AIR ACCIDENTS INVESTIGATION INSTITUTE
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CZ-19-0776

FINAL REPORT

**Investigation of causes of a serious incident
of the Boeing B737-800 aircraft, registration mark OK-TVO,
flight TVS1125 from LGSM to LKPR
on 22 August 2019**

Prague
July 2020

Contents

Abbreviations Used

AC	Altocumulus
ACARS	Aircraft Communication Addressing and Reporting System
ACC	Area Control Centre
ACC EXE	ACC Executive Controller
ACC PLN	ACC Planner / Planning Controller (PC)
AFDS	Autopilot Flight Director System
AFM	Aircraft flight manual
AGL	Above ground level
AirFASE	Aircraft Flight Analysis and Safety Explorer
ALTN	Alternate airport
AMC	Acceptable Means of Compliance
AMSL	Above Mean Sea Level
APP	Approach Control
ASDA	Accelerate-stop distance available
ATC	Air Traffic Control
ATIS	Automatic terminal information servis
ATS	Air traffic services
BASE	Cloud base
BKN	Broken
BR	Mist
CI	Cirrus
CAVOK	Visibility, cloud and present weather better than prescribed values or conditions
CCM	Cabin Crew Member
CB	Cumulonimbus
CRM	Crew resource management
CU	Cumulus
CVR	Cockpit voice recorder
ČHMÚ	Czech Hydrometeorological Institute
CWP	Controller Working Position
DFDAU	Digital Flight Data Acquisition Unit
DFDR	Digital Flight Data Recorder
EASA	European Aviation Safety Agency
ETOPS	Extended Range Twin Engine Operations
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FDM	Flight Data Monitoring
FE	Flight Examinator
FEW	Few

FI	Flight Instructor
FL	Flight Level
FMS	Flight Management System
F/O	First Officer
GW	Gross Weight
IFR	Instrument flight rules
IRS	Inertial reference system
ISA	International Standard Atmosphere
KIAS	Knots Indicated Airspeed
LDA	Landing distance available
LGSM	Public International Aerodrome Samos Aristarchos
LKAA	Flight Information Region Prague
LKPR	Public International Aerodrome Prague Ruzyně
MCC	Maintenance control centre
MCT	Maximum Continuous Thrust
METAR	Aviation routine weather report
MLW	Maximum landing weight
MSL	Mean sea level
NCC	Non-Normal Checklist
NIL	None
NITS	Nature, Intentions, Time, Specialities
OFP	Operational Flight Plan
OPC	Operator proficiency check
ORO	Organisation Requirements for Air Operations
PA	Passenger Address
PAN PAN	Urgency – A condition of being concerned about safety and of requiring timely but not immediate assistance, a potential distress condition
PAX	Passengers
PF	Pilot flying
PIC	Pilot in command
PM	Pilot monitoring
QNH	Altimeter sub-scale setting to obtain elevation when on the ground,
QRH	Quick Reference Handbook
REG QNH	Regional pressure, the lowest atmospheric pressure in the area reduced to mean sea level according to standard atmospheric conditions
REQ	Requirement
RETS	Recent Thunderstorm
RMK	Remark
RVR	Runway visual range

RVSM	Reduced vertical separation minimum
RWY	Runway
SCC	Senior cabin crew
SCT	Scattered
SKC	Sky Clear
SMS	Safety management system
TCU	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
TS	Thunderstorm
TWR	Tower
TWY	Taxiway
UIR	Upper flight information region
UTC	Co-ordinated universal time
AAII	Air Accidents Investigation Institute
VCTS	Thunderstorm in the vicinity
Vr	rotation speed
VREF	Reference landing approach speed
VRB	Variable

Used Units

ft	Foot (unit of length – 0.3048 m)
hPa	Hectopascal (unit of atmospheric pressure.)
kt	Knot (unit of speed – 1.852 km·h^{-1})

A) Introduction

Operator:	Smartwings, a. s.
Aircraft manufacturer:	Boeing
Type of aircraft:	Boeing 737- 800 - 8CX
Identification mark:	OK-TVO
Location of incident:	LGSM – LKPR
Event date and time:	22 August 2019, 07:05 UTC (all times are UTC)

B) Synopsis

On 22 August 2019, the AAII was notified by the domestic air operator of the Boeing 737-800 aircraft, identification OK-TVO, about a power unit failure during the TVS1125 flight, callsign TVS4MP, from LGSM to LKPR. Shortly after ascending to FL360, engine No. 1 shut down. The crew reported a technical issue to the ACC as a reason for descending from FL360 to FL240. They attempted to restart the shutdown engine twice. After the second unsuccessful start-up, the PIC decided to continue flying with only one operating power unit to the LKPR destination which he designated as a suitable airport. No sooner than upon entering the LKAA FIR, the crew declared PAN PAN, reported the defect nature, and landed at LKPR with 170 passengers on board. No passengers or crew members were injured.

The cause of the serious incident was investigated by the AAII commission. The investigation team comprised:

Commission chairman:	Pavel Mráček, AAII
Commission members:	Ing. Stanislav Petrželka, AAII
	Ing. Ctirad Coufal, Smartwings, a. s.
	Ing. Václav Vašek, CAA

The Final Report was issued by:

AIR ACCIDENTS INVESTIGATION INSTITUTE
Beranových 130
199 01 PRAGUE 9

29 June 2020

This Final Report consists of the following main parts:

1. Factual Information
2. Analyses
3. Conclusions
4. Safety Recommendations
5. Appendices

1 Factual Information

1.1 History of the Flight

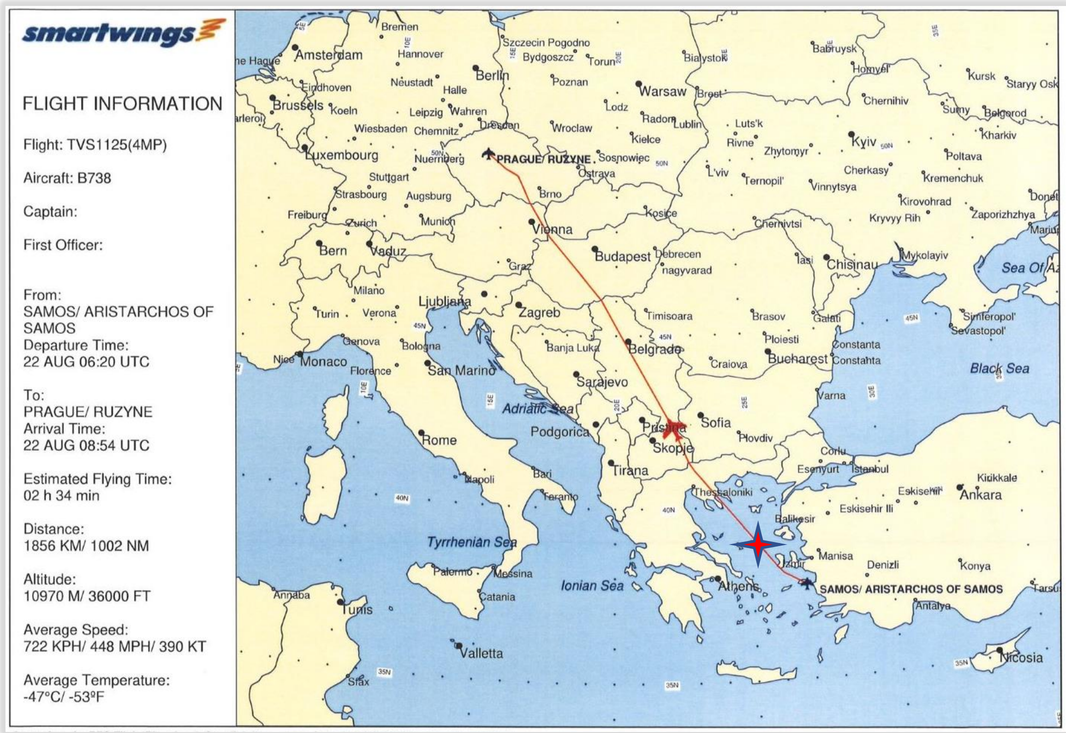

Fig.1 TVS1125 flight route after engine failure (red star) to LKPR

1.1.1 General Information

On 22 August 2019, the crew commenced the first flight with Boeing B737-800 from LKPR to LGSM at 03:08:00. The flight log of the second, event flight TVS1125 from LGSM to LKPR started at the Samos Aristarchos aerodrome at 06:21:00. There were 170 passengers on board on the TVS1125 flight. The flight crew was composed of the Captain, as the Pilot-in-command ("PIC") and the pilot monitoring (hereinafter the "PM"), and the First Officer ("F/O"), as the Co-pilot and the pilot flying (hereinafter the "PF"). The cabin crew consisted of the Senior Cabin Crew Member (hereinafter the "SCC") and three cabin crew members (hereinafter the "CCMs"). Aircraft take-off weight was 66.7 t. Departure information, ATIS: "T" 05:20 RWY09 TL85 020°/7knots CAVOK 26/18 QNH1012. At 06:27, the aircraft took off from RWY 09. The output values of both the engines were set to the reduced number of revolutions N1 to 88.63%. According to the statement of the PIC and the F/O, the engine parameters of the reduced take-off seemed the same or nearly the same during the take-off. Upon reaching FL360 at 06:46:22, the engine output was reduced to about 88% of N1 revolutions. The engines stabilised briefly. At 06:47:27, N1 revolutions of engine No. 1 started decreasing. Engine No. 1 then failed – *flame out*. The AFDS responded to engine shutdown by ailerons drive which the F/O nearly immediately aided by actuating the rudder. At 06:49:26, the B737-800 aircraft started descending from FL360 to FL240 "for technical reasons". The lowest recorded initial speed at descent commencement with one operating engine in the MCT mode from FL360 to FL240 was 226 KIAS and GW 64.7 t. This fact was caused by delayed FL change as confirmed by the F/O's statement. During descent, the speed increased by approx. 20 KIAS and at 06:56:39, reached 310 KIAS necessary for engine start-up in flight using autorotation *(windmill).* This attempt was not successful. At 07:07:45, the crew made the second attempt to start up the engine at FL240 using compressed air from the operating engine *(crossbleed)*. The crew reported a spontaneous failure of engine No. 1 at FL360 to the operational control centre via ACARS. The crew reported an unsuccessful attempt to start up the engine by *windmill* and the second attempt by *crossbleed* according to *Engine-In-Flight Start NNC*. The PIC said that given the aircraft condition and the amount of fuel on board, he had selected the LKPR as the "suitable airport". Shortly after entering the LKAA FIR, the aircraft left FL240. Having switched to the frequency allocated by the LKPR ACC, the PIC declared PAN PAN. At 09:06:26, the aircraft with 170 passengers on board, weighing 59.8 t, landed on RWY 06 at LKPR. At 09:07:25, the TVS1125 flight departed from RWY 06 via taxiway B. At 09:09:27, the crew switched off engine No. 2.

1.1.2 Flight Information according to the PIC

During engine start-up at the Samos aerodrome, the PIC noticed an unsteady, cyclic rise in revolutions of engine No. 1, which was, in his opinion, caused by crosswind blowing to the engine during start-up. Having set the take-off revolutions on RWY 09, the PIC as PM *called out:* "*thrust set".* The difference between the sounds of engine No. 1 and engine No. 2 was, according to him, indistinguishable, and so he did not notice it. Subsequently, the aircraft took off with slight pancaking which the PIC described as a result of wind shear that is typical for the Samos aerodrome. Upon reaching FL360, revolutions of engine No.1 dropped. The PIC did not think about the causes of engine No. 1 failure, whether or not it was a flame out, and started resolving this abnormal case. He was unable to contact the ACC immediately when he needed to leave the allocated flight level. When asked whether he considered at least *offset* and where in QRH he found the relevant flight level for the given aircraft weight or whether he interpolated it, the PIC literally replied: *"I used a wrong phrase – maintenance issue, I require descent – level 240, then corrected it – due to technical problem. At first, there was a misunderstanding with ATC concerning the flight level, after we had reached an understanding, the required flight level clearance was issued without any restrictions, so the offset was not applied."* When asked whether he had thought the ATC would have assisted them in declaring PAN PAN, or whether it was unnecessary in case of failure of one power unit in two-engined aircraft, the PIC replied: *"I did not assume that the ATC would be more helpful after PAN PAN declaration in the given situation."* The PIC said he did not like reporting a specific issue on the frequency. The First Officer was PF, and after the *malfunction* occurred, he required NNC procedure. The PIC said that during NNC they did not ask CCMs to visually check engine No. 1 as the engine was not indicated as damaged. First of all, they agreed upon *initial descent* to the determined FL. They used information first from FMS, secondarily from QRH. The PIC further stated: *"I knew that I was flying at maximum altitude for Long Range Cruise Altitude Capability; therefore, it could be expected that in order to maintain speed at this level, I would have to use maximum continuous thrust."* Among the most important parameters which had a major effect on decision-making about precautionary landing at the selected airport, the PIC listed the following: *"Airport, equipment, weather."*

The PIC decided to use the route from LGSM to LKPR due to the corresponding amount of fuel as per OFP without the need of *extra fuel*. In order to improve the operational efficiency, fuel tankering was employed, which in this case represented a larger quantity of fuel on board left after the first part of the flight to the Samos aerodrome. The PIC did not remember the *final reserve* value. In his testimony, he said: *"The Prague destination was later considered as en-route alternate during the flight."* The PIC described his decision to continue with the flight as follows: *"Between two attempts to restart the engine, we switched to Athens ACC, where I said that I would continue to Prague so that it would be clear that I wanted to continue along the originally planned route until there was sufficient information to make a decision about a reserve airport. I then agreed with the pilot flying that the alternative airport for the selected Prague reserve airport would be the Budapest airport."* When selecting the airport, the PIC said that he excluded LGTS (Thessaloniki), and LYBE (Belgrade) was underneath to the right. He excluded Vienna due to heavy traffic. The PIC knew that the aircraft did not comply with ETOPS requirements, but at the same time stated that Boeing had no restrictions for the given range. When asked if the F/O's opinion in such a situation was of any help for him, he replied*: "In my opinion, our cooperation and the method of resolving this situation in terms of CRM were OK and I found the co-pilot's activity helpful."* The PIC signed the CRM ASSESSMENT HANDBOOK in his capacity as the Flight Manager of the company, saying that the document is generally binding, and it is important that pilots with many hours flown also abide by it. He confirmed that by saying: *"There are no exceptions of course, the CRM is neutral."* The PIC knew that QRH contained Boeing's statement clearly defining precautionary landing at the nearest suitable airport in case of flight with a single operational power unit. At the same time, the PIC confirmed that he knew Boeing's restrictions in OM-B, chapter *Performance*, describing the procedure where the pilot shall reach a reserve airport at best within one hour while one hour is not considered mandatory. He confirmed that his utmost priority when conducting flights in commercial air transportation is safety. His decision to continue with the single-engined flight up to LKPR was in the PIC's testimony literally described as: *"My decision."* When asked whether he had ever experienced a similar flight with passengers without one power unit operative during his previous career in commercial air transportation, he stated that he had not. Having calculated fuel consumption, the PIC considered LKPR as a *suitable airport*. When asked when he carried out fuel calculation, the PIC said: *"The basic calculation was probably done before Belgrade."* However, the PIC did not enter the record of the calculation into the OFP. When asked how he calculated the necessary amount of fuel, the PIC said in his testimony: *"Having conducted the methodological calculation based on comparison of OFP with FMS and then according to the procedure in QRH, I communicated the result to the co-pilot who had no objections."* Upon reaching the borders of LKAA FIR, the crew decided to declare PAN PAN to make arrival smooth and have the ability to vector in the area with heavy air traffic. By declaring PAN PAN, he assumed that the Local Stand-By would be activated at the Prague aerodrome and the F/O agreed with this procedure. When asked if his (PIC's) flying experience was sufficient so as to be able to assess the risks related to decision-making which took place during the TVS1125 flight, he responded: *"I am convinced that my extensive flying experience is sufficient in order to be able to assess all the risks related to the decision-making process; nevertheless, I realise that such circumstances may arise which deserve to be treated with due care."* When asked whether oil and fuel had been collected for a post-flight test, the PIC stated: *"I don't know the engineers' procedures, I made a record into TLB that there was in-flight shutdown."* The PIC described communication with the cabin crew as follows: *"Based on the NITS briefing with the flight crew, we had a conversation with the SCC who was instructed regarding the possibility to declare an unprepared emergency."* According to his statement, the SCC informed the PIC that she had visually inspected the shutdown engine. When asked how he ensured CVR compliance with the procedure described in OM, the PIC answered: *"I informed the engineers about the situation and about the fact that the cards would have to be secured so*

I expected the CVR cards to be removed and secured. After that I heard the cards being removed." To conclude, when asked whether the PIC could now in retrospect see some of his mistakes which he would like to explain, he replied: *"When looking back and assessing my flight performance, I am convinced that flight safety was not jeopardised."* In his statement, the PIC also said that his decision-making had not been affected by financial aspects. He said that his reasoning was operation-oriented. In his statement, he literally said that if he could make it to the airport without breaching anything nor endangering anybody, and with the fuel he had, he saw no reason why not to fly as far as to the final destination.

1.1.3 Flight Information according to the F/O

When departing from the Samos aerodrome, the F/O did not notice any major difference between N1 revolutions of both the engines during take-off performance setting. He said that he had been at this airport for the first time. The aerodrome has a short runway, the flaps position was set at 25 degrees, and crosswind was blowing, which was considered the cause of revolution fluctuation in engine No. 1. F/O said: *[…"All in all, I was slightly nervous about that airport"…*]. His initial response when the engine shut down was to move his foot forward. When asked how many times he had undergone simulator training focused on one power unit failure and which procedures had been applied in such simulated flights, the F/O said: *"I have undergone it once, and I could draw some experience from it for the real-life situation. Such as procedures, cockpit activities, communication with the cabin crew, ATC, PAN PAN declaration in order to prevent compromising flight safety, and landing at the nearest suitable airport."* When asked what he had proposed when they had been unable to contact ATC, and whether he had considered *offset*, the F/O replied: *"I was nervous as the speed was decreasing, and I wanted to start descending. I pressed the Captain to communicate descent and I expected a standard phrase. If we were not able to establish connection, I was prepared to use the offset."* The F/O confirmed that the PIC had been using borrowed BOSE headphones. In this respect he said: *"I think he had a problem with his headphones as the headset functionality was reduced. Several attempts were made – about 4 or 5. With the constantly decreasing speed nervousness in the cockpit was increasing. It might have been the cause of delayed establishment of connection."* The F/O did not remember for how long they had been flying at FL360 with one engine only. The initial reading of the FMS descent level was done by the PIC. When asked who had determined the level for *Long Range Cruise Altitude Capability* and based on what and whether they had checked the FL with regards to the weight and ISA, the F/O stated: *"It was done by the Captain; the initial descent reading was done from FMS. I relied on his function as I was busy flying the aircraft. The Captain did not ask me to check his results. I asked for the implementation of NNC procedure and we followed the checklist. I find the Captain's procedure standard."* Having descended from FL360, the TVS1125 flight continued at FL240. The F/O was unable to recall connection with Athina ACC because he heard them badly and because he was piloting the aircraft as the PF. He expected the PIC to make a decision. The PIC was making calculations according to QRH and communicating with the operational control centre at the same time. The F/O noticed one of PIC's answers mentioning Brno or Budapest aerodrome. The PIC then informed him of the content of the communication. Having finished communication with the operational control centre, the PIC decided to continue with the TVS1125 flight to the destination at LKPR. After such a decision of the PIC, the F/O tried to reverse the PIC's decision by requiring another NNC performance in order to confront the PIC with the last item in the QRH checklist. In his testimony, the F/O described his position during the flight when exercising the PF function as follows: *"Internally, I disagreed with this decision and I asked the Captain to perform NNC once* *again. In my opinion, the QRH declaration is binding."* The F/O cannot recall discussing any airports in terms of suitability for precautionary landing with the PIC afterwards. Upon descending to FL240, the F/O had to use MCT because the aircraft speed was decreasing. With regards to MCT on engine No. 2, the PIC suggested that the F/O should reduce the running engine revolutions in order to keep FL240. The PIC explained such revolution reduction by the following words: […*"so that we wouldn't melt the live engine"*…]. It was the PIC who performed fuel calculation for reaching of LKPR. The PIC did not present the performed calculations to the F/O and only told him the result, i.e. that they would make it, as a matter of fact. The F/O decided not to contest another decision of the PIC and was prepared to continue along the original flight route. He was mentally preparing for landing at LKPR. When carrying out NNC, the PIC and F/O were contacted by the SCC on her own initiative. When they finished communicating with the SCC, both the PIC and the F/O were going through the NNC procedures. The F/O further said that he could not recall whether or not the PIC had called the SCC. When the SCC entered the cockpit, she asked whether something was happening. The PIC then advised her of the situation. The SCC told the crew that other cabin crew members noticed that the engine was not running, and that the aircraft had descended. The SCC was asked whether the passengers knew about the situation and whether there was a panic on board. The SCC confirmed that the passengers did not know anything about the situation. The PIC carried out PA and announced to the passengers that it was necessary to descend due to a technical defect. As they approached the border, the F/O realised that he had not heard the PIC declaring PAN PAN. He thus proposed to declare it and the PIC agreed. The PIC declared PAN PAN when switching to the allocated frequency of LKAA FIR. The F/O could not recall whether communication with the SCC had taken place before or after the PAN PAN declaration. The SCC was advised that they would land in a standard manner with runway vacating. The F/O does not remember issuance of instructions for an unprepared evacuation. The F/O knew the obligation to retain CVR recording in such cases. The PIC did not talk about CVR with the F/O. The F/O confirmed that his assertiveness during the flight might have been influenced by the PIC's personality. Although the PIC had the right to ultimately carry out the flight, when asked whether he would have done anything differently, the F/O immediately replied: *"I would do something differently. I would choose a different suitable airport. I would declare PAN PAN, I would use my right."* Before leaving LKPR, the engineers advised the F/O of vibrations of engine No. 2. The PIC took a picture of engine values when going to Samos. The F/O said it did not make sense to continue with a shutdown power unit to Prague. After landing, the PIC made an entry into the *Journey Log*. He does not remember *circuit brakers* (CB) extension in connection with the obligation to keep the CVR recording. He said that two engineers had come to the cockpit and had been talking to the PIC before the passengers disembarked. He does not recall the content of that conversation. The F/O did not notice any activity regarding CVR recording erasure in the cockpit. He was absolutely certain of that.

1.1.4 Flight Information according to the SCC

While on duty, the SCC perceived atypical "rocking" of the aircraft during the flight. She noticed the first atypical movement of the aircraft while attending to passengers, approx. "halfway through the cab". The SCC called the cockpit and stopped servicing. The crew told her they had no time at that moment because they were resolving a technical issue. The *chaim* signal was then announced twice. The crew used this standard signal to call the SCC to the cockpit. The PIC informed the SCC that they "had lost one engine" which they were unable to restart again, but they would continue flying. The SCC asked whether it was necessary to prepare the cabin (meaning for possible evacuation after landing). The PIC answered that it was not necessary yet. He said that they presently did not have enough fuel to make it to Prague, so they were considering landing either in Brno or Budapest. However, the final decision was not made yet. The SCC asked the PIC whether he was going to inform the passengers of the occurred situation or whether she should do so. The PIC responded by suggesting he would inform the passengers about the situation at the moment when it would be clear where they would be landing and would explain the landing by technical reasons. One engine failure would not be announced to the passengers in order to avoid a panic on board. The Captain asked both, the F/O and the SCC, whether they agreed with his proposal and both of them agreed. The SCC informed the CCMs in the front galley about the PIC's decision. When asked when the PIC indicated that he would land in Prague, the SCC said*: "About 45 minutes before the landing, it was clear that the fuel would suffice up to Prague."* The SCC did not remember whether during the service, the passenger signs "Fasten Seatbelts" had been off. The SCC confirmed that the situations for technical defects were not specified. The SCC confirmed that the cabin crew is instructed by the PIC as to whether prepare the cabin or not. The SCC confirmed that the cabin crew were regularly trained to prepare the cabin for emergency landing, not for a particular defect. When asked whether the PIC agreed with the SCC on preparation of the cabin for evacuation, she said: *"Nothing was required of us, we were informed that we would land normally.* When asked whether they agreed on unprepared evacuation, she replied: *"No, we didn't, but we are trained to be ready all the time."* Having received information about the technical defect, the SCC told the rest of the cabin crew everything she knew about the given situation. The SCC requested other CCMs not to discuss the shutdown engine in the cabin so that the passengers would not be informed. The SCC also confirmed that the condition of the shutdown engine was not visually checked through the window so that the passengers would not notice anything. The landing at LKPR was standard. The aircraft did not taxi to the *gate*, but remained "in the field"[1]. Based on the passengers' reactions, the SCC thought they had not noticed anything during the flight. After the passenger boarding stairs were brought to the aircraft, engineers were the first ones to board the aircraft.

1.1.5 Flight Information according to the Controller

The Control Centre received the first information about the TVS 1125 flight via the ACARS datalink system at 07:20. The crew informed them about engine shutdown and also confirmed they were continuing with the flight to Prague. They also confirmed that they might not have enough fuel, but they had *alternate* aerodromes in Budapest and Brno, and we should write our preference. We confirmed reception of the message and commenced relevant procedures. The Controller inquired the MCC to find out which aerodrome would be better from their perspective. The MCC confirmed that both the aerodromes were suitable in terms of operational aspects. After that, the Controller responded to the PIC by writing that as soon as they would find out all that was necessary, they would let the crew know. The Controller than started proceeding according to the checklist. He informed the management, i.e. the *orange group*. When the Operating Officer, who was interested in the situation, came in, the Controller provided him with the latest information. The Control Centre received information from the MCC that Budapest would be more suitable and presented that information to the crew via the datalink. As soon as the PIC wrote to them that "he was going to make it" to Prague, the Control Centre confirmed reception of that message. The Controller did not remember how much time elapsed between the initial information about

[1] "In the field" means standing in the aerodrome area without a boarding bridge.

engine shutdown and the information about flying up to Prague. When asked whether some information about continuation of the flight to Prague was received, the Controller replied*: "I can't recall when the information about flying to Prague was received. However, the first option was Budapest, or Brno."* The Controller was not saving ongoing reports from the TVS1125 via the datalink because the checklist does not stipulate so.

1.1.6 Flight Information according to the Engineers

When the aircraft stopped, the engine was turned off, and boarding airstairs were brought up, two engineers from Smartwings, a. s. boarded the aircraft. They already knew about the occurrence of a "single-engined flight"; therefore, after entering the cockpit, they started collecting as much information as possible. They said that the mood in the cockpit was standard, corresponding to the situation. They asked what had happened, where the problem had occurred, and what the crew had done. One engineer removed the DFDAU card. He then went to the engine, checked the oil, etc. After that, he returned to the pilot cabin. When asked whether the PIC had issued any instruction regarding CVR, the first of the two engineers said: *"I don't remember anything being said regarding the CVR."* The second engineer added: *"Me neither."* One of the engineers said: *"The DFDAU card is removed automatically as regards CVR, it's at the supervisor's command. I don't remember any instruction given by the aircraft Captain."* The engineers said that it did not happen even later, approx. 17 hrs, CVR, nor any instruction to download the CVR recording was given.

1.2 Injuries to Persons

Tab. 1 Injuries to persons

Zranění	Posádka	Cestující	Ostatní osoby (obyvatelstvo apod.)
Smrtelné	0	0	0
Těžké	0	0	0
Lehké/bez zranění	0/6	0/170	0/0

1.3 Damage to Aircraft

The aircraft fuel pump was destroyed.

1.4 Other Damage

NIL

1.5 Personnel Information

1.5.1 Crew Information

1.5.2 Pilot-in-command/PIC

Man, age 53 years, a holder of the ATPL (A) Pilot Licence.

- OPC was renewed on 28 September 2018.
- Line check was carried out on 4 April 2019.
- Valid class 1 medical certificate
- Flight experience:
  - Flying experience: 20,980:00 hrs
  - Hours flown on the type: 8,065:09 hrs

  - Over the last 90 days: 219:46 hrs
  - In the last 24 hours before the flight on 22 August: 00:00 hours
- The PIC held the Flight Manager position in the corporate AOC structure.
- Qualification: FI, FE

1.5.3 First Officer, F/O

Man, age 35 years, a holder of the ATPL (A) Pilot Licence.

- OPC was renewed on 14 February 2019.
- Line check was carried out on 28 January 2019.
- Valid class 1 medical certificate
- Flight experience:
  - Flying experience: 3,400:00 hrs
  - Hours flown on the type: 2,488:24 hrs
  - Over the last 90 days: 204:31 hrs
  - In the last 24 hours before the flight on 22 August: 00:00 hours

1.5.4 Flight crew rest

Tab. 2 Flight crew rest before the event flight

PIC	F/O
27:18 hrs	24:00 hrs

1.6 Aircraft Information

1.6.1 Baseline figures for B 737-800

- Aircraft type: Boeing B737-800
- Power units: CFM56-7
- Made in: 2002, Serial number 32360
- Registration: OK-TVO
- Certificate of Airworthiness: EASA Standard Certificate of Airworthiness
- Valid Certificate of Airworthiness Inspection
- The aircraft was serviced according to PART 145

1.7 Meteorological Information

1.7.1 TAFs for the flight route

WEATHER FORECAST printed on **22.8.2019** at **16:58** UTC smartwings

TVS1125 SMI-PRG 2019-08-22

TAF

MUGLA/DALA	LTBS	221040Z 2212/2312 21012KT 9999 FEW030 BECMG 2216/2218 VRB02KT CAVOK BECMG 2306/2308 21012KT FEW030
USAK	LTBO	221340Z 2215/2224 07013KT 9999 SCT040 BECMG 2215/2218 CAVOK BECMG 2218/2220 VRB02KT
RHODOS DIA	LGRP	221100Z 2212/2312 25010KT 9999 FEW025 BECMG 2218/2220 VRB05KT BECMG 2310/2312 18015KT
KARPATHOS	LGKP	221400Z 2215/2224 33024KT 9999 FEW020
MULGA/MILA	LTFE	221040Z 2212/2312 03016KT 9999 FEW035 BECMG 2213/2215 CAVOK BECMG 2218/2221 06006KT BECMG 2306/2309 03016KT
KOS	LGKO	221100Z 2212/2312 36016KT 9999 FEW025 TEMPO 2212/2218 35016G26KT
SAMOS	**LGSM**	221400Z 2215/2224 36013KT CAVOK TEMPO 2215/2221 36015G25KT
ZAFER	LTBZ	221340Z 2215/2224 02012KT 9999 SCT030
IZMIR ADNA	LTBJ	221040Z 2212/2312 01020G30KT CAVOK BECMG 2220/2222 35013KT BECMG 2306/2309 01020G30KT
IZMIR KAKL	LTFA	221340Z 2215/2224 34012KT 9999 FEW040 BECMG 2215/2218 CAVOK
SANTORINI	LGSR	221100Z 2212/2312 35018G28KT 9999 FEW025
BALIKESIR/	LTFD	221340Z 2215/2224 07018KT 9999 FEW035 BECMG 2216/2218 CAVOK
MIKONOS	LGMK	221400Z 2215/2224 36018KT 9999 FEW018 TEMPO 2215/2221 36020G30KT
MITILINI	LGMT	221400Z 2215/2224 33012KT 9999 FEW025 TEMPO 2215/2221 33012G25KT
CANAKKALE	LTBH	221340Z 2215/2224 04012KT CAVOK
ATHENS ELE	LGAV	221100Z 2212/2312 03022KT 9999 FEW025 TEMPO 2212/2218 03022G32KT BECMG 2301/2303 03020G30KT
GOKEADA	LTFK	221340Z 2215/2224 36012KT CAVOK
LIMNOS	LGLM	221400Z 2215/2224 02016KT CAVOK
ALEXANDROU	LGAL	221400Z 2215/2224 04015KT 9999 FEW025 TEMPO 2215/2217 04015G25KT
KAVALA MEG	LGKV	221100Z 2212/2312 21010KT 9999 FEW030 SCT080 BECMG 2216/2218 06010KT CAVOK
PLOVDIV	LBPD	221100Z 2212/2312 04008KT CAVOK BECMG 2217/2219 VRB04KT
THESSALONI	LGTS	221100Z 2212/2312 17012KT 9999 FEW030 BECMG 2218/2220 VRB03KT
IOANNINA	LGIO	221400Z 2215/2224 VRB03KT 9999 FEW030 SCT080
SOFIA	LBSF	221100Z 2212/2312 06010KT CAVOK BECMG 2218/2219 VRB04KT
OHRID	LWOH	221430Z 2215/2315 16006KT 9999 FEW050
ALEXANDER	LWSK	221430Z 2215/2315 VRB02KT CAVOK
CRAIOVA	LRCV	221400Z 2215/2224 VRB04KT CAVOK
TIRANA MOT	LATI	221100Z 2212/2312 33010KT CAVOK TX35/2312Z TN20/2304Z BECMG 2216/2218 VRB03KT
PRISTINA	BKPR	221130Z 2212/2312 05008KT 9999 FEW050
NIS/KONSTA	LYNI	221100Z 2212/2312 32012KT CAVOK TX32/2312Z TN14/2303Z BECMG 2216/2218 04006KT
PODGORICA	LYPG	221100Z 2212/2312 18006KT CAVOK TX36/2214Z TN22/2304Z
KRALJEVO/L	LYKV	221100Z 2212/2312 32006KT CAVOK TX31/2213Z TN17/2304Z
BEOGRAD/NI	LYBE	221100Z 2212/2312 33008KT CAVOK TX32/2312Z TN18/2304Z
TIMISOARA	LRTR	221100Z 2212/2312 VRB04KT CAVOK PROB40 TEMPO 2214/2217 VRB15G25KT -TSRA SCT040CB
ARAD	LRAR	221400Z 2215/2224 VRB04KT CAVOK TEMPO 2215/2218 FEW040CB PROB30 TEMPO 2215/2218 VRB15G25KT -TSRA
SARAJEVO I	LQSA	221100Z 2212/2312 30005KT 9999 SCT050 TX31/2214Z TN15/2304Z
ORADEA	LROD	221400Z 2215/2224 03010KT CAVOK TEMPO 2215/2217 FEW040CB
DEBRECEN	LHDC	221415Z 2215/2224 03009KT CAVOK

Fig. 2 Aerodrome weather forecast – TAF

OSIJEK KLI	LDOS	221125Z 2212/2312 35006KT CAVOK TX28/2214Z TN17/2303Z
BANJA LUKA	LQBK	221100Z 2212/2312 35005KT 9999 SCT040 TX29/2214Z TN16/2304Z
BUDAPEST L	LHBP	221115Z 2212/2312 04007KT CAVOK BECMG 2222/2224 VRB03KT BECMG 2307/2309 04007KT
POPRAD TAT	LZTT	221100Z 2212/2312 07008KT 9999 FEW030 BKN050 TEMPO 2212/2221 -SHRA FEW030CB BKN060 PROB40 TEMPO 2212/2218 VRB15KT 4000 TSRA SCT030CB BKN040 TEMPO 2221/2307 25005KT PROB30 TEMPO 2222/2306 VRB02KT 3000 BCFG SCT003 BKN100
SLIAC	LZSL	221400Z 2215/2300 01004KT 9999 SCT052 BKN100 PROB40 TEMPO 2215/2218 -TSRA FEW040CB BKN050
HEVIZ/BALA	LHSM	221115Z 2212/2221 36007KT CAVOK BECMG 2212/2215 06005KT TEMPO 2212/2218 -SHRA SCT030TCU BKN040 PROB30 TEMPO 2212/2218 VRB15KT 6000 TSRA SCT025CB BKN033
KRAKOW-BAL	EPKK	221430Z 2215/2315 07010KT 9999 SCT040 PROB30 TEMPO 2215/2217 07015G25KT
GYOR-PER	LHPR	221415Z 2215/2224 35005KT CAVOK TEMPO 2215/2224 -SHRA SCT036CB BKN080 PROB30 TEMPO 2215/2219 -TSRA
ZAGREB	LDZA	221125Z 2212/2312 04004KT CAVOK TX27/2311Z TN18/2305Z PROB30 2212/2214 -TSRA FEW050CB PROB30 TEMPO 2217/2221 -TSRA FEW050CB
CERKLJE	LJCE	221400Z 2215/2224 06005KT 9999 FEW040 BKN080 TEMPO 2215/2224 BKN045 PROB40 TEMPO 2215/2220 -SHRA BKN045TCU
PIESTANY	LZPP	221400Z 2215/2300 05005KT 9999 SCT037 BECMG 2218/2220 VRB02KT
BRATISLAVA	LZIB	221100Z 2212/2312 06005KT 9999 SCT030 BKN080 PROB40 TEMPO 2212/2217 -SHRA FEW030TCU BKN050 PROB30 TEMPO 2212/2216 4000 TSRA SCT030CB BKN040 BECMG 2218/2220 VRB02KT
MARIBOR/OR	LJMB	221400Z 2215/2315 03005KT 9999 SCT045 BKN140 PROB40 TEMPO 2215/2315 SHRA SCT035TCU BKN060 TEMPO 2221/2314 SCT025 BKN040 PROB30 TEMPO 2311/2315 36010KT 8000 TSRA BKN045CB
KATOWICE-P	EPKT	221130Z 2212/2312 08010KT 9999 SCT040 TEMPO 2212/2216 07015G25KT
OSTRAVA MO	LKMT	221100Z 2212/2318 04012KT 9999 SCT035 TEMPO 2212/2218 05012G24KT BECMG 2218/2220 02006KT TEMPO 2303/2306 5000 BR BKN012 PROB30 TEMPO 2304/2306 3000 BR BKN005 BECMG 2306/2308 CAVOK
GRAZ	LOWG	221115Z 2212/2312 15005KT 9999 FEW050 BKN060 TX23/2214Z TN18/2302Z TEMPO 2212/2219 FEW050CB SCT120 BKN250 TEMPO 2301/2304 SHRA FEW050TCU BKN060 PROB30 TEMPO 2309/2312 SHRA FEW040CB BKN050
WIEN SCHWE	LOWW	221415Z 2215/2321 VRB02KT 9999 FEW045 SCT120 BKN300 TX26/2316Z TN17/2304Z TEMPO 2215/2218 05007KT FEW050TCU BKN240 TEMPO 2300/2306 -SHRA FEW050CB BKN070 TEMPO 2316/2318 SCT050 FEW050CB BKN180
KLAGENFURT	LOWK	221115Z 2212/2312 VRB02KT 9999 FEW030 BKN050 TX23/2215Z TN18/2305Z TEMPO 2213/2218 11007KT BKN040 FEW040CB TEMPO 2304/2309 SHRA BKN030 FEW040TCU
BRNO TURAN	LKTB	221100Z 2212/2318 07012KT CAVOK TEMPO 2220/2308 02003KT 7000 SCT012
NAMEST	LKNA	221100Z 2212/2312 05010KT CAVOK TEMPO 2212/2218 09006KT BKN030 PROB30 2303/2306 35004KT 6000 SCT010
WROCLAW ST	EPWR	221430Z 2215/2315 10008KT CAVOK
PARDUBICE	LKPD	221100Z 2212/2312 06006KT CAVOK TEMPO 2303/2305 3000 BR PROB40 TEMPO 2303/2305 0600 FG
CASLAV	LKCV	221100Z 2212/2312 06006KT CAVOK TEMPO 2212/2214 SCT035 BECMG 2217/2219 VRB02KT PROB40 2303/2307 2000 BR BECMG 2309/2311 03005KT
LINZ	LOWL	221115Z 2212/2312 10007KT 9999 SCT030 TX23/2312Z TN16/2304Z BECMG 2216/2218 06004KT BECMG 2306/2308 10008KT
ZIELONA GO	EPZG	221430Z 2215/2224 10007KT CAVOK
PRAHA/VACL	**LKPR**	221100Z 2212/2318 06006KT CAVOK BECMG 2301/2303 34003KT 1200 BR MIFG BKN004 TEMPO 2303/2306 0500 FG OVC002 BECMG 2306/2308 04008KT CAVOK
DRESDEN	**EDDC**	221100Z 2212/2312 08007KT CAVOK BECMG 2220/2222 16005KT BECMG 2307/2309 07006KT
KARLOVY VA	LKKV	221100Z 2212/2318 05012KT 9999 SCT045 BECMG 2217/2219 VRB02KT CAVOK TEMPO 2302/2306 2500 BR SCT005 TEMPO 2309/2315 9999 SCT035
BERLIN SCH	EDDB	221100Z 2212/2312 14004KT CAVOK
BERLIN TEG	EDDT	221100Z 2212/2312 15004KT CAVOK
LEIPZIG-AL	EDAC	221400Z 2215/2224 06003KT CAVOK
LEIPZIG	EDDP	221100Z 2212/2312 12005KT CAVOK BECMG 2217/2219 VRB03KT BECMG 2309/2312 07005KT
NURNBERG	EDDN	221100Z 2212/2312 10010KT 9999 FEW040 BECMG 2213/2215 07005KT BECMG 2216/2218 VRB03KT BECMG 2308/2310 09005KT

Fig. 3 Aerodrome weather forecast – TAF (cont.)

1.7.2 METARs

MUGLA/DALA	LTBS	221620Z 23006KT 9999 FEW030 29/23 Q1009 NOSIG RMK RWY19 20006KT
RHODOS DIA	LGRP	221650Z 24007KT CAVOK 31/21 Q1007 NOSIG
KARPATHOS	LGKP	221650Z 31020KT 9999 FEW018 26/22 Q1009
MULGA/MILA	LTFE	221550Z 01012KT 340V040 CAVOK 36/11 Q1008 NOSIG RMK RWY10 01011KT
KOS	LGKO	221650Z 36012KT CAVOK 30/19 Q1010
SAMOS	**LGSM**	221650Z 34014KT 300V010 CAVOK 32/18 Q1010
IZMIR ADNA	LTBJ	221620Z 03015KT 9999 FEW030 34/16 Q1011 NOSIG RMK RWY16 03014KT
SANTORINI	LGSR	221650Z 33011KT CAVOK 27/19 Q1012
BALIKESIR/	LTFD	221550Z 07016KT CAVOK 31/17 Q1014
MIKONOS	LGMK	221650Z 36013KT CAVOK 27/16 Q1014
MITILINI	LGMT	221650Z 32007KT 270V360 CAVOK 29/19 Q1013
CANAKKALE	LTBH	221550Z 06020KT CAVOK 32/18 Q1015
ATHENS ELE	LGAV	221650Z 01010KT CAVOK 31/12 Q1015 NOSIG
LIMNOS	LGLM	221650Z 36005KT CAVOK 30/18 Q1015
ALEXANDROU	LGAL	221650Z 06013KT CAVOK 33/15 Q1016
KAVALA MEG	LGKV	221650Z 21004KT 9999 FEW030 29/23 Q1015
PLOVDIV	LBPD	221630Z AUTO 06010KT 9999 NCD 32/14 Q1018 NOSIG
THESSALONI	LGTS	221650Z 18007KT 9999 FEW025 33/13 Q1016 NOSIG
KOZANI	LGKZ	221650Z AUTO 04006KT //// // ////// 29/07 Q1020 RE//
IOANNINA	LGIO	221650Z 06004KT 9999 FEW040 31/12 Q1017
SOFIA	LBSF	221630Z 05008KT CAVOK 30/11 Q1021 NOSIG
OHRID	LWOH	221630Z 12001KT 9999 FEW050 28/11 Q1020
ALEXANDER	LWSK	221630Z 25003KT CAVOK 34/11 Q1017 NOSIG
CRAIOVA	LRCV	221630Z AUTO 27003KT 230V290 9999 NCD 32/12 Q1019
TIRANA MOT	LATI	221650Z 32006KT CAVOK 29/18 Q1016 NOSIG
PRISTINA	BKPR	221630Z 04006KT 9999 FEW050 30/11 Q1020 NOSIG
NIS/KONSTA	LYNI	221630Z 33012KT CAVOK 30/15 Q1019 NOSIG
PODGORICA	LYPG	221630Z VRB02KT CAVOK 34/13 Q1016 NOSIG
KRALJEVO/L	LYKV	221630Z 03007KT 010V080 CAVOK 30/16 Q1020 NOSIG
BEOGRAD/NI	LYBE	221630Z 03006KT CAVOK 29/18 Q1021 NOSIG
TIMISOARA	LRTR	221630Z 05006KT CAVOK 31/18 Q1020
ARAD	LRAR	221630Z 01006KT 330V030 CAVOK 31/17 Q1020
SARAJEVO I	LQSA	221630Z 33004KT 300V030 9999 SCT045 SCT070 27/17 Q1021 NOSIG
ORADEA	LROD	221630Z 36014KT CAVOK 29/17 Q1021
DEBRECEN	LHDC	221615Z AUTO 36012KT CAVOK 27/16 Q1022 NOSIG
OSIJEK KLI	LDOS	221630Z 35006KT CAVOK 28/19 Q1021
BANJA LUKA	LQBK	221630Z 01004KT CAVOK 28/18 Q1021 NOSIG
BUDAPEST L	LHBP	221630Z 36007KT CAVOK 27/18 Q1022 NOSIG
POPRAD TAT	LZTT	221630Z 17003KT 120V230 9999 -SHRA FEW005 SCT043CB BKN080 14/13 Q1027
SLIAC	LZSL	221630Z 02004KT 350V060 CAVOK 21/17 Q1024
HEVIZ/BALA	LHSM	221615Z AUTO 34007KT CAVOK 23/17 Q1023 NOSIG
KRAKOW-BAL	EPKK	221630Z 08008KT 9999 BKN033 20/13 Q1027
GYOR-PER	LHPR	221615Z AUTO 34005KT 300V010 9999 //////TCU 24/16 Q1023
ZAGREB	LDZA	221630Z VRB02KT CAVOK 22/17 Q1022 NOSIG
CERKLJE	LJCE	221630Z 07004KT 040V120 CAVOK 21/17 Q1023 RMK BLU
PIESTANY	LZPP	221630Z 36008KT CAVOK 24/16 Q1023
BRATISLAVA	LZIB	221630Z 11005KT 9999 FEW035 BKN067 25/16 Q1023 NOSIG
MARIBOR/OR	LJMB	221630Z 01004KT CAVOK 22/14 Q1023
KATOWICE-P	EPKT	221630Z 09009KT 9999 BKN046 20/12 Q1027
OSTRAVA MO	LKMT	221630Z 03010KT CAVOK 21/13 Q1025 NOSIG
GRAZ	LOWG	221650Z VRB01KT 9999 FEW045 BKN050 21/13 Q1024 NOSIG
WIEN SCHWE	LOWW	221650Z 34004KT 9999 FEW035 SCT060 BKN300 23/15 Q1024 NOSIG
KUNOVICE	LKKU	221400Z 05006KT 020V090 9999 FEW035 23/14 Q1025
KLAGENFURT	LOWK	221650Z VRB02KT 9999 FEW030 SCT300 22/15 Q1024 NOSIG

Fig. 4 Aviation routine weather report – METAR

BRNO TURAN	LKTB	221630Z 06009KT 9999 FEW042 22/14 Q1025 NOSIG
NAMEST	LKNA	221600Z 03009KT 9999 BKN043 21/13 Q1025 NOSIG RMK BLU BLU
WROCLAW ST	EPWR	221630Z 12005KT 9999 FEW042 22/13 Q1027
PARDUBICE	LKPD	221600Z 01004KT 9999 SCT047 SCT100 BKN220 22/13 Q1025 NOSIG RMK BLU BLU
CASLAV	LKCV	221600Z 03006KT 9999 FEW040 BKN090 22/14 Q1025 NOSIG RMK BLU BLU
LINZ	LOWL	221650Z AUTO 18003KT 150V210 9999 FEW032 SCT034 BKN038 21/14 Q1025 NOSIG
ZIELONA GO	EPZG	221630Z 10006KT 070V130 CAVOK 23/11 Q1027
PRAHA/VACL	**LKPR**	221630Z 09005KT 050V150 9999 FEW045 21/11 Q1026 NOSIG
DRESDEN	**EDDC**	221650Z 06008KT CAVOK 23/12 Q1025 NOSIG
KARLOVY VA	LKKV	221630Z 05007KT CAVOK 20/09 Q1026
BERLIN SCH	EDDB	221650Z 12006KT 090V160 CAVOK 25/08 Q1025 NOSIG
BERLIN TEG	EDDT	221650Z 12005KT 100V160 CAVOK 25/09 Q1025 NOSIG
LEIPZIG-AL	EDAC	221650Z 05004KT 010V080 CAVOK 24/08 Q1025
LEIPZIG	EDDP	221650Z VRB02KT CAVOK 25/07 Q1025 NOSIG
NURNBERG	EDDN	221650Z 02004KT 330V050 CAVOK 24/10 Q1025 NOSIG

Fig. 5 Aviation routine weather report – METAR (cont.)

1.7.3 Suitable airports

The Commission identified suitable airports for precautionary landing after a power unit loss, i.e. after the second unsuccessful attempt to start up the power unit: LGKV, LBSF, LYBE.

1.8 Radio Navigational and Visual Aids

NIL

1.9 Communications

Original communication transcripts, communication of AAIASB and TSB Hungary pertaining to the TVS1125 flight, callsign TVS4MP:

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

The Greek authority responsible for AA investigation confirmed that it has not been established and recorded that there had been relevant TVS1125 flight communication 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.
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 Ciao
07:10:10	ACC PLN Skopje calling Belgrade: Sa moje strane TVS4MP, jel ga vidis na FL240? OK, due technical problem spustio sa 360 na 240 I do kraja hoce da ide na 240, samo da znas, da aj ciao. (Indicative translation: As for me, TVS4MP, can you see it on FL240? OK, they descended due to

a technical problem from 360 to 240. They want to go to 240, just for your information, bye.)

1.9.4 Transcript of communication between TVS4MP and ACC EXE Skopje on the frequency of 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 Beograd 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.

1.9.6 Transcript of communication between TVS4MP and 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 Prag 1-2-7-1-2-5 bye-bye
08:37:27	1-2-7-1-2-5 goodbye TVS4MP

1.9.7 PAN PAN declaration

Transcript of communication of TVS4MP when switching to the frequency of 127.125 MHz ACC PRAGUE

08:39:29

TVS4MP	Prague Radar, dobré dopoledne [good morning] TVS4MP.
127,125	TVS4MP, dobré dopoledne [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	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	Yes, of course, proceed to VLM and VLM4T arrival.
TVS4MP	VLM, VLM4T, TVS4MP.

Part of the communication is not provided due to non-relevance.

08:52:36

127,580	TVS4MP, Praha?
TVS4MP	Go ahead.
127,580	Do you request local stand-by or full emergency or any assistance?
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	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	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	Ano, dávejte. [yes, go ahead]
TVS4MP	My nebudeme potřebovat žádnou inspekci na dráze, vyjedeme normálně B a jedeme na 52, předpokládám, a tam si to uděláme. [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	Určitě, jenom je to náš postup, my musíme zkontrolovat dráhu za váma, takže vy ji normálně vykliďte na B, klidně. [Sure except it is our procedure to check the RWY after you, so you may freely vacate via B]
TVS4MP	Jo, je mi to jasný. Děkuju. [Yeah, got it, thanks]

1.10 Aerodrome Information

1.10.1 LGSM

The ARISTARCHOS OF SAMOS is a Greek international aerodrome. RWY 09/27 has an altitude of 20 ft. Given the approach and departure method, local meteorological conditions, location and runway length with regards to the obstacles, the aerodrome is classified as category C. The published departure from and arrival on RWY 09/27 rank among very challenging ones. For that reason, pilots need to acquire necessary qualification to take part in the traffic at this aerodrome. RWY 09 has the same TORA, TODA, ASDA 2100 m for take-off upon demand.

1.10.2 LKPR

The Václav Havel Airport Prague is an international aerodrome. The aerodrome is equipped for IFR flights. It has two runways marked RWY 06/24 and RWY 12/30. Runway 24 is equipped for precision instrument approach up to the minimum meteorological category of ICAO CAT IIIb. On the said day, at the time of TVS 1125 landing, RWY 06 was operated.

1.11 Flight Recorders and Other Means of Recording

1.11.1 Graphic illustration of the vertical flight profile

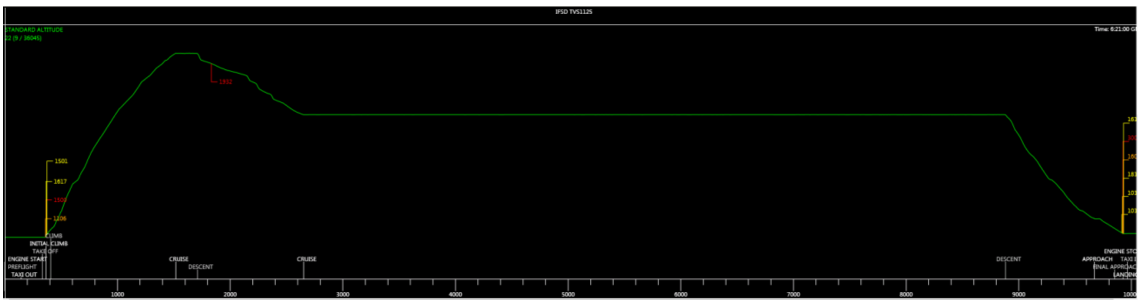

Fig. 6 Flight chart

1.11.2 Transcript of flight data from DFDAU

06:21:00 UTC: start of the flight recording

06:26:57UTC: take-off rotation, gross weight 66.7 tons

During the take-off, the difference between revolutions N1 of both the engines was more than 1.5%.

06:27:14 UTC: 400 ft AMSL – Vertical acceleration 0.53G recorded as crew stated
06:27:28UTC: 880 ft AMSL – flaps retraction was initiated
06:28:30UTC: 2560 ft AMSL – flap retraction completed and 250 KIAS was established
06:30:56UTC: passing FL100, speed increasing 299 KIAS
06:46:22UTC: FL360 established
06:47:27UTC: N1 on the eng. No.1 dropping down

IRS pos.: N39°11'31'' E025°09'00''

06:47:49UTC: N1 on the eng. No.1 stabilized at 25 %
06:49:26UTC: MCP altitude set to FL240 and descent was initiated
06:49:31UTC: the lowest recorded speed – 226 KIAS 0.689M
06:50:02UTC: drift down speed 244 KIAS established
06:56:39UTC: speed increasing up to 310 KIAS
07:02:32UTC: speed 310 KIAS established, passing FL260
07:05:04UTC: speed 311 KIAS, FL241, Engine start lever at "IDLE DETENT" position for windmilling restart
07:05:18UTC: FL240 established, gross weight 64.2 tons

IRS pos.: N40°44'13'' E023°16'12''

07:06:13UTC: Engine start lever at "CUTOFF" position
07:07:45UTC: Engine start lever at "IDLE DETENT" position for crossbleed start
07:08:56UTC: Engine start lever at "CUTOFF" position for remainder of the flight

IRS pos.: N41°04'48'' E023°09'07''

Irrelevant section
08:49:05 UTC: descend initiated to FL170

IRS pos.: N49°22'O1'' E015°12'00''

09:01:47UTC: Flaps 1
09:02:41UTC: Flaps 5
09:03:18UTC: Gear Down
09:03:26UTC: Flaps 15
09:06:26UTC: main gear touchdown, gross weight 59.8 tons
09:07:25UTC: RWY06 vacated via B
09:09:04UTC: ACFT stopped, Ground speed 0kts
09:09:27UTC: Eng No. 2 stopped

1.12 Wreckage and Impact Information

NIL

1.13 Medical and Pathological Information

NIL

1.14 Fire

NIL

1.15 Search and rescue

NIL

1.16 Tests and Research

1.16.1 Fuel Pump

The essential information in the report of the organisation authorised to examine the fuel system pertains to the fuel pump concerned. Individual components of the fuel system disconnected from engine No. 1 CFM56-7B, serial number 888760, were sent to the organisation authorised to carry out an expert examination. Expert examination confirmed the conclusions of the Preliminary Technical Report of the operator's Technical Department, see Appendices 1, 2 and 3. It confirmed the clogging of the fuel system with swarf and fragments originating primarily from the engine fuel pump. The conclusions of the expert examination of individual components revealed the findings which are described in more detail in the following chapters.

1.16.2 Main fuel filter

The filter was contaminated with swarf and fragments in size from 1 to 10 mm and in number greater than 100 pcs. Swarf analysis identified the material composition: aluminium-copper-magnesium (AlCuMg) and aluminium-silicon alloy (AlSi). Apart from the said swarf and fragments, the filter did not show any other abnormalities. The main fuel filter was not found to be the cause of a fuel pump defect leading to engine failure.

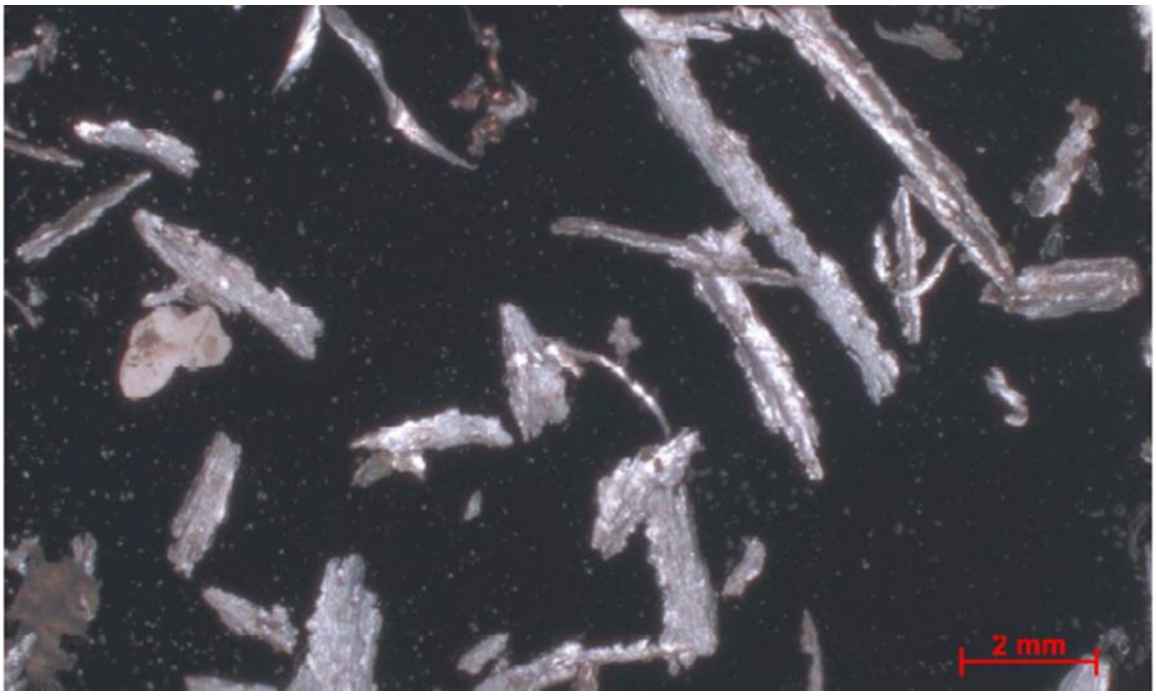

Fig. 7 Fragments collected by the main fuel filter

1.16.3 Fuel nozzle filter

The filter was contaminated with scales in size from 0.5 to 1.5 mm and in number greater than 100 pcs. All the analysed fragments contained copper alloy and corresponded to a copper, tin and lead alloy (CuSnPb). Apart from the said swarf and fragments, the filter did not show any other abnormalities. The fuel nozzle filter was not found to be the cause of a fuel pump defect leading to engine failure.

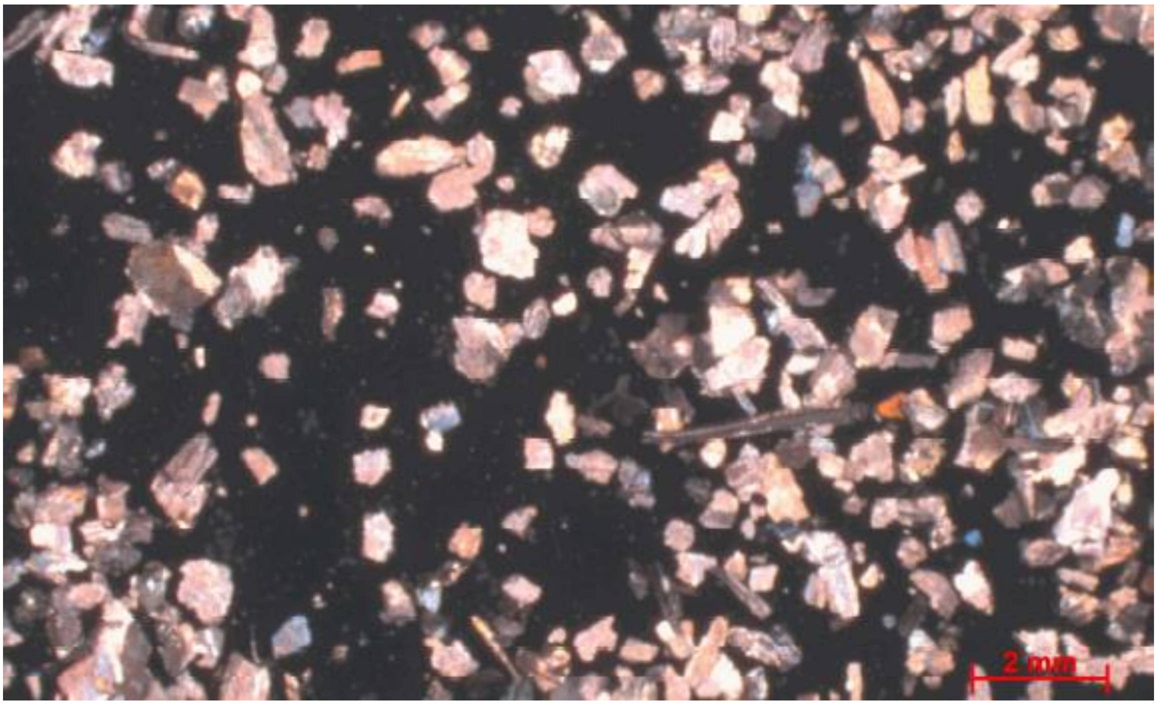

Fig. 8 Fragments collected in the fuel nozzle filter

1.16.4 Hydromechanical unit (HMU)

The entire HMU was completely dismantled. All parts of the HMU were highly contaminated with bronze-stained swarf and fragments. This high level of contamination significantly affected, even prevented, the operation of various moving parts of the HMU and thus the functionality of the entire hydromechanical unit. This is documented with the pressure/shut-off valve found in a closed position and heavily contaminated with bronze-stained swarf and fragments. For this reason, the valve piston was “sticky” and difficult to remove.

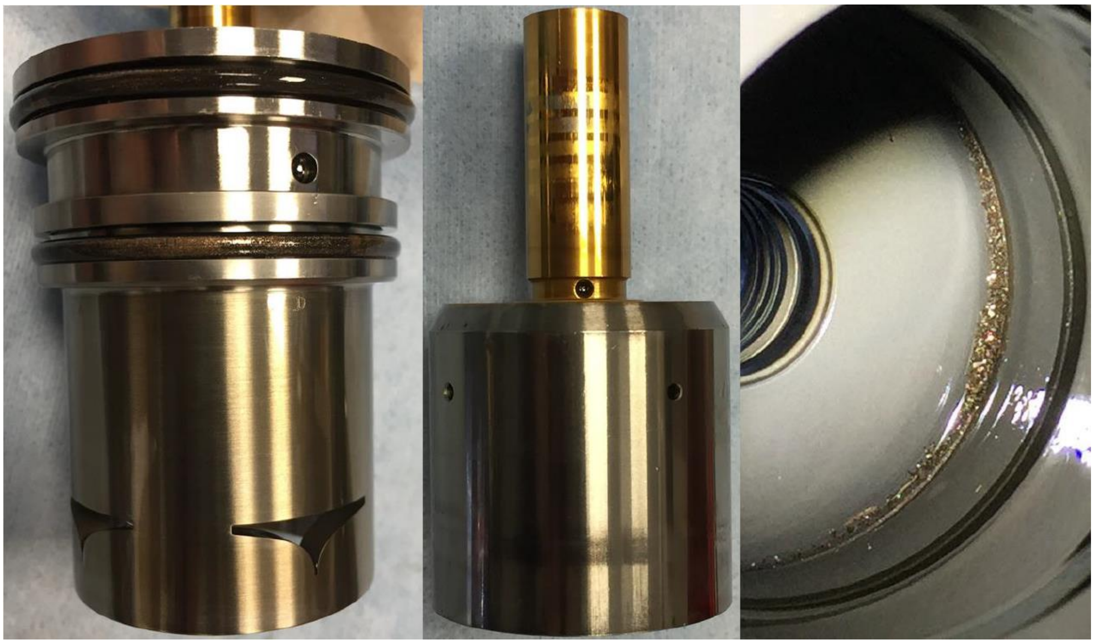

Fig. 9 The shut-off valve was in a closed position and had limited functionality due to contamination.

1.16.5 Main fuel pump

The fuel pump was contaminated with swarf and fragments in size from 1 to 10 mm and in number greater than 100 pcs. Swarf analysis identified the material composition: aluminium-copper-magnesium (AlCuMg) and aluminium-silicon alloy (AISi). The following material was extracted from the pump: copper (Cu) in alloy with traces of nickel (Ni) and lead (Pb), carbon (C), fluorine (F), and aluminium (Al). The rotating part of the pump showed wear due to dry friction. The flaky fragments removed from the impeller blades were composed of aluminium alloy with about 10% of silicon. The pump housing showed traces of friction with the rotating part of the pump – impeller. Swarf collected from the housing corresponded to the material composition of the impeller. Traces of melted metal were also found on the pump housing, demonstrating high operating temperatures caused probably by running “dry”, i.e. without fuel as a lubricant.

Fig. 10 Traces of melted metal in the pump housing.

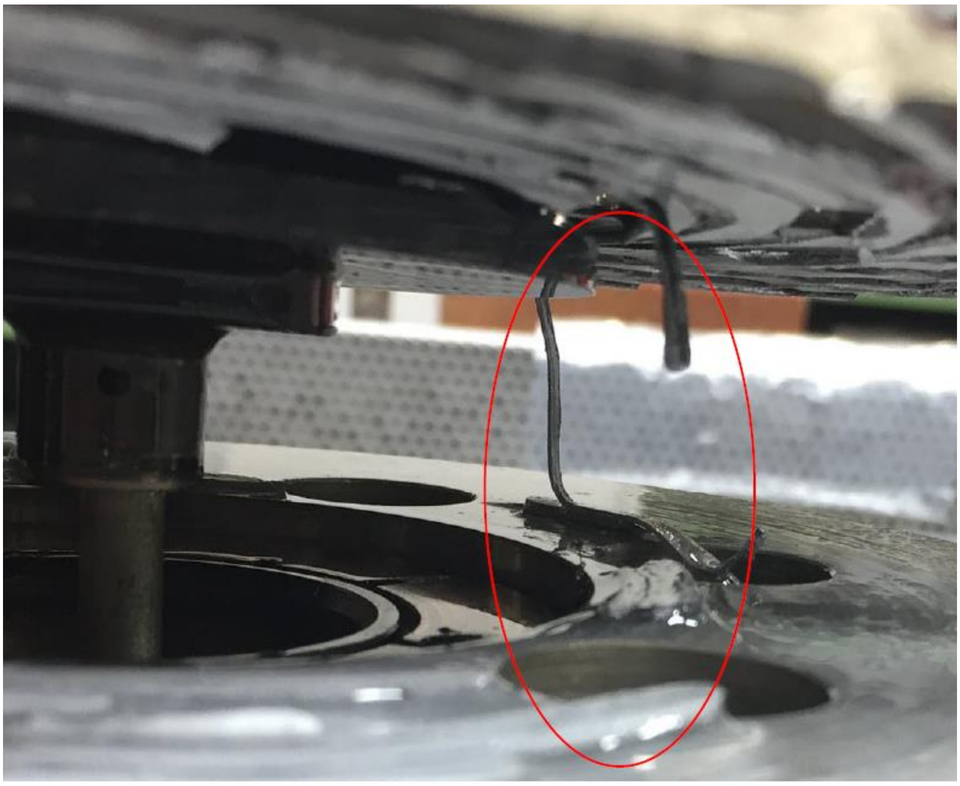

Fig. 11 When the impeller was dismantled, there was noticeable partial welding with a pump housing wall there.

Conclusion:

Findings on the main fuel pump indicate the operation of the pump without fuel which works as a lubricant during normal operation. Operating the pump “dry” may well explain the damage to the fuel pump and the resulting contamination with so produced swarf and fragments of other engine fuel system components. This gradually significantly reduced the functionality of the entire fuel system, which resulted in engine failure.

Note: As per the record in the Defect Logbook (DL No. 107847), the engineers were resolving a defect recorded by the PIC after return from the previous flight. The entry concerned a difference in revolutions N1 at start-up and climb on engine No. 1 compared to engine No. 2. The difference was 1.5%. The fault was resolved by the engineers, among other things, by fuel filter exchange. It may be concluded from this fact that the fuel system malfunctioning had begun earlier than on the event flight where the spontaneous engine No. 1 shutdown occurred.

1.17 Organisational and Management Information

Maintenance of the aircraft was performed by an authorised maintenance organisation in accordance with PART 145.

The Safety Department of Smartwings, a. s. issued the following safety recommendations in an internal final report, revision No. 3, regarding 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 (i.e. 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.

Responsible: Leasing Deadline: 30 SEP 2019

1.18 Supplementary Information

1.18.1 Commission Regulation (EU) No. 965/2012

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

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

Relevant AIR OPS provisions

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 specialised operation authorisation (SPO authorisation) or declaration

(b) Every 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.OP.MPA.280 In-flight fuel management — aeroplanes

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.

(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; or

(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; or

(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.

Commission Implementing Regulation No. (EU) 923/2012

Commission Implementing Regulation (EU) No. 923/2012 of 26 September 2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation and amending Implementing Regulation (EU) No. 1035/2011 and Regulations (EC) No. 1265/2007, (EC) No. 1794/2006, (EC) No. 730/2006, (EC) No. 1033/2006 and (EU) No. 255/2010, as amended (hereinafter the “SERA”) According to Article 11 thereof, this Regulation shall be binding in its entirety and directly applicable in all Member States.

Relevant SERA provisions

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.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.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.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.

1.18.2 Act No. 49/1997 Coll., on civil aviation, as amended by later regulations and amendments to Act No. 455/1991 Coll, on trade licensing (Trade Licensing Act), as amended

Section 102(2)

Operators of airports and airstructures, persons authorised to operate air services, operators of aviation activities and other persons involved in civil aviation are obliged to comply with aviation regulations which, according to international treaties that are part of legislation, are issued by

a) the International Civil Aviation Organisation,

b) the Joint Aviation Authorities under EU regulations, and

c) EUROCONTROL, the European Organisation for the Safety of Air Navigation,

in the wording adopted by the Czech Republic represented by the Ministry of Transport. These regulations are published in the Aeronautical Information Publication and are available at the Ministry of Transport and the Authority.

1.18.3 Greek AIP – Extract from the section dealing with the 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.

1.18.4 RVSM airspace procedures

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**; or

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

The aforementioned is part of OM

1.18.5 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 limitations, as defined by the original equipment manufacturer (AFM, FCOM) for the aircraft type they operate.

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 penal 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 penal then the written form shall be confirmed by CEO.

1.18.6 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 divert. 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.

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.

1.18.7 *Black Swan*

The *Black Swan Theory*[2] refers to *Black Swan* events, unpredictable events that go beyond what is expected of the situation and have potentially serious consequences. The occurrence of the so-called Black Swan is extremely rare, has a serious impact and is unpredictable.

The Black Swan Theory was developed by Nassim Nicolas Taleb. Since Nicolas Taleb is a finance expert and scholar, author, and former Wall Street trader, the theory is originally linked with the financial sector. Nonetheless, the Black Swan Theory may be applied to any other sector – including aviation.

Air accidents and incidents in aviation that fell beyond the boundary of anticipation as for the impact and rarity, were designated as “black swans” (for instance Germanwings Flight 9525, Malaysian Airlines MH370, US Airways flight 1549, Qantas flight QF32 A380). These black swans serve as a proof of nothing being impossible and present a challenge to increase the awareness levels regarding aviation safety. High quality crew training together with adherence to the regulations and safety rules may sometimes save human lives. An effective SMS airline programme will never represent a bad investment.

1.19 Useful or Effective Investigation Techniques

Annex 13 was adhered to at all times during the investigation of the serious incident.

2 Analyses

2.1 Sources and Methods Applied to Serious Incident Investigation

The Commission based its investigation on two delivered internal Final Reports of Smartwings, a. s. The first Final Report, revision 0, was issued on 5 September 2019. The second Final Report, revision 3, was issued on 6 February 2020. Various parts of information regarding the flight are described in the statements given by the PIC, F/O, SCC, technical staff, and Air Traffic Controller on duty at the given time. Transcripts of correspondence issued from individual ATC stations as well as the transcripts of the ACC communication in individual flyover states were acquired and used. The evaluation of safety and operational aspects of urgency communication was provided by ANS CR. The DFDAU data were analysed. The Commission evaluated the potential that particularly serious faults on the part of the crew held by the method of the worst scenario impact – *Black Swan.*

2 Excerpt from article titled *The Black Swan Theory in Aviation* by Ana JURIC.

2.2 Analysis of the PIC's Decision-making Process

2.2.1 Not declaring PAN PAN

The urgency PAN PAN call has a priority, except for the emergency calls MAY DAY, over any other correspondence and all the stations are obliged to ensure that at no time the transmission of the priority correspondence is interfered with. The F/O was PF, thus primarily responsible for aircraft piloting. He was well aware that the aircraft with an out-of-order power unit was not able to hold the reached FL360. He knew he had to begin to descend speedily to the set FL where the aircraft with one non-operational power unit would be able to fly safely. The PIC was, however, unable to perform the F/O's requested immediate descent manoeuvre without prior urgency communication. The PIC was equipped with a BOSE headset. According to the F/O's statement, this type of headset was most likely the cause of deteriorated communication between the PIC and ATC as well as within the crew. Notwithstanding the fact the PIC was, after several attempts, unable to establish contact with ATC, he did not immediately start the communication with urgency signal PAN PAN which clearly defines the nature of diligence communication so that it could be processed by ATC as a priority signal. Neither the circumstances ensuing from the nature of the malfunction, growing nervousness within the crew, nor the warning of decreasing flight speed did not induce the PIC to change his decision and to instantly use the urgency PAN PAN signal. Disregard of hazard on the part of the PIC thus led to the flight continuing at FL360 with one non-operational engine for over 2 minutes while the flight speed decreased to 226 KIAS. This situation led the F/O to determine that in case of forced descent he would carry out *offset* manoeuvre without ATC's approval in order to avoid potential conflicting situations likely to take place in operations at lower flight levels. The F/O was responsible for piloting. For that reason, he was closely watching the trend in deceleration so that he would not find himself in a situation wherein the speed would drop below the values necessary for safe manoeuvring, or as the case may be, down to the stall speed limit. The said risks ensuing from the nature of the aircraft defect at FL360 led the F/O in the given situation to an increased level in assertiveness toward the PIC during his non-compliant attempts to request descent from ATC. The regulations AMC2 SPA.RVSM105 (d)(2)(1.18.6) and OM-A, Section .8.3.2.4 PROCEDURES IN THE EVENT OF SYSTEM DEGRADATION (see Appendix 4) in this case, clearly define the obligation on the part of the crew to notify ATC in a relevant and correct manner of the failure circumstances and the loss of ability to maintain the flight level by transmitting the urgency signal. By ignoring the stated rules and using incorrect procedures, the PIC caused growing uncertainty and stress in the crew as the speed was decreasing. By his way of communication, the PIC thus totally ignored the instruction issued by the F/O who was primarily in charge of piloting. The DFDAU record reads that upon engine No. 1 shutdown at 06:49:31 at FL360, there was deceleration all the way down to 226KIAS/0.689M. The power failure of engine No. 1 reading was made at 06:47:27. Due to his failure to use the communication prescribed by the rules, the PIC enabled the stress gradient within his crew to grow for over 2 minutes.

Based on the statements given by the crew members and also on the provided records from individual ATCs during flight through their aerospace up to LKAA FIR, no urgency or emergency communication was used during the period of loss of one of the power units. In order to obtain the clearance for descent, the phrase "*maintenance issue*" was used three, or four times. According to RVSM procedures as given in OM-A (1)(8.3.2.5.4.) – see Appendix 4 – In case of impaired system functionality, urgency or emergency communication procedures must be used.

Urgency communication was applied and performed only at the time of entering LKAA FIR. The PIC subsequently carried out communication with ATC in a non-standard and quite informal way.

2.2.2 Operational and safety aspects in not issuing a PAN PAN signal by the crew after the loss of thrust in one of the two aircraft power units as viewed by ATC.

Conflict settlement safety:

- General: limited manoeuvrability
- Sudden “insolvability” of the critical situation = loss of time and concentration!
- It is infeasible to apply a “well-rehearsed” procedure from the training (much longer time needed for solving the situation)
- The instruction “immediately turn” is not executable
- The instruction “immediately climb/descend” is not executable

Generally, ATC counts with a standard performance output of the given ACFT type and in its plan of solving conflict contingencies, the limited performance takes precious time and reduces the number of feasible options to make effective manoeuvres successfully solving the given operational situation.

Operational aspects:

- It is infeasible to carry out the instruction “increase/decrease speed” in the expected extent (standard separation/sequence).
- FL cannot be changed for separation (ascent impossible / descent = higher fuel consumption).
- Considerably limited manoeuvrability in response to instruction TCAS/INFORMATION
- The prepared selected concept cannot be used = loss of time and concentration, mental strain and stress increase
- REQs of successive ATCs cannot be performed

Prevention in case of a standard procedure in notification of system degradation:

- Continuous deflecting of traffic under ACFT (in case of “deterioration” of the situation)
- Selecting the shortest possible flight trajectory
- Submitting timely information to the successive ATCs/units
- Concept of air traffic control management adapted to the limited performance output of the ACFT in question

2.2.3 Not signalling the PAN PAN – evaluation by the method of the the worst scenario impact – *Black Swan*

After the engine failure, the PIC did not begin to transmit the urgency signal to ATC units. Since the PIC was attempting to request descending by communication outside of the regulations’ framework, he lost the time necessary to adapt his own safety strategy in case of the other engine malfunction. He could not know whether the engine failure had been caused by contaminated fuel. Should the other power unit shut down as well at the time when the aircraft speed dropped down to 226 KIAS, the rapid descent gradient would logically force the F/O to necessarily commence an emergency descent by a rough pushdown in order to avoid a stall speed situation. Such serious intervention on the part of the F/O would lead with a great degree of probability to possible injuries of passengers with unfastened seatbelts. The logical further loss of aircraft speed would consequently limit the F/O in possibilities to perform safely the *offset* manoeuvre enabling him to avoid potentially conflicting traffic. The aircraft would then have to begin an emergency descent directly ahead of itself without prior securing of vertical separation distances from the potential opposite-direction or same-direction traffic at lower levels. Without sending the urgency PAN PAN signal and without the intelligence of circumstances of the forced, or emergency descent, the ATC would not have been able to evaluate the safety and operational aspects of the situation, see 2.1.2. and to ensure the aircraft and the surrounding traffic safe vertical separation distances. The PIC did not evaluate potential risks and by using communication outside of regulation protocol lost time for further decision making on the part of the crew and caused the reduction of the manoeuvre flight speed at FL360. The PIC thus disabled the F/O in his role of PF to be ahead in solving potential situations, to be in the position "ahead of the aircraft timewise".

2.2.4 Plan to land at the nearest suitable airport

The operations manuals issued by Smartwings, a.s. approved/accepted by the Civil Aviation Authority of the Czech Republic state that the manual with QRH and operating manuals of FCOM flight crews are used as an integral part of OM-B, Chapter 2(1)(2)(a), see Appendix 7. The situation *Engine Failure or Shutdown* required using the QRH issued by the manufacturer to perform procedures in non-standard situations. The FCOM by the manufacturer provides complete lists of procedures described in OM-A and OM-B. Further information and recommendations are represented in OM-C and OM-D. Engine Failure or Shutdown NNC can be found on page. 7.18 QRH, see Appendix 8A. The crew continued up to item No. 13, page 7.20 QRH, see Appendix 8B, when they decided to attempt a repeated in-flight engine starting and went over to checklist Engine In-Flight Start NNC, page 7.27, see Appendix 9A. After instructions on page 7.28, see Appendix 9B, proceeded to page 7.29, see Appendix 9C. Engine in-flight starting *(windmill and crossbleed start)* was unsuccessful. Engine In-Flight Start NNC was terminated. Following procedure with item No. 10: **Plan to land at the nearest suitable airport** is described on page 7.30 of QRH, see Appendix 9D with the note: **Do not use FMC performance prediction***.* The checklist guides the crew to **Go to One Engine Inoperative Landing checklist** on page 7.34 of QRH.

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

Instructions for the QRH checklist, chapter CI(2), paragraph: Non-Normal Checklist Operation, see Appendix 10, explains what this statement means in NNC. See 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 Appendix 12, guides the crew to determining the nearest suitable airport. The PIC shall determine the suitable alternate airport on the route in accordance with paragraph OM-A: 8.1.2.5., see Appendix 5 for details.

2.3 Quick Reference Handbook

2.3.1 Plan to land at the nearest suitable airport – instruction in the meaning from FCTM

"Plan the landing at the nearest suitable airport" is the wording of the instruction used in the QRH. This part explains the grounds for the given statement and manner of its application. In an unusual situation, the PIC **is obliged** as the authorised person in charge of the operation and safety of the flight to make the decision to continue in flight in accordance with the flight plan, or to deflect. In an emergency situation, the PIC can opt for necessary deflections from any and all rules in order to accommodate the emergency. **In any case, it is expected that the PIC would choose the safest measures regarding the occurrence of all types of risks.** The QRH aids the crews in the decision-making process by introducing situations in which landing at the nearest suitable airport is required. Such situations are described in the introduction of “Checklists”, or in the individual NNCs. Most regulatory agencies specify that the Pilot-in-command of a twin-engined aircraft that has an engine failure or engine shutdown **shall land at the nearest suitable airport.** A suitable airport is defined by the operational authority of the operator on the basis of the supplementary material text, generally it shall be equipped with adequate facilities and shall fulfil certain minimum meteorological condition requirements.

2.3.2 Checklist Complete

Each QRH Checklist, or more precisely its implementation should be terminating with the phrase: *“NNC (here the specific reading shall be applied) Complete”.* Considering that item No. **10 Plan to land at the nearest suitable airport** had not been confirmed in the Engine In-Flight Start NNC, the termination wording of NNC ***“Engine In-Flight Start Complete*** "could not be pronounced. At 07:08:56 UTC: Engine start lever at “CUTOFF” position for remainder of the flight. Subsequently, the PIC should have completed the unsuccessful attempts at Engine in Flight Start as per NNC QRH by the laid-down procedure. The timing of this laid-down procedure would be added to 07:08:56 and, in case of the ensured CVR PIC record according to the regulations, at 09:09:27 UTC – Eng. No. 2 stopped – it would be possible to determine in what manner the PIC completed the QRH NNC.

2.4 Cockpit Voice Recorder

According to the statements provided by the crew, the PIC did not carry out the procedure for securing CVR recording as stated in OM-A, paragraph: 11.7.4.1., see Appendix 6, which was, in this particular case, defined by the regulation for the investigational purposes. Not even oral instruction to download the CVR record was given to the maintenance staff members, and there was no relevant entry made into the *Defect Logbook*either.

2.5 Crew Resource Management

The CRM evaluation manual serves the CRM instructors, ground preparation instructors, route and type training instructors, and testing inspectors evaluating the operation of flight crews. The flight crews are obliged, within the framework of carrying out their operational duties, to apply countermeasures in order to avert threats, to eliminate possible errors and undesirable effects of aircraft systems on decreasing the safety limits in flight operation. The primary examples of such countermeasures include communication, checklists, briefings, Call-Outs and SOPs as well as personal strategies and approaches leading to safe flight completion.

The CRM requirements for the crew competence are as follows:

- Communication
- Application of the threat and error management in accordance with the CRM rules
- Threat and error management
- Leadership and teamwork
- Situation awareness

- Workload management
- Problem-solving and decision-making
- Applying automation
- Task sharing
- Stress, stress management techniques

2.5.1 CRM evaluation

Behavioural Marker Notechs chart represents a matrix which enables performance of specific evaluations based on more than one item as laid down in the CRM EVALUATION, paragraph 3.1., see Appendix 14. Four general areas with their sub-sections have been evaluated using the crew evaluation manual based on the crew testimonies and the DFDAU records. The classification marks range from very poor (1) to very good (5). The internal evaluation carried out internally by Smartwings, a.s. has indicated an immense commander gradient levels in PIC in the cockpit leading to the F/O being in fact unable of participating in the decision-making process within the crew. Average evaluation of the PIC fell within **1.26–1.43.** CRM throughout the event flight was **"very bad".**

2.6 Driftdown Speed / Level OFF altitude – the speed of descent with a decreased power / stabilised altitude – transition into horizontal flight

Performance Inflight - QRH
Engine Inoperative

BOEING
737 Flight Crew Operations Manual

737-800W/CFM56-7B26
JAA
Category C/N Brakes

ENGINE INOP

MAX CONTINUOUS THRUST

Driftdown Speed/Level Off Altitude

100 ft/min residual rate of climb

WEIGHT (1000 KG)		OPTIMUM DRIFTDOWN SPEED (KIAS)	LEVEL OFF ALTITUDE (FT)		
START DRIFTDOWN	LEVEL OFF		ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
85	82	271	18500	17300	15900
80	77	263	20200	19000	17700
75	72	255	21600	20600	19400
70	67	247	23100	22200	21100
65	62	238	24700	23800	22800
60	57	229	26800	25800	24700
55	53	219	29100	28100	27000
50	48	209	31200	30400	29400
45	43	199	33300	32600	31700
40	38	187	35600	34900	34000

Includes APU fuel burn.

Fig. 12 Chart from the QRH showing values for descending with decreased power

The initial aircraft weight at FL240 was 64.1 t. ISA reading from OFP was +7 °C. By approximating 64.1 between 62 and 67 we obtain LEVEL OFF ALTITUDE (FT) 24090.

2.6.1 Long Range Cruise Altitude Capability

Performance Inflight - QRH
Engine Inoperative

BOEING

737 Flight Crew Operations Manual

737-800W/CFM56-7B26
JAA
Category C/N Brakes

ENGINE INOP

MAX CONTINUOUS THRUST

Long Range Cruise Altitude Capability
100 ft/min residual rate of climb

WEIGHT (1000 KG)	PRESSURE ALTITUDE (FT)		
	ISA + 10°C & BELOW	ISA + 15°C	ISA + 20°C
85	15200	12600	9900
80	17200	15300	12500
75	19200	17400	15000
70	20900	19700	17300
65	22500	21300	19800
60	24100	23000	21600
55	26300	24800	23500
50	29000	27700	25800
45	31400	30500	29200
40	33800	33000	31800

With engine anti-ice on, decrease altitude capability by 1200 ft.
With engine and wing anti-ice on, decrease altitude capability by 5500 ft.

Fig. 13 Chart from the QRH used for determining usable FL

The chart shows the maximum altitude that can be maintained with the given weight value, air temperature, and deviation from ISA, based on the cruise speed for long-range distances applying the maximum applicable thrust with the residual rate of climb at 100 ft/min. Given the weight at 64.1 t, applicable PRESSURE ALTITUDE (FT) is approx. 22,788 ft. The nearest applicable FL thus cannot have been FL240 but FL220. The crew had to apply MCT for approx. 7 min at FL240 in order to stop the aircraft speed decreasing, therefore could not apply the 100 ft/min climb rate condition, or to retain the existing indicated speed.

2.6.2 Long Range Cruise Control

737-800W/CFM56-7B26
JAA
Category C/N Brakes

BOEING
737 Flight Crew Operations Manual

Performance Inflight - QRH
Engine Inoperative

ENGINE INOP

Long Range Cruise Control

WEIGHT (1000 KG)		PRESSURE ALTITUDE (1000 FT) 10	15	17	19	21	23	25	27	29	31
85	%N1	91.8	95.5	97.9							
	MACH	.561	.600	.616							
	KIAS	311	303	300							
	FF/ENG	3067	3033	3052							
80	%N1	90.1	94.0	95.9	98.5						
	MACH	.545	.590	.603	.621						
	KIAS	302	299	294	291						
	FF/ENG	2875	2870	2846	2886						
75	%N1	88.4	92.5	94.0	96.1						
	MACH	.528	.579	.593	.607						
	KIAS	293	293	288	284						
	FF/ENG	2684	2709	2674	2662						
70	%N1	86.5	90.7	92.3	94.0	96.2					
	MACH	.510	.562	.582	.595	.610					
	KIAS	282	284	283	278	274					
	FF/ENG	2494	2518	2520	2481	2487					
65	%N1	84.5	88.7	90.4	92.2	93.9	96.4				
	MACH	.491	.542	.563	.584	.596	.612				
	KIAS	271	274	274	273	268	265				
	FF/ENG	2306	2327	2330	2330	2295	2317				
60	%N1	82.3	86.5	88.3	90.0	91.9	93.7	96.4			
	MACH	.471	.521	.543	.564	.585	.597	.614			
	KIAS	261	263	263	263	263	258	254			
	FF/ENG	2124	2137	2139	2140	2143	2114	2146			

Fig. 14 Chart from QRH indicating weight data and corresponding conservative flight range calculations

The chart provides the target revolutions N1 in % for the cruise level of a long-range flight with a non-operating engine, Mach number, KIAS, and fuel flow for the given weights and barometric flight altitude. The fuel flow values in this chart reflect the working engine fuel consumption. In the case of an initial weight value at 64.1 t the values of the nearest given higher weight are usable, i.e. 65 t. The values applicable for FL250 and weight of 60 t are highlighted in the blue square.

2.7 Fuel

The amount of fuel for the complete rotation LKPR – LGSM – LKPR was, upon the decision made by the PIC, determined and recorded into the OFP at 15,500 kg. This decision was based on the operator’s policy to avoid refuelling at LGSM. Providing of the fuel addition data has been analysed using the AirFASE (FDM) software. The fuel amount reading after the first flightpath leg from LKPR to LGSM, following the engines shutdown, was 9,460 kg. The amount recorded in the OFP was 9,500 kg. The fuel amount required, based on the QFP calculations, for the LGSM–LKPR flight, was 9,217 kg. At the moment of take-off from

LGSM, the fuel amount reading was at the value of 9,310 kg. The fuel amount in the aircraft tanks at the moment of touch-down at LKPR was 2,435 kg and after the engine shutdown the reading was 2,340 kg. The calculated fuel amount value in accordance with OFP, FMS RES was 2,412 kg = 1,328 kg ALTN Fuel +1,083 kg Final Reserve, (the fuel values copied from OFP also with the different result 2,412 kg). FUEL REM entered by the PIC into OFP showed 2,370 kg. OFP marks 3 checks of existing fuel amount performed by the PIC after the failure of engine No. 1. After one power unit failure, the FMC PERFORMANCE PREDICTIONS cannot be applied, and QRH prohibits such practice in the note to point 10 of NNC – see Appendix 9D. For this reason, the conservative calculation of the remaining fuel amount is performed using the relevant charts with the data available from QRH, see 2.6.2. Not a single record in the OFP was made of the manner of the remaining fuel amount calculation as stipulated in QRH at the planned landing aerodrome in one engine inoperative flight conditions as given in the chapter Performance Inflight – QRH Engine Inoperative. It is beyond any doubt that the development of the variance in fuel amount between Fuel Actual and FMS Reserve played a principal role in the decision-making process on the part of the PIC. This conclusion is only confirmed by the statements given by the Crew Controller or SCC who learned only about 45 min prior to the landing that “there was enough fuel onboard to make it to Prague.” The PIC nonetheless decided to continue in the flight all the way to LKPR destination. With no recorded updates of Fuel Actual entries and no continuously calculated remaining fuel amounts applying relevant and correct data from QRH, the PIC must have been either only estimating, or using incorrect values, prohibited in checklist values from FMS, when calculating the remaining fuel amount available for a flight to LKPR. In consideration of the fuel amount limit difference of 23 kg between FMS RES 2,412 kg and actual 2,435 kg after the landing, the PIC cannot have been certain at the moment of arrival to LKPR of not commencing to consume the fuel from FMS RES. In spite of the given situation, the PIC declared to ATC the ability to fly all the way to LKPR without cancelling ALTN, or otherwise declared procedure. If the PIC had carried out the procedures systematically, that is using the only correct way of conservative method of calculating the remaining fuel amount from QRH, he would have reached the conclusion of necessity to carry out precautionary landing earlier than LKPR, or to cancel ALTN.

2.7.1 Fuel policy – evaluation by the method of the worst scenario impact – *Black Swan*

PIC did not calculate into his decision to continue in flight to LKPR unpredictable circumstances linked with a very low amount of available remaining fuel onboard. At the moment of landing, the aircraft was carrying 2,435 kg of fuel onboard, while the minimum calculated FMS RES fuel for flight to the alternate aerodrome was 2,412 kg, and that would be in case of both power units operating. During the potential overflight to the nearest alternate aerodrome in Dresden, the lowered aircraft output would have required the MCT of the operating engine and combined with the increased drifting aircraft drag. Thus, it would have consumed more than 1,328 kg of the fuel amount planned for overflight to ALTN in case of both the power units operating. The decision-making process in this case could not have included an overflight to an alternate aerodrome as the charts used for fuel consumption calculations in cases of climb with non-operating power unit do not exist. Chaining of the previous incorrect decisions would thus ultimately lead to commencing of consumption of the Final Reserve of fuel in the amount of 1,083 kg still before reaching ALTN. Under such circumstances, the PIC would have had to declare emergency (MAY DAY) for the reasons of remaining fuel amount in order to ensure the assistance of ATC – the highest landing priority. Small amount of fuel available onboard and the loss of one power unit led to further stress level increase within the crew and heightened risk of possible errors occurring at landing. At the same time, the F/O was not specifically informed of such limit value of fuel amount and simply accepted the stated fact that there was enough fuel available to perform the flight to LKPR. The PIC did not know the true cause of the engine failure and thus could not know whether the engine No. 1 shutdown had not been caused by contaminated fuel.

2.8 SAFETY ALERT 2/2015

LGSM aerodrome, classified as C category, had coinciding value of 2,100 m for TORA, TODA, and ASDA. Following the evaluation of the calculated parameters, it should have been clear to the PIC that any deviation or variance from the engine parameters during the take-off would have led to shift in the calculated values towards the limit value of the RWY length. The PIC did not note the difference (more than 1.5%) between the N1 RPM values of both the engines and performed *Call Out Thrust Set*. For the distance parameter EO-STOP (*Engine out-stop*), the value of 1,978 m was calculated and thus 122 m of the total RWY length of 2,100 m remained for the case of take-off abortion for the reason of one power unit failure prior to reaching the V1 speed. In order to address such cases, the company issued a document called SAFETY ALERT 2/2015 under which the crews are, in such cases, obliged to unequivocally proceed in accordance with this document so as to secure and increase safety of performing either take-off, or landing. The PIC thus clearly, as stipulated by OM-B Chapter 2 NORMAL PROCEDURES, Section (b) PRE-DEPARTURE and by SAFETY ALERT 2/2015, speaking about necessity of including TEM *(Threat And Error Management)* into every flight (departure) briefing, did not take safety procedures and recommendations supposed to aid when solving expected threats into his considerations during the take-off.

2.8.1 TEM – evaluation by the method of the worst scenario impact – *Black Swan*

In case of an engine failure during take-off and N1 revolutions reduced by 1.5% of the operating engine, it is certain that the calculated ASDA and EO-STOP values would not correspond to the real ASDA and EO-STOP values. The output of the operating engine No. 1 lowered by 1.5% would in case of engine No. 2 shutdown lead to inevitable shift of V1 and Vr that could lead to reaching EO-STOP 2,100 m. The crew would have lost 122 m of reserve in case of take-off abort. Any sort of hesitation prior reaching the V1 speed, or slow response on the part of PIC during take-off abort would have therefore led to the aircraft exceeding the calculated limits (red circle – 3). The aircraft could have run off from the runway, or, in case of rotation, would have performed the take-off beyond the limit of 2,100 m and thus have not kept a safe distance from obstacles.

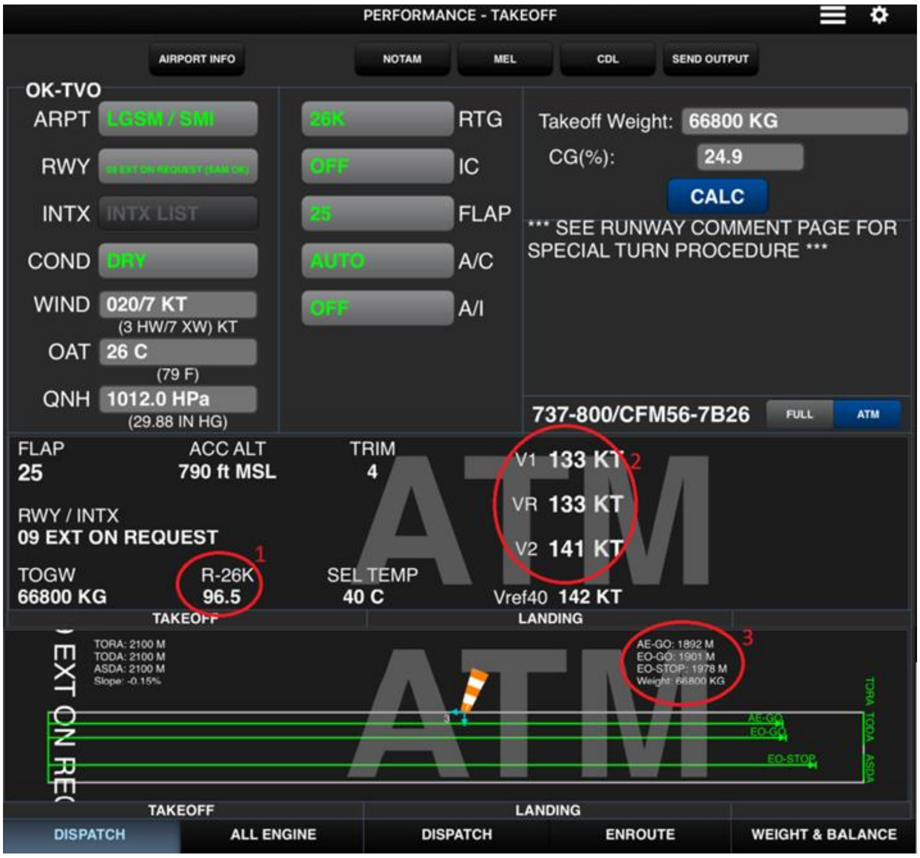

Fig. 15 FMS calculated take-off data

2.9 Alteration in Final Report No. 3 and included 5.13 OM-B, Section: 4.3.

During the incident investigation process, a new fact was found. The AAII Commission received two Final Reports from Smartwings, a. s. The first Final Report ZZ 03/2019 IFSD, revision 0, was dated 5 September 2019. The second, ZZ 03/2019 ISFD, revision 3, delivered to the AAII, was dated 6 February 2020. The two Final Reports differed namely in the content of the included provision 5.13. OM-B, Section: 4.3., see Appendix 13. Section: 4.3. of this regulation reads the manner of flight performance with one non-operating power unit at the speed 290 KIAS for the maximum range to reach the alternate aerodrome at the defined aircraft flight speed with one non-operating engine (Maximum Diversion Distance 1 ENG INOP 400 NM).

2.10 “Quasi” procedure OM-B 5.13. Section: 4.3. SPEED AND DISTANCE – 1 ENG INOP

“Historic construct” included into the second Final Report, No. 3, reads in Sub-section 5.13. OM-B, Section: 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 “historic construct” and the reading of the stated “quasi” procedure could not be found in the text of the regulation. OM-A in the Introduction part defines OM-B as “PART CONTAINING INSTRUCTIONS AND PROCEDURES NECESSARY IN SECURING SAFE OPERATION OF ALL AIRCRAFT TYPES.” This reading of OM-A delimits the instructions and procedures contained in OM-B. The reading of these procedures and instructions must comply with the FCTM issued by the manufacturer and is binding on any and all flight crews. In the course of the investigation, it has been ascertained that the purpose of the created and included “quasi” procedure into OM-B thus defined should have been solely concerning flight planning. As much as this confusing, or even misleading, “quasi” procedure was designated for the planning, it was in contradiction with OM-A, Section: 8.1.2.5 Tab. 8.1-a: Threshold Distance. At the same time, this “historic construct” and its “quasi” procedure could have been understood neither as a relevant, nor correct for the corresponding NNC QRH procedure. The obligation on the part of the PIC was to proceed and complete the NNC QRH with point 10 **Plan to land at the nearest suitable airport** in accordance with relevant and correct reading of the FCTM issued by the type manufacturer. The PIC was obliged to comply with the procedure stipulated in OM-A and to take into consideration the safety rule as stipulated in QRH Introduction, see Appendix 10.

During the investigation it was not ascertained that at any time the pilots of Travel Service, a. s. and subsequently of Smartwings, a. s. followed the reading of this “quasi” procedure, while drilling the NNC QRH on synthetic flight simulators, in any way. No relevant corresponding way was found that would in any way allow the pilot to be directed to follow the “quasi” procedure reading during carrying out the NNC QRH steps. No manner cannot thus be inferred in which the said “quasi” procedure could be projected into the decision-making process on the part of the PIC holding at the same time the position of the Flight Manager of the company. The Commission has found the mentioned “quasi” procedure to represent a system error within the OM-B of Smartwings, a.s.

2.11 Conflict in the Decision-making Process of the Pilot-in-command

The PIC had had approx. 20,900 flight hours of experience, mostly in commercial air transport. He had therefore possessed vast experience and knowledge. Besides the position of the PIC, he was also a holder of both, the FI and the FE qualifications, of which both represent the imaginary pinnacle of knowledgeability and experience needed in order to be able to pass them on in teaching other pilots. In his position of the corporate Flight Manager which he has been holding for over fifteen years he has approved binding operational documents that had a determinative effect on safety. For this reason, it is therefore hard to comprehend his actions during one flight in which he ignored, breached, or denied the obligations following from individual relevant provisions of the binding OM-A, and further also of the QRH, FCOM, FCTM of the manufacturer, regulations, and safety recommendations. The PIC’s decision-making process after the loss of one power unit thus did not follow the defined procedure as given by the NNC QRH terminating at point 10 and described in the FCOM. QRH was, in this case, the primary and relevant procedure manual for the aircraft crew in resolving the corresponding NNC onboard and a responsible Pilot-in-command would have therefore had to follow the relevant NNC procedures. The PIC’s decision-making process was aiming at completing the flight at the LKPR destination with no regard to sufficiency of suitable airports available for performing a precautionary landing. The PIC’s decision-making process was therefore in contradiction with a standard decision-making process based on following the regulations, procedures, and safety rules described in the relevant operational documents.

It has not been feasible to satisfactorily prove what level of influence the management culture in the given company had on the decision-making process of the PIC who also held the position of the Flight Manager within the same company. At the same time, it was not feasible to satisfactorily prove whether or in what way the PIC was influenced during the decision-making process by corporate financial aspects linked with the re-entry of the aircraft into operation after an engine failure. It thus cannot be rationally inferred for what reason there was a discrepancy between the following of stipulated obligations ensuing from exercising the functions of the Pilot-in-command and the PIC's personal decision to continue in flight with one non-operational power unit all the way to the LKPR destination. Despite the fact that the Captain stated that there had not been any financial aspects behind the steps taken, a discrepancy occurred between the factual flight performance and his statement. The PIC's decision-making process was not in accordance with the above-mentioned binding procedures stipulated in the OM.

3 Conclusions

3.1 Summary of Factual Information Logical Links

3.1.1 The flight crew

- The pilots were valid Pilot Licence holders, had sufficient flight experience on the B737-800 type.

3.1.2 Pilot-in-command/PIC

- By using his own *headset* reduced the legibility of communication,
- Did not proceed in accordance with the safety recommendation TEM Safety Alert 2/2015 and did not perform the check of the take-off engine revolutions for category C aerodromes with a limited RWY length properly,
- Ignored the justified request from the F/O to speedily descend to a lower flight level as the aircraft speed was decreasing after the power unit failure, and thus increased the stress level within the crew,
- Ignored the safety rules described in flight operational procedures in OM-A and OM-B issued by the operator and delineated by regulations, requiring the application of the urgency PAN PAN call in case of power unit failure in the RVSM,
- By not performing the urgency PAN PAN call following a power unit failure disabled the ATC units to effectively solve a possible conflicting traffic in the aerospace under their liability; did not follow the prescribed regulation procedures upon entry into the FIR LKAA having used much delayed PAN PAN call,
- Did not carry out correct output calculations for determining the Long Range Cruise Altitude Capability – ENGINE INOP,
- During flight through their aerospace, concealed from the ATCs of individual states the nature of the defect, and that all the way up to the LKAA FIR border,
- Was performing the NNC procedures in unusually speedy form of communication thus decreasing the F/O's ability of an effective cross-checking of the correctness of the taken steps,
- Was not discussing with the F/O the safety aspects ensuing from the nature of the given situation, thus disallowing forming of a real and common strategy for the safe completion of the flight,
- Was not following the CRM principles in order to effectively solve technical and non-technical problems,
- Was notifying the F/O of his own individual decisions with a high commander gradient, as a matter of fact,

- Did not complete the relevant procedure of NNC QRH at point **10 Plan to land at the nearest suitable airport**, albeit he was repeatedly guided by the F/O to the relevant NNC QRH procedure where the stated instruction is given,
- Notified the Athina ACC of ability to continue in single-engined flight all the way to the LKPR, which he simultaneously declared as a suitable airport in spite of the fact that at the time of the same notification he was aware of not having sufficient amount of fuel for reaching the declared destination,
- Established his own construct for flight completion which he changed in his statement, [I] quote: *"The Budapest airport will be the alternate airport for the selected alternate Prague airport,"*
- Made only 3 (three) entries regarding the fuel quantities,
- Did not carry out relevant conservative calculation of fuel remaining to LKPR systematically in accordance with *Performance Inflight – Engine Inoperative* QRH,
- By deciding to continue to LKPR he caused the aircraft onboard fuel amount to be 2,435 kg at the moment of landing, whereas the FMS RES Fuel was 2,412 kg. Absence of safety strategy respecting operating and safety aspects, both of which he was supposed to discuss with the F/O, was projected into the above said decision. Evaluation of the remaining fuel limit was supposed to form part of the safety strategy. 2,435 kg of fuel at the time of landing was 23 kg above the 2,412 kg FMS RES for both operating power units,
- Did not inform the passengers about the true nature of the defect, nor about adopting the plan to land at the nearest suitable airport for the reason of their safety,
- Stated, in divergence with the SCC's statement, that the SCC informed the cabin crew of the shutdown power unit visual check performance,
- Did not issue instructions regarding CVR securing stipulated by regulations,
- Did not make a relevant entry into the *Defect LogBook*.

3.1.3 First Officer, F/O

- For the reason of the decreasing speed, he was assertively requesting FL lowering,
- Did keep situation awareness level and during the rising stress level was ready to apply *offset,*
- Co-operated and performed all the cross-checks on the procedures performed, in spite of the PIC performing the NNC QRH procedures abnormally quickly,
- Repeatedly attempted to guide the PIC to the relevant provision of point 10 of NNC in QRH in order to comply with the requirement to adopt the plan to land at the nearest suitable aerodrome,
- Considered continuation of the flight to the LKPR destination as illogical,
- Was piloting under an enormous pressure of commanding gradient, the result of which was that he accepted the PIC's conclusions as facts,
- Did not contest the PIC's decision to continue to LKPR in concern for avoiding deterioration of conditions for co-operation within the crew necessary for accomplishing of the flight,
- At the moment of approaching the FIR LKAA border, assertively appealed to the PIC to declare PAN PAN and to notify the ATC of the nature of defect,

- Completed the flight to LKPR in accordance with the decision made by the PIC,
- Did not note any instruction from the PIC regarding securing of the CVR recording.

3.1.4 SCC

- Actively responded to the alteration in the aircraft behaviour and requested notification from the PIC,
- Asked the PIC a clear question as to who would notify the passengers of the occurred situation,
- Accepted, together with the F/O the decision of the PIC, [I] quote: *"…when it'd be clear where we'd be landing, he would notify them [the passengers] of landing for technical reasons and that the situation regarding one of the engines wouldn't be mentioned in order not to raise panic"*,
- Subsequently relayed the technical defect notification to the other cabin crew members and requested of them not to discuss amongst themselves the arisen situation in the passenger cabin,
- Did not perform any visual checks of possible damage on the shutdown engine through the passenger windows so that the passengers would not notice anything,
- About 45 minutes prior to landing, received from the PIC information that there would be enough fuel available to complete the flight to Prague,
- Confirmed no discussion nor understanding was made between the CCM and SCC concerning the event of an unprepared evacuation,
- Declared the full readiness of the cabin crew personnel in case of an emergency aircraft landing,
- Did not notice any response or reaction on the part of passengers concerning the technical condition of the aircraft throughout the whole flight.

3.1.5 Engineers

- Were informed of the arisen situation prior to the landing,
- Confirmed that the CVR recordings are collected upon the instruction given by superior staff member,
- Did not confirm that any instruction whatsoever was given by the PIC concerning CVR,
- Stated that not even later, approx. 17 hrs, did not receive an instruction to download CVR.

3.1.6 Controller

- Stated that there is no system of information time flow recording in the dispatching service when it comes to troubled flights.

3.1.7 Aircraft

- Had a valid ARC;
- Had a valid liability insurance;
- The difference in N1 revolutions on the regular airline was recorded by the previous crew into the DL,

- The aircraft was serviced and released into operation according to PART 145,
- The engine shutdown was caused by interrupted fuel supply into the engine,
- The loss of the fuel system function was caused by the fuel pump running dry without the fuel acting as a lubricating agent.

3.1.8 OM

- A "quasi" procedure was found in OM-B, originally intended for planning, that was incorrect,
- No relevant path leading to the mentioned "quasi" procedure during performing NNC QRH was found.

3.1.9 Impact on safety

- Defective decision-making process of the aircraft Pilot-in-command endangered the TVS1125 flight safety. At the same time, the safety of the other air traffic and in the relevant air traffic areas was decreased.

3.2 Causes

The cause of the serious incident was defective decision-making process of the aircraft Pilot-in-command after the loss of one of the power units as the said decision-making process was not compliant with the QRH and FCTM procedures. The procedures are mandatory.

Chain of events:

- The fuel pump operating "dry" prior to the event flight, see DL No.107847,
- The fuel pump running "dry" without the fuel acting as lubricating agent during the event flight,
- Engine failure and subsequent loss of one power unit,
- Clear ignoring and breaching of flight operating procedures, OM, relevant regulations, provisions, and safety recommendations,
- Incorrect determination of a suitable airport for performing a precautionary landing with one non-operational power unit after the fuel pump failure,
- Incorrect execution of the fuel policy,
- The Pilot-in-command did not proceed in accordance with the principles of performing CRM when implementing the NNC QRH procedures and rendered thus impossible for the F/O to effectively partake in the decision-making process,
- By not completing the relevant procedure of NNC QRH with point **10 Plan to land at the nearest suitable airport** the PIC avoided the obligation to perform precautionary landing at the nearest suitable aerodrome stipulated by the procedure given in QRH and FCTM of the manufacturer and valid and effective in the commercial air transportation,
- It cannot be satisfactorily proven, nor reliably excluded that the decision making of the aircraft Pilot-in-command and at the same time the Flight Manager of the company, was influenced by the financial aspects of the occurred situation as described in Clause 2.11.

4 Safety Recommendations

1. Based on the flight performance and the persisting conviction on the part of the PIC that his final decision-making process was carried out correctly, the AAII recommends to Smartwings, a.s. to submit the PIC to psychological examination at the Institute of Aviation Medicine.

2. The AAII recommends to CAA to inspect compliance of the procedures stated in the OM of the Smartwings, a.s. with the FCTM of Boeing as the manufacturer of the aircraft.

3. The AAII recommends Smartwings, a.s. Technical Department to review/adapt the procedures for resolving logged defects and failures so that the cause is removed and not only the manifestation of defect (in this specific case the contamination of the system beyond the fuel pump).

In Prague, 23 July 2020

Appendix No. 1

smartwings

SMARTWINGS a.s.
Technical Department

To whom it may concern

PRELIMINARY TECHNICAL REPORT

REG: MARK: **OK-TVO**
MODEL: B737-800
A/C SN: 32360
Event: In Flight Shut Down
Flight: SMI – PRG
Date: 22-Aug-2019
Affected Engine:
CFM56-7B26, ESN 888760, position 1
TSN: 51 757 CSN: 30 607
TSO: 4 637 CSO: 1 917
The Engine overhaul was performed on 23-Apr-2018. Since this maintenance no engine repair has been done.

Basic Informations:

On 21-Aug-2019, the last flight of the day, the captain reported the 1,5% N1 difference between the engines, reference **DL 107847**. The technical staff performed the VBV and VSV actuator tests, Engine Health Check to check the pneumatic valves and replaced the fuel filter to be sure there is no fuel contamination. All test were passed, no findings on the fuel filter was reported. The Engine Condition was checked by the CFM monitoring web tool, all parameters were in line with the expected figures, the oil consumption was within limit, no shift was visible. Next day on 22-Aug-2019 the captain was adviced to check the N1 on both engines during the flight to confirm the engine status. After the first flight the pilot reported the 0,1% difference and the problem was considered as solved. We are not sure whether the above mentioned snag is linked with the IFSD event, but we are reporting this to take into account all aspects.

After the second flight of the day the captain reported the In Flight Shut Down on the flight level 360, reference **DL 107849**. The engine relight attempts during the flight were unsuccessful.

The CFMI, LHT and Boeing were informed about the event.

Troubleshooting:

DL 107849

The **FIM 73-06 TASK 808 Engine Flameout, Engine Restart not OK** - Fault Isolation was used.

The technical staff performed the engine visual inspection, no damage was visible, no fluid leakage was found. The **Magnetic** Chip Detectors were checked, no findings. The Fuel Filter was

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Appendix No. 2

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SMARTWINGS a.s.
Technical Department

removed and checked. The bronze particles were found indicating the Main Fuel Pump internal damage. New Fuel Filter was installed. The Fault Isolation Manual and the AMM was followed.

DL 107850

The **Fuel Spare Valve test iaw. AMM 28-22-00-710-801-0** passed

The **EEC bite test iaw. FIM 73-00 Task 801** was performed, the MSG (short time, leg 1) - 73-31551 **FUEL FLOW WAS NOT DETECTED DURING START ATTEMPT** occured. Based on the FIM chart the technical staff continued with **FIM 73-31 TASK 803**. The HMU High Pressure Shut of Valve Control Power test passed.

DL 121051

Wet motoring of the engine was done. The Fuel Spare Valve valve was opened – correct – but the "Eng Valve Closed" light on panel P5 (the HPSOV indication in HMU) remained in bright (closed) and no fuel went to the fuel nozzles.

Based on these findings and the bronze particles on the fuel filter the technical staff replaced the HMU, Fuel Heat Exchanger, Servo Fuel Heater, Fuel Pump and the Fuel Nozzle Filter, reference **DLs 121052 - 121056**

DL 121057

Engine Test No 5 (Power Assurance Check) was done – passed.

The Work Done by Engineering:

The Engine Condition Monitoring Data were checked including the Oil consumption, no shift was detected, all data were normal.

The Flight Data parameters from DFDAU shows the short time fluctuations of the Fuel Flow (a few seconds) and then dropped to zero. All linked parameters like the EGT, N1, N2, the Oil Pressure followed the Fuel Flow trend. When the engine flame out occured the oil pressure was more than 13 psid. According to AMM subtask 71-00-00-210-037-F00 (Zone A) the engine removal was not necessary. The MCD check confirmed no bearings damage.

The A/C was released to service.

Removed Component Informations:

The engine is 16 MOs after the overhaul in LHT. All removed parts were maintained during this event and most of them were overhauled including the Fuel Pump. Smartwings policy regarding the planned workscope during the engine shop visit is very conservative and we are strictly following the CFM recommendations when we plan the engine repair workscope.

The list of the removed parts (now in quarantine till the CFM decision is made):

·	Filter – Fuel Nozzle	P/N FA00631C	S/N YP932603-K	OVH in LHT
·	Fuel Heat Exchanger	P/N 11-841193-4	S/N YY081326-V	OVH in LHT
·	Servo Fuel Heater	P/N 45731-1381	S/N YB002678-1	REP in LHT
·	Fuel Pump	P/N 828300-11	S/N YA010362-U	OVH in LHT

Company address
Smartwings a.s.
Technical Department
K letišti 1068/30
161 00 Praha 6
Czech Republic

Appendix No. 3

SMARTWINGS a.s.
Technical Department

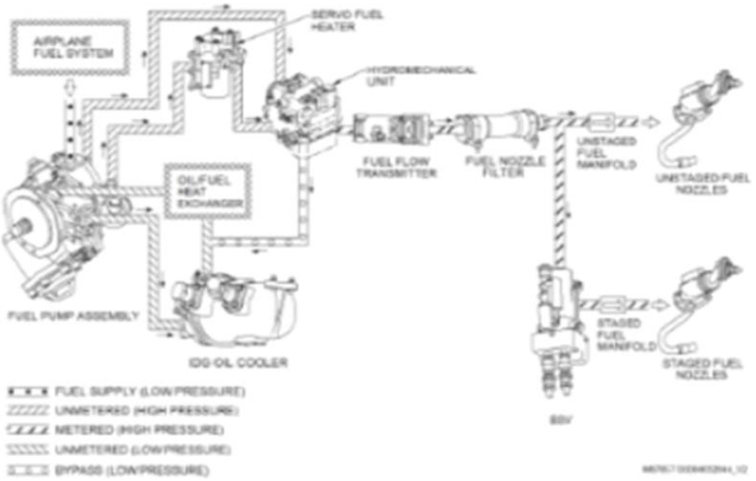
HMU	P/N 442653	S/N BECW0553	OVH in LHT

Part of the Fuel Pump is the Fuel Flow Differential Pressure Switch, which is not tracked part, but we are replacing this periodically. The last time the switch was replaced by new part during the last engine shop visit. This part will be investigated as well to explain no filter clogging indication.

We provided the data from the flight to CFMI and asked them to give us the approval to send the affected parts to LHT for special investigation because of our very good experience with them.

Conclusion:

The bronze particles indicate the main bearing damage in the Main Fuel Pump. We can expect that bronze particles contamined the HMU and blocked the fuel line to the fuel nozzles, but the special investigation might show other faults on the removed components and the root cause might be a mixture of defects. The MTBO (Mean Time Between Overhaul) of the components will be evaluated when the special investigation is finished.



Appendix No. 4

smartwings OPERATIONS MANUAL PART A	**OPERATING PROCEDURES** **FLIGHT PROCEDURES**	8.3-11 07 MAR 19 REV 0

b) Before entering RVSM airspace, the initial altimeter cross-check of primary altimeters should be recorded.

8) In normal operations, the altimetry system used to control the aircraft should be selected for input to the altitude reporting transponder transmitting information to ATC. Use ATC1 if using AFDS 1 or ATC2 if using AFDS 2.

9) If the pilot is advised in real time that the aircraft has been identified by a height – monitoring system as exhibiting a TVE greater than ± 300 ft and/or ASE greater than ±245 ft then the pilot should follow established regional procedures to protect the safe operation of the aircraft.

10) If the pilot is notified by ATC of an AAD which exceeds 300 ft then the pilot should take action to return to cleared flight level as quickly as practicable.
Note:
Assigned Altitude Deviation (AAD) – the difference between height transmitted by Mode C transponder and the cleared altitude / flight level.

11) The last 1000 ft to cleared flight level should be flown with vertical speed not exceeding 1000 ft.min-1.plan as before entering RVSM airspace.

12) After reaching the cleared flight level the altimeter cross check of primary and standby altimeters (standby altimeter for information only) should be recorded in company flight plan as before entering RVSM airspace.

8.3.2.5.4. Procedures in the event of system degradation

AMC2 SPA.RVSM.105 (d)(2)

The pilot should notify ATC of contingencies (equipment failures, weather) which affect the ability to maintain the cleared flight level, and co-ordinate a plan of action appropriate to the airspace concerned.

Examples of equipment failures which should be notified to ATC:

1) failure of all automatic altitude-control systems aboard the aircraft
2) loss of redundancy of altimetry systems
3) loss of thrust on an engine necessitating descent
4) any other equipment failure affecting the ability to maintain flight level

Where an aircraft's Mode C displayed level indicates a deviation from the cleared flight level of 300 ft or more, the controller shall inform the pilot as soon as practicable and the pilot shall return to his cleared flight level immediately.

Where informed by the pilot that the aircraft's equipment has degraded to below altimetry MASPS (Minimum Aircraft System Performance Specification) compliance levels while operating within RVSM airspace, the controller shall provide for either a minimum vertical separation of 2000 ft or an appropriate horizontal separation.

If an aircraft is unable to continue flight in accordance with its ATC clearance (e.g. loss of thrust on an engine, rapid depressurization, loss of an accuracy of navigation,and other), a revised clearance shall, whenever possible, be obtained prior to initiating any action.

This shall be accomplished using the radiotelephony distress or urgency signal as appropriate.
If prior clearance cannot be obtained, an ATC clearance shall be obtained at the earliest possible time and, in the meantime, the pilot shall:

1) broadcast position (including the ATS route designator or the track code, as appropriate), and intentions on frequency ATC or frequency 121,5 MHz at suitable intervals until ATC clearance is received.
2) make maximum use of aircraft lights to make the aircraft visible
3) maintain a watch for conflicting traffic

Appendix No. 5

5.9. OM-A PARA.: 8.1.2.5.

smartwings OPERATIONS MANUAL PART A	OPERATING PROCEDURES FLIGHT PREPARATION INSTRUCTIONS	8.1-8 07 MAR 19 REV 0

8.1.2.4. Responsible personnel for determining the adequancy of aerodromes

Determination of the adequacy of aerodrome is performed by the Deputy Director Flight Operations for Boeing fleet and by the Fleet Manager for Cessna fleet.

The final responsibility for the airport categorization is assigned to Director Flight Operations. During his absence, this responsibility may be assigned to his deputy in accordance with procedure specified in OM-A, para 1.3.10.11.

8.1.2.5. Guidance to determine suitable en route alternate airports

If applicable, the Commander shall determine suitable en route alternate airport preferably from the List of categorized airports published in Operations manual Aerodrome Categorization: PŘ-III-LU-018B (for B737 fleet) and PŘ-III-LU-018C (for C680 fleet).

The Commander may also determine suitable en route alternate airport other than an aerodrome/rundy published in Operations manual Aerodrome Categorization: PŘ-III-LU-018B (for B737 fleet) and PŘ-III-LU-018C (for C680 fleet) based on conditions below.

To determine suitable en route alternate airport the Non-ETOPS 60 minutes Threshold Distance shall be taken into account:

Tab. 8.1 – a: *Treshold Distance*

Aeroplane type	Non-ETOPS Threshold			
	Time	**Distance**	**Speed**	**Ref. weight**
B737-700	60 min	400 nm	.79/290	65 t
B737-800W	60 min	400 nm	.79/290	75 t
B737-900 ERW	60 min	400 nm	.79/290	80 t
B737-8	60 min	400 nm	.79/290	78 t
C680 / 680+	120 min	638 nm	.53/219	28000 lbs

Note:
for ETOPS flights refer to applicable parts of OM-A and OM-B.

In determination of suitable en route alternate airport and establishing aerodrome operating minima, the following factors shall be taken into account:

1) Type, performance and handling characteristics of the aeroplane.
2) Composition of the flight crew, their competence and experience.
3) Dimensions and characteristics of the runways which may be selected for use.
4) Adequacy and performance of the available visual and non-visual ground aids.
5) Equipment available on the aeroplane for the purpose of navigation and/or control of the flight path, as appropriate, during the take-off, the approach, the flare, the landing, roll-out and the missed approach.
6) Obstacles in the approach, the missed approach and the climb-out areas required for the execution of contingency procedures and necessary clearance.
7) Obstacle clearance altitude/height for the instrument approach procedures.
8) Specific terrain features.
9) Means to determine and report meteorological conditions.

Appendix No. 6

5.10. OM-A PARA.: 11.7.4.1.

smartwings OPERATIONS MANUAL PART A	HANDLING, NOTIFYING AND REPORTING ACCIDENTS, INCIDENTS AND OCCURRENCES AND USING THE CVR RECORDING PROCEDURES FOR PRESERVATION OF RECORDINGS	11.7-2 07 MAR 19 REV 0

The use of FDR is specified in AFM/FCOM (for B737 fleet) and in AFM/Citation Sovereign Pilot Training Materials (for C680 fleet).

11.7.3. FLIGHT DATA MONITORING (FDM) RECORDER

In the B737 fleet, selected flight parameters from the Digital Flight Data Acquisition Unit are stored on a replaceable medium after each flight for the purpose of Flight Data Monitoring as required by Commission Regulation (EU) 965/2012.

11.7.4. ACCIDENT, INCIDENT OR OTHER OCCURRENCE

11.7.4.1. The Role of Flight Crew

IOSA FLT 3.11.52

The Commander shall ensure that Flight Recorders are not switched off during the flight. If preservation of recordings of Flight Recorders is required by an investigating authority or in the event of:

1) An accident or
2) A serious incident or
3) An occurrence other than an accident or serious incident (that shall be reported to the competent authority)

The Commander shall ensure that

1) Flight Recorder recordings are not intentionally erased;
2) Flight Recorders are deactivated immediately once the flight is completed and
3) Precautionary measures to preserve the recordings of Flight Recorders are taken before leaving the flight crew compartment.

In order to preserve recordings, the Commander shall enter this request to the Defect Logbook and contact MCC to assure appropriate maintenance action. If no maintenance personnel are available and the aircraft is to be left unattended by the crew, the CVR and FDR circuit breakers shall be pulled out before aircraft shutdown if the situation permits (e.g. no emergency evacuation performed).

11.7.4.2. Preservation, Production and Protection

Flight Recorder removal from the aircraft can be required:

1) By an investigating authority; or
2) By the Company's Safety Manager;

with due regard to the seriousness of the occurrence and the circumstances, including the impact on operation.

After an aircraft accident has occurred, the Flight Recorder recordings must be submitted to the corresponding authority. The Company must make maximum effort to have its representative present at the Flight Recorders play back.

In some countries, there is an obligation to submit the Flight Recorder recordings even in the case of an incident. If a crew is requested to keep the Flight Recorder record, they shall proceed in accordance with the AFM/FCOM provisions and report the situation to the OCC Prague.

The removal of Flight Recorders from the aircraft is ensured by the TED.

The Flight Recorder records are kept in the Safety department and must not be used for other purposes than the investigation of aircraft accidents or incidents which are subject to mandatory

Appendix No. 7

smartwings OPERATIONS MANUAL PART B B737	NORMAL PROCEDURES	2 - 2 2.7.2019 REV 3

2(a) PRE-FLIGHT

GENERAL

These Standard Operations Procedures (SOP), add and develop the B737 NG relevant Normal Procedures issued in Flight Crew Operations Manual (FCOM) Vol.1 and together with the Flight Crew Training Manual (FCTM) form integral OM Part B of Travel Service Company (TVS).
This OM Part B is completed with the Quick Reference Handbook (QRH) describing crew actions in case of non-normal situations as well as containing performance calculation charts for normal and non-normal configuration respectively. All information contained must be observed during all ground and flight operations.
The flight methodology mentioned in this SOP serves the purpose of clarifying duties and functions of the crew in such a manner that satisfies the operational requirements of the Travel Service.

USE OF NORMAL CHECKLIST

Normal Checklists are used as verification, that certain essential or critical steps of the preceding procedures have been accomplished. The pilot, who is designated to respond to the checklist challenge, shall visually confirm that the challenged action has been properly accomplished. He should then respond appropriately to the challenge, confirming the action or describing the configuration. Any action, which has not been performed or completed when challenged, must be then completed before the next checklist challenge is read. The pilot reading checklist is responsible for verification of his checklist items. In addition, he shall crosscheck the all responses to ensure that the appropriate actions have been completed.

All checklists are read in accordance with QRH.
When the appropriate checklist has been completed, the pilot reading the checklist should announce:

"..................... CHECKLIST COMPLETED".

Company issued Normal checklists, which are identical to those issued by Boeing, equips all TVS planes. These checklists indicate who is reading and who responding each particular checklist item.
Ref. Appendix 1 AOM B

STANDARD CALLOUTS

Standard callouts are used to improve crosscheck, coordination and mutual crew member awareness and are typically used to:
Give commands, delegate a task
Acknowledge a command or confirm receipt of an information
Challenge and respond to checklist items
Call a change of an indication
Identify a specific event
Identify exceedences

Procedures described in the OM contain the Standard callouts. Standard callouts are required.

Appendix 8A

Engine Failure or Shutdown

Condition: One of these occurs:
- An engine failure
- An ENG FAIL alert shows
- An engine flameout
- Another checklist directs an engine shutdown.

1 Choose one:

◆**Airframe vibrations with abnormal engine indications** exist:

► ► **Go to the ENGINE FIRE or Engine Severe Damage or Separation checklist on page 8.2**

■ ■ ■ ■

◆An engine has **separated**:

► ► **Go to the ENGINE FIRE or Engine Severe Damage or Separation checklist on page 8.2**

■ ■ ■ ■

◆Airframe vibrations with abnormal engine indications do **not** exist **and** an engine has **not** separated:

► ► **Go to step 2**

2 Do an engine shutdown only when flight conditions allow.

3 Autothrottle (if engaged). . . . . .Disengage

▼ Continued on next page ▼

Appendix 8B

▼**Engine Failure or Shutdown continued**▼

YA371, YA372, YC385, YC394, YD005, YF123 - YH641, YJ908, YJ977, YK665, YK955, YL939

10 Transponder mode selector . . . . TA ONLY

This prevents climb commands which can exceed single engine performance capability.

11 ISOLATION VALVE switch. . . . . Verify AUTO

This ensures bleed air is available to both wings if wing anti-ice is needed.

12 A restart may be attempted if there is N1 rotation and no abnormal airframe vibration.

13 Choose one:

◆A restart will be **attempted**:

►►**Go to the Engine In-Flight Start checklist on page 7.27**

■ ■ ■ ■

◆A restart will **not** be attempted:

►►**Go to step 14**

14 Plan to land at the nearest suitable airport.

Note: Do not use FMC performance predictions.

►►**Go to the One Engine Inoperative Landing checklist on page 7.34**

■ ■ ■ ■

Appendix 9A

Engine In-Flight Start

Condition: An engine start is needed and all of the following are true:
- There was **no** engine fire
- There is N1 rotation
- There is **no** abnormal airframe vibration.

Note: Oil quantity indication as low as zero is normal if windmilling N2 RPM is below approximately 8%.

1 Do this checklist **only** after completion of any of the following checklists:

Engine Failure or Shutdown

Engine Limit or Surge or Stall

Loss of Thrust on Both Engines

Volcanic Ash

YA371 - YH641, YJ474 - YR506

2 Check the In-Flight Start Envelope. X-BLD or XB indication may not match the envelope. Starts are not assured outside of the In-flight Start Envelope.

YJ472

3 Check the In-Flight Start Envelope. X-BLD START indication may not match the envelope. Starts are not assured outside of the In-flight Start Envelope.

Note: If the N2 is less than 8%, ENGINE START switch must be in CONT to display the EGT.

▼ Continued on next page ▼

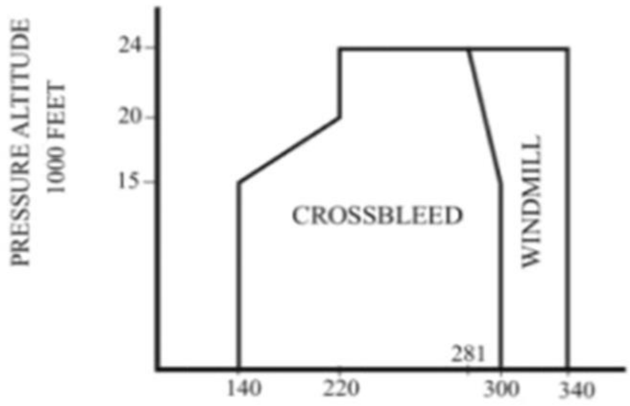
Appendix 9B

▼Engine In-Flight Start continued▼

Note: For engines shut down one hour or more, or if EGT is less than 30°C, attempt a restart:

- At an altitude at or below 20,000 feet
- With airspeed at or above 220 knots
- Using a crossbleed start.

IN-FLIGHT START ENVELOPE



4 Thrust lever
(affected engine) . . . . . . Confirm . . . . Close

5 Engine start lever
(affected engine) . . . . . . Confirm . . . . . . CUTOFF

6 Engines can accelerate to idle very slowly, especially at high altitudes or in heavy precipitation. If N2 is steadily increasing and EGT stays within limits, do not interrupt the start.

▼ Continued on next page ▼

Appendix 9C

▼**Engine In-Flight Start continued**▼

7 Choose one:

◆**Windmill** start:

ENGINE START switch
(affected engine) . . . . .FLT

►►**Go to step 8**

◆**Crossbleed** start:

PACK switch (affected side) . . . . OFF

DUCT PRESSURE . . . . . . Minimum 30 PSI

Advance the thrust lever to increase duct pressure if needed.

ENGINE START switch
(affected engine) . . . . .GRD

►►**Go to step 8**

8 **When** N2 is at or above 11%:

Engine start lever
(affected engine) . . . . .IDLE detent

Monitor EGT to ensure it does not rise rapidly or exceed the start limit during the start attempt.

▼ **Continued on next page** ▼

Appendix 9D

▼Engine In-Flight Start continued▼

9 Choose one:

◆EGT **increases** within 30 seconds **and** a normal start occurs:

►►**Go to step 11**

◆EGT does **not** increase within 30 seconds **or** another abort start condition as listed in the Normal Procedures occurs:

Engine start lever
(affected engine) . . .Confirm . . . CUTOFF

YA371 - YD025, YH051 - YK405, YK955 - YR506
ENGINE START switch
(affected engine) . . . . OFF

YF123, YK665
ENGINE START switch
(affected engine) . . . . AUTO

Note: If the engine has been shutdown for more than one hour, multiple start attempts can be needed.

►►**Go to step 10**

10 Plan to land at the nearest suitable airport.

Note: Do not use FMC performance predictions.

►►**Go to the One Engine Inoperative Landing checklist on page 7.34**

■ ■ ■ ■

11 Engine GEN switch (affected side) . . . . .ON

12 PACK switch (affected side) . . . . AUTO

▼ Continued on next page ▼

Appendix No. 10

Non–Normal Checklist Operation

Non–normal checklists start with steps to correct the situation. If needed, information for planning the rest of the flight is included. When special items are needed to configure the airplane for landing, the items are included in the Deferred Items section of the checklist. Flight patterns for some engine-out situations are located in the Maneuvers chapter and show the sequence of configuration changes.

While every attempt is made to supply needed non–normal checklists, it is not possible to develop checklists for all conceivable situations. In some smoke, fire or fumes situations, the flight crew may need to move between the Smoke, Fire or Fumes checklist and the Smoke or Fumes Removal checklist. In some multiple failure situations, the flight crew may need to combine the elements of more than one checklist. In all situations, the captain must assess the situation and use good judgment to determine the safest course of action.

It should be noted that, in determining the safest course of action, troubleshooting, i.e., taking steps beyond published non-normal checklist steps, may cause further loss of system function or system failure. Troubleshooting should only be considered when completion of the published non-normal checklist results in an unacceptable situation.

There are some situations where the flight crew must land at the nearest suitable airport. These situations include, but are not limited to, conditions where:

- the non–normal checklist includes the item "Plan to land at the nearest suitable airport."
- fire or smoke continues
- only one AC power source remains (engine or APU generator)
- only one hydraulic system remains (the standby system is considered a hydraulic system)
- any other situation determined by the flight crew to have a significant adverse effect on safety if the flight is continued.

It must be stressed that for smoke that continues or a fire that cannot be positively confirmed to be completely extinguished, the earliest possible descent, landing, and evacuation must be done.

If a smoke, fire or fumes situation becomes uncontrollable, the flight crew should consider an immediate landing. Immediate landing implies immediate diversion to a runway. However, in a severe situation, the flight crew should consider an overweight landing, a tailwind landing, an off-airport landing, or a ditching.

Checklists directing an engine shutdown must be evaluated by the captain to determine whether an actual shutdown or operation at reduced thrust is the safest course of action. Consideration must be given to the probable effects of running the engine at reduced thrust.

Appendix No. 11

Non-Normal Situation Guidelines

When a non-normal situation occurs, the following guidelines apply:

- NON-NORMAL RECOGNITION: The crewmember recognizing the malfunction calls it out clearly and precisely
- MAINTAIN AIRPLANE CONTROL: It is mandatory that the Pilot Flying (PF) fly the airplane while the Pilot Monitoring (PM) accomplishes the NNC. Maximum use of the autoflight system is recommended to reduce crew workload
- ANALYZE THE SITUATION: NNCs should be accomplished only after the malfunctioning system has been positively identified. Review all caution and warning lights to positively identify the malfunctioning system(s)

Note: Pilots should don oxygen masks and establish crew communications anytime oxygen deprivation or air contamination is suspected, even though an associated warning has not occurred.

- TAKE THE PROPER ACTION: Although some in-flight non-normal situations require immediate corrective action, difficulties can be compounded by the rate the PF issues commands and the speed of execution by the PM. Commands must be clear and concise, allowing time for acknowledgment of each command prior to issuing further commands. The PF must exercise positive control by allowing time for acknowledgment and execution. The other crewmembers must be certain their reports to the PF are clear and concise, neither exaggerating nor understating the nature of the non-normal situation. This eliminates confusion and ensures efficient, effective, and expeditious handling of the non-normal situation
- EVALUATE THE NEED TO LAND: If the NNC directs the crew to plan to land at the nearest suitable airport, or if the situation is so identified in the QRH section CI.2, (Checklist Instructions, Non-Normal Checklists), diversion to the nearest airport where a safe landing can be accomplished is required. If the NNC or the Checklist Instructions do not direct landing at the nearest suitable airport, the pilot must determine if continued flight to destination may compromise safety.

Troubleshooting

Troubleshooting can be defined as:

- taking steps beyond a published NNC in an effort to improve or correct a non-normal condition
- initiating an annunciated checklist without a light, alert, or other indication to improve or correct a perceived non-normal condition
- initiating diagnostic actions.

Appendix No. 12

Fly a normal glide path and attempt to land in the normal touchdown zone. After landing, use available deceleration measures to bring the airplane to a complete stop on the runway. The captain must determine if an immediate evacuation should be accomplished or if the airplane can be safely taxied off the runway.

Landing at the Nearest Suitable Airport

Appendix A.2.11

"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 divert. 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 Instructions 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 should land at the nearest suitable airport at which a safe landing can be made.

A suitable airport is defined by the operating authority for the operator based on guidance material but, in general, must have adequate facilities and meet certain minimum weather and field conditions. If required to divert to the nearest suitable airport, the guidance material 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 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.

Appendix No. 13

smartwings OPERATIONS MANUAL PART B B737	PERFORMANCE	4 - 10 7.3.2019 REV 0

4.2(b) drift-down data

Refer to FCOM Vol. 1 Chapter PI.
Refer to QRH Chapter PI.

4.2(c) effect of de-icing/anti-icing fluids

Refer to OM part A Chapter 8

4.2(d) flight with landing gear down

Refer to FCOM Vol. 1 Chapter PI.
Refer to QRH Chapter PI.

4.2(e) for aircraft with 3 or more engines, one-engine-inoperative ferry flights

N/A

4.2(f) flights conducted under the provisions of the configuration deviation list (CDL)

Refer to TVS MEL/CDL.
Refer to outputs of performance software Boeing OPT.
TVS uses performance software based on Boeing and NAVBLUE database.

4.3 SPEED AND DISTANCE – 1 ENG INOP

Generally

The speed and distance for B737 are determined according to the Flight Planning and Performance Manuals.

Maximum Diversion Distance 1 ENG INOP: **400 NM**
One ENG out Diversion Speed: **290 KIAS**

Determinations of both above arise from Area of Operation Engine Inop tables. There is taking into account the possibility to maintain 10000 ft in case of depressurization.
The distance and diversion speed are determined only for flight planning purposes. 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.
For determination of the IAS and available FL, the crew should take into account the terrain relief (obstacle clearance), ISA deviation, present weight, icing conditions, aircraft conditions, etc. For determination of Net Level Off Weight and speed, refer to chapter CP 1.2 or 1.3.

Appendix No. 14

TRAVEL SERVICE CRM ASSESMENT HANDBOOK	CRM ASSESSMENT HANBOOK BEHAVIOURAL MARKER SYSTEMS	3-2 15 JAN 18 REV 0

3.1. THE NOTECHS BEHAVIOURAL MARKER SCHEME

	Elements	Example Behaviours (positive)
Co-operation	Team building and maintaining	Establishes atmosphere for open communication and participation
	Considering others	Takes condition of other crew members into account
	Supporting others	Helps other crew members in demanding situations
	Conflict solving	Concentrates on what is right rather than who is right
Leadership and managerial skills	Use of authority and assertiveness	Takes initiative to ensure involvement and task completion
	Maintaining standards	Intervenes if task completion deviates from standards
	Planning and co-ordinating	Clearly states intentions and goals
	Workload management	Allocates enough time to complete tasks
Situation awareness	System awareness	Monitors and reports changes in system's states
	Environmental awareness	Collects information about the environment
	Anticipation	Identifies possible future problems
Decision making	Problem definition/diagnosis	Reviews causal factors with other crew members
	Option generations	States alternative courses of action. Asks other crew members for options
	Risk assessment/option choice	Considers and shares risks of alternative courses of action

Very poor	Poor	Acceptable	Good	Very good
1	2	3	4	5
Observed behaviour directly endangers flight safety	Observed behaviour in other conditions could endanger flight safety	Observed behaviour does not endanger flight safety but needs improvement	Observed behaviour enhances flight safety	Observed behaviour optimally enhances flight safety and could serve as an example for other pilots