INSTITUTE FOR PROFESSIONAL SURVEYS
CAUSE OF AIRCRAFT ACCIDENTS
Beranových 130
199 01 PRAGUE 99

CZ-19-0776

FINAL REPORT

on expert investigation of the causes of a serious incident
Boeing B737-800 aircraft, license plates OK-TVO
flight TVS1125 from LGSM to LKPR
of 22 August 2019

Prague
July 2020

This investigation has been carried out in accordance with Regulation (EU) No 996/2010 of the European Parliament and of the Council, Act No 49/1997 Coll , on Civil Aviation and Annex No 13 to the Convention on International Civil Aviation The sole purpose is to prevent future accidents and incidents without apportioning blame or liability Final the report, the findings and the conclusions contained therein, concerning air accidents and incidents, possibly systemic

deficiencies endangering operational safety are for information purposes only and may not be used otherwise than as a recommendation for the implementation of measures to prevent further air accidents and incidents with similar causes The Contractor of the Final Report expressly declares that the Final Report cannot be used to establish guilt or liability in connection with the determination of the causes of the accident or incident and cannot be used for the assertion of claims in the event of an insured event

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Used shortcuts

AC	Altocumulus (Altocumulus)
ACARS	Aircraft Communication Addressing and Reporting System communication address and notification system)
ACC	Area Control Center
ACC EXE	ACC Executive Controller (regional air traffic controller)
ACC PLN	ACC Planner / Planning Controller (PC) (planning controller, assistant air traffic controller for planning and coordination)
AFDS	Autopilot Flight Director System aircraft)
AFM	Aircraft flight manual
AGL	Above ground level
AirFASE	Aircraft Flight Analysis and Safety Explorer (FDM))
ALTN	Alternate airport
AMC	Acceptable Means of Compliance card)
AMSL	Above Mean Sea Level
APP	Approach Control
ASDA	Accelerate-stop distance available take-off)
ATC	Air Traffic Control
ATIS	Automatic terminal information service end controlled areas)
ATS	Air traffic services
BASE	Cloud base
BKN	Broken (cloudy to overcast)
BR	Mist
WHOSE	Cirrus (Cirrus)
CAVOK	Visibility, cloud and present weather better than prescribed values or conditions (visibility, clouds and weather conditions are better than set values or conditions)
CCM	Cabin Crew Member
CB	Cumulonimbus (Cumulonimbus - storm cloud),
CRM	Crew resource management (crew interaction optimization)
CU	Cumulus (Kumulus)
CVR	Cocpit voice recorder (cockpit voice recorder)
CHMI	Czech Hydrometeorological Institute)

	institute)
CWP	Controller Working Position

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DFDAU	Digital Flight Data Acquisition Unit
DFDR	Digital Flight Data Recorder
EASA	European Aviation Safety Agency
	aviation)
ETOPS	Extended Range Twin Engine Operations
	extended range aircraft - with the possibility of extended range on
	one engine)
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FDM	Flight Data Monitoring (flight monitoring and analysis system)
FE	Flight Examinator
FEW	Few (almost clear)
FI	Flight Instructor (Flight Instructor)
FL	Flight Level
FMS	Flight Management System (flight management and optimization system)
F / O	First Officer
GW	Gross Weight
IFR	Instrument flight rules
IRS	Inertial reference system
ISA	International Standard Atmosphere
	atmosphere)
KIAS	Knots Indicated Airspeed
LDA	Landing distance available
LGSM	Public International Aerodromeo Samos Aristarchos (public
	Samos Aristarchos International Airport)
LKAA	Flight Information Region Prague
LKPR	Public International Aerodrome Prague Ruzyně)
	Prague Ruzyně Airport)
MCC	Maintenance control center
MCT	Maximum Continuous Thrust
SWEEPER	Aviation routine weather report (regular aviation meteorological report)
	message)
MLW	Maximum landing weight
MSL	Mean sea level
NCC	Non-Normal Checklist
NILE	None
NITS	Nature, Intentions, Time, Specialties (factors for solutions
	non-standard procedures)

OFP Operational Flight Plan (operational flight plan, operators)
OPC Operator proficiency check

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ORO	Organization Requirements for Air Operations organizations in the field of air traffic)
BYE	Passenger Address
PAN PAN	Urgency - A condition of being concerned about safety and of requiring timely but not immediate assistance, a potential disstres urgency signal - a condition of safety concerns and requiring timely but not immediate assistance, a potential condition need)
PAX	Passengers
PF	Pilot flying
PIC	Pilot in command
PM	Pilot monitoring
QNH	Altimeter sub-scale setting to obtain elevation when on the ground, (atmospheric pressure reduced to mean sea level according to standard atmosphere conditions)
QRH	Quick Reference Handbook instructions)
REG QNH	Regional pressure, the lovest atmospheric pressure in the area reduced to mean sea level according to standard atmospheric conditions (regional pressure, lowest atmospheric pressure in the territory, reduced to mean sea level, according to standard conditions atmosphere)
REQ	Requirement
RETS	Recent Thunderstorm (after the storm)
RMK	Remark (note)
RVR	Runway visual range
RVSM	Reduced vertical separation minimum spacing)
RWY	Runway
SCC	Senior cabin crew
SCT	Scattered (partly cloudy)
SKC	Sky Clear
SMS	Safety managenent system
TCU	Towering Cumulus (towering cumulus)
TDZ	Touchdown zone
TEC	Tower Executive Controller
THR	Threshold
TLB	Technical Log Book
TODA	Take-off distance available

TOP	Cloud top
TORA	Take-off run available

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TS	Thunderstorm
TWR	Tower (airport control tower)
TWY	Taxiway
UIR	Upper flight information region
UTC	Co-ordinated universal time
ÚZPLN	Institute for Professional Investigation of the Causes of Aircraft Accidents
VCTS	Thunderstorm in the vicinity (near Thunderstorm)
Vr	rotation speed
VREF	Reference landing approach speed
	landing with all engines running)
VRB	Variable

Used units

ft	Feet (foot - unit length - 0.3048 m)
hPa	Hectopascal (unit of atmospheric pressure)
kt	Knot (knot - speed unit - 1,852 km · h^{-1})

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A) Introduction

Operator:	Smartwings, as
Aircraft manufacturer:	Boeing
Aircraft type:	Boeing 737-800 - 8CX
License plate:	OK-TVO
Event location:	LGSM - LKPR
Date and time of the event:	Aug 22, 2019, 07:05 UTC, (all times in UTC)

B) Information overview

On 22 August 2019, ÚZPLN received a notification from a domestic aircraft operator Boeing 737-800, license plate OK-TVO on the withdrawal of one aircraft power unit flight TVS1125, call sign TVS 4MP during the flight from LGSM to LKPR. Shortly after reaching FL360 engine No. 1 stopped. The crew reported to the ACC a technical problem as a reason for descending from FL360 to FL240. Twice she tried to restart the dropped engine. After the second unsuccessful engine start, the PIC decided to continue the flight only with one working power unit up to the destination LKPR, which he marked as suitable airport. Only when entering the FIR LKAA, the crew declared PAN PAN, announced the nature defects and with an airplane with 170 passengers landed on LKPR. None of the passengers or crew he was not injured.

The cause of the serious incident was determined by the ÚZPLN commission composed of:

Commission Chairman:	Pavel Mráček, ÚZPLN
Committee members:	Ing. Stanislav Petrželka, ÚZPLN
	Ing. Ctirad Coufal, Smartwings, as
	Ing. Václav Vašek, ÚCL

The final report was issued by:

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On June 29, 2020

The main part of the report contains:

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1 Factual information

1.1 The course of the flight

Fig 1 TVS1125 flight path after engine shutdown (red star) up to LKPR

1.1.1 General information

The crew started the first flight on August 22, 2019 with a Boeing B737-800 aircraft from LKPR to LGSM at 03:08:00. The flight recording of the second, critical, TVS1125 flight from LGSM to LKPR began on Samos Aristarchos airport at 06:21:00. Flight TVS1125 had 170 passengers on board. Flight the crew was composed of a captain, in the position of commander of the aircraft (also "PIC"), in the role of pilot Flight Monitor (hereinafter referred to as "PM") and first officer (also "F / O"), acting as co-pilot, in the role of a pilot flying (hereinafter "PF"). The cabin crew consisted of the head of the cabin (hereinafter referred to as "SCC") and 3 cabin crew members (hereinafter "CCM"). The take-off weight of the aircraft was 66.7 t. Departure information, ATIS: "T" 05:20 RWY09 TL85 020 ° / 7knots CAVOK 26/18 QNH1012. At 06:27 the crew took off from RWY 09. The power of both engines was set to reduced speed values 88.63% N1. Engine parameters of reduced take - off according to the PIC and F / O statements during take-off and climb appeared to be the same or almost the same. After reaching FL360 at 06:46:22 the engine power was reduced to about 88% of N1 speed. Engines are stabilized briefly. At 06:47:27, the speed of the N1 engine No. 1 began to decrease. It followed *flame out* engine shutdown No. 1. AFDS responded to engine shutdown by swinging the ailerons, which the F / O helped almost immediately by deflecting the rudder. At 06:49:26 the plane The B737-800 began the descent from FL360 to FL240 for "technical reasons". The lowest recorded initial speed at the beginning of the descent with one engine running in MCT mode from FL360 to FL240 was 226 KIAS and GW 64.7 t. This was due to the delayed changes in FL, as evidenced by the statement of F / O. During the descent, this speed increased by an increase

about 20 KIAS and in the time 06:56:39 reached the value of 310 KIAS needed to start the engine for flight using autormotation *windmill*. This attempt was not successful. Second run attempt

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engine performed by the crew on the FL240 at 07:07:45 using compressed air from a working *crossbleed* engine . Through ACARS, the crew reported spontaneous shutdown of engine No. 1 on FL360 to the operation control room. The crew announced an unsuccessful attempt to start the engine using *windmill* and a second attempt using *crossbleed* by *Engine-In-Flight Start NNC* . The PIC stated that given the condition of the aircraft and the quantity fuel on board was chosen by LKPR as a "suitable airport". The aircraft left the FL240 shortly after entering to FIR LKAA. During the transition to the assigned frequency ACC LKPR PIC declared PAN PAN. Airplane with 170 passengers on board at 09:06:26 with a weight of 59.8 t landed on RWY 06 on LKPR. At 09:07:25, TVS1125 left RWY 06 via taxiway B. In time 09:09:27 the crew turned off engine No. 2.

1.1.2 Flight information from PIC statement

While starting the engine at Samos Airport, the PIC noticed a continuous, so-called cyclic one ramp-up of engine No. 1, which in his opinion was the result of blowing the engine sideways wind during start-up. After setting the take-off speed on RWY 09, the PIC performed the role of PM *call out:* " *thrust set*". The difference between engine No. 1 and engine No. 2 was, according to his statement indistinct and therefore did not even notice it. A takeoff followed with a light landing the aircraft, which the PIC described as a consequence of the wind shear that is common at Samos airport. After reaching FL360 there was a decrease in engine speed No. 1. On the causes of engine shutdown No. 1, whether it was a flame break, the PIC did not think and began to work on solving this abnormal case. If he had to leave the assigned level, he could not call immediately ACC components. To the question of whether he did not consider at least the *offset* and where he found the appropriate level in QRH for the weight of the aircraft, or interpolated it, the PIC literally replied: "*I used the wrong one phrase, maintenance issue, descent requested, level 240, then due to technical correction problem, at first a misunderstanding with ATC regarding the level, after a misunderstanding was received permission of the required flight level without restriction, therefore no offset was applied*. " To the question of whether he thought that the ATC would meet them when the PAN PAN was declared, or that it was in the context of a withdrawal one power unit of a twin-engine aircraft useless, PIC replied: "*I did not expect that ATC would be more helpful after the announcement of PAN PAN in the given situation*. " PIC said that the frequency of hate to inform about a specific problem . First Officer was PF and after the onset of *malfunction* required the NNC procedure. The PIC stated that during the NNC did not request the CCM to visually inspect the No. 1 engine because it was indicated by the engine undamaged. First, they clarified the *initial descent* to a given FL. To information from FMS was used, secondarily *from* QRH . The PIC added: "*I knew I was flying on maximum altitude for Long Range Cruise Altitude Capability, so it was possible expect that it will be necessary to use maximum continuous to maintain speed at this level thrust*. " The most important parameters , which had a major influence in the decision to security landing at a selected airport PIC listed the following: "*Airport, equipment, weather.*"

For the line from LGSM to LKPR, the PIC decided for the corresponding amount of fuel according to OFP without increased *extra fuel* . Due to the higher efficiency of operation, the method of "tankering" was determined, which in this case represented a larger amount of fuel on board, which was left for the first time part of the flight to Samos airport. The PIC no longer remembered the amount of fuel in the *final reserve* . In his statement he stated the following: "*The Prague destination was later considered enroute during the flight alternate*. "*The* PIC described its decision to continue the flight as follows: " *Between two attempts to restart the engine there was a transition to Athena ACC, where I used the wording, that I will continue to the destination Prague to make it clear that I want to continue to the original*

planned route until there is sufficient information to decide on the backup airport. After agreement with the pilot flying, there was mutual agreement that the alternative airport for the chosen alternative airport in Prague will be Budapest Airport. " In the decision-making process, the PIC stated that

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that the airport LGTS (Thessaloniki) ruled out, LYBE (Belgrade) was right below it. He ruled out Vienna due to traffic. The PIC knew that the aircraft did not meet the requirements of ETOPS, but that Boeing has no restrictions on this range. To the question of whether he was F / O's opinion in such helpful, he replied *: "In my opinion, cooperation and how to deal with this situation from the point of view of CRM, I perceive it as okay and the activity of the co-pilot was helpful to me*. " The CRM ASSESSMENT HANDBOOK document was signed by the PIC as Flight Director company and stated that this document is generally binding and is relevant to this the document was also controlled by pilots with a high raid. He confirmed this with the words: "*Of course, it is without exceptions, CRM is neutral*. " PIC knew that QRH contained a wording from Boeing that clearly refers to the safe landing at the nearest suitable aerodrome in the event of a flight with only one functional drive unit. At the same time, the PIC confirmed that it knew the restrictions Boeing in the OM-B section of the *performance* chapter , which describes the procedure where the pilot it must preferably reach the alternate airport within one hour, with one hour not taken as mandatory. He confirmed that his highest priority when conducting flights in the air Commercial traffic is safety. The decision to continue the single - engine flight until LKPR was literally described in PIC's statement as: "*My decision*." To the question of whether he experienced during his previous career a similar flight with passengers without a single power unit at commercial air transport, he said no. After the fuel calculation from the PIC, it was said that LKPR is a *suitable airport* . When asked where he calculated the fuel, the PIC said: "*Basic the calculation was probably made before Belgrade*. " However, the PIC did not record this calculation to OFP. When asked how the required amount of fuel was calculated, The PIC stated in its statement: "*After performing a methodological calculation according to the comparison of OFP with FMS and subsequently according to the procedure in QRH, I reported the result to the second pilot, who did not* " On arrival at the FIR LKAA border, the crew decided to declare PAN PAN due to the smooth arrival and the possibility of vectoring in the area of increased air traffic. With the announcement of PAN, PAN assumed that the Local Stand-By service at the airport would be activated Prague and F / O agreed to this procedure. When asked if his (PIC) is a flight experience large enough to be able to assess the risks associated with the decision-making process, which took place during the TVS1125 flight, replied: "*I am convinced that my rich the flight experience is large enough to be able to assess all the risks involved With the decision-making process, however, I realize that circumstances may arise they deserve to be treated with due care*. " PIC asked if he was removed oil and fuel for the test after the flight said: "*I do not know the procedures of technicians, I wrote down to the TLB that there was an In-flight Shutdown during the flight*. "*The* PIC described the course of the agreement with the cabin crew as follows: "*On the basis of the NITS, which took place in the flight crew, an agreement was reached SCC, which has been instructed about the possibility of an impromptu announcement of emergency situation*. " According to In his statement, the SCC informed the PIC that it had carried out a visual inspection of the landed man engine. When asked how you performed the CVR according to the procedure described in OM, PIC he replied: "*I have given the technicians information about the situation and that and so I assumed that the cards would be removed from the CVR and secured. Then I heard the cards are excluded*. " At the end of his statement, whether the PIC sees today some of its mistakes, which would gladly explained he replied: "*In retrospecting my flight performance, I am convinced that the safety of the flight was not violated*. "*The* PIC also stated in its resignation that its decision-making the process was not affected by economic aspects. According to PIC, he thought only operationally. He stated literally that if he arrived and did not break anything, he would not endanger anyone, with fuel , what he was supposed to have, he saw no reason not to reach the destination.

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1.1.3 Flight information from F / O expression

During his departure from Samos Airport, the F / O did not notice any significant difference in speed N1 of both engines when setting the take-off power. F / O said he was at this airport first. The airport has a short runway, the flap setting was 25 and the crosswind, which was attributed to fluctuations in engine speed No. 1. F / O said: *[… "overall, I was slightly out of the airport nervous* "…]. His initial reaction when stopping the engine was to step on his foot. To the question how many times he completed flights on the simulator with a "failure" of one power unit and what they were procedures and procedures during this / these simulated flights, F / O replied: *"Once upon a time completed, it was possible to derive some experience in a real situation. Procedures, activities in the cockpit, communication with the cabin crew, ATC, announcement of PAN PAN for avoidance reducing flight safety and landing at the nearest suitable airport.* " When asked when you are could not call ATC what you suggested, you did not consider the *offset* , F / O replied: *"I was nervous because the speed was falling, I wanted to start falling. I pushed the captain, to communicate the decline, I assumed the use of a standard phrase. If we wouldn't call, I was ready to use the offset.* " F / O confirmed that the PIC had borrowed BOSE headphones. In this context, he stated: *"I think there was a problem with his headphones, the functionality of the headset has been reduced. Several attempts have been made - about 4 or 5. Given to the ever-decreasing rate, the nervousness in the cockpit increased. To delay the connection probably for this reason.* " As long as they flew with one engine on the FL 360, the F / O he did not remember. The initial reading of the descent level from the FMS was performed by the PIC. When asked who performed determining the level for the *Long Range Cruise Altitude Capability* and from whether they have performed the check FL with respect to weight and ISA, F / O stated: *"The action was performed by the captain, the initial deduction for the descent took place from the FMS. I relied on his role because I was in charge airplane. The captain did not ask me to check his results. I asked for a procedure NNC and checklist led us. I find the captain's standard procedure.* " After the descent from FL360 continued flight TVS1125 to FL240. F / O failed to establish a connection with ACC Athina, because he heard them badly, and because, as a PF, he piloted. He expected the PIC to do it decision. The PIC performed calculations according to QRH and at the same time its communication with the operational one took place dispatching. F / O noticed one of the PIC responses mentioning Brno or Budapest airports. Then the PIC acquainted him with the content of the communication. After completing communication with the operating dispatching, PIC decided to continue the flight TVS1125 to the destination LKPR. After this PIC decision, F / O still tried to reverse the PIC decision by requesting a retry performing an NNC to confront the PIC with the last point of the checklist in the QRH. F / O in his statement he described his position during the flight and the performance of his function as PF as follows: *"I am internally disagreed with this decision, I asked the captain to implement it again NNC. In my opinion, the QRH statement is binding.* " After this event, F / O no longer remembered that they would discuss some airports with the PIC in terms of suitability for security landing. After descending on the FL240, the F / O had to use the MCT because the aircraft began to crash speed. In connection with the use of MCT on engine No. 2 to keep on FL240, PIC suggested F / O speed reduction of the running engine. PIC justified this reduction in speed with these words words: [… "*so that we do not melt the running engine*" …]. Fuel calculation to achieve LKPR performed by the PIC. The PIC did not inform the F / O of the calculations performed and communicated the result to him as a fact that fly. The F / O decided not to contradict further PIC decisions and was ready to continue in the original flight path. He was mentally preparing to land at LKPR. During the implementation of the NNC PIC and F / O were contacted by SCC on its own initiative. Communication with SCC has been terminated and PIC with F / O focused on NNC procedures. F / O further stated that he does not remember whether the PIC called

SCC. After arriving at the cockpit, the SCC asked if anything was going on. Then the PIC met her situations. The SCC informed the crew that the other cabin crew members had noticed that the engine is not running and that they have seen a drop. The SCC was asked if passengers knew

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about the situation and whether panic broke out on board. SCC confirmed that passengers about the situation nothing they did not know. The PIC carried out a PA, informing passengers that it was necessary due to a technical defect to descend, and did not disassemble it further. Arriving at the border, F / O realized he hadn't heard of a PIC declared by PAN. He therefore made a proposal for its promulgation, with which the PIC agreed. PIC declared PAN PAN during the transition to the assigned frequency FIR LKAA. F / O no longer remembered whether the agreement with the SCC took place before or after the proclamation of PAN PAN. The SCC has been notified that a normal landing will take place leaving the runway. To issue instructions for F / O does not remember an unprepared evacuation. F / O knew duty in such cases keep CVR. PIC did not talk to F / O about CVR. F / O confirmed that his assertiveness during the flight could be affected by a PIC person. Although the PIC had the final right to make the flight, When asked if he would take some steps differently, F / O immediately replied, "*I would do something otherwise. I would choose another suitable airport. Proclamation of PAN PAN, I would exercise my right.* " Before departure from LKPR, the F / O mechanics was alerted to engine vibration no.2. PIC performed photo documentation of engine values during the flight to Samos. F / O said it had no logic continue with the power unit deployed to Prague. After landing, the PIC made an entry in *Log Journey* . On the ejection of CB - *circuit brakers* in connection with the obligation to keep the CVR does not remember. He said that before the passengers disembarked, two mechanics came to the cockpit to have fun with PIC. He does not recall the content of this interview. There was no activity in the cockpit F / O, which would involve deleting the CVR record. He was absolutely sure of that.

1.1.4 Flight information from SCC statement

During SCC service, she felt the aircraft's atypical "sway" while flying on the surface. The first atypical movement aircraft recorded during the operation, about in the "half of the cabin". SCC called to the cockpit and stopped service. The crew informed her that they do not currently have time because they are dealing with technical problem. Then the *chaim* signal sounded twice . Crew with this standard signal called SCC to the cockpit. The PIC informed the SCC that they "lost one engine", which failed run again, but that will fly on. The SCC asked whether it was necessary to set up a cabin (this is meant for possible evacuation after landing). The PIC replied that it was not necessary yet. He announced that fuel is not currently coming to Prague, and therefore a landing in Brno or Budapest. But the decision has not yet been made. The SCC asked the PIC if it would inform passengers of the situation or have them notified. PIC responded with a suggestion that it will only notify passengers of the situation when it is clear where it will land at the same time with the fact that it lands for technical reasons. Stopping one engine will not be a passenger announce to avoid panic on board. The captain asked the F / O and the SCC if they agreed, and both agreed with his proposal. The SCC informed the CCM of the PIC's decision in the front kitchen. When asked when the PIC indicated that it would land in Prague, the SCC stated *: "About 45 minutes before by landing it was clear that the fuel was coming to Prague. "The* SCC no longer remembered whether they had during passenger service switched off banners "Fasten". The SCC has confirmed that they are not situations for technical defects specified. SCC confirmed that the cabin crew is instructed by the PIC, from which it will sound whether to prepare the cabin or not. SCC confirmed that the cabin crew is regularly trained to prepare the cabin in the event of an emergency landing, not the nature of the defect. When asked if the PIC agreed with the SCC on the preparation of the cabin to the evacuation, she replied: "*Nothing was required, there was information that we would land normally.*" When asked if there was a convention for unprepared evacuation, she replied: "*No, but we are trained be prepared at all times.* " After receiving information about the technical defect of the SCC to other members the flight attendants communicated everything she knew. The SCC asked the other CCMs to they did not like the passengers not to be informed about the engine stopped in the cabin. SCC as well

confirmed that no visual inspection of the condition of the stopped engine had been carried out through the window passengers so that passengers do not notice anything. The landing at LKPR was standard. Airplane

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he did not drive to the *gate* , but remained standing "in the field" [1] . According to the passengers' reactions, the SCC felt that you were they probably didn't notice anything during the flight. After bringing the stairs to the plane, they were the first to board technicians.

1.1.5 Flight information from the dispatcher's statement

The first information from the TVS 1125 flight was received by the data control room (ACARS) at 07:20. Together with information about the engine shutdown, the crew confirmed that they were continuing the flight to Prague. At the same time confirmed that they may not get their fuel in Prague, but that they have *alternates* Budapest, Brno, and to write our preference. The receipt of the report was acknowledged and the relevant procedures started. The dispatcher asked the MCC to ask which airport was better from their point of view. MCC confirmed that it complied with both operational aspects. Then the dispatcher wrote off the PIC that once everything will be found, they will let the crew know. Subsequently, the dispatcher started the procedure according to the checklist. Was informed management, the so-called *orange group* . After the arrival of the operations director, who interested in the situation, the dispatcher provided him with current information. The dispatcher received information from MCC that Budapest suits better and passed this message on to the crew after the date. Once the PIC he wrote that it was "coming out" to Prague, the dispatching center confirmed the receipt of his information. For how long after the initial information about the engine shutdown came information that it would fly to Prague, the dispatcher no longer remembered. When asked if there was any clear information about the continuation of the flight to Prague, the dispatcher replied *: "I can't remember when the information came that he would fly to to Prague. The first variant, however, was Budapest or Brno.* " Dispatcher of the ongoing flight report TVS1125 did not save after the datalink, because it is not listed in the checklist.

1.1.6 Flight information from technicians' statements

After stopping the plane, turning off the engine and bringing up the stairs, two boarded the plane technicians of the company Smartwings, as They were acquainted in advance about the origin of the "single - engine flight "and therefore after entering the cockpit of the aircraft tried to get as much information as possible. that the mood in the cockpit was standard, appropriate to the situation. They asked the event what to do it happened where the problem was and what the crew did. The technician removed the DFDAU card. Then he went to the engine, checked the oils, etc. He then returned to the cockpit. When asked if he sounded from the PIC some instruction regarding CVR, the first of the technicians replied as follows: "*I don't remember that anything about CVR fell.* " The other technician added, "*Neither do I.*" One of the technicians stated: "*DFDAU is taken out automatically as far as CVR is concerned, so it is at the command of the superior, I don't remember any instruction from the captain of the aircraft. "The* technicians said that this did not happen in later years, about 5 pm, nor was there any instruction to download the CVR record.

1.2 Personal injury

Tab 1 Personal injuries

Injury	Crew	Passenger	Other persons (population, etc.)
Mortally	0	0	0
Heavy	0	0	0
Light / no injuries	0/6	0/170	0/0

1 in the field means a separate stand at the aerodrome without a boarding bridge

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1.3 Damage to the aircraft

The aircraft had its fuel pump destroyed.

1.4 Other damages

NILE

1.5 Information about people

1.5.1 Crew information

1.5.2 Pilot-in-Command, PIC

The 53-year-old man held an ATPL (A) license.

- OPC renewed on 28 September 2018
- Line inspection performed on 4 April 2019
- Valid medical certificate valid, 1st class
- Flight experience:
  - o Total raid: 20 980: 00
  - o Air raid type: 8,065:09
  - o In the last 90 days: 219: 46 hrs
  - o In the last 24 hours before the flight 22.8: 0:00
- PIC's position in the company's AOC structure was the flight director
- Qualifications: FI, FE

1.5.3 First Officer, F / O

The 35-year-old man held an ATPL (A) license.

- OPC renewed on 14 February 2019
- Line inspection performed on 28 January 2019
- Valid medical certificate valid, 1st class
- Flight experience:
  - o Total raid: 3,400: 00
  - o Air raid type: 2,488: 24 hrs
  - o In the last 90 days: 204: 31
  - o In the last 24 hours before the flight August 22: 0:00

1.5.4 Flight crew rest

Tab 2 Rest of the flight crew before the flight in question

PIC	F / O
27:18	24:00

1.6 Aircraft information

1.6.1 Basic information about the aircraft B 737-800

- Aircraft type: Boeing B737-800

• Drive units: CFM56-7
• Manufactured: 2002, serial number 32360

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• Registration: OK-TVO
• Certificate of Airworthiness: EASA Standard Certificate of Airworthiness
• a valid Airworthiness Review Certificate
• The aircraft was serviced according to PART 145

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1.7 Meteorological situation

1.7.1 Flight path TAFs

Giant 2 Airport weather forecast - TAF

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Giant 3 Airport weather forecast - TAF (continued)

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1.7.2 METARs

Giant 4 Regular aeronautical meteorological report - METAR

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Giant 5 Regular aeronautical meteorological report - METAR (continued)

1.7.3 Suitable airports

The Commission has identified suitable aerodromes for a safe landing following the loss of a powerplant, ie after the second unsuccessful attempt to start the power unit: LGKV, LBSF, LYBE.

1.8 Radionavigation and visual aids

NILE

1.9 Connection service

Original transcripts of communications, communications AAIASB and TSB Hungary to flight TVS1125 callers TVS4MP brand:

1.9.1 Hellenic Air Accident Investigation and Safety Board, (AAIASB)

The Greek authority responsible for the LN investigation confirmed that it had not been found and noted that the relevant communication of the TVS1125 flight took place after the shutdown of one power unit.

1.9.2 Communication between ACC EXE Skopje Radar and Athina ACC

07:07:00 ACC EXE: Go ahead
07:07:01 Athina ACC: Yes, regarding TVS4MP from my side, pilot requested to maintain FL240 to destination. He requested to descent from FL360 due to a technical problem, but now he is at FL240 and said that he will go to its destination.
(Orientation translation: Yes, as far as TVS4MP is concerned, the pilot asked maintain the FL240 until the destination airport. He asked to drop out of the FL360 due technical problem, but now it's on the FL240 and it says it's flying to the target destination.)
07:08:00 ACC EXE: Its proceeding to RAXAD?
07:08:10 Athina ACC: I think he is, because he is with Thessaloniki now. He is with Thessaloniki now, bye.

1.9.3 Communication between ACC PLN Skopje, ACC Thessaloniki and Belgrade

07:07:20 ACC PLN Skopje calling Thessaloniki: Mam, is TVS4MP on your

frequency? OK, send it to RAXAD. OK Hello

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07:10:10 ACC PLN Skopje calling Belgrade: Sa moje side TVS4MP, jel ga vidis on FL240? OK, due technical problem started with 360 to 240 I in the region although he goes to 240, he only knows, he also knows. (Orientation translation: If as for me, TVS4MP, do you see it on the FL240? Well, for technical reasons problem went down from 360 to 240 And finally he wants to go to 240, just so you know Hi.)

1.9.4 Transcript of TVS4MP connection with ACC EXE Skopje at 119.375 MHz

07:09:47 TVS4MP: Skopje, good morning TVS4MP FL240 to RAXAD
07:09:52 ACC EXE: TVS4MP Skopje Radar identified
07:21:00 ACC EXE: TVS4MP Contact Belgrade radar 121.025
07:21:04 TVS4MP: 121.025 TVS4MP, bye bye, thank you

1.9.5 Transformation Safety Bureau (TSB Hungary)

TVS4MP was transferred from Belgrade ACC to Hungarian ACC with the information that the aircraft encountered a technical problem and that is the reason for flying at FL240, but they did not inform any of the ACC about engine failure. The flight overflew the Hungarian West Lower sector at FL240 without any incident.

(Orientation translation: TVS4MP was transferred from the Belgrade ACC to the Hungarian ACC with the information that the aircraft has a technical problem, and that is why it flies the FL240, but no ACC engine failure was reported. The flight flew over the Hungarian western lower sector on the FL240 without any incident.)

1.9.6 Transcript of TVS4MP connection with APP CWP Austro Control

08:25:52 WIEN control, TVM4PS eh good morning FL2-4-0 to NAVTI
08:25:58 TVS4MP hello identified maintain level 2-4-0
08:26:02 Maintaining FL2-4-0 TVS4MP
08:37:21 TVS4MP contact Prague 1-2-7-1-2-5 bye-bye
08:37:27 1-2-7-1-2-5 goodbye TVS4MP

1.9.7 Proclamation of PAN PAN

Transcription of TVS4MP connection during the transition to the frequency 127.125 MHz ACC PRAGUE

08:39:29

TVS4MP Prague Radar, good morning [good morning] TVS4MP.
127,125 th most common TVS4MP, good morning, radar contact, VLM4T, squawk 1000.
TVS4MP Squawk 1000, VLM4T and we have PAN PAN state, single engine operation, appreciate any shortcut if possible.
127,125 th most common TVS4MP, say again, I'm sorry, say again last part.
TVS4MP It's a PAN PAN situation, single engine operation, maintaining FL240, steady and if possible request shortcut.
127,125 th most common Yes, of course, proceed to VLM and VLM4T arrival.
TVS4MP VLM, VLM4T, TVS4MP.
Part of the communication is not listed due to irrelevance.

08:52:36

127,580 th most common TVS4MP, Prague?

TVS4MP Go ahead.
127,580 th most common Do you request local stand-by or full emergency or any assistance?

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TVS4MP Negative. It's no assistance required. We are steady and anyway we'll not block the runway. We'll vacate via B most probably and we have the stand 52, which is close to the runway. So, no assistance required.
127,580 th most common TVS4MP, roger, just to be sure we have declared local stand-by.
TVS4MP Yeah, it's OK, it's PAN PAN. Thank you.

09:04:35

134,560 th most common TVS4MP, RWY06 cleared to land, wind 060 °, 8 knots.
TVS4MP Cleared to land RWY06, TVS4MP.

09:05:44

TVS4MP Věžko [tower (familiar)], 4MP?
134,560 th most common Yes, go. [yes, go ahead]
TVS4MP We won't need any track inspection, we'll drive normally B and we're going to 52, I suppose, and we'll do it there. [We won't need any inspection on the RWY, we'll vacate normally via B and will taxi to 52, I expect and will work it out there]
134,560 th most common Sure, it's just our progress, we have to check the trajectory behind you, so you normally clear it to B, feel free. [Sure except it is our procedure to check the RWY after you, so you may freely vacate via B]
TVS4MP Yeah, I get it. Thank you. [Yeah, got it, thanks]

1.10 Airport information

1.10.1 LGSM

Airport ARISTARCHOS OF SAMOS is a Greek international airport. RWY 09/27 has altitude 20 ft. The airport is due to the method of approach and departure, to the locals meteorological conditions, position and length of the runway in relation to obstacles, included in the category C. The published departure and arrival on RWY 09/27 is thus very demanding. For this reason pilots must be qualified to operate at this aerodrome. RWY 09 has for take-off identical TORA, TODA, ASDA 2100 m, on request.

1.10.2 LKPR

Prague / Ruzyně Airport is an international airport. The airport is equipped for flights according to IFR rules. It has two runways marked RWY 06/24 and RWY 12/30. Runway runway 24 is Equipped for precision instrument approaches to meteorological minima ICAO CAT IIIb. On that day, at the time of landing, TVS 1125 was in operation on RWY 06.

1.11 Flight recorders and other recording devices

1.11.1 Graphical representation of the vertical flight profile

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Giant 6 Flight chart

1.11.2 Transcription of flight data from the DFDAU

06: 21: 00UTC:	start of the flight recording (start of flight record)
06: 26: 57UTC:	take-off rotation, gross weight 66.7 tons (lift of the bow landing gear at take - off, total weight 66.7 tonnes)

During take-off, the N1 speed difference between the two engines was more than 1.5%.

06: 27: 14UTC:	400 ft AMSL - Vertical acceleration 0.53G recorded as crew stated (400 feet AMSL - vertical acceleration 0.53G corresponding crew termination)
06: 27: 28UTC:	880 ft AMSL - flaps retraction was initiated (Flap retraction was activated at 880 feet AMSL)
06: 28: 30UTC:	2560 ft AMSL - flap retraction completed and 250 KIAS was established (2560 feet AMSL - flap retraction completed and speed reached 250 KIAS)
06: 30: 56UTC:	passing FL100, speed increasing 299 KIAS (FL100 flight, speed increase to 299 KIAS)
06: 46: 22UTC:	FL360 established (Mounted on FL360)
06: 47: 27UTC:	N1 on the eng. No.1 dropping down (decreasing speed N1 of engine no. 1)

IRS pos .: N39 ° 11'31 " E025 ° 09'00 "

06: 47: 49UTC:	N1 on the eng. No.1 stabilized at 25% (N1 on engine No. 1 stabilized at 25%)
06: 49: 26UTC:	MCP altitude set to FL240 and descent was initiated (MCP was set to FL240 and descent was started)
06: 49: 31UTC:	the lowest recorded speed - 226 KIAS 0.689M ***(lowest recorded speed 226 KIAS 0.689M)***
06: 50: 02UTC:	drift down speed 244 KIAS established (steady rate of descent 244 KIAS)
06: 56: 39UTC:	speed increasing up to 310 KIAS (speed increases up to 310 KIAS)
07: 02: 32UTC:	speed 310 KIAS established, passing FL260 (speed 310 KIAS reached, FL260 flight)
07: 05: 04UTC:	speed 311 KIAS, FL241, Engine start lever at “IDLE DETENT” position for windmilling restart (speed 311 KIAS, FL241, engine start lever in position "IDLE DETENT" position for restarting in mode autorotation)
07: 05: 18UTC:	FL240 established, gross weight 64.2 tons (mounted on FL240, total weight 64.2 tons)

IRS pos .: N40 ° 44'13 " E023 ° 16'12 "

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07: 06: 13UTC:	Engine start lever at “CUTOFF” position (Engine start lever in "CUTOFF" position)
07: 07: 45UTC:	Engine start lever at “IDLE DETENT” position for crossbleed start (Engine start lever in "IDLE DETENT" position for crossbleed start)
07: 08: 56UTC:	Engine start lever at “CUTOFF” position for remainder of the flight (Engine start lever in "CUTOFF" position for the rest of the flight)

IRS pos .: N41 ° 04'48 " E023 ° 09'07 "

Irrelevant section

08: 49: 05UTC:	descend initiated to FL170 (descent started on FL170)

IRS pos .: N49 ° 22'O1 " E015 ° 12'00 "

09: 01: 47UTC:	Flaps 1 (Flaps 1)
09: 02: 41UTC:	Flaps 5 (Flaps 5)
09: 03: 18UTC:	Gear Down (Chassis extended)
09: 03: 26UTC:	Flaps 15 (Flaps 15)
09: 06: 26UTC:	main gear touchdown, gross weight 59.8 tons (seat of the wheels of the main chassis, weight 59.8 t)
09: 07: 25UTC:	RWY06 vacated via B (release of RWY06 via taxiway B)
09: 09: 04UTC:	ACFT stopped, Ground speed 0kts (aircraft stopped, speed 0 knots)
09: 09: 27UTC:	Eng No. 2 stopped (engine No. 2 off)

1.12 Description of the accident site and wreckage

NILE

1.13 Medical and pathological findings

NILE

1.14 Fire

NILE

1.15 Search and Rescue

NILE

1.16 Tests and research

1.16.1 Fuel pump

Essential information from the report of the authorized organization in charge of fuel system expertise are related to the fuel pump in question. Individual elements of the fuel system

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Suspended from the engine number 1 CFM56-7B serial number 888760 were sent to the authorized organizations to carry out the expertise. The expertise confirmed the conclusions of the Preliminary Technical Report technical department of the operator, see Annexes 1, 2 and 3. The expertise confirmed the clogging fuel system with chips and fragments originating primarily from the engine fuel pumps. The conclusion of the expertise according to the individual components examined revealed that which are described in more detail in the following chapters.

1.16.2 Main fuel filter

The filter was contaminated with chips and fragments of 1 to 10 mm in size greater than 100 pcs. Chip analysis determined the material composition: aluminum-copper-magnesium (AlCuMg) and alloy aluminum and silicone (AISi). Apart from the mentioned chips and fragments, the filter did not show any other abnormalities. The main fuel filter was not found to cause the failure of the fuel pump manager to engine failure.

Giant 7 Fragments captured by the main fuel filter

1.16.3 Fuel nozzle filter

The filter was contaminated with scales with a size of 0.5 to 1.5 mm in a number higher than 100 pieces. All analyzed fragments contained a copper alloy and corresponded to a copper alloy, tin and lead (CuSnPb). Apart from the mentioned chips and fragments, the filter did not show any other abnormalities. Filter The fuel nozzle was not found to cause the failure of the fuel pump manager to engine failure.

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Giant 8 Fragments captured by the fuel nozzle filter

1.16.4 Hydromechanical unit (EMU)

The entire EMU was completely dismantled. High levels were found in all parts of EMU contamination by bronze-colored chips and fragments. This high contamination significantly influenced, even prevented, the activity of individual moving parts of EMU and thus functionality of the whole hydromechanical unit. This is also documented by the pressure / shut-off valve, which was found in a closed position and heavily contaminated with bronze-colored chips and fragments. For this reason, the valve piston was "sticky" and difficult to remove.

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Giant 9 The shut-off valve was in the closed position with limited functionality due to contamination

1.16.5 Main fuel pump

The fuel pump was contaminated with chips and fragments of 1 to 10 mm in number higher than 100 pcs. Chip analysis determined the material composition: aluminum-copper-magnesium (AlCuMg) and an aluminum-silicone alloy (AISi). Other contaminant material removed from the pump showed this material composition: copper (Cu) in an alloy with traces of nickel (Ni) and lead (Pb), carbon (C), fluorine (F) and aluminum (Al). The rotating part of the pump showed dry friction wear. The flaky fragment, removed from the Impeller blades, had an aluminum material composition alloys with about 10% silicone. The pump housing showed traces of friction with the rotating part of the pump - Impeller. The chips removed from the case showed the material composition of the Impeller. In the closet traces of molten metal proving high operating temperatures were also found in the pumps probably caused by running "dry", ie without fuel as a lubricant.

Giant 10 Traces of molten metal in the pump housing

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Giant 11 Partial welding was observed when the Impeller was disassembled with pump housing wall

Conclusion:

The findings on the main fuel pump indicate the operation of the pump without fuel access, which acts as a lubricant during normal operation. By running the pump "dry" it is possible explain well the damage to the fuel pump and at the same time the subsequent contamination, chips and fragments thus formed, other components of the engine fuel system.
This gradually led to a significant reduction in the functionality of the entire fuel system, which subsequently led to engine failure.

Note: According to the entry in the Defect Logbook (DL No. 107847), the technicians solved the defect registered by the PIC after returning from the previous flight. The entry concerned the difference between the N1 speeds at the start and ascent on engine No. 1 compared to engine No. 2. This difference was 1.5%. The defect was technical solved, inter alia, by replacing the fuel filter. From this it can be deduced that incorrect operation fuel system started earlier than on a specific flight, when there was a spontaneous engine shutdown No. 1.

1.17 Information on operational organizations

The maintenance of the aircraft was performed by an authorized organization according to the PART 145 transcript.

The Safety Department of Smartwings, as issued an internal final report in revision No. 3 the following safety recommendations for this incident.

Inform all flight crewmembers about the occurrence revised report

Responsible: Safety Deadline: 31 AUG 2019

Include requirement for engine run-up after a pilot TLB write-up on an inadequate engine response and / or performance

Responsible: MNT Deadline: 30 SEP 2019

Carry out a recurrent simulator training aiming at F / O assertiveness (ie let the F / Os to break the chain of events)

Responsible: FLT Deadline: 30 SEP 2019

Carry out an observation flights to the subject pilots aimed at CRM and done by a CRM instructor, followed by the Line Check done by TRE

Responsible: FLT Deadline: 30 SEP 2019

Provide training to the subject pilots on manufacturer's procedures and QRH usage

Responsible: FLT Deadline: 30 SEP 2019

Provide training to FCs on emergency procedures and communication

Responsible: FLT Deadline: 30 SEP 2019

Establish procedure for crew suspending from the flight operations

Responsible: FLT / Safety Deadline: 30 SEP 2019

Provide guidance for risk level non-normal management in OMs

Responsible: FLT / Safety Deadline: 30 SEP 2019

Provide training to FCs on CVR / DFDR securing procedures on recurrent trainings

Responsible: FLT / Safety Deadline: 30 SEP 2019

Provide the report to all current and potential partners

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Responsible: Leasing Deadline: 30 SEP 2019

1.18 Additional information

1.18.1 Commission Regulation (EU) No 965/2012

Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air traffic under Regulation of the European Parliament and of the Council (EC) No 216/2008, as amended (hereinafter AIR OPS)

According to Article 10 thereof, this Regulation shall be binding in its entirety and directly applicable in all Member States Member States

Relevant AIR OPS provisions in English and Czech

AIR OPS ORO GEN 110 Operator responsibilities

(a) The operator is responsible for the operation of the aircraft in accordance with Annex IV to Regulation (EC) No 216/2008, as applicable, the relevant requirements of this Annex and its air operator certificate (AOC) or specialized operation authorization (SPO authorization) or declaration

(b) Each flight shall be conducted in accordance with the provisions of the operations manual

AIR OPS ORO GEN 110 Operator responsibility

(a) An operator shall be responsible for the operation of an aircraft in accordance with Annex IV to Regulation (EC) No 216/2008 the relevant requirements of this Annex and its Air Operator Certificate (AOC) for special operations or declarations

(b) Each flight shall be conducted in accordance with the provisions of the Operations Manual

AIR OPS CAT GEN MPA 195 Preservation, production and use of flight recorder recordings

(a) Following an accident or an incident that is subject to mandatory reporting, the operator of an aircraft shall preserve the original recorded data for a period of 60 days unless otherwise directed by the investigating authority

AIR OPS CAT GEN MPA 195 Retention, submission and use of flight recorder records

(a) In the event of an accident or incident for which mandatory reporting is required, the operator shall retain the aircraft the original recorded data for a period of 60 days, unless otherwise ordered by the investigating authority

AIR OPS CAT OP MPA 280 In-flight fuel management - airplanes

The operator shall establish a procedure to ensure that in-flight fuel checks and fuel management are carried out according to the following criteria

(a) In-flight fuel checks

(1) The commander shall ensure that fuel checks are carried out in-flight at regular intervals. The usable remaining fuel shall be recorded and evaluated to:

(i) compare actual consumption with planned consumption;

(ii) check that the usable remaining fuel is sufficient to complete the flight, in accordance with (b); and

(iii) determine the expected usable fuel remaining on arrival at the destination aerodrome.

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(2) The relevant fuel data shall be recorded

(b) In-flight fuel management

(1) The **flight shall be conducted so that the expected usable fuel remaining on arrival at the destination aerodrome is not less than:**

(i) the required alternate fuel plus final reserve fuel steed

(ii) the final reserve fuel if no alternate aerodrome is required

(2) If an in-flight fuel check shows that the expected usable fuel remaining on arrival at the destination aerodrome is less than:

(i) the required alternate fuel plus final reserve fuel, the commander shall take into account the traffic and the operational conditions prevailing at the destination aerodrome, at the destination alternate aerodrome and at any other adequate aerodrome in deciding whether to proceed to the destination aerodrome or to divert so as to perform a safe landing with not less than final reserve fuel steed

(ii) the final reserve fuel if no alternate aerodrome is required, the commander shall take appropriate action and proceed to an adequate aerodrome so as to perform a safe landing with not less than final reserve fuel

(3) The commander shall declare an emergency when the calculated usable fuel on landing, at the nearest adequate aerodrome where a safe landing can be performed, is less than final reserve fuel

AIR OPS CAT OP MPA 280 In - flight fuel management - airplanes

The operator shall establish a procedure to ensure that fuel quantity checks and fuel management are carried out system in flight in accordance with these criteria

(a) In - flight fuel checks

(1) The commander shall ensure that in-flight fuel checks are carried out at regular intervals intervals. The amount of usable remaining fuel is recorded and evaluated to:

i) comparison of actual and planned consumption,

(ii) Check that the usable remaining fuel is sufficient to complete the flight in in accordance with point (b), and

(iii) determination of the expected amount of usable fuel remaining on arrival at the aerodrome determination.

2) Important fuel data is recorded

b) In-flight fuel management

(1) The flight shall be conducted so that the expected amount of usable fuel remaining on arrival to the airport of destination was not less than:

(i) required replacement fuel plus final reserve fuel, or

(ii) final reserve fuel, if no alternate aerodrome is required

(2) If an in-flight fuel check reveals that the expected usable amount would be the fuel remaining on arrival at the destination airport was less than:

(i) The required alternative fuel plus final reserve fuel, the commander shall take into account the operation and the operating conditions prevailing at the destination aerodrome, the destination alternate aerodrome and any other reasonable airport when deciding whether to proceed to the destination airport or to divert the flight so that it lands safely with at least an amount equal to the final reserve fuel,
or

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(ii) The final reserve of fuel, if no alternate aerodrome is required, shall be accepted by the commander appropriate measures and continues the flight to an appropriate aerodrome so that it can land safely at least with an amount of fuel equal to the final reserve fuel

(3) The commander shall declare an emergency when the calculated usable fuel on landing is the nearest reasonable aerodrome at which a safe landing can be made, less than required final fuel reserve

1.18.2 Commission Implementing Regulation (EU) No 923/2012

Commission Implementing Regulation (EU) No 923/2012 of 26 September 2012 establishing a common rules of the air and operating rules for air navigation services and procedures and amending Implementing Regulation (EC) No 1035/2011 and Regulation (EC) No 1265/2007, (EC) No 1794/2006, (EC) No 730/2006, (EC) No 1033/2006 and (EU) No 255/2010, as amended (hereinafter referred to as SERA) Pursuant to Article 11 thereof, this Regulation shall be binding in its entirety and directly applicable in all Member States

Relevant SERA provisions in English and Czech

SERA 11013 Degraded aircraft performance

(a) Whenever, as a result of failure or degradation of navigation, communications, altimetry, flight control or other systems, aircraft performance is degraded below the level required for the airspace in which it is operating, the flight crew shall advise the ATC unit concerned without delay Where the failure or degradation affects the separation minimum currently being employed, the controller shall take action to establish another appropriate type of separation or separation minimum

SERA 11013 Reduced aircraft performance

a) At any time due to failure or degradation of navigation, communication, altimeters or other systems, the performance of the aircraft is reduced below the level required in airspace, in which the aircraft is flying, the flight crew must notify the appropriate ATC unit without delay As soon as a failure or degradation affects the currently applied minimum separation, the controller must take measures to ensure another appropriate type of spacing or minimum spacing

SERA 2010 Responsibilities

(a) Responsibility of the pilot-in-command

The pilot-in-command of an aircraft shall, whether manipulating the controls or not, be responsible for the operation of the aircraft in accordance with this Regulation, except that the pilot-in-command may depart from these rules in circumstances that render such departure absolutely necessary in the interests of safety

(b) Pre-flight action

Before beginning a flight, the pilot-in-command of an aircraft shall become familiar with all available information appropriate to the intended operation Pre-flight action for flights away from the vicinity of an aerodrome, and for all IFR flights, shall include a careful study of available current weather reports and forecasts, taking into consideration fuel requirements and an alternative course of action if the flight cannot be completed as planned

SERA 2010 Responsibility for compliance with the rules of flying

(a) Responsibility of the pilot - in - command

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The pilot-in-command of an aircraft, whether or not the pilot-in-command, is responsible for the flight in accordance with this Regulation, except where it may derogate from those rules under conditions where there is a derogation absolutely necessary in order to maintain security

b) Pre-flight preparation

Before commencing the flight, the pilot-in-command shall be acquainted with all available information relating to it intended flight Pre-flight preparation for flights outside the airport and for all IFR flights must include a careful study of available current meteorological reports and forecasts, taking into account the fuel requirement and determining an alternative procedure in case a flight is not possible complete as planned

SERA 2015 Authority of pilot-in-command of an aircraft

The pilot-in-command of an aircraft shall have final authority as to the disposition of the aircraft while in command

SERA 2015 Authority of the pilot-in-command of an aircraft

The pilot-in-command of the aircraft must have the final right to decide whether to conduct the flight

SERA 3101 Negligent or reckless operation of aircraft

An aircraft shall not be operated in a negligent or reckless manner so as to endanger life or property of others

SERA 3101 Careless or careless handling of aircraft

The aircraft must not be handled carelessly or carelessly in a way that could endanger life or life property of others

1.18.3 Act No. 49/1997 Coll., On Civil Aviation and on Amendments to Act No. 455/1991 Coll., On Trade Licensing (Trade Licensing Act), as amended regulations

§ 102, paragraph 2

Operators of airports and aircraft structures, persons authorized to operate air services, air operators and other persons involved in civil aviation are required comply with aviation regulations that are in line with the international agreements to which they are a party legal order, issued

a) the International Civil Aviation Organization,

(b) by an association of aviation authorities in accordance with European Union regulations, and

c) the European Organization for the Safety of Air Navigation (EUROCONTROL),

as adopted by the Czech Republic represented by the Ministry of Transport These regulations they are published in the Aeronautical Information Manual and are available at the Ministry of Transport and at the Office

1.18.4 Greek AIP - Excerpt from the section on RVSM airspace

ENR 1 3 3 Reduced vertical separation minimum (RVSM)

1 3 3 1 **HELLAS UIR is a part of the "EUR RVSM airspace".**

1 3 3 2 RVSM shall be applicable in part of that volume of Greek airspace between FL 290 and

FL 410 inclusive

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Professional translation

ENR 1 3 3 Reduced minimum vertical spacing (RVSM)

1 3 3 1 HELLAS UIR is part of the EUR RVSM airspace

1 3 3 2 The RVSM will apply to part of this Greek airspace range between FL 290 and FL 410 inclusive

1.18.5 Procedures in the RVSM space in English and Czech

AMC2 SPA RVSM 105 RVSM operational approval

OPERATING PROCEDURES

(d) In-flight procedures

(2) Contingency procedures after entering RVSM airspace are as follows:

The pilot should notify ATC of contingencies (equipment failures, weather) that affect the ability to maintain the cleared flight level and coordinate a plan of action appropriate to the airspace concerned The pilot should obtain to the guidance on contingency procedures is contained in the relevant publications dealing with the airspace

(ii) **Examples** of equipment failures that should be notified to ATC are:

(A) failure of all automatic altitude-control systems aboard the aircraft

(B) loss of redundancy of altimetry systems

(C) **loss of thrust on an engine necessitating descent** steed

(D) any other equipment failure affecting the ability to maintain cleared flight level

AMC2 SPA RVSM 105 RVSM operational approval

OPERATING PROCEDURES

(d) In - flight procedures

(2) Standby procedures after entering RVSM airspace are as follows:

The pilot should inform ATC of unforeseen events (equipment failure, weather) that affect the ability to maintain flight level and coordinate a plan of action appropriate to the person concerned airspace The pilot should be provided with instructions on the emergency procedures contained in relevant airspace publications

(ii) **Examples** of equipment failures that should be reported to ATC are:

(A) failure of all automatic altitude control systems on board the aircraft

(B) loss of backup of altimeter systems

(C) **loss of engine thrust requiring descent** or

(D) Any other equipment failure affecting the ability to maintain a clean flight level

The above is part of OM

1.18.6 OM-A

1 4 Authority, duties and responsibilities of the commander

The Commander shall comply with the laws, regulations and procedures of those States in which operations are conducted and which are pertinent to the performance of his duties and is familiar with the laws, regulations and procedures pertinent to the performance of his duties The Commander shall comply with operating limits, as defined by the original equipment

manufacturer (AFM, FCOM) for the aircraft type they operate

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1 4 Powers, duties and responsibilities of the pilot-in-command

The pilot-in-command is required to comply with the laws and procedures of the states in which the operation is conducted carried out and which relate to the performance of his duties, and has been acquainted with the law and procedures relating to the performance of his duties The pilot-in-command must comply with the operating defined by the original equipment manufacturer (AFM, FCOM) for the type of aircraft on which it operates

1 4 1 Violation of flight operation procedures

All flight operations personnel shall avoid wilful and deliberate violation of flight operations organizational policies and procedures In the event of wilful, deliberate violence or negligent disobedience to those rules and regulations stated within the flight operations manuals and operations directives, the personnel concerned may become subject to disciplinary, legal or penalty action The decision and responsibility to propose the appropriate level of disciplinary or other actions rests with the Director Flight Operations and shall be specified by written form If the action is decided to be legal or penalty then the written form shall be confirmed by CEO

Professional translation

1 4 1 Violation of air traffic procedures

All air traffic controllers must avoid intentional and willful violations organizational arrangements and air traffic procedures In case of intentional, willful breach or negligent non-compliance with the rules and regulations contained in the air traffic manuals and operational guidelines, disciplinary, legal action may be taken against the workers concerned or criminal proceedings It shall decide on the appropriate level of disciplinary or other proceedings and the responsibility for its design rests with the Director of Air Traffic and must be specified in writing form In the case of a decision on legal or criminal proceedings, this written form will be confirmed CEO

1.18.7 FCTM - Boeing 737 NG Flight Crew Training Manual

Landing at the Nearest Suitable Airport

“Plan to land at the nearest suitable airport” is a phrase used in the QRH This section explains the basis for that statement and how it is applied

In a non-normal situation, the pilot-in-command, having the authority and responsibility for operation and safety of the flight, must make the decision to continue the flight as planned or fun In an emergency situation, this authority may include necessary deviations from any regulation to meet the emergency In all cases, the pilot-in-command is expected to take a safe course of action

The QRH assists flight crews in the decision making process by indicating those situations where “Landing at the nearest suitable airport” is required These situations are described in the Checklist Introduction or the individual NNC

The regulations regarding an engine failure are specific Most regulatory agencies specify that the pilot-in-command of a twin engine airplane that has an engine failure or engine shutdown shall land at the nearest suitable airport at which a safe landing can be made

Professional translation

Landing at the nearest suitable airport

"Plan your landing at the nearest suitable airport" is the instruction used in the manual with fast accessible instructions (QRH) This section explains the basis of this statement and how to applies

In an unusual situation, the pilot-in-command, who has authority and responsibility for operation and safety decide whether to continue the flight as planned or to fly to an alternate aerodrome

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In an emergency, within the framework of this power, it may, where necessary, derogate from the rules to resolve the emergency **In all cases, the pilot-in-command is expected to be proceed safely.**

QRH assists flight crews in the decision-making process by listing when "landing at the nearest suitable airport" is required. These situations are described in the introduction checklist of actions or in individual NNCs.

The engine failure regulations are specific **Most regulatory agencies state that the pilot-in-command of a twin-engine aircraft in which the engine fails or stops must land at the nearest suitable aerodrome where a safe landing can be made.**

Suitable Airport - Guidance material

In general must have adequate facilities and meet certain minimum weather and field conditions If required to divert to the nearest suitable airport (twin engine airplanes with an engine failure), the guidance material also typically specifies that the pilot should select the nearest suitable airport “in point of time” or “in terms of time ” In selecting the nearest suitable airport, the pilot-in-command should consider the suitability of nearby airports in terms of facilities and weather and their proximity to the airplane position The pilot-in-command may determine, based on the nature of the situation and an examination of the relevant factors, that the safest course of action is to divert to a more distant airport than the nearest airport For example, there is not necessarily a requirement to spiral down to the airport nearest the airplane's present position if, in the judgment of the pilot-in-command, it would require equal or less time to continue to another nearby airport For persistent smoke or a fire which cannot positively be confirmed to be completely extinguished, the safest course of action typically requires the earliest possible descent, landing and passenger evacuation This may dictate landing at the nearest airport appropriate for the airplane type, rather than at the nearest suitable airport normally used for the route segment where the incident occurs

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Suitable airport - advisory document

In general, they must have adequate facilities, equipment and services, and meet certain minimum weather and operating conditions for airports If it is required to change the destination flight to the nearest suitable aerodrome (twin-engine airplanes with engine failure), advisory the document usually also specifies that the pilot should choose the nearest suitable aerodrome “in terms of specific time ” 2 or“ due to the duration of the event ” 3 When selecting the nearest suitable one airport, the pilot-in-command should consider the suitability of nearby airports in terms of facilities, equipment, services and weather, and if they are close to the position of the aircraft The pilot-in-command may, depending on the nature of the situation and an assessment of the factors involved to determine that the safest course of action is to deviate to to a more distant airport than to the nearest airport For example, a descent in is not necessarily required spiral to the airport that is closest to the current position of the airplane, if at the discretion of the commander the aircraft required to continue the same or a shorter time to another nearby airport As regards persistent smoke or fire that cannot be positively confirmed to have been completely extinguished, The safest procedure usually requires descending, landing and evacuating passengers as soon as possible possible This may command a landing at the nearest aerodrome appropriate to the airplane type, rather than landing at the nearest suitable aerodrome normally used for the section of route where it occurs to the incident

2 specific time related to a specific place in a given event

3 taking into account the time required to fly to the nearest suitable aerodrome

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1.18.8 *Black Swan*

The *Black Swan Theory* [4] refers to the so-called *Black Swan* events, unpredictable events, which are beyond what is expected of the situation and have potentially serious consequences. The occurrence of the so-called black swan is characterized by extreme rarity, serious impact and the impossibility of prediction.

The Black Swan Theory was developed by Nassim Nicolas Taleb. Because Nicolas Taleb is a finance professor, writer and former Wall Street businessman, is a theory originally associated with the financial sector. Nevertheless, the Black Swan theory can be applied to any other sectors, including aviation.

Air accidents and aviation events that were beyond expectations were in perspective impact and exceptionality called the black swan, (Germanwings Flight 9525, Malaysian Airlines MH370, US Airways flight 1549, Qantas flight QF32 A380). These black swans are proof that that nothing is impossible and are a challenge to raise awareness of aviation safety. Good crew training along with compliance with regulations and safety rules can sometimes save people's lives. An effective airline SMS program will never be bad investment.

1.19 Methods of expert investigation of causes

Annex 13 was followed during the technical investigation into the causes of the serious incident.

2 Analyzes

2.1 Sources and methods used to investigate a serious incident

During the investigation, the Commission proceeded from two received internal ZZ Smartwings, as První ZZ revision 0, was prepared on 5 September 2019. The second ZZ revision 3, was prepared on 6 February. 2020. Flight information describes the statements of PIC, F / O, SCC, technical personnel and the services of an acting dispatching officer. Correspondence transcripts were obtained and used individual ATC units and communication between the ACCs of the relevant transit States. Evaluation safety and operational aspects of diligence communication were provided by ANS PRAGUE. It was analyzed data from DFDAU. Potential for particularly serious mistakes by the commission crew evaluated by the worst possible *Black Swan* impact method .

2.2 Analysis of the PIC decision-making process

2.2.1 Non-announcement of PAN PAN

The diligence of PAN PAN takes precedence, with the exception of MAY DAY emergency messages, before all correspondence and all stations must ensure that the broadcast diligence correspondence was not canceled. F / O was PF, and therefore primarily responsible for piloting the aircraft. He was well aware that an aircraft with one inoperative power unit was not capable keep the FL360 reached. He knew he had to start descending to the set FL as soon as possible, on which an airplane with one non-operating unit will be able to fly safely. But there was no PIC able to meet the F / O requirement for an immediate descent without initiating urgency communication. The PIC was equipped with a BOSE headset for flight. This headset according to F / O testimony most likely impaired PIC communication with both the ATC and the crew. Although the PIC was not

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after several attempts to establish a connection with ATC, he did not start communication immediately urgency signal PAN PAN, which clearly defines the nature of urgency communication to be ATC processed as a matter of priority. Not even the circumstances arising from the nature of the defect, growing nervousness in the crew, warnings of declining flight speed did not lead the PIC to change its mind and the immediate use of the PAN PAN urgency signal. The PIC's ignoring of risks led to the fact that the flight continued on the FL360 with one engine inoperative for more than 2 min and the flight speed dropped to 226 KIAS. This situation led the F / O to take a decision that in the event of a forced descent without the permission of ATC will perform an *offset* maneuver in order to thus avoiding potential conflicting traffic at lower flight levels. F / O was responsible for piloting. Therefore, he followed the trend of declining speed in order not to get into a situation when the flight speed falls below the value needed for safe maneuvering, resp. to fall speed limit. These risks resulting from the nature of the aircraft defect led to the FL360 F / O in a given situation to increased assertiveness towards the PIC during its non-prescription attempts request an ATC descent. For AMC2 SPA.RVSM105 (d) (2) see 1.18.6 and OM-A PARA.8.3.2.4 PROCEDURES IN THE EVENT OF SYSTEM DEGRADATION see Annex 4, in this case, it clearly defines the obligation for the crew to report the circumstances in a relevant and correct manner ATC failure, loss of ability to maintain flight level by performing diligent communication. By ignoring these rules and self-misconduct, the PIC allowed it to be declining At the same time, the speed of the flight increased the uncertainty and stress in the flight crew. The F / O instruction that was primarily responsible for piloting, the PIC thus completely ignored the way of communication. That DFDAU record after stopping engine No. 1 at 06:49:31 on FL360, the decrease is subtracted speeds up to 226KIAS / 0.689M. Engine No. 1 shutdown was deducted at 06:47:27. Due to the non-use of prescription communication, the PIC allowed the stress gradient in the crew to increase more than 2 min.

According to the testimony of the crew and the provided records of individual ATCs during the flight of the aircraft their airspace up to FIR LKAA, was not at the time of the loss of one of the two propulsion urgency or emergency communication is used for airplane units. To obtain permission to descend the phrase " *maintenance issue*" was used three or four times . According to RVSM procedures referred to in OM-A (1) (a) 8.3.2.5.4., See Annex 4, - In case of impaired functionality urgency or emergency communication procedures must be used in the system.

Diligence communication was started and carried out only at the time of entering the FIR LKAA. PIC subsequently, he communicated with ATC in a non-standard to familiar manner.

2.2.2 Operational and safety aspects in case the PAN is not declared by the crew after the loss thrust of one of the two power units of the aircraft from the point of view of ATC.

Conflict resolution security:

- in general: limited maneuverability
- sudden "unsolvability" of a crisis situation = loss of time and concentration!
- it is not possible to apply a "trained" procedure in training (more time is needed to resolve the situation)
- "immediately turn" command cannot be fulfilled
- "immediately climb / descent" command cannot be fulfilled

In general, ATC takes into account the standard performance of a given type of ACFT and its solution plan limited conflicts, his limited performance takes up valuable time and reduces options effective maneuvers to successfully resolve the current operational situation .

Operational aspects:

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- the "increase / decrease speed" command cannot be fulfilled in the expected range (standard spacing / sequence)
- it is not possible to change the FL for the spacing (it is not possible to rise / fall = higher consumption)
- Significantly limited maneuverability to respond to a TCAS / INFORMATION command
- pre-selected concept cannot be used = loss of time and concentration, increase in load and stress
- The REQ of subsequent sites cannot be met

Prevention in case of standard system degradation notification procedure:

- continuous diversion of traffic under ACFT (in case of "deterioration" of the situation)
- selection of the shortest flight trajectory
- Timely information to downstream sites / units
- air traffic management concept adapted to limited performance the ACFT concerned

2.2.3 Non-announcement of PAN PAN - evaluation by the worst impact method *Black Swan*

The PIC did not initiate diligent communication with the ATC components after stopping the engine. Because attempted by the PIC to request a fall by non-prescribed communication, he lost the time needed to adopt its own safety strategy in case of failure of the second engine. He couldn't know whether the engine shutdown was caused by fuel contamination. In the case of discontinuation, the second power units at a time when the speed dropped to 226 KIAS would increase rapidly gradient decrease of the aircraft speed led F / O naturally to the need to immediately initiate an emergency descent by rough suppression so as not to reach the rate of fall. Such a gross F / O impact to driving would in all likelihood lead to possible injury to the unrestrained passengers. A regular further loss of aircraft speed would then limit the F / O option safely perform an *offset* maneuver to avoid conflicting traffic. The plane would have to start in an emergency descend directly in front of you, without pre-secured vertical distances from the potential counter-operation or concurrent operation at lower levels. Without declaring diligence PAN signal and knowledge of the circumstances of the forced or emergency descent would not be ATC able to correctly evaluate safety and operational aspects see. 2.1.2. and secure the aircraft and safe vertical spacings for surrounding traffic. The PIC did not assess the potential risks, using non-prescribed communication lost time for further crew decisions and the FL360 caused a reduction in maneuvering speed. PIC thus prevented F / O in the role of PF from being ahead dealing with possible circumstances, so-called being "in time before the plane".

2.2.4 Plan to land at the nearest suitable airport - Plan to land at the nearest suitable airport airport

Operating manuals of Smartwings, as approved / accepted by the Civil Service Office aviation states that the manual with quickly available QRH instructions and operations manual FCOM flight crew are used as an integral part of OM-B Chapter 2, paragraph 1 (a). 2 (a), see Annex 7. The *Engine Failure or Shutdown* situation required the use of the manufacturer's QRH to carry out procedures for unusual situations. FCOM manufacturer provides complete lists procedures described in OM-A and OM-B. Additional information and recommendations are represented in OM-C and OM-D. Engine Failure or Shutdown NNC is on page 7.18 QRH, see Annex 8A. The crew continued until point 13 page 7.20 QRH, see Annex 8B, where decided to attempt to restart the engine and switched to control

For an In-Flight Start NNC list, page 7.27, see Appendix 9A. Following the instructions on page 7.28,

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see Appendix 9B, proceeded to page 7.29, see Appendix 9C. Starting the engine in flight, *windmill and crossbleed start,* were unsuccessful. The In-Flight Start NNC engine would terminate. Following procedure with item no.10: **Plan to land at the nearest suitable airport** is on page 7.30 QRH, see Annex 9D with note: **Do not use FMC performance prediction** . Control the list directs the crew to the **Go to One Engine Inoperative Landing checklist** on page 7.34 QRH.

The plan used to land at the nearest suitable airport is the instruction used in QRH.

Guidelines for QRH Checklist, Chapter CI, Section 2, paragraph: Non-Normal Checklis Operation, see Annex 10, explains what this statement means in NNC. Also FCOM Non-Normal Operations, Chapter 8.2: paragraph: Non-Normal Situational Guidelines, see appendix 11, and paragraph: Landing at the Nearest Suitable Airport, see Annex 12, leads the crew to determine the nearest suitable airport. The pilot-in-command shall designate a suitable alternate aerodrome on the route according to paragraph OM-A: 8.1.2.5., see Annex 5.

2.3 Quick Reference Handbook

2.3.1 Plan to land at the nearest suitable aerodrome - meaning instructions from the FCTM

"Plan a landing at the nearest suitable airport" is the instruction used in QRH. This part explains the basis of this statement and how to use it. In an unusual situation **, the** commander **must** the pilot, who has the authority and responsibility for the operation and safety of the flight, to make a decision continue the flight according to the plan or diversion. In an emergency, the PIC may make it necessary derogations from any regulations in order to accommodate an emergency situation. **In all cases expects the pilot-in-command to choose the safest course of action in view of the potential risks.** QRH assists flight crews in the decision-making process by presenting when a landing at the nearest suitable airport is required. These situations are described in the introduction "Checklists" or in individual NNCs. Most regulatory agencies stipulate that the pilot in command a twin - engined airplane which has an engine failure or stop **must land on to the nearest suitable airport.** A suitable aerodrome is defined by the operating authority operator on the basis of auxiliary material, but in general must have adequate equipment and must meet certain minimum meteorological conditions.

2.3.2 Closing the Checklist

Each QRH Checklist, resp. its implementation should end with the wording: "*NNC (specific* As " NNC Engine In-Flight Start has not been confirmed item **10 Plan to land at the nearest suitable airport,** could not be heard exit NNC "***Engine In-Flight Start Complete*".** At 07:08:56 UTC: Engine start lever at "CUTOFF" position for remainder of the flight - engine start lever in position "CUTOFF" for the rest of the flight. Subsequently, the PIC had to complete the failed Engine in Flight attempts Start NNC QRH according to the specified procedure. The time of this established procedure would be added to 07:08:56 and in the case of prescribed security of the CVR PIC record at 09:09:27 UTC - Eng No.2 stopped - engine No.2 was turned off, it would be possible to find out how to PIC terminated the NNC QRH.

2.4 Cockpit Voice Recorder

According to the testimony of the crew, the PIC did not perform the procedure for securing the CVR according to OM-A para .: 11.7.4.1. see Annex 6, which in this case was defined by the regulation for the purposes of the investigation. It was not handed over nor an oral instruction to download the CVR record of maintenance personnel and was not executed accordingly

Defect Logbook entry .

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2.5 Crew Resource Management

The CRM Assessment Guide is for CRM instructors, ground training instructors, line and type training instructors and checking inspectors who evaluate the activity airplane crews. Flight crews must, in the normal course of their duties, perform their duties use countermeasures to avert threats, eliminate possible errors and side effects aircraft systems to reduce air traffic safety limits. Among the primary examples Countermeasures include communications, checklists of procedures, briefings, call-outs and SOPs, as well as the personal strategy and tactics of the crew leading to the safe completion of the flight.

The CRM requirements for crew competence are:

- Communication
- Application of threat and error management policies according to CRM rules
- Threat and error management
- Leadership and teamwork
- Situational awareness
- Workload management
- Problem solving and decision making
- Use of automation
- Task sharing
- Stress, stress management

2.5.1 CRM evaluation

The *Behavioral Marker Notechs schema* is a matrix that allows you to perform a specific multi-item evaluation according to paragraph CRM EVALUATION: 3.1. see annex 14. The four general areas with their subcomponents were evaluated using the Handbook for crew evaluation based on crew testimony and DFDAU record. Range of degrees Ratings range from very poor (1) to very good (5). Evaluation done inside Smartwings, as showed an enormous PIC command gradient in the cockpit, which led to the fact that the F / O could not actually participate in the decision-making process in the crew. Average the rating of the commander was **1.26 - 1.43.** The CRM during the flight in question was **“very poorly".**

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2.6 Driftdown Speed / Level OFF altitude - speed of descent at reduced power / steady altitude - transition to level flight

Giant 12 QRH table for lowering at reduced power

The aircraft had an initial weight on FL240 of 64.1 t. ISA read from the OFP was +7 ° C. By approximating 64.1 between 62 and 67 we get LEVEL OFF ALTITUDE (FT) 24090.

2.6.1 Long Range Cruise Altitude Capability - Applicable cruise altitude long range mode

Giant 13 QRH table to determine the applicable FL

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The table shows the maximum altitude that can be maintained at a given aircraft weight, temperature air and deviations from ISA, based on long-distance cruising speed, using the maximum usable thrust of the engine with a residual rate of climb of 100 ft / min. For weight 64.1 t, is usable PRESSURE ALTITUDE (FT) approx. 22 788 ft. The nearest usable, therefore, could not be FL240 but FL220. The crew had to use the MCT for a while about 7 minutes on the FL240 to stop the decrease in speed of the aircraft and thus could not apply condition of 100 ft / min climb, or maintain the current indicated speed.

2.6.2 Long range Cruise Control - Long range cruise mode

Giant 14 QRH table with data for weights and conservative range calculation

The table provides the target speed N1 in%, for the long-range travel level with inoperative engine, Mach number, KIAS and fuel flow for mass and pressure altitude flight altitude. The fuel flow values in this table reflect the fuel consumption of a functioning engine. In the case of an initial weight of 64.1 t, the values applicable to the next higher weight are applicable 65 t. For FL250 and weight 60 t values are highlighted in the blue square.

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2.7 Fuel

The amount of fuel for the whole LKPR - LGSM - LKPR rotation was determined by the PIC decision and registered in the OFP for 15 500 kg . This decision was based on the company's refueling policy, to avoid refueling on the LGSM. The provision of fuel addition data was analyzed by AirFASE software (FDM). Amount of fuel after the first leg of the flight from LKPR - LGSM after stopping the engines, had a value of 9,460 kg. Quantity entered in OFP was 9,500 kg. The required amount of fuel according to the OFP calculation for the LGSM - LKPR section was 9,217 kg. The amount of fuel at the time of takeoff from the LGSM was 9310 kg. Amount of fuel on board the aircraft at the time of landing on LKPR was at a value of 2435 kg and after stopping the engine at a value of 2340 kg. The calculated fuel value according to OFP, FMS RES was 2412 kg = 1328 kg ALTN Fuel +1083 kg Final Reserve, (rewritten fuel values from OFP with different resulting in 2412 kg). The FUEL REM registered PIC in the OFP had a value of 2370 kg. OFP indicates 3 PIC checks of the current amount of fuel after engine shutdown 1. After shutdown FMC PERFORMANCE PREDICTIONS and QRH cannot be used with one power unit this is prohibited by the NNC Note to Note 10, see Annex 9D. Therefore, it is done conservative calculation of the remaining amount of fuel from the relevant tables with available data from QRH, see 2.6.2. There is no single entry in the OFP on the method of calculating the fuel residue according to QRH at the intended aerodrome for landing in flight conditions without a single power unit in accordance with Chapter Performance Inflight - QRH Engine Inoperative. There is no doubt that the development of the difference in quantity Fuel Actual and FMS Reserve played a key role in the PIC decision-making process. This only confirms the statement of the crew crew dispatcher or SCC, which only learned about 45 minutes before landing, "that there is enough fuel on board the plane to Prague". Yet the PIC decided to continue the flight to the destination LKPR. No continuous fuel entries Actual and continuously calculated residual fuel calculations using relevant and correct data from QRH, PIC had to estimate the rest of the fuel at LKPR or use the wrong one and a checklist of the forbidden value from the FMS. Due to the limit difference in the amount of fuel 23 kg between FMS RES 2412 kg and 2435 kg after landing, the PIC could not be sure on arrival at LKPR, that it will not start consuming fuel from the FMS RES. Nevertheless, the PIC declared the ATC's ability to fly except for LKPR without canceling the ALTN or otherwise declared procedure. If the PIC did methodically, the only correct way to conservatively calculate fuel from QRH would be concluded that he must make a safe landing before the LKPR or cancel the ALTN.

2.7.1 Fuel policy - *Black Swan* worst impact assessment

The PIC did not calculate unforeseen circumstances until its decision to continue the flight Prague Airport due to the small fuel residue on board. At the time of landing he had an airplane on on board 2435 kg, with the minimum calculated fuel FMS RES for departure to an alternate aerodrome was 2412 kg, in the case of both working power units. Reduced performance of the aircraft on departure to the nearest replacement airport in Dresden would force the MCT to work engine and together with the increased resistance of the drifting aircraft. Therefore, he would consume more than 1328 kg of the planned amount of fuel for overflight on the ALTN in the case of both working power units. The decision-making process in this case could not involve departure to the backup airport, because the tables to calculate consumption in case of climb they do not exist with the drive unit inoperative. By chaining previous wrong decisions would ultimately lead to the start of consumption of the last fuel supply of 1083 kg Final Reserve, before reaching ALTN. In this case, the PIC would have to declare an emergency (MAY DAY), due to the rest of the fuel, to provide flight assistance from the ATC components - the highest landing priority. A small amount of fuel on board and the loss of the propulsion unit would lead to more an increase in crew stress and an increased risk of possible landing errors. F / O was not

at the same time specifically informed of such a fuel limit and only accepted the fact that the fuel on

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LKPR is coming out. The PIC did not know the cause of the engine shutdown and therefore could not know whether the shutdown engine No. 1 was not caused by fuel contamination.

2.8 SAFETY ALERT 2/2015

The LGSM airport, classified in category C, had the same value of 2100 m for TORA, TODA and ASDA. After evaluating the calculated parameters, the PIC should be clear that any deviation engine parameters during take-off would lead to a shift of the calculated values towards the limit runway length value. The PIC did not notice a difference (more than 1.5%) between the N1 speed values both engines and performed a *Call Out Thrust Set* . For the distance parameter EO-STOP (*Engine out-stop*) the value of 1978 was calculated and 122 m of the total length of the runway remained 2100 m in case of interruption of take-off when one of the propulsion units is stopped before the speed V1. For these cases, the company issued the document SAFETY ALERT 2/2015, on which On this basis, crews have an obligation to act unequivocally in such cases with this document to secure and increase the safety of take-off or landing. PIC thus apparently according to OM-B chapter 2 NORMAL PROCEDURES, section (b) PRE-DEPARTURE and SAFETY ALERT 2/2015, which discusses the need to include TEM *(Threat And Error Management - management of threats and errors)* to each departure briefing, did not take into account take-off safety procedures and recommendations during the take-off expected threats.

2.8.1 TEM - *Black Swan* worst impact assessment

In case of engine shutdown during take-off and reduced speed N1 by 1.5% of running engine it is certain that the calculated ASDA and EO-STOP values would not correspond to the real ASDA values and EO-STOP. Less power of the running engine No. 1 by 1.5% would in the case of shutdown of engine No. 2 led to a lawful displacement of V1 and Vr, which could lead to the achievement of EO-STOP 2100 m. The crew would lose 122 m of reserve in the event of a missed take-off. Any hesitation to speed V1, or a slow PIC response when the take-off is interrupted, would therefore lead to that the aircraft would exceed the calculated limits (red circle - 3). The plane could get off the runway, or could take off beyond 2100 m in the event of rotation and would not keep it safe distance from obstacles.

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Giant 15 FMS calculated data for take-off

2.9 Change in Final Report No. 3 and inserted 5.13 OM-B PARA .: 4.3.

During the investigation process of the event, a new fact was discovered. Commission of Inquiry ÚZPLN received two Final Reports from Smartwings, as First ZZ 03/2019 IFSD, revision 0 was dated 5 September 2019. The second ZZ 03/2019 ISFD revision 3, which was delivered to ÚZPLN, was dated 6 February 2020. The two Final Reports differed mainly from each other the content of the inserted provision 5.13. OM-B Para .: 4.3. see Annex 13. Para .: 4.3. this the provision explains how to operate a flight with one power unit inoperative at a speed of 290 KIAS at the maximum distance to reach the alternate aerodrome at defined airplane speed with one engine inoperative (Maximum Diversion Distance 1 ENG INOP 400 NM).

2.10 "Quasi" OM-B procedure 5.13. Para .: 4.3. SPEED AND DISTANCE - 1 ENG INOP

The "historical construction" inserted in the second ZZ No. 3 is interpreted in paragraph 5.13. OM-B para .: 4.3. the following "quasi" procedure: ***In case of 1 ENG operation, the crew must take suitable action to reach the alternate aerodrome, if possible within 1 hour, but this is not mandatory.*** The created "historical construction" and the interpretation of the said "quasi" procedure could not be found in the prescription. OM-A in the Introduction section defines OM-B as "PART CONTAINING INSTRUCTIONS AND PROCEDURES NECESSARY TO ENSURE SAFE OPERATION OF ALL TYPES OF AIRCRAFT. "This interpretation of OM-A defines the instructions and the procedures contained in OM-B. Interpretation of these procedures and instructions must be in accordance with FCTM manufacturers and compliance with them is the responsibility of flight crews. The investigation revealed that the purpose of creating and inserting a "quasi" procedure into the OM-B thus defined should be

flight planning only. Although this confusing "quasi" procedure was intended for planning, it was

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contrary to the valid procedure in OM-A Para .: 8.1.2.5 Tab. 8.1-a: Threshold Distance. At the same time this "historical construction" and its "quasi" process could not even be understood as relevant nor as correct for the relevant NNC QRH procedure. It was PIC's responsibility to proceed and complete NNC QRH point 10. **Plan to land at the nearest suitable airport** as relevant and the correct interpretation of the FCTM by the manufacturer. The PIC was to follow the procedure given in OM-A and take into account the safety rule set out in the QRH section.

The investigation did not reveal that sometimes the pilots of Travel Service, as and subsequently Smartwings, as by interpreting this "quasi" procedure however in the drilling of NNC QRH on synthetic flight simulators controlled. No relevant path was found that would allow it in any way pilot to explain the "quasi" procedure in the implementation of NNC QRH. It is therefore not possible to how could this "quasi" procedure be reflected in the decision-making process of a PIC with a function flight director of the company. The commission found this "quasi" procedure to be a systemic error procedure manual OM-B Smartwings, as

2.11 Conflict in the decision-making process of the pilot-in-command

PIC had experience of about 20,900 flight hours, most of it in commercial air transport. He had thus great aviation experience and knowledge. In addition to the function of commander of the aircraft, he was also the holder FI and FE qualifications, which represent the imaginary pinnacle of knowledge and experience needed for their transfer to other pilots. As the flight director of the company he held more for 15 years, approved binding operating documents that had a decisive influence on safety. It is therefore difficult to understand that during one flight he ignored or violated or denied the obligations arising from the individual relevant provisions of the binding OM-A, further QRH, FCOM, FCTM manufacturer, regulations and safety recommendations. Decision - making the process of the commander of the aircraft after the loss of the propulsion unit did not proceed according to the defined procedure NNC QRH completed by point 10 and described in FCOM. QRH was in this case the primary and relevant airplane crew procedure manual for dealing with the applicable The NNC on board the aircraft and the responsible commander of the aircraft thus had to take appropriate NNC procedures adhere to. The decision-making process of the commander of the aircraft was aimed at completing the flight to the destination LKPR regardless of sufficient suitable aerodromes for a safe landing.
The decision-making process thus took place in conflict with the standard decision-making process based on compliance with the regulations, procedures and safety rules described in the relevant operational documents.

It was not possible to satisfactorily prove the influence of the company's management culture on decision-making the process of an airplane commander who also held the position of flight director. At the same time it was not possible to demonstrate satisfactorily whether or how the PIC was affected during decision-making process by the economic aspects associated with the re-launch of the airplane put into operation after an engine failure on a company basis. It is therefore not possible to rationally deduce from which For this reason, there was a conflict between the PIC's compliance with the set obligations in the performance of its function the pilot-in-command and his personal decision to proceed with one inoperative powerplant unit to the destination LKPR. Although the captain stated in his resignation that he undertook steps did not cost economic aspects, there was a discrepancy between the actual execution of the flight and his termination. The decision-making process of the pilot-in-command was not in accordance with the above-mentioned binding ones procedures specified in the OM.

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3 Conclusions

3.1 Summary of logical links between factual information

3.1.1 Flight crew

- Pilots held valid licenses, had sufficient flight experience on type B737-800.

3.1.2 Pilot - in - Command, PIC

- use your own *headset to* reduce the readability of the communication,
- did not comply with the TEM Safety Alert 2/2015 and did not properly check the take-off speed setting of the engines at the airport category C with runway limit length,
- ignored the justified F / O request for accelerated flight level reduction due to decreasing speed of the aircraft after the shutdown of the power unit, and as a result caused gradation of stress in the crew,
- ignored the safety rules described in the air traffic procedures in OM-A and OM-B operator and described by regulation, requiring the use of a diligence signal PAN PAN in case of shutdown of the propulsion unit in the RVSM area,
- failure to perform diligent communication PAN PAN after shutdown of the drive unit prevented ATC units from effectively resolving the possible emergence of conflicting traffic in the airspace of their responsibility; in case of late announcement of urgency signal PAN PAN when entering the FIR LKAA did not follow the regulatory procedure,
- did not perform proper performance calculations to determine Long Range Cruise Altitude Capability - ENGINE INOP,
- concealed the true nature of the defect from the ATC units of the individual transit states, up to along the borders of FIR LKAA,
- Performed NNC procedures in an unusually fast way to communicate, thereby reducing F / O the possibility of effective cross-checking of the correctness of their implementation,
- did not discuss with the F / O about safety aspects arising from the nature situation, and thus did not allow to create a real and common strategy in the crew for safe completion of the flight,
- did not follow the principles of CRM in order to effectively solve technical and non-technical problems,
- F / O announced its own decisions with a high command gradient as a fact
- did not complete the relevant NNC QRH procedure with point **10 Plan to land at the nearest suitable airport** , although the F / O has been repeatedly guided to the appropriate NNC procedure QRH, where this instruction is given,
- informed the ACC of Athens about the ability to continue the single - engine flight until to the destination LKPR, which at the same time declared a suitable airport, although in time he knew this statement that he did not have enough fuel to achieve it,
- created his own design to complete the flight, which he mentioned in his statement, I quote: *"the alternative airport for the chosen alternative airport Prague will be Budapest Airport"* ,
- only 3 entries were made on the current fuel level,
- did not perform a methodologically relevant conservative calculation of the remaining fuel

on LKPR according to *Performance Inflight - Engine Inoperative* QRH,

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- the decision to continue to Prague Airport caused him to have an airplane at the time of landing on board 2,435 kg, with FMS RES Fuel being 2,412 kg. Do this wrong The decision reflected the absence of an operational security strategy and safety aspects, which he was to discuss with F / O. Included security the strategy should be to assess the fuel limit. Amount of fuel 2,435 kg at the time of landing was larger by 23 kg over 2,412 kg FMS RES for both working propulsion units,
- did not inform the passenger of the true nature of the defect or of the acceptance of the landing plan at the nearest suitable airport for reasons of safety,
- stated, contrary to the SCC's statement, that the SCC had informed the flight crew of the execution visual inspections of the condition of the disengaged power unit,
- has not issued instructions for securing the CVR stipulated by the regulation,
- did not make a relevant entry in the *Defect LogBook* .

3.1.3 First Officer, F / O

- requested an assertive reduction in FL due to declining speed,
- maintained situational awareness and was prepared to use *offset* during increasing stress ,
- cooperated and cross-checked the procedures carried out, although the PIC performed NNC QRH procedures unusually fast,
- repeatedly tried to guide the PIC to the relevant provision of point 10 NNC of the QRH, to meet the requirement to accept a plan to land at the nearest suitable aerodrome,
- considered the continuation of the flight to LKPR to be illogical,
- piloted under an enormous command gradient, which resulted in PIC conclusions accepted as a fact
- did not contradict the PIC's decision to proceed with LKPR for fear that it would worsen crew co-operation necessary to complete the flight,
- on arrival at the FIR LKAA border, he assertively called on the PIC to declare PAN PAN and notification of the nature of the ATC failure,
- completed the flight to LKPR according to the PIC decision,
- did not record any PIC instruction to secure the CVR.

3.1.4 SCC

- actively responded to changes in aircraft behavior and requested information from the PIC,
- asked the PIC a clear question as to who would report the situation to passengers,
- Adopted with the F / O decision of the PIC, I quote: " Once *it is clear where we will land that with them declares that it is landing for technical reasons and will not name one situation engine to avoid panic* " ,
- subsequently communicated information about the technical defect to the other members of the flight crew and asked them not to discuss the situation in the passenger cabin,
- did not visually inspect the stopped engine for damage through the window passengers, so that passengers do not notice anything,
- received information from the PIC about 45 minutes before landing that their fuel would run out to Prague,
- confirmed that no agreement had been reached between the CCM and the SCC on unprepared evacuation,

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- declared the full readiness of the flight crew in the event of an emergency landing the aircraft,
- during the entire flight did not record any passenger reaction, in connection with the technical condition of the aircraft.

3.1.5 Technicians

- were informed of the situation before landing,
- confirmed that the CVR record is downloaded at the direction of the superior,
- did not confirm that there was any instruction from the PIC regarding CVR,
- stated that even at a later time, approximately 5 pm, they had not received an instruction to withdraw the CVR.

3.1.6 Dispatcher

- stated that there is no information flow recording system in place for the dispatchers service in time about the course of problem flights.

3.1.7 Aircraft

- held a valid Airworthiness Review Certificate,
- had valid statutory insurance,
- the speed difference N1 on the regular line was recorded by the previous crew in the DL,
- the aircraft has been serviced and released for operation in accordance with PART 145,
- engine shutdown was caused by an interruption in the fuel supply to the engine,
- The loss of function of the fuel system was caused by the operation of the fuel pump without fuel as a lubricant.

3.1.8 OM

- a "quasi" procedure was found in OM-B, originally intended for planning, which is incorrect,
- No relevant path was found to the "quasi" procedure when performing NNC QRH.

3.1.9 Impact on safety

- Defective decision-making process of the pilot-in-command endangered the safety of TVS1125 flight. At the same time, the safety of further air traffic was reduced at the same time security in the relevant area of the flight.

3.2 Cause

The cause of the serious incident was a faulty decision-making process of the aircraft commander after the loss of propulsion unit that did not comply with QRH and FCTM procedures. These procedures are binding.

Event string:

- operation of the fuel pump to "dry" before a critical flight, see DL No.107847,
- operation of the fuel pump to "dry" without fuel as a lubricant during critical flight,
- engine shutdown and subsequent loss of the drive unit,
- Obvious disregard and violation of the applicable OM air traffic procedures, as applicable regulations, provisions and safety recommendations,

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- Defective determination of a suitable aerodrome for a safe landing with one non-operating drive unit after fuel pump failure,
- poor implementation of fuel policy,
- The pilot-in-command did not follow the principles of CRM implementation when performing NNC procedures QRH and thus made it impossible for F / O to participate effectively in the decision-making process,
- failure to complete the relevant NNC QRH procedure with point **10 Plan to land at the the nearest suitable airport** , the PIC avoided the obligation to make a safe landing at the nearest suitable aerodrome specified by the manufacturer's QRH and FCTM procedure and valid in commercial air transport,
- can not be satisfactorily demonstrated, but even reliably ruled out that the decision of the commander aircraft and at the same time the flight director of the company were affected by economic aspects situations that have arisen, as described in point 2.11.

4 Safety recommendations

1. ÚZPLN recommends to Smartwings, as on the basis of the flight a PIC's continuing belief that its final decision-making process has been carried out correctly, perform a psychological examination at the ÚLZ at the PIC.

2. ÚZPLN recommends ÚCL to check the compliance of the procedures specified in the OM airline Smartwings, as with FCTM manufacturer Boeing.

3. ÚZPLN recommends checking / adjusting the procedures of the company's technical department Smartwings, as when eliminating registered defects so that the cause is eliminated and not only a manifestation of the fault (in this case the cantamination of the system behind the fuel pump).

Prague, 23 July 2020

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