engine surge, and finally, massive overheating of the turbine stages and complete engine shutoff.

2.2 Flight crew activity

After taxiing to the runway and receiving the take-off clearance, the flight crew released the wheel brakes and increased engine power to the value necessary for take-off by pushing the throttles forward gradually in order to begin the take-off run. During the running up of the engines, the crew perceived a loud bang first, and then strong vibration. The instruments showed a drastic increase in the exhaust gas temperature (EGT) leaving the left side Engine №1. One second after perceiving the noise, the pilots started to abort take-off. During that, they set the engine throttles of the engines to idle immediately, and, practically simultaneously, they applied the wheel brakes. They managed to stop the aircraft in the eighteenth second after perceiving the noise. The entire process from the application of the brakes to the complete stop of the aircraft took 36 seconds. The aircraft achieved a maximum speed of 28 knots during the aborted take-off, and covered a distance of ca. 350 m.

The decision of the flight crew to abort take-off immediately due to the unexpected and intensive noise perceived during the take-off run complied with professional rules and unambiguously worked for safety. Owing to the low speed, the risks of running over the end of the runway and wheel brake overheating were low. At the same time, they avoided take-off with an airplane in uncertain conditions and emitting an irregular noise. The information obtained later also proved that Engine №1 had become fully unserviceable.

2.3 Reaction by the airport services

At 16:22 hours, practically simultaneously with the stopping of the aircraft, the crew reported the ADC (at the 118.1 MHz frequency) the engine malfunction and the abortion of the take-off. Detecting smoke above the aircraft, the ADR announced “Aircraft Related Incident” alert, and closed Runway 13R/31L which was occupied by the malfunctioned aircraft. The first fire trucks of the Airport Fire Service arrived at the scene within three minutes. Their intervention was not needed, however, because the smoke had dissipated in the meantime, and the thermographic camera showed no dangerously high temperatures in the brakes or on the outside of the engines. As some of the fire

FINAL REPORT

trucks were reserved, the fire crew commander temporarily (till 16:41) lowered the fire-fighting category of Runway 13R/31L (which continued work) from 9 to 7. The pilots turned the other engine off too, upon command from the fire chief. The passengers were evacuated on the runway, using a passenger stair towed to the scene, and then they were carried by buses to the transit area of Terminal 2B. According to the report in relation to the event written by Airport Fire Service, proficient handling of the event was hindered by several difficulties (see Section 1.15), but that had no perceivable impact on the course of events.

During the check of the aircraft, molten metal debris was found in the tail pipe of the malfunctioned engine, and, at the same time, the FMC screen showed “EGT HOT START”, an engine start fault message. Between 17:20 and 17:30 hours, the aircraft was towed from Runway 31L to Stand №223. The “Aircraft Related Incident” alert was cancelled at 17:31, with giving notification to those involved. After checking it for obstacles and contamination, Runway 13R/31L was reopened for traffic at 17:39.

The engine was inspected at the stand by the experts of ACE assigned by the operator, and then the operator’s experts sent to the scene. The noise and light effect accompanying the malfunction of the engine, as well as the molten metal debris found in the tail pipe indicated some inner damage of the engine. Confirming this, the boroscopic examination showed that the high pressure turbine of the engine had been damaged seriously. Finally, a decision was made to replace the engine.

2.4 Message on MCDU following the occurrence

After the occurrence, the FMC screen in the flight cabin showed “EGT HOT START”, an engine start fault message, with the time of the abortion of the start (16:21Z). According to information from the engine manufacturer (received via NTSB), the content of the message comes from the FADEC device of the affected engine. The message is generated by an increase of the EGT gas temperature over 725°C combined with a simultaneous low N2 rpm value, regardless of whether the trend of rpm change shows increase or decrease.

According to the IC, an message referring to an engine start irregularity after an event which took place not during engine start may confuse and slow down the investigation of events, as well as the finding and elimination of a possible fault.

FINAL REPORT

3. CONCLUSIONS

3.1 Factual findings

The flight crew had the appropriate licences and ratings as well as sufficient experience for the given flight task. They performed the flight in compliance with the rules and regulations in effect.

The aircraft was fit for flight before the engine malfunction. It had valid airworthiness certificate. The mass and the mass distribution of the aircraft were within the required limits. The aircraft was refuelled with fuel of the right quality and quantity for the flight.

The occurrence took place daytime, in good visibility conditions, with no weather phenomena worth mentioning.

No reflection emerged relevant to air traffic control, airport parameters or the activity of the airport services in connection with the occurrence.

During take-off in Budapest, more closely during engine running up, Engine №1 malfunctioned with intensive accompanying light and noise, its rpm decreased, and its gas temperature and vibration increased.

The pilots immediately aborted the take-off, and stopped the malfunctioned engine.

The ADC immediately declared “Aircraft Related Incident” alert.

Intervention by the fire service was not needed, but their efficient operation was hindered by several technical and organisational problems.

3.2 Causes of the event

During the technical investigation the IC concluded that the probable causes of the occurrence were as follows:

– Fatigue cracks were formed in two blades of the high pressure turbine.

– The engine malfunction was caused by fracture of one of the cracked blades.

– The oxidation blisters in the inner surface of the blades may have played a role in the formation of the fatigue cracks.

FINAL REPORT

4. SAFETY RECOMMENDATION

4.1 Action taken by the operators/ authorities/etc. during the investigation

According to information from the manufacturer of the engine, they were aware of the problem of this kind of breakage of high pressure turbine blades of the affected type at the time of the occurrence, and they had already eliminated it by modifying the construction of the blades.

4.2 Safety recommendation issued during the investigation

The TSB IC did not find such circumstances which would justify the issuance of Safety Recommendations.

4.3 Safety recommendation issued after the investigation

The TSB IC did not find such circumstances which would justify the issuance of Safety Recommendations.

Budapest, 14 September 2018

György Háy
Investigator in Charge

Gábor Torvaji
Member

László Bogár
Member

FINAL REPORT

ANNEX 1

Surveillance camera recordings of the occurrence

The TS-IOK aircraft at the holding point A2 of Runway 31L

The TS-IOK aircraft on Runway 31L

The moment of the malfunction. A bright flash can be seen behind the engine.

FINAL REPORT

ANNEX 2

A-SMGCS recordings of the occurrence

The TS-IOK aircraft (TAR4671) aborts take-off.

The alarmed fire trucks of the Fire Service arrive at the scene.

The aircraft, escorted by fire trucks, is towed to the stand.