

**NATIONAL BUREAU  
OF AIR ACCIDENTS INVESTIGATION**

**ACCIDENT**

**FINAL REPORT**

**RUNWAY EXCURSION  
DURING LANDING AT “ODESA” AERODROME**

<b>AIRCRAFT OPERATOR:</b>	Turkish Airlines
<b>AIRCRAFT TYPE:</b>	B-737-800
<b>REGISTRATION NO.:</b>	TC-JGZ
<b>PLACE OF OCCURRENCE:</b>	“Odesa” Aerodrome
<b>STATE OF OCCURRENCE:</b>	UKRAINE
<b>DATE OF OCCURRENCE:</b>	21.11.2019

*The Report is issued for the sole purpose of prevention of future air accidents*

## **FINAL REPORT**

### **on Investigation into Accident (Runway Excursion) with Aircraft B-737-800, Registration No. TC-JGZ, Which Took Place on November 21, 2019, During Landing at "Odesa" Aerodrome**

#### **Brief Description of Accident**

<b>Aircraft Operator:</b>	<b>Turkish Airlines</b>
<b>Aircraft Type and Registration Number:</b>	<b>B-737-800 TC-JGZ</b>
<b>Number and Type of Engines:</b>	2, CFM International CFM56-7B26, S/N 892726 CFM56-7B26E, S/N 892770
<b>Date and Time of Accident:</b>	21.11.2019, 18:55 UTC

On November 21, 2019, at 18:55 UTC (20:55 Kyiv time), at night, in the visual weather conditions, during landing onto Runway 16 of «Odesa» Aerodrome, in the conditions of strong omnidirectional crosswinds, the aircraft B-737-800 TC-JGZ of Turkish Airlines, which performed flight TK 467 en-route Istanbul (Turkey) - Odesa, suffered a runway excursion and suffered substantial structural elements damage.

**Note:**

- Hereinafter, the Universal Time Coordinated (UTC) is indicated. The difference between the local time and UTC on the date of the accident was +2 hours; the use of UTC in the Report is caused by the fact that the UTC is indicated in the records of air traffic services (ATS), meteorological, aeronautical information and synchronized data of the Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR);

- Nature of the aircraft damage is described in paragraph 1.3 of Section 1 Factual Information.

The occurrence report was received by the NBAAI at 21:21 UTC on November 21, 2019, from the Central Dispatch Service (CDS) of the State Aviation Administration (SAA) of Ukraine (CDS of the SAA reforwarded to the NBAAI the occurrence report, which was drawn up by the Municipal Enterprise (ME) «Odesa International Airport». The NBAAI did not receive directly the occurrence report from the ME «Odesa International Airport». The NBAAI did not receive any occurrence report from the ME «Odesa International Airport» and ATS units of the Odesa Regional Subdivision of the UkSATSE. In accordance with paragraph 12.12 of the

Regulations of Emergency Rescue and Fire Fighting Support of Flights of Ukraine, approved by the Order of the Ministry of Infrastructure of 07.05.2013 No.286, registered with the Ministry of Justice on May 24, 2013, under No.809/23341, the ATS authority shall forward the initial notification of an air occurrence to the NBAAI.

Pursuant to Section 4.1 of Annex 13 to the Convention on International Civil Aviation, on November 22, 2019, the NBAAI sent the Notification of the accident to the Turkish Transport Safety Investigation Center (UEIM), International Civil Aviation Organization (ICAO) and, on December 2, 2019, - to the US National Transportation Safety Board (NTSB) (State of Design and State of Manufacture.) In turn, the UEIM of Turkey has appointed an Accredited Representative with a group of advisers, which it reported to the NBAAI on November 22, 2019.

In accordance with the Standards and Recommended Practice of the International Civil Aviation Organization, this Report is issued for the sole purpose of prevention of future air accidents.

This Report and technical investigation materials should not be used by administrative, official, procuratorial, judicial authorities or insurers to establish guilt or liability (in accordance with the requirements of Article 119 of the Air Code of Ukraine.)

Due to the absence of the national rules in Ukraine for the technical investigation of air accidents and incidents, the investigation is conducted in accordance with the provisions of Annex 13 to the Convention on International Civil Aviation.

### **List of Abbreviations Used in This Report**

ACC	- Area Control Center;
ACN	- Aircraft Classification Number;
ADF	- Automatic Direction Finder;
AMM	- Aircraft Maintenance Manual;
AOC	- Air Operator Certificate;
ARP	- Aerodrome Reference Point;
ATC	- Air Traffic Control;
ATIS	- Automatic Terminal Information Service;
ATS	- Air Traffic Service;
Cfr	- Friction Coefficient;

CTA	- Control Area;
CVR	- Cockpit Voice Recorder;
DME	- Distance Measuring Equipment;
DMI	- Deferred Maintenance Item;
FCTM	- Flight Crew Training Manual;
FDR	- Flight Data Recorder;
FIR	- Flight Information Region;
FPRL	- Fire Protection Required Level;
HST	- High Speed Taxiway;
ICAO	- International Civil Aviation Organization;
ILS	- Instrument Landing System;
METAR	- Regular aeronautical meteorological report on the aerodrome weather in WMO code form (with or without TREND forecast);
MH	- Magnetic Heading;
MH <sub>land</sub>	- Magnetic Heading for Landing;
NLG	- Nose Landing Gear;
NOTAM	- Notice to Airmen – a report sent by telecommunication, containing the information on the commissioning, condition or modification of any aeronautical equipment, maintenance and regulations, or information on hazards, timely warning, which are important for the personnel involved in the flight operation;
PCN	- Pavement Classification Number;
PFI	- Pre-flight inspection;
P/N	- Part Number;
RSU	- Regional Subdivision of UkSATSE;
RW	- Runway;

S/N	- Serial Number;
SNDB	- Standalone Non-Directional Beacon;
SPECI	-Special aeronautical meteorological report on the aerodrome weather in WMO code form (with or without TREND forecast);
TAF	- Aerodrome weather forecast in WMO code form;
TMA	- Terminal Maneuvering Area;
TWR	- Tower;
VOR	- Very High Frequency Omnidirectional Range;
QFE	- code designation of the pressure at the level of the aerodrome or runway threshold: Question Field Elevation – Field Elevation Pressure (Q-code);
QNH	- code designation of the pressure reduced to the mean sea level: Question Normal Height – Sea Level Pressure (Q-code) by standard atmosphere;
UTC	- Universal Time Coordinated.

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## **1. Factual Information**

### **1.1 Flight History**

On November 21, 2019, a regular THY2UT flight en-route Istanbul – Odesa at B-737-800 aircraft, nationality and registration mark TC-JGZ of the Turkish Airlines, was performed by the aircraft crew consisting of the Pilot-in-Command (PIC), co-pilot and four flight attendants of the aircraft.

In fact, the departure from Istanbul Airport was performed at 17:33. The actual aircraft landing took place at 18:55.

According to the flight plan, the alternate aerodromes were Istanbul and Chişinău.

There were 136 passengers and 2793 kg of luggage on board the aircraft.

The PIC was a Pilot Flying, and the co-pilot was a Pilot Monitoring of the aircraft.

The pre-flight briefing of the crew, according to its explanations, was carried out before departure from the Istanbul Airport, after which the PIC took the decision to perform the flight.

The climb and level flight were performed in the normal mode.

The landing approach was performed to the Runway16 with ILS system at a significant crosswind component of variable directions. At the final stage of approaching with ILS to Runway 16, the ATC controller of the aerodrome control tower (ATC Tower) gave the aircraft crew a clearance for landing. The aircraft crew confirmed the controller's clearance and continued the landing approach. Subsequently, from a height of about 50 meters, the aircraft performed a go-around due to the aircraft non-stabilization before landing. Following the go-around, the aircraft headed to the holding area to wait for favorable values of wind force and direction.

At 18:45, the PIC took the decision to carry out a repeated landing approach, reported of that to the ATC controller, who provided ATS in the Odesa Terminal Maneuvering Area (TMA.)

At 18:51, the crew re-contacted the Tower controller and received the clearance to land.

At 18:55, after touchdown, during the runway run, the aircraft began to deviate to the left and veered off of the runway to the left onto the cleared and graded area. After 550 m run on the soil, the aircraft returned to the runway with its right main landing gear and nose part (while moving on the soil, the nose landing gear collapsed) and came to rest at the distance of 1612 m from the runway entrance threshold. The crew performed an emergency evacuation of passengers from the aircraft.

As a result of the accident, the aircraft suffered a significant damage to the nose part of the fuselage and left engine. None of the passengers or crew members was injured.

## **1.2 Injuries**

There were 136 passengers and 6 crew members on board.

Injuries	Crew	Pax	Total Onboard Aircraft	Other Persons
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	-
None	6	136	142	-
Total	6	136	142	0

None of the passengers or crew members sought medical help at the «Odesa» Aerodrome medical point, and there is no information on complaints about the health of those on board the aircraft.

## **1.3 Aircraft Damage**

As a result of the runway excursion, the aircraft suffered the following damage:

- Destruction of the retraction and extension link attachment assembly of the nose landing gear (NLG), collapse of the NLG backward vs. the flight direction, with destruction of the fuselage skinning and electronic equipment access door (Photos 1, 2, 3);



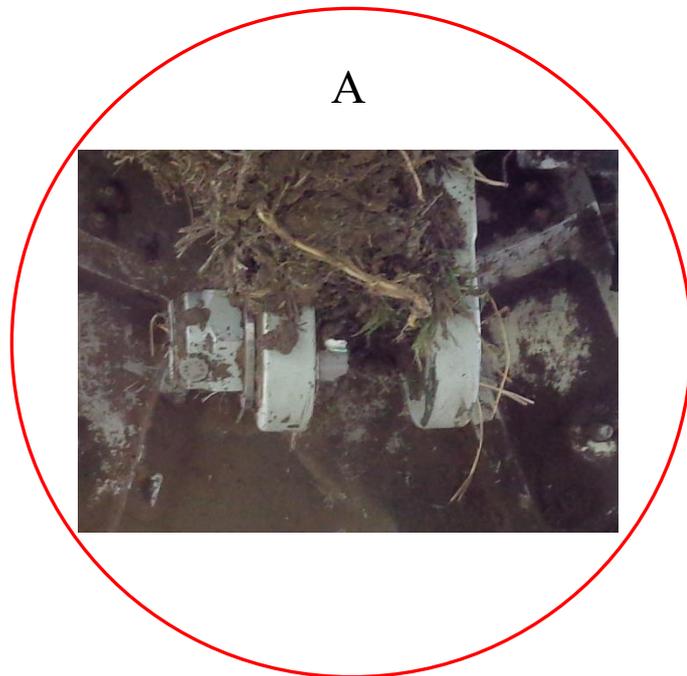
Photo 1. NLG position after the accident



Photo 2. Destruction of the lower fuselage skinning due to NLG collapse



Photo 3. NLG retraction and extension link attachment assembly



On the soil, at the distance of approximately 125-130 m from the NLG exit point of the left side boundary of the runway, the investigation team found the remains of a bolt (Photo 4, 5) of the NLG retraction and extension link attachment assembly (AMM 32-21-00 p.410 [18] PIN) (Fig.1).

**Note:** Upon exit of the aircraft nose landing gear to the soil with the destroyed left wheel turned to the right, the NLG retraction and extension link attachment assembly suffered off-design loads due to deepening into the soil during 120-130 meter movement, which led to NLG collapse backward vs. the flight direction, and aircraft nose section sinking down onto the ground.

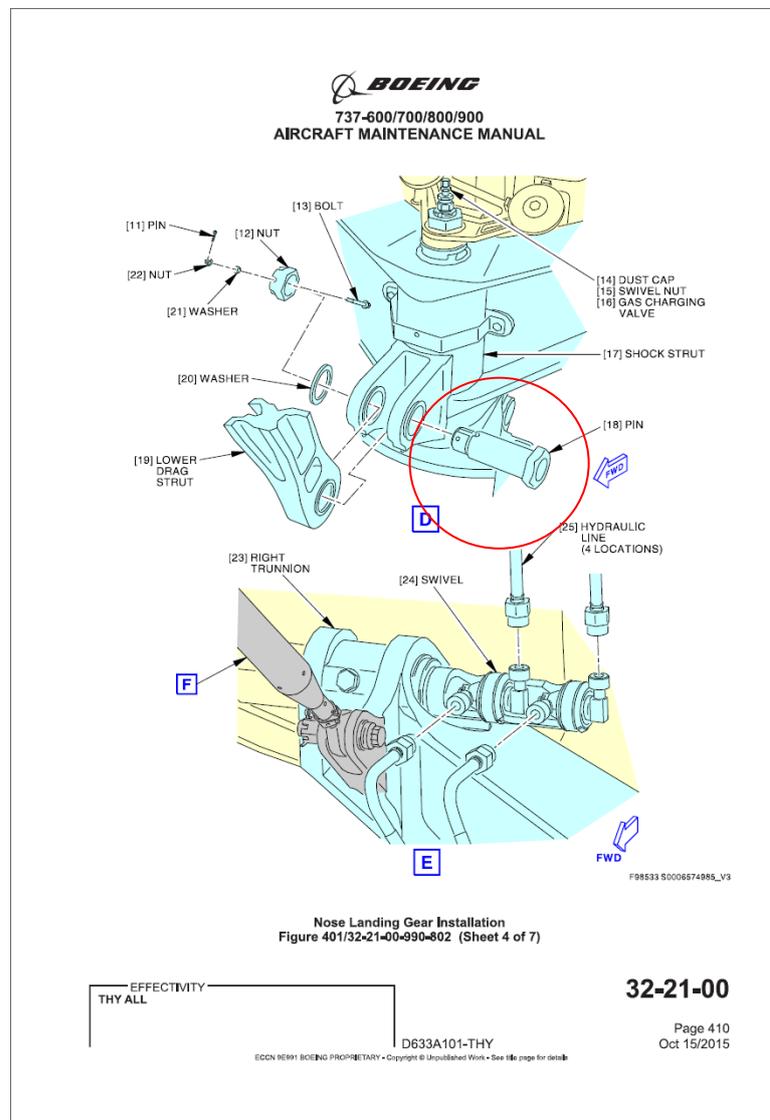


Fig.1



Photo 4



Photo 5

- destruction of the left wheel and left and right tires of the NLG (Photos 6, 7);

*Note: The condition of the tires indicates that the NLG wheels were turning and skidding when the aircraft was moving, and the NLG was turned to the right of the aircraft movement direction.*

- deformation (corrugations) of the lower left and right skin of the fuselage nose section, deformation of bulkheads and stringers STA 178 to STA 259.5 (Photos 8, 9);



Photo 6. NLG left wheel destruction



Photo 7. NLG tire destruction



Photo 8. Lower nose part of the aircraft  
(left one)



Photo 9. Lower nose part of the aircraft  
(right one)

- destruction and damage of the NLG door extension-retraction mechanism and damage of NLG doors (Photos 10, 11, 12);

*Note: destruction of the NLG door extension-retraction mechanism took place after NLG collapse and aircraft nose section sinking down onto the ground.*



Photo 10. NLG right door attachment and  
retraction-and-extension assembly



Photo 11. NLG left door retraction-and-  
extension mechanism assembly



Photo 12. Damage to NLG doors

- multiple damage of the acoustic panel and blades of the engine fan No.1 (Photo 13.)

*Note: Damage to the acoustic panel and fan blades of the engine No.1 occurred due to foreign objects penetration into the running engine as a result of NLG deepening into the soil and movement after the aircraft exit from the runway and left engine contact with the ground.*



Photo 13. Damage to the acoustic panel and all blades of engine No.1

- damage to the inlet guide vanes, left side and bottom of the composite skin of the hoods of engine No.1 caused by collision with side lights and friction with the soil after the aircraft exit from the runway (Photos 14, 15);



Photo 14



Photo 15

Traces of collision with side lights

- damage to blades 6, 14, 20, 22, 24 of the fan of engine No.2 (Photo 16);



Photo 16

- damage to the composite skin in the lower part of engine No.2 caused by friction with the runway surface (Photo 17).



Photo 17

#### **1.4 Other Damage**

According to the Act drawn up by the commission of ME "Odesa International Airport" on November 22, 2019, as a result of the runway excursion of the aircraft, 4 side lights of the runway and 1 taxi light of KO-A type (TW-3) were damaged. The nature of the damage is as follows: the side lights of Runways Nos. 17, 24, 26 – the body is deformed, and the optical system is broken, the side light of Runway No. 27 – the breakaway coupling is broken, light of TW-3 No. 1 – the body is deformed, the optical system is broken. The Aerodrome Service of Electrical Lighting Support of Flights replaced the mentioned lights with new ones.

#### **1.5 Personnel Data**

<b>Position</b>	<b>PIC</b>
Sex	Male
Date of birth	16.09.1977
Educational and professional background	Istanbul University, French Language and Literature (1996 - 2002), graduation date - 12.07.2002. Flight school: Sindel Aviation

	(2007 - 2008), graduation date - 20.09.2008.
Total flight hours	6094 hours
Flight hours as PIC	5608 hours
Flight hours on this type of the aircraft - Boeing 737-800	5608 hours
Flight hours for 20.11.2019	03 hours 10 minutes
Flight hours for the day of the accident 21.11.2019	01 hours 23 minutes
Flight hours for 7 days	17 hours 59 minutes
Flight hours for the last 30 days (month)	96 hours 52 minutes
Meteorological minimum	Cat III B valid until 31.01.2020
Number and validity of the Pilot's License	TR-A-08509 13.04.2015 --- 10.01.2022
Medical certificate	Class 1 23.09.2019 Valid until 24.09.2020
Date of qualification test (SIMULATOR)	Passed on 06.07.2019
Flight inspection date	30.01.2019
Date of passing the Advanced Training Course on Aircraft Type	19-20.12.2018 and 24-26.12.2018
Certificate of Level 6 English proficiency	Lifetime

<b>Position</b>	<b>Co-Pilot</b>
Sex	Male
Date of birth	12.06.1988
Educational and professional background	Higher school: Kugel High School, Holon (2003 - 2006), graduation date - 14.06.2006.  Flight schools: - Bristol Ground School (2015 - 2016), graduation date - 20.12.2016; - Stapleford Flight Center (2017), graduation date – 30.06.2017.
Total flight hours	252 hours 50 minutes
Flight hours on this type of the	175 hours 15 minutes

aircraft - Boeing 737-800	
Flight hours for 20.11.2019	03 hours 10 minutes
Flight hours for the day of the accident 21.11.2019	01 hours 23 minutes
Flight hours for 7 days	31 years 59 minutes
Flight hours for the last 30 days (month)	90 hours 17 minutes
Number and validity of the Pilot's License	GBR. FCL.CP.521235J.A Valid until 30.11.2019
Medical certificate	Class 1 12.03.2019 Valid until 12.03.2020
Date of qualification test (SIMULATOR)	Passed on 19.11.2019
Flight inspection date	Valid until 11.11.2020
Date of passing the Advanced Training Course on Aircraft Type	08-12.09.2019
Certificate of Level 6 English proficiency	Lifetime

The break between the previous and last flights of the crew was:

PIC – 18 hours 31 minutes, co-pilot – 18 hours 22 minutes.

Before the flight, the crew rested at home.

Earlier, PIC performed the flight to «Odesa» Aerodrome about a year ago.

Co-pilot – for the first time.

Pre-flight inspection of the aircraft in the volume of PFI was conducted before departure from the Istanbul Airport (Flight Log page No. 056738.)

#### **b) Aerodrome Service Personnel Data**

*Aerodrome operation engineer, who worked in the evening shift (from 18:00 November 21, 2019 to 06:00 November 22, 2019, UTC.)*

Year of birth – 1979.

Education – complete higher education:

1) National Aviation University, 2002, specialty – Automobile Roads and Aerodromes, qualification – Master.

2) National Aviation University, Institute of Postgraduate Studies, 2006, qualification – Transport Engineer.

Work experience in the aviation industry – 16 years.

Work experience at the position held – 15 years.

Advanced training in "Aerodrome Flight Support", National Aviation University, 2011.

### **c) ATS Personnel Data**

Data on the personnel on duty of the control shifts of the Odesa ACC and Odesa Tower:

#### ***Air Traffic Management Center***

Acting ACC Chief of Duty Shift, Senior Air Traffic Controller, born in 1982, has a higher special education (higher education in Air Traffic Services, DLAU, Kirovograd, 2004), has a valid certificate of a traffic service controller and medical certificate, ICAO 4<sup>th</sup> level of English language proficiency, admission to work as a ACC flight operations director-duty shift supervisor, to work at the flight data processing workplace (FDP workplace), a special mark of the traffic service controller-instructor and admissions of the Odesa ACC: ACC/OVN, ACC/OVC, ACC/OVL, ACC/OVU, ACC/OVL+OVU.

The Air Traffic Control Controller of Area Control Center (at the time of the accident, he acted as an Executive Controller and Planning Controller at the ACC/OVT sector), born in 1985, has a complete higher special education (DLAU, Kirovograd, 2007), has a valid traffic service controller certificate and medical certificate, ICAO 5<sup>th</sup> level of English language proficiency, admission of the Odesa ACC - ACC/OVT.

The Air Traffic Control Controller of Area Control Center (at the time of the accident, he acted as an Executive Controller and Planning Controller at the ACC/OVT sector), born in 1989, has a complete higher special education (DLAU, Kirovograd, 2007), has a valid traffic service controller certificate and medical certificate, ICAO 5<sup>th</sup> level of English language proficiency, admission of the Odesa ACC - ACC/OVC, ACC/OVS, ACC/OVC+ OVS.

#### ***Odesa Tower***

Acting Tower Flight Operations Director, Tower Senior Air Traffic Controller, born in 1965, complete higher education in Aeronautics, DLAU graduation in 2011, has a valid traffic controller certificate and medical certificate, ICAO 4<sup>th</sup> level of English language proficiency. His ratings: TWR/AIR, TWR/GMC, TWR/air/RAD (UKOO), and he has been admitted to work at the following workplaces: TWR/OO1, TWR/OO2, TWR/OO3, TWR/OO1+TWR/OO2.

Tower Air Traffic Controller (at the time of the accident, he was acting as a TWR/OO1 (Tower) Controller), born in 1971, has a higher education in the specialty

of “Air Traffic Services” - DLAU graduation in 1998, has a valid traffic service controller certificate and medical certificate, ICAO 4<sup>th</sup> level of English language proficiency. His ratings: TWR/AIR, TWR/GMC, TWR/AIR/RAD (UKOO), and he has been admitted to work at the following workplaces: TWR/OO1, TWR/OO2, TWR/OO1+TWR/OO2.

Tower Air Traffic Controller (at the time of the accident, he was acting as a TWR/OO2 (Ground) Controller), born in 1987, higher education in "Air Traffic Services" specialty, Kirovograd DLAU graduation in 2009, has a valid certificate of a traffic service controller and medical certificate. His ratings: TWR/AIR, TWR/GMC, TWR/AIR/RAD (UKOO), and he has been admitted to work at the following workplaces: TWR/OO1, TWR/OO2, TWR/OO3, TWR/OO1+TWR/OO2.

Tower Air Traffic Controller (at the time of the accident, he was acting as a TWR/OO3 (Aux Tower) Controller), born in 1969, complete higher education in the specialty of "Air Traffic Services", Kirovograd DLAU graduation in 1997, has a valid certificate of traffic service controller and medical certificate. His ratings: TWR/AIR, TWR/GMC, TWR/AIR/RAD (UKOO), and he has been admitted to work at the following workplaces: TWR/OO1, TWR/OO2, TWR/OO3, TWR/OO1+TWR/OO2.

## **1.6 Aircraft Data**



Photo 18

Manufacturer: Boeing (Seattle, USA).

Type: **Boeing 737-800.**

MSN: **35739.**

Manufactured (date of the first flight): **16.06.2008.**

Nationality: **Turkey.**

State and Registration Marks: **TC-JGZ.**

Registration Certificate: **No. 2011**, issued on **03.07.2008**.

Owner: **CRANE S.A.S (France)**.

Operator - "**TURKISH AIRLINES INC**".

Airworthiness Certificate **No.2011** - issued on **30.04.2014**.

Airworthiness Review Certificate **No.2011** valid until **13.04.2020**.

Total Time Since New: **38464** hours; **22633** cycles.

Operating Time Since Last Base Maintenance in the volume of **C Check**, 23.01.2018: **5718** hours; **4038** cycles.

Operating Time Since Last Base Maintenance in the volume of **A Check**, 11/12/2019: **175** hours; **110** cycles.

Operating Time Since Last Base Maintenance in the volume of **DY Check**, 20.11.2019: 6 hours 13 minutes; 5 cycles.

Take-off weight of the aircraft - 66,306 kg.

Maximum takeoff weight of the aircraft – **79,015** kg.

Landing weight of the aircraft - 63519 kg (approximately.)

Maximum landing weight - **66,360** kg.

Fuel on board before the flight - 8883 kg.

### **Engine No.1**

Type - CFM56-7B26, S/N - 892726.

Date of Manufacture: 25.01.2006

Total Time Since New: 47503 hours; 23567 cycles.

Date of Repair: 29.06.2016

Operating Time Since Repair: 8494 hours; 6083 cycles.

### **Engine No.2**

Type - CFM56-7B26E, S / N - 862770.

Date of Manufacture: 18.01.2016

Total Time Since New: 10684 hours; 6553 cycles.

Date of Repair: N/A.

Operating Time Since Repair: N/A.

### **Nose Landing Gear (Photo 19):**

BOEING COMPANY

Table 1

Manufacturer	GOODRICH
P/N	162A1100-13
S/N	MAL01789Y2592
Date of Shop Visit	23.06.2017 (TURKISH TECHNIC)
Date of Installation on	25.07.2017

Aircraft	
Operating Time Since Shop Visit	6912 hours 5011 cycles



Photo 19

### 1.6.1 Maintenance

One deferred maintenance item (DMI) was detected at the aircraft, relates to the kitchen equipment No. 2 (flight technical log page No.056736), and is not relevant to this accident.

Before the flight, the aircraft underwent the line maintenance check in the volume of 48H DY Check 20.11.2019 (flight log page No. 056731).

### Aircraft Load:

Calculation of the aircraft takeoff, landing weights and Center-of-Gravity position:

<b>Total take-off weight:</b>	<b>66,306 kg</b>
Dry operating weight	43,328 kg
Full load	14,095 kg
Fuel weight on takeoff	8,883 kg

Fuel used	≈ 4,100 kg
	<b>63,519 kg</b>

**Aircraft Center-of-Gravity Position:**

At take-off	27.3 % CAX
At landing	26.5 % CAX

The investigation established that the take-off, landing weights and Center-of-Gravity positions are in the operating range and do not exceed the limits.

**1.7. Meteorological Information**

***Actual Weather at «Odesa» Aerodrome***

According to a special report, MET REPORT (SPECIAL) for «Odesa» Aerodrome, compiled at 18.32 UTC: direction of the surface wind 090 degrees; wind speed 10 meters per second, direction changed from 040 to 110 degrees, maximum wind speed 17 meters per second, minimum 6 m/s; wind at the runway threshold – direction 090 degrees, wind speed 11 m/s, the direction varied from 040 to 110 degrees; maximum 17 m/s, minimum 7 m/s, visibility 10 km; light snow; overcast 510 meters high; air temperature + 02°C; dew point temperature - 01°C; pressure QNH 1030 hectopascals; QFE 1024 hectopascals, the trend over the next two hours: no significant changes.

SPECIAL for 18:58 UTC: surface wind: 080 degrees; speed 11 m/s; direction varied 050 to 120 degrees; maximum wind speed 15 m/s, minimum 6 m/s, direction changed 040 to 110 degrees, maximum wind speed 17 m/s, minimum 5 m/s, visibility 10 km; overcast 570 meters high; air temperature + 02°C; dew point temperature – 01°C; pressure QNH 1030 hectopascals, QFE 1024 hectopascals; trend over the next two hours: no significant changes.

***Weather Forecast for «Odesa» Aerodrome (TAF)***

The forecast for the «Odesa» Aerodrome, made at 17.06 UTC on the 21<sup>st</sup>, valid from 18.00 UTC November 21<sup>st</sup> till 18.00 UTC November 22<sup>nd</sup>:

*Surface wind direction 080 degrees; speed 10 m/s with gusts up to 18 m/s; visibility 6000 meters; scattered clouds 120 meters high; broken clouds 210 meters high; scattered cumulonimbus clouds 450 meters high; forecasted maximum air temperature +5°C for 12.00 UTC November 22<sup>nd</sup>; forecasted minimum air*

temperature  $-1^{\circ}\text{C}$  for 04.00 UTC November 22<sup>nd</sup>; occasionally, within the period of 18.00 UTC November 21<sup>st</sup> till 06.00 UTC November 22<sup>nd</sup>: visibility 2100 meters, showers of slight rain.

From 18:34:23 to 19:01:00, ATIS "SIERRA" information was broadcasted in English on the frequency of 133.1 MHz:

*Odesa ATIS Information «SIERRA» 18:32. ILS Approach, NDB Approach, runway in-use one six. Runway surface condition report at one eight zero five: dry clear, measured coefficient decimal six, decimal six, decimal six. Estimated surface friction-good. Transition level- one one zero. Turns on the runway should be made at the end of the runway on abeam taxiway three. Caution: construction works in progress seven zero meters to the north of the threshold runway one six. Caution: large flocks of birds in the vicinity of aerodrome and on final. Present weather: wind touchdown zone - zero nine zero degrees one zero meters per second, gust maximum one seven, minimum zero six meters per second. Varying between zero four zero and one one zero degrees, stopend - zero nine zero degrees one one meters per second, gusts maximum one seven, minimum zero seven meters per second. Varying between zero four zero and one one zero degrees. Visibility one zero kilometers. Light snow, cloud overcast five one zero meters. Temperature – zero two, dew point – minus zero one. QNH one zero three zero Hecto Pascals, QFE one zero two four Hecto Pascals. Trend: NOSIG. Acknowledge information «SIERRA».*

According to the results of the control measurement of the weather upon "Alarm" signal at 18:57, the meteorological authority of «Odesa» Aerodrome issued the SPECIAL report at 18:58, which contained the following information:

*surface wind: 080 degrees; speed 11 m/s; deviation from the average wind direction 040 to 110 degrees; maximum speed 15 m/s, minimum speed 06 m/s, at the end of the runway: surface wind 080 degrees, speed 10 m/s, deviation from the average wind direction 040 to 110 degrees, maximum speed 17 m/s, minimum 05 m/s, visibility 10 km; overcast 570 meters high; air temperature  $+02^{\circ}\text{C}$ ; dew point temperature  $-01^{\circ}\text{C}$ ; QNH pressure 1030 hectopascals; pressure QFE 1024 hectopascals, landing forecast: no changes.*

ATIS "November" listened by the crew before the approach briefing, was broadcasted in English and contained the following information:

*Odesa ATIS Information «November» 17:34. ILS Approach, NDB Approach, runway in-use one six. Runway surface condition report at one six one zero: dry clear, measured coefficient decimal six, decimal six, decimal six. Estimated surface friction-good. Transition level- one one zero. Turns on the runway should be made at the end of the runway on abeam taxiway three. Caution: construction works in progress seven*

*zero meters to the north of the threshold runway one six. Caution: large flocks of birds in the vicinity of aerodrome and on final. Present weather: wind touchdown zone - zero seven zero degrees nine meters per second, gusts maximum one three, minimum zero five meters per second. Varying between zero three zero and zero nine zero degrees, stop-end - zero eight zero degrees one two meters per second, gusts maximum one six, minimum zero six meters per second. Varying between zero four zero and one zero zero degrees. Visibility one zero kilometers. Light snow showers, cloud scattered cumulo-nimbus five one zero meters, broken 600 metres. Temperature – zero two, dew point – minus zero one. QNH one zero three zero Hecto Pascals, QFE one zero two four Hecto Pascals. Trend: NOSIG. Acknowledge information «November».*

In accordance with paragraph 2.4.1.3 of the Instruction on Meteorological Servicing of Aircraft Flights at «Odesa» Aerodrome, the averaging period for wind observations shall be 2 minutes for local regular and special reports and for the data displayed on the weather displays installed at ATS workplaces, as well as on request. The weather display shows the current data on the average wind speed and direction values, significant changes in the wind direction with an averaging period of 2 minutes, maximum speed values observed for the last 2 minutes for each instrument with indication of the location of observations and units of measurement.

In accordance with paragraph 2.6 of the Operating Instruction of the Odesa Area Control Center of 03.08.2018 No.4.3.2-08-522, the procedure for use of the meteorological information by the control staff of the OVT ATS sector, which is displayed on the weather display of the automated meteorological observation station AMAS AVIA, is given in “Operator's Manual “WEATHER DISPLAY. AMAS Avia-1 Complex.”

According to paragraph 2.6.4 of the Odesa Tower Operating Instruction, the information about the weather at the aerodrome, which is subject to be transmitted on board the aircraft, shall be delivered by the aerodrome meteorological authority to the ATC controller workplace by means of the weather display of the automated meteorological aerodrome station "AMAS Avia-1." At the request of the aircraft crews, the ATC controller shall read out the current meteorological data from the weather display. The procedure for using the meteorological information of "AMAS Avia-1", which is displayed to ATC controllers, is established by the Instruction on Use by Odesa RSU Control Personnel of Meteorological Information Displayed on Weather Display of Automated Meteorological Observation Station of AMAS AVIA (Modernized) Type. At the same time, at the request of the NBAAI, UkSATSE did not provide the said Instruction for consideration by the Investigation Team, explaining that it had expired, and noting that, at the time of the accident, the ATS personnel of

Odesa RSU was guided by the document “AMAS-Avia-1 WEATHER DISPLAY COMPLEX. Operator's Guide” of 2018. According to clause 3.2.11 of this document, the wind speed and direction data is displayed in rectangular windows with the image of wind limbs, one of which corresponds to the operating heading and is highlighted in red. According to clause 3.2.11.2, the direction of the surface wind is displayed rounded to 10 degrees (rounded up from 5 degrees) with account of the magnetic inclination. In the pie chart, the radius highlighted in green shows the average wind direction for 2 minutes, and the yellow arc of the sector – the wind direction change from the wind direction minimum value to the maximum one for 2 minutes. In particular, the wind parameters values for 2 minutes are displayed in the lower part of these windows:

**“2 min”:**

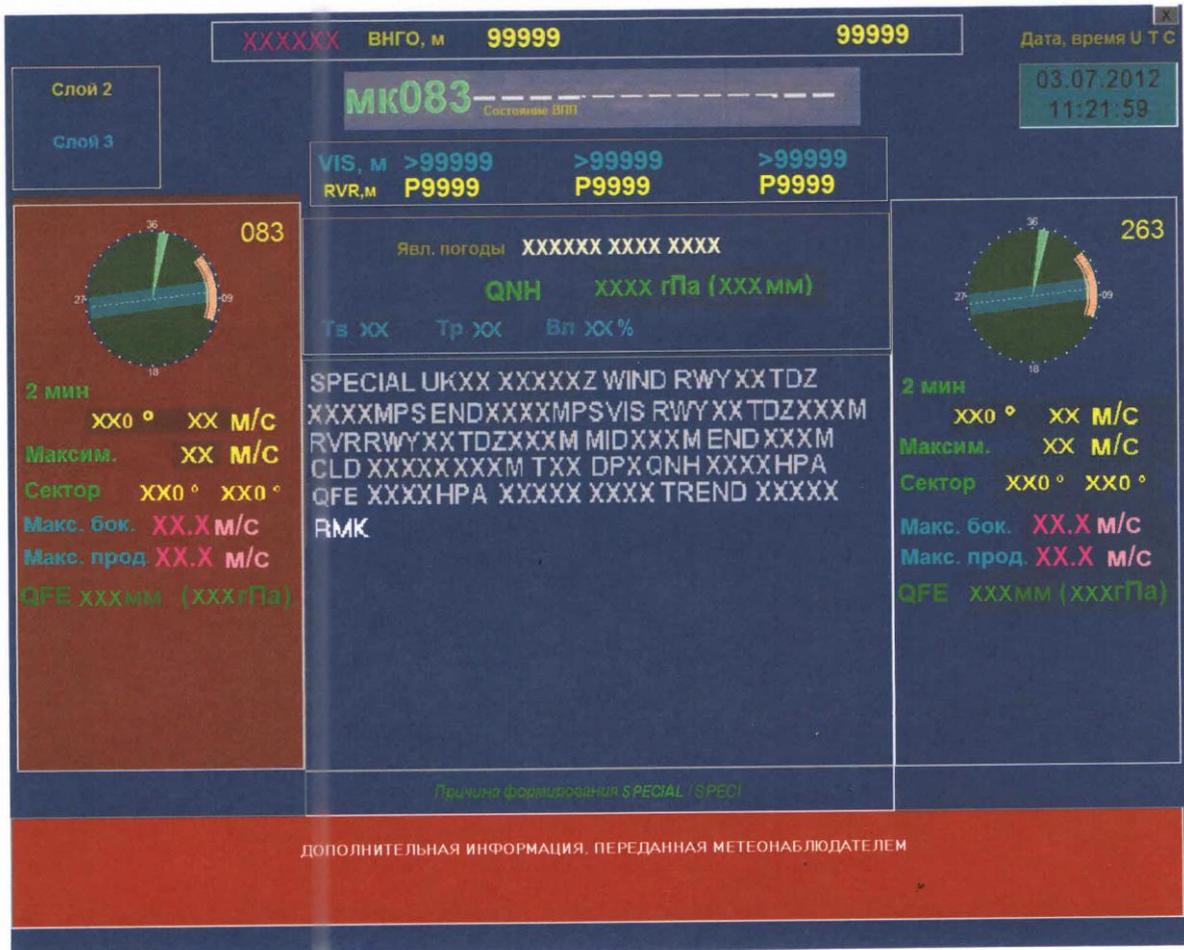
- average direction, with the accuracy of 10°,
- average wind speed, with the accuracy of 1 m/s;

**“Max”:**

- maximum value of the wind speed, with the accuracy of 1 m/s;

**“Sector”:**

- extreme values of the wind direction in the frame are displayed only when the wind direction changes by 60° or more, with the accuracy of 10°.



*Weather display information window*

Every 3 seconds, the values of the cross-wind and along-wind components are calculated from the current instantaneous data of the speed and direction. Then, for the current 2 minutes, from 40 values for each component, the maximum values of the cross-wind and along-wind components are selected and displayed on the weather display. However, ATS controllers do not inform the crews of the aircraft the values of the cross-wind and along-wind components of the wind.

### 1.8 Navigation Aids

The aerodrome is equipped with the SP-80M landing system and SNDB radio navigation aids with both directions for landing.

UkSATSE Odesa RSU's navigation aids include:

- VOR/DME radio beacon, at «Odesa» Aerodrome;
- ADF-75 direction finders, at «Odesa» Aerodrome.

Landing system SP-80M factory No. 10767 of 1991 manufacture. Landing system SP-80M factory No. 90149 of 1990 manufacture. In 2006, the manufacturing plant (Federal State Unitary Enterprise "Kuznetsk Radio Instruments Plant", Russian

Federation) carried out the Performance Restoration Shop Visit of the product SP-80M factory No. 10767, and the technical service life was extended by 5 years (until 30.12.2011.) The information on SP-80M factory No. 90149 shop visit is missing.

The technical service life of the localizer beacon before a major repair is 80,000 hours for 10 years (according to the Localizer Beacon Log TZh 1.400.106 Fo.) According to the final accounting of the localizer beacon operation, which was provided by ME "Odesa International Airport", its operating hours as of the end of November 2019 were 87,690 (since new), as of the end of June 2020 – 88774 hours, i.e. its technical service life is expired.

No shop visits of the SP-80M system were performed after 2006. At the same time, as of November 21, 2020, the service life of the radio beacon landing system was extended by the State Aviation Administration till 2021, and the SP-80M system factory No. 10767 and factory No. 90149 is recognized by the State Aviation Administration as one that meets the certification requirements, operational documentation and is suitable for its intended use.

### **1.9 Communication**

Aviation telecommunication means are as follows:

According to the charts of organization of aviation air and aviation ground telecommunication, the aviation air and ground telecommunication was provided by:

- MULTIFONO M600 voice communication switching system, factory No. 119.588;
- SU4200 radio transmitters (Rohde & Schwarz) from the transmission center;
- SU4200 radio receivers (Rohde & Schwarz) from the reception center;
- retransmission radio stations;
- reserve LRS radio stations (Rohde & Schwarz) and Polet-1 radio stations.

### **1.10 Aerodrome Data**

«Odesa» Aerodrome is a certified civil aviation aerodrome entered into the State Register of Civil Aerodromes of Ukraine (Certificate of Aerodrome Registration No. AP 15-01, issued on 04.08.2003 by the State Department of Aviation Transport.) As of the time of the accident, the Aerodrome Certificate No. AP 15-01 was valid until February 1, 2020. The owner and operator of the aerodrome is the Municipal Enterprise "Odesa International Airport."

The Paved Runway has the dimensions of 2800x56m, type of pavement – mixed, PCN 35/R/B/X/T, equipped for precision landing approach by the ICAO I category of landing with MHLand 157°/337°.

The aerodrome is equipped with the Lighting System of High-Intensity Lights (LS HIL-I).

Certificate of Suitability of Aerodrome Equipment, namely, Lighting System of High-Intensity Lights with MHland 159°/339°, for Operation No. AO 15-01-139, issued by the State Aviation Administration of Ukraine on 31.05.2017, valid until 31.05.2020. The aerodrome operates: approach lights and horizon bar lights, entrance and limiting lights of the paved runway, glide lights – since 2006, runway side lights – since 2003, TW lights – since 1987.

**Note:** Instruction on Operation of Lighting Equipment of «Odesa» Aerodrome from Tower Controllers' Workplaces Using Remote Control Equipment ID-6.2, which was approved by the General Director of ME "Odesa International Airport" on 12.05.2011, contains tables for determining the brightness degree of light subsystems of the lighting system, the contents of which does not meet the requirements of Table D.11.2 of Annex 11 to paragraph 8.2.6 SVCAU. In addition, this Instruction contains a reference to the document NAESTOP GA-86, which was null and void at the time of the accident.

Aerodrome Class – B (4C).

The aerodrome is suitable for operation day and night, all year round.

According to the "Odesa" Aerodrome Inspection Act for Compliance with Certification Requirements of 18.11.2019, drawn up by the Commission of ME "Odesa International Airport", the following types of aircraft are operated at the aerodrome:

A-321, A-320, A-319, B-733, B-734, B-735, B-736, B-737, B-738, B-739, ATR-72, CRJ-900, Dash 8 Q400, An-24, An-72, An-74, An-26, An-30, An-32, An-140, E-145, E-170/175, E-190/195, Yak-42 and others.

Aerodrome reference point coordinates: 462536N; 0304035E.

Aerodrome elevation is 52 m.

Magnetic inclination is 6°E.

Runway thresholds elevation:

- with MHland 157° - 52.3 m;

- with MHland 337° - 50.4 m.

According to paragraph 9 of the Appendix to the Certificate, the aerodrome is suitable for receiving the aircraft of Index 5, 6 (Code 4C) with restrictions and lighter aircraft with no restrictions.

**Note:**

- according to ICAO Doc 9981: Procedures for Air Navigation Services (PANS) - Aerodromes, second edition, 2016, the aircraft type B-737-800 has the Code 4C;

- operation of the aircraft B-737-800 at the «Odesa» Aerodrome is carried out with restrictions on the maximum takeoff, landing weights and traffic intensity.

According to paragraph 12 of the Appendix to the Aerodrome Certificate, the operation of the aircraft with a larger code letter is performed with the prior consent of the aerodrome operator in accordance with the Procedure for Operation of Aerodrome with Larger Code Letter. The taxiing of the aircraft of Index 6 (Code 4D) shall be performed only via TW-1.

### **Runway Status Information**

The aerodrome operation engineer took over at 18:00 on November 21, 2019, and monitored the condition of the aerodrome pavement surface before landing of the B-737-800 TC-JGZ aircraft.

Information about the runway condition was recorded in the Odessa Airfield Flight Status Journal and passed to the ADV dispatcher and the weather forecaster of the Odessa Air Station, which later included it in the METAR / SPECI weather report.

The runway status data was recorded in the Airfield Status Log of «Odesa» Aerodrome and transmitted to the Tower controller and shift weather forecaster of the Aeronautical Meteorological Station Civil "Odesa", who shall further include such into METAR/SPECI weather reports.

The following entry was made in the Log about the airfield status at 18:10: *“Paved Runway with MH 157° is dry, clean. Cfr. = 0.60/0.60/0.60. Code R16/090060. Estimated surface friction is "good". Aprons, HSTs, TWs are dry, in working condition. Closed are Ramps 6,7, section of T4 route abeam Ramps 6,7 until 17:00 UTC 22.11.2019. Soil strength - 8 kg/cm<sup>2</sup>.”*

After the accident, at 19:05, a commission consisting of a shift engineer of the aerodrome service, a representative of the airport safety department, the chief of the field operations control center shift and representative of the airline conducted an unscheduled inspection of the Paved Runway of «Odesa» Aerodrome, the respective Act was drawn up. As a result of the inspection, it was established that, as of 19:05, the Paved Runway status was as follows: *“Paved Runway16 is dry, Cfr = 0.60/0.60/0.60, fragments of the aircraft structure and fragments of the runway lighting equipment (light) were found”*. After the accident, the following entry was made in the Airfield Status Log for 20:05: *“Paved Runway with MH 157° is dry. Cfr = 0.60/0.60/0.60. Code R16/090060. Estimated braking action is "Good". Closed are Ramps 6,7, section of T4 route abeam Ramps 6,7 till 17:00 UTC 22.11.2019. There were found fragments of the aircraft structure and fragments of the runway lighting equipment (light) and*

*aircraft that lost the ability to move at the edge of the Paved Runway on the east side in the area of the 4<sup>th</sup> Paved Runway light counting from TW-3.*

**Note:** According to the statements of the aerodrome service engineer, he erroneously indicated the time of the unscheduled inspection of Paved Runway in the Airfield Status Log as 20:05. In fact, the Paved Runway inspection was conducted at 19:05.

Due to the absence of precipitation on the day of the accident, during the inspection of the Paved Runway immediately before aircraft B-737-800 TC-JGZ landing, and during the unscheduled inspection of the Paved Runway, the friction measurement was not performed on the Paved Runway surface using the ATT-2 towed aerodrome brake trolley. The friction coefficient  $Cfr. = 0.60/0.60/0.60$  was entered in the Airfield Status Log on the basis of Cfr. control measurements in 2018 on a dry Paved Runway. For consideration of the Investigation Team, the Acts of Cfr. Control Measurements on Dry Runway of «Odesa» Aerodrome of 20.08.2018 to 21.08.2018 No. 17-24 were provided. The measurements were performed by three ATT-2 towed aerodrome brake trolleys operated by the airport aerodrome service. According to the measurement results, the arithmetic mean values of Cfr. were calculated, which are in the range from 0.60 to 0.68.

**Note:** According to paragraph 3.7 of Annex 1 to paragraph 5.2 of the Methodical Instructions on Development of Technology of Flight Support Services Interaction During Works on Aerodrome Movement Area, approved by the Order of the Ministry of Transport of Ukraine of 06.08.2004 No. 463, Cfr. measurement on a dry pavement of the Paved Runway shall not be carried out at a stable weather with technical devices.

Paragraph GM1 ADR.OPS.C.010(b)(3) (c) of Acceptable Means of Compliance (AMC) and Guidance Material (GM), which clarifies the provisions of the Aviation Regulations of Ukraine "Technical Requirements and Administrative Procedures for Certification of Aerodromes", establishes that the braking action characteristics for existing surfaces should be periodically evaluated in order to avoid reducing the braking action characteristics below the minimum level. The frequency of the measurements depends on a number of factors, in particular, on an aircraft type and frequency of runway use, climatic conditions, pavement type and maintenance requirements. At the same time, the documents, which regulate the procedures for Odessa aerodrome pavements operation and maintenance, contain no requirements to periodicity of assessment of braking action characteristics.

The aerodrome service of ME "IA "Odesa" operates three devices for measuring the surface friction coefficient on the Paved Runway, namely, three ATT-2 towed

aerodrome brake trolleys, which do not provide documentation of measurement results: ATT-2 ones with factory numbers 1468, 628 and 321.

All the devices were calibrated as of the day of the occurrence and at the time of Cfr. control measurements on the dry runway pavement in 2018.

During the aerodrome runway inspection conducted by the Investigation Team on November 23, 2019, the runway pavement status met the requirements of subparagraph "a" paragraph 6.9.1 Certification Requirements for Civil Aerodromes of Ukraine, approved by the Order of the State Aviation Administration of Ukraine dated March 17, 2006, No. 201.

### **1.11. Flight Recorders**

B-737-800 reg. TC-JGZ aircraft is equipped with:

- protected SOLID STATE UNIVERSAL FLIGHT DATA RECORDER manufactured by Honeywell, P/N 980-4700-042, S/N 5778;
- protected SOLID STATE MEMORY COCKPIT VOICE RECORDER manufactured by Honeywell, SER 120-07096 DMF 092004 MFR 97896.

The FDR corresponds to the 3C description in the document Boeing-D226A101-2 Rev H DIGITAL FLIGHT DATA ACQUISITION UNIT and DATA FRAME INTERFACE CONTROL, according to which, more than 300 flight parameters are recorded with saving the information about the last 27 hours of operation in the storage.

The voice recorder has 4 recording channels (3 from the crew headsets and 1 common microphone) and records the information received from the channels from the crew headsets – for the last 30 minutes of operation and from the common microphone channel – for the last two hours.

### **FDR Information**

For the purpose of reading-out the information from the flight recorders, their storages were removed from the aircraft with participation of representatives of the NBAAI and Turkish Airlines, and the corresponding act was drawn up. The storages were in “not damaged” condition. Subsequently, the storage was handed over to the Adviser to the Accredited Representative from the Transport Safety Investigation Center of Turkey to carry out the data read-out procedure due to the absence of the data read-out equipment in Ukraine (at the time of the accident.) The information obtained in this way was delivered to the NBAAI in the form of a set of computer files in the "raw data" format.

The initial analysis of the FDR data showed that the record contains the data on the TC-JGZ aircraft flights for the period of November 19, 2019, to November 21, 2019, including the data on the accident occurred during landing at the «Odesa» Aerodrome on November 21, 2019.



Photos 20, 21. Flight Data Recorder

### *CVR Data*

CVR information analysis showed that data on the accident under investigation was saved from all four recording channels throughout the flight from the takeoff till landing – via the common microphone channel, and during the last 30 minutes of the flight – via the crew headset channels. The requirements for the crew's actions to ensure preservation of the CVR data have been met.



Photo 22 Cockpit Voice Recorder

## **1.12. Wreckage and Impact Data**

The location of fragments of the aircraft landing gear tires and structural elements is shown below in the sketch of the accident place.

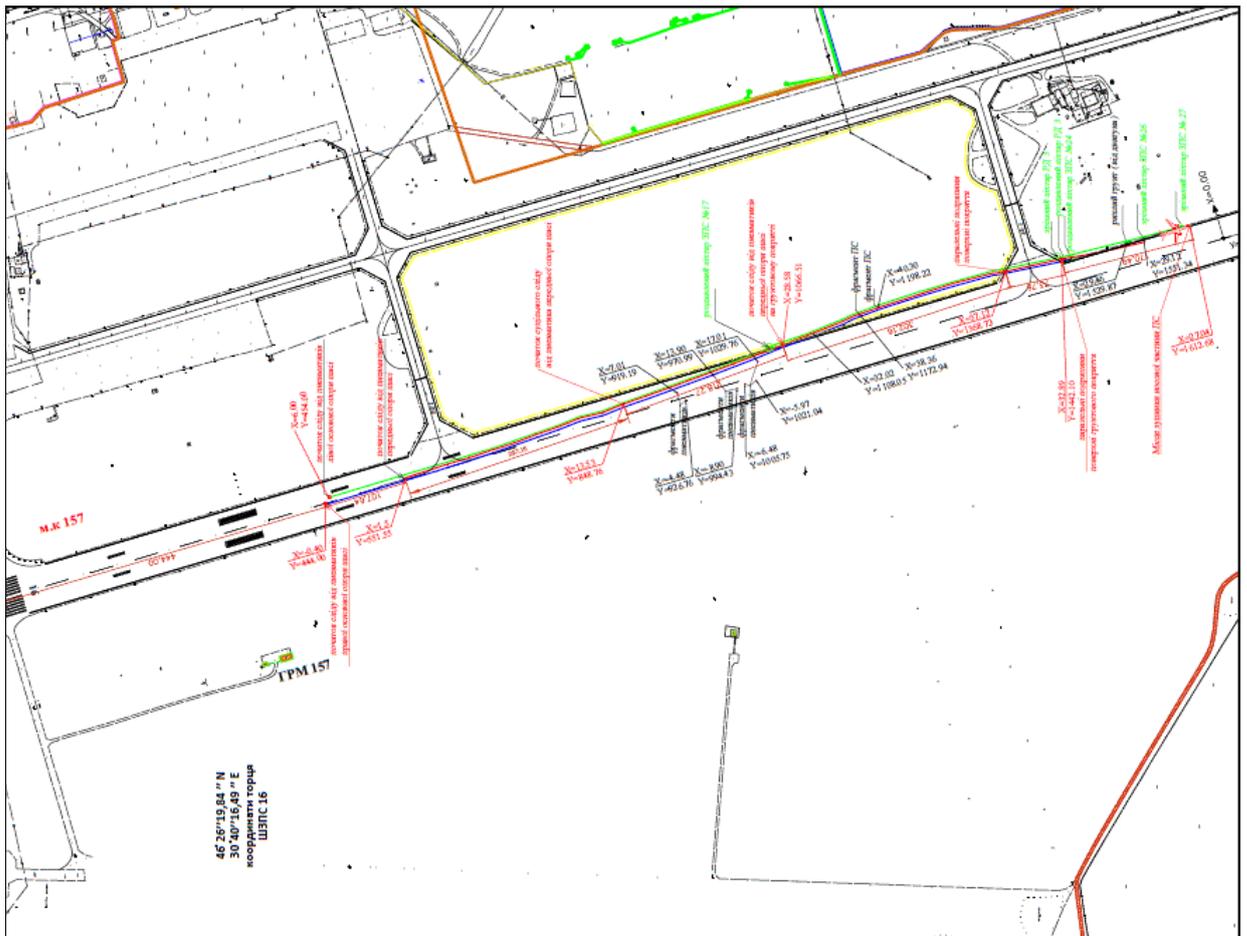


Fig. 2. Sketch of the accident with B-737-800 TC-JGZ operated by the Turkish Airlines, which took place on November 21, 2019, at 18:55 at the «Odesa» Aerodrome

### 1.13. Medical Information and Brief Results of Post-Mortem Examinations

According to the entry in the Log of Registration of Control Test Results for Alcohol Consumption at the medical post at the air terminal building of the ME "Odesa International Airport", at 21:00, employees of the medical post conducted a control test for alcohol consumption by the flight crew members. According to the results of the test, no signs of alcohol consumption by the crew were found.

### 1.14 Fire

There was no fire during the accident.

## **1.15 Survival Factors**

### **Actions of Emergency Rescue and Fire Fighting Teams**

Search-and-rescue operations, including the operations on prevention of fire at the aircraft and site of occurrence, were organized and conducted by the personnel of the emergency rescue team (ERT) of the Odessa aerodrome under the Action Plan for Aircraft Emergencies at Aerodrome of ME “Odessa International Airport” (hereinafter referred to as the Emergency Plan.)

Certificate of Conformity No. ODS-SPARZP-50-04 of the Emergency Rescue and Fire Fighting Flight Support of ME "Odesa International Airport" was issued by the State Aviation Administration of Ukraine on 06.08.2017 valid until 05.08.2020.

The Category of «Odesa» Aerodrome by the required fire protection level (hereinafter referred to as RFPL) is 7.

According to the Statement of the head of the emergency rescue and firefighting flight support service of ME "Odesa International Airport", on November 21, 2019, 11 employees (10 people - emergency rescue and 1 person - communication controller) took up duty as part of the guard.

**Note:** a duty shift manning of the rescue and firefighting unit of the Rescue Team meets the requirements of Table 4.1 of Annex 4 to the Regulations of Emergency Rescue and Fire Fighting Support of Flights.

There were 3 aerodrome fire trucks on duty: AA-12-110 MAN, AA-60 160 MAZ – 7310 and AA-40 KAMAZ 43106 with the necessary stock of fire extinguishers.

According to the Passport of the general-purpose foaming agent for extinguishing of fires - "ALPEN", which is applied in ME “Odesa International Airport”, the critical application rate of working solution of foaming agent during extinguishing by MEDEX foam –  $0.034 \text{ dm}^3/(\text{m}^2 \cdot \text{s})$ , and, therefore, the foam meets the characteristics of level B (in accordance with Annex 3 of the Regulations of Emergency Rescue and Fire Fighting Support of Flights.) The foaming agent was usable on the date of the accident.

**Note:** according to Table 3.2 of Annex 3 to the Regulations of Emergency Rescue and Fire Fighting Support of Flights, for FPRL 7 aerodrome category,

*when using a foam corresponding to level B characteristics, the minimum number of fire vehicles shall be 2 units.*

The aircraft landing was observed by an employee of the emergency rescue and firefighting service, who was on duty at the observation tower at the time, and reported the runway excursion to the chief of guard through the intercommunication system.

The "Alarm" aerodrome signal was announced by the ACC Tower controller under instruction of the flight operations director at 18:56:18. The "Alarm" signal was immediately duplicated by the field operations control center controller via all communication channels (loudspeaker, and radio station – channels 1, 3, 12), after which the field operations control center controller began to notify of the accident the command and control staff (by telephone.)

After the Rescue Team received the "Alarm" signal, 3 fire trucks and an emergency rescue unit of the emergency rescue and fire support service headed to the place of accident. Together with the emergency and rescue unit, the medical unit, special transport service unit, aerodrome service unit, aviation security service, etc. took part in carrying out the emergency rescue operations. The Rescue Team meeting was organized in the TW3 area.

The recording of voice communication through radio communication channels during the emergency rescue operations was not conducted by ground means of recording, which does not meet the requirements of the Regulations of Emergency Rescue and Fire Fighting Support of Flights.

*Note: according to paragraph 4.11 of the Regulations of Emergency Rescue and Fire Fighting Support of Flights, the voice communication via direct communication and radio exchange channels during emergency rescue operations are subject to automatic recording by means of live monitoring and recording.*

*According to par 12.3.9 of ICAO Doc 9137 "Airport Services Manual", Part 7 "Airport Emergency Planning", it is recommended to install recording equipment with time units in the operational centers and/or at the mobile command post to ensure recording of all the voice communication for the further analysis. In addition, it is advisable to record all the emergency communication, including the radio teletype one.*

Due to the absence of records of the voice communication via radio communication channels at the emergency rescue operations by the live

monitoring and recording means, the Investigation Team established the chronology of the emergency rescue operations (after announcing the "Alarm" signal to Rescue Team units due to the aircraft runway excursion), using records from CCTV cameras installed at the aerodrome, as well as from the statements of the personnel involved in the emergency rescue operations. CCTV footage allows viewing the accident site and aircraft from the left side.

As a result of the analysis of the mentioned information, the following sequence of events was established:

- 18:58:10 – opening of the rear left doors of the aircraft;
- 18:58:15 – emergency slide deployment from the rear left door of the aircraft;
- 18:58:28 – opening of the front left doors of the aircraft;
- 18:58:29 – arrival of the first fire truck to the accident place;
- 18:58:33 – emergency slide deployment from the front left door of the aircraft;
- 18:58:35 – the first passenger starts to leave the plane on the emergency slide from the rear left door of the plane, other passengers start to evacuate behind him;
- 18:58:36 – rescuer ran out of the first fire truck and headed towards the front left door;
- 18:58:51 – two rescuers from the first fire truck enter the aircraft cabin to find out the situation on board, at the same time, passengers begin to evacuate via the emergency slide;
- 18:59:54 – mobile command post approaches the accident place with the aerodrome flight director and paramedic with first aid kits;
- 19:01:57 – arrival to the accident place of a paramilitary security service vehicle;
- 19:02:05 – arrival of the aerodrome service vehicle to the place of accident;
- 19:02:30 – arrival of an escort vehicle of the field operations control center;
- 19:02:48 – arrival of the first bus to transport passengers;
- 19:03:31 - arrival to the place of accident of the medical unit vehicle;
- 19:03:45 – arrival of the second fire truck KAMAZ 1065 (after announcement of the "Alarm" signal, it headed to the place of meeting of the Rescue Team in the area of TW3 and, so far, was there in a state of readiness);
- 19:04:42 – arrival of the TUG tractor (not part of the Rescue Team);
- 19:04:51 – arrival of a mobile stairway, which stopped at a distance of about 50 m from the plane;

- 19:05:08 – arrival of the KRAZ-255 aerodrome tractor;
- 19:06:34 – arrival of a convoy of special vehicles from the TW-3 side, including a mobile stairway, second bus to transport passengers and other vehicles;
- 19:08:08 – arrival of the third fire truck MAZ 7313 (after announcement of the "Alarm" signal, it headed to the place of meeting of the Rescue Team in the area of TW3 and was still there in a state of readiness.)

Thus, the first fire truck arrived at the place of accident 2 minutes 11 seconds after announcement of the "Alarm" signal, which meets the requirements of paragraph 13.3.4 of the Certification Requirements for Civil Aerodromes of Ukraine.

Evacuation of passengers was carried out via three inflatable slides. Due to the fact that the passengers of the plane did not contact the airport medical point after the accident, there is no information about their injuries during the runway excursion or evacuation procedures. According to the senior flight attendant, the evacuation of passengers was complicated by the fact that some of them tried to take away their luggage from the cabin.

According to the head of the emergency rescue and firefighting flight support service of ME "Odessa International Airport", after the passengers were evacuated to the terminal at 19:15, the fire and rescue unit of the emergency rescue and fire support service of the airport, in order to localize the possible spread of fluid from the aircraft NLG, applied a solution of foaming agent on the section of the Runway in the area of the NLG. There were no fires at the place of accident. Under instruction of the head of emergency rescue operations, the MAN fire truck was left at the place of accident to ensure fire safety, two other fire trucks headed to the boxes of the emergency rescue station.

The all-clear signal was announced at 19:55.

Due to the fact that the Runway was blocked, the aerodrome was closed by NOTAM from 20:05 21.11.2019 till 20:00 22.11.2019.

The evacuation of the plane from the runway lasted from 17:50 to 19:45 on November 22, 2019, the plane was delivered to the "L" apron. A delay in the aircraft evacuation from the runway was caused by the need to wait for the arrival of a representative of Turkish Airlines with the required equipment. Works on the aircraft evacuation were performed by employees of the airline under the supervision of the Acting General Director of ME "Odessa International Airport". The following special vehicles, which are on the airport balance, were used to evacuate the aircraft from the runway: KRAZ 258 B with a platform, TADANO hoisting crane, AA-12-110 MAN fire truck, Gazelle GFZ-2705 ambulance. The Turkish Airlines equipment delivered from Turkey was partially used to evacuate the aircraft.

## **1.16. Tests and Research**

Not carried out.

## **1.17 Information on Organizations and Administrative Activities Relevant to Accident**

### **Turkish Airlines**

Turkish Airlines Corporation was founded in 1933. Valid Aircraft Operator Certificate (AOC) No. TR-001 was issued by the General Directorate of Civil Aviation of the Ministry of Transport, Maritime Affairs and Communications of Turkey (date of entry into force – 09.02.2017) with Operating Specifications dated 04.11.2019. The airline operates international and domestic scheduled and charter flights.

The airline's fleet consists of 347 aircraft. During 2019 winter period, the airline operated flights to Lviv, Zaporizhzhya, Kherson, Boryspil, Odesa and Kharkiv.

### **ME "Odesa International Airport"**

The owner of the Aerodrome Certificate is the Municipal Enterprise "Odesa International Airport", which is in a municipal property of the city of Odesa. The airport is located 7.5 km southwest of the center of Odesa. The airport includes an aerodrome, terminals, complex of ground structures, airport services for reception-and-release of aircraft, passengers, luggage, mail and cargo, aircraft maintenance. The airport operates around the clock and has an international status.

### **UkSATSE**

Air navigation service provider: Ukrainian State Air Traffic Services Enterprise (UkSATSE). In accordance with the Charter, the State regulation of UkSATSE activities shall be carried out by the Ministry of Infrastructure of Ukraine.

Air Navigation Services Certificate was issued by the State Aviation Administration of Ukraine on December 22, 2017.

## **State Aviation Administration of Ukraine**

The State Aviation Administration (SAA) is a central executive body, which activities are directed and coordinated through the Minister of Infrastructure by the Cabinet of Ministers of Ukraine, which implements the state policy in the field of civil aviation and use of airspace of Ukraine, and it is a civil aviation authority.

In accordance with the Regulation on the State Aviation Administration, the State Aviation Administration shall adopt and implement aviation regulations of Ukraine, conduct supervision and control over compliance by aviation entities with the requirements of the legislation, aviation regulations of Ukraine.

## **Odesa Aeronautical Meteorological Station Civil**

Meteorological service of flight operation at «Odesa» Aerodrome is provided by a meteorological service provider – Odesa Aeronautical Meteorological Station Civil - a full reporting synoptic station – of the Hydrometeorological Center of the Black and Azov Seas.

The Odesa Aeronautical Meteorological Station Civil provides services and provides the meteorological information to:

- Odesa Tower: workplaces of ATC controllers (GND workplaces, Tower workplaces), workplace of ATIS/VOLMET radio broadcasting operator (OrMET workplace);
- Odesa ATS Center: workplaces of ATC controllers of Odesa TMA (Zone 1, Zone 2, Zone 3) (OVT sector, which provides the control service for approach), workplace of the weather forecaster of the meteorological monitoring unit (SIN workplace);
- Southwestern Aviation Search and Rescue Assistance Center.

The meteorological observation point is located at a distance of 135 m from the threshold of the Runway-34 and 3000 m to the south of the Tower building, where continuous meteorological observations are carried out by meteorologists at the Odesa Aeronautical Meteorological Station Civil. At the observation point, instrumental observations of visibility, surface wind, base of clouds, air temperature and humidity, atmospheric pressure are carried out using the automated meteorological aerodrome station "AMAS Avia – 1."

AMAS Avia-1 provides automated meteorological observations, processing of measurement results, compilation of reports, their dissemination by communication channels, and display of real-time meteorological observations data.

According to paragraph 2.1 of the Instruction on Meteorological Servicing of Aircraft Flights at «Odesa» Aerodrome of 11.01.2018 No.01/i, the information about the weather at the aerodrome, which should be transmitted onboard the aircraft, shall be reported by the Odesa Aeronautical Meteorological Station Civil to the ATS authorities using weather displays. The weather display is an integral part of AMAS Avia-1. The control weather display is installed at the workplace of the aircraft meteorologist-technician of the Odesa Aeronautical Meteorological Station Civil.

### **1.18 Additional Information**

In their Statements on the accident circumstances, the PIC and co-pilot noted the poor condition of the runway at «Odesa» Aerodrome, in particular, noting the unevenness and corrugations of the runway surface, which, in their opinion, may have contributed to the accident to a certain extent.

By its letter dated 27.10.2017 No. 05-1031, ME “Odesa International Airport” informed the representative office of Turkish Airlines that the operation of certain types of aircraft is possible with appropriate restrictions on weight and traffic intensity, in particular, the operation of the aircraft B-737-800 with a weight of up to 63.3 tons is limited to 3 takeoff and landing operations per day, with a weight of up to 70.7 tons - 2 takeoff and landing operations per week. At the same time, in the Scientific and Technical Report by Progrestech-Ukraine LLC named “Field tests and determination of bearing capacity of artificial pavements, classification number of pavements (PCN) of Paved Runway, HST, TW and aprons of ME “Odesa International Airport” (April 2018), the following recommendations on the aircraft B-737-800 operation mode were issued:

- 10 flights per day with a weight not exceeding 63751 kg;
- 2 flights per day with a weight not exceeding 67434 kg;
- 1 flight per day with a weight not exceeding 71609 kg;
- with no intensity restriction – with a weight not exceeding 54910 kg.

ME “Odesa International Airport” did not inform the Turkish Airlines about the new restrictions on the pavement operation mode after the 2018 tests.

The landing weight of the TC-JGZ aircraft of Turkish Airlines was 63519 kg.

According to the results of the recalculation of the bearing capacity of the artificial pavements of the aerodrome elements, which was performed by Progrestech-Ukraine LLC in January 2019, the Scientific and Technical Report defines new classification numbers for aerodrome pavements, in particular, for the Paved Runway - 45/R/B/X/T. In turn, the aerodrome operator issued NOTAM C3770/19, according to which, for the period from 08:30 10.10.2019 to 23:59 31.12.2019, a new PCN - 45/R/B/X/U was established for the runway of «Odesa» Aerodrome.

Depending on the ratio of PCN/ACN, for hard pavements, the appropriate operating modes are set with restrictions on the aircraft traffic intensity with loads that exceed the design ones. In particular, at a ratio of  $1 > \text{PCN/ACN} > 0.85$  (ACN is 52 of a maximum loaded aircraft of B-737-800 type according to the data provided in the Ukraeroproekt's report of 2018, thus, the ratio of  $\text{PCN/ACN} = 45/52 \approx 0.87$ ) - the average daily intensity is recommended to be limited to 10 aircraft\*departures per day.

According to the information provided by the ME «Odesa International Airport», on the day of the accident (for 24 h of November 21, 2019), 6 B-737-800 aircraft performed a take-off from the aerodrome and 1 aircraft of this type landed (TC-JGZ of Turkish Airlines.) That is, there were no violations by the aerodrome operator of the B-737-800 aircraft operation mode (in terms of the traffic intensity) on the day of the accident.

In January 2019, Progrestech-Ukraine LLC prepared a Scientific and Technical Report "Code under DK021:2015 - 71240000-2 – Architectural, Engineering and Planning Services (Recalculation of the bearing capacity of artificial pavements on the Paved Runway; TW-1; TW-2 ; TW-6; Ramp-1; Ramp-2; Ramp-3; Ramp-4; Ramp-11; Ramp-12; Ramp-13; Ramp-23 of ME «Odesa International Airport" taking into account the new flight schedule for 2019)." Preparation of the data for the recalculation was performed on the basis of a thorough inspection of the technical condition of aerodrome pavements, which was conducted by Progrestech-Ukraine LLC's experts in August 2018. Based on the results of the inspection and assessment of the technical condition of the artificial pavements of the aerodrome elements, the following information on the technical condition of the Paved Runway surface was provided. The Paved Runway pavement at «Odesa» Aerodrome was built in 1961 of M300/45 cement concrete, 0.24-0.26 m thick, on the basis of a 0.05 m thick layer of sand. The pavement is divided by expansion joints into 7x4m slabs. Edge reinforcement is arranged in the transverse seams of the slabs. In 1986, reinforcement of the existing Paved Runway artificial pavement with layers of asphalt concrete and reinforcing mesh was completed. During the long (over 30 years) operation of the asphalt concrete reinforcement layer, under the action of operational loads, temperature changes and due to the deterioration (over time) of the physical and

mechanical properties of the asphalt concrete, there occurred characteristic destructions and defects. The most significant defects of the Paved Runway pavement are through cracks that have arisen over the expansion joints and cracks of the cement concrete pavement. Areas with temperature-shrinkage cracks and a grid of residual deformation cracks were also formed on the busiest sections of the runway pavement. Partially, the cracks have broken edges. Due to the action of the mentioned destructive factors, on a large area of the reinforcement layer, there emerged surface destructions of asphalt concrete (erosion) in the form of chips down to 24 mm deep, which in some areas led to formation of corrugations. In general, the condition of the Paved Runway pavements can be defined as "satisfactory"; no foreign objects, defects and destruction of pavements, which can pose a threat to flight safety, were revealed. The degree of destruction of the upper layer - "Average".

The commission, which consists of the deputy general director of the airport, leading aerodrome operation engineer, head of the aerodrome service, head of the flight safety management service and flight safety inspector, conducts monthly (during a month) inspections of the technical status of Odessa airport aerodrome pavements. In particular, such an inspection was conducted in the period from 01.10.2019 to 31.10.2019. The inspection results, types of damage, types and terms of performance of works on their elimination (works on elimination of the recorded damage during October, 2019, were carried out on pavements of TW-4, taxiing routes T-4 and T-5, Ramp 6 to Ramp 22 and Apron "N") are set out in the relevant Act of 01.11.2019 No. 01.24-627 approved by the acting general director of ME "Odesa International Airport". No Paved Runway damage was noted in the Act.

### **1.19 Useful or Effective Methods Used in Investigation**

Standard methods were used in the investigation.

## 2. Analysis

On November 21, 2019, a regular THY2UT flight en-route Istanbul – Odesa was performed with the B-737-800 aircraft, state and registration marks TC-JGZ, operated by the Turkish Airlines, by the aircraft crew consisting of PIC, co-pilot and four flight attendants.

There were 136 passengers and 2793 kg of luggage on board the aircraft.

According to the Statement of PIC, he and co-pilot arrived at the Istanbul Airport for a pre-flight briefing, where they were acquainted with the meteorological information on the destination «Odesa» Aerodrome and alternate aerodromes - Istanbul, Chisinau, as well as with the current NOTAM, flight plan, information on the aircraft loading, refueling and technical condition.

During the briefing, the crew was particularly concerned about the direction and strength of the wind at the «Odesa» Aerodrome, because the wind was variable, and the value of its strength, in particular, of the side component, was close to the maximum allowable value. Take-off and landing weights did not exceed the maximum allowable values for these conditions. Take-off and landing Center-of-Gravity positions were average and did not exceed the limits.

The amount of fuel for the flight was sufficient to perform go-around to the most remote alternate destination aerodrome of Istanbul from the decision altitude.

Having analyzed this information, the PIC took the final decision to take off for destination. Departure from Runway 35L at Istanbul Airport was performed at 17:33. The take-off, climb to the target level FL360 and flight en-route took place without deviations and peculiarities. According to the CVR, during the flight in the FIR control area of Romania (call sign - "Constantsa"), prior to descent, at 17:55, the crew listened to the ATIS "November" information for 17:34 of the «Odesa» Aerodrome and began approach briefing.

***Note:** ATIS for 17:34 contained the following information about the wind direction and speed: touchdown zone – 070°, 9 m/s, gusts maximum 13 m/s, minimum 05 m/s, varies in the sector from 030° to 090°; runway end: 080°, 12 m/s, gusts maximum 16 m/s, minimum 06 m/s, varies in the sector from 040° to 100°.*

The values of the cross wind component were 13 m/s (25 knots) and were less than the maximum allowable ones for taking decision to perform landing.

Taking into account the wind direction change (from 30° to 90°) and wind gusts up to 13 m/s, the tail wind component reached 7.8 m/s, which was equal to 15.6 knots and exceeded the limits (15 knots) set by Boeing 737-800 Flight Manual. During the approach briefing, the crew did not discuss the non-conformity of the force of the tail wind, and the PIC took decision to continue the landing approach.

During the approach briefing, PIC instructed the co-pilot to monitor the value of the cross wind component with FMC ("*progress page*"), drew his attention to adverse weather conditions, in particular, that the wind force values are close to the maximum allowable ones, and urged the co-pilot to be careful because of the possibility of go-around ("*Weather is a threat for us we have to be careful because maybe 90 percent we gonna do a go-around, ok?*"). At the same time, the PIC did not draw attention of the co-pilot to the fact that, taking into account a significant change in wind direction, the tail wind component reached 7.8 m/s (15.6 knots) and exceeded the established limits.

**Note:** The maximum wind gusts, as reported in the ATIS November, were 16 m/s ( $\approx$  32 knots) at the end of the runway, the direction varied from 40 to 100°, so, the wind speed values calculated by the crew did not exceed the maximum allowable values for the declared runway status. According to the requirements of Section 4, page 9 B-737-800 Aircraft Flight Manual (AFM), in case of winglets installed, the maximum permissible speed of the cross wind component shall be 30 knots. The value of the tail wind component was not calculated by the crew, although it exceeded the established limits of 15 knots.

The AUTOBRAKE automatic braking system was initially set to position "3", however, according to the PIC's instructions, the co-pilot should have been ready to set it to position "MAX", if necessary.

At 18:04:24, the crew started the descent down to FL 300. During the descent, the crew listened to ATIS "Quebec" for 18:05, which contained the information about the following values of wind direction and speed: touchdown zone - 080°, 9 m/s, gusts – maximum 15 m/s, minimum 06 m/s; runway end - 090°, 10 m/s, gusts - maximum 15 m/s, minimum 06 m/s, wind direction changed from 050° to 120°.

*«Odesa ATIS Information «QUEBEC» 18:05. ILS Approach, NDB Approach, runway in-use one six. Runway surface condition report at one eight zero five: dry clear, measured coefficient decimal six, decimal six, decimal six. Estimated surface friction-good. Transition level- one one zero. Turns on the runway should be made at the end of the runway on abeam taxiway three. Caution: construction works in progress seven zero meters to the north of the threshold runway one six. Caution: large flocks of birds in the vicinity of aerodrome and on final. Present weather: wind touchdown zone - zero eight zero degrees nine meters per second, gusts maximum one five, minimum zero six meters per second. Stopend zero nine zero degrees one zero meters per second, gusts maximum one five minimum zero six meters per second. Varying between zero five zero and one two zero degrees. Visibility one zero kilometers. Light snow, cloud overcast five one zero meters. Temperature – zero two, dew point – minus zero one. QNH one zero three zero Hecto Pascals, QFE one zero two four Hecto Pascals. Trend: NOSIG. Acknowledge information «QUEBEC».*

The meteorological minimum qualification of the crew allowed landing at the values of cloud ceiling and visibility indicated in the ATIS. The approach was performed according to the approach route OGLAR 3Y and vectoring till capture of Runway 16 ILS.

The descent to the altitude of 2,000 feet was within normal limits.

At 18:22:29, the ATC controller of the CTA Odesa OVT sector gave clearance to the crew to descend to the absolute altitude of 2,000 feet and gave clearance to the ILS landing approach to Runway 16 and instruction to report the localizer beam capture, which was confirmed by the crew.

At 18:26:09, the ATC controller of the CTA Odesa OVT sector asked the aircraft crew about the localizer beam capture.

The aircraft crew confirmed the localizer beam capture.

The ATC controller of the CTA Odesa OVT sector informed the aircraft crew about its location relative to the touchdown point and instructed to switch the communication to ATC controller of Odesa TWR on the frequency of 125.5 MHz, which was confirmed by the crew.

The aircraft crew, being in the area of responsibility of CTA Odesa OVC and OVT sectors, did not report to ATC controllers of Odesa ACC about listening to ATIS information and did not make a request to obtain the information contained in the ATIS radio broadcast.

From 18:05:40 to 18:32:32, on the frequency of 133.1 MHz, ATIS "QUEBEC" information was broadcasted in English.

According to the requirements of subparagraph e) of paragraph 4.3.6.1 of Chapter 4 of Annex 11 to the Convention on International Civil Aviation "Air Traffic Service", aircraft shall acknowledge receipt of the ATIS information upon establishing communication with the ATS unit providing approach control service or aerodrome control service. According to the third part of paragraph 1.5.2 of Section En-route 1 "General Rules and Procedures" of the Aeronautical Information Publication of Ukraine (AIP of Ukraine), at availability of ATIS radio broadcast at the aerodrome, the aircraft shall acknowledge the current information monitored (ATIS code letter) upon establishing communication with the ATS unit providing approach control service. In addition, ATIS themselves at the end of the text reported shall contain an instruction to addressed aircraft to acknowledge the information monitored ("*... Acknowledge information... (ATIS code letter)*").

At 18:26:33, the aircraft crew contacted the ATC controller of the Odesa Tower on the frequency of 125.5 MHz and reported Runway 16 localizer beam capture.

The ATC controller of the Odesa Tower instructed the crew to continue the landing approach to Runway 16, because the runway was occupied.

At 18:27:03, the ATC controller of the Odesa TWR provided the aircraft crew with the information on a surface wind of 80 degrees, 12 m/s, gusts of 14 m/s, and gave a control clearance for landing. At that, the controller did not inform the aircraft crew about significant changes in the wind direction. The aircraft crew confirmed the information about the surface wind and control clearance for landing.

On the final approach, the crew extended the landing gear and flaps to 30°. After the Ukrainian International Airlines plane, which performed the flight in front, landed and vacated the runway, at 18:28, the Tower controller gave clearance to the crew to the aircraft landing on Runway 16, which was confirmed by the crew. Surface wind parameters were within permissible values.

**Note:** at 18:28:17, the ATC controller of the Odesa Tower provided the crew with the information on the surface wind direction and speed – 080°, 11 m/s, gusts of 14 m/s and again did not indicate the presence of a significant change in the wind direction. In addition, the co-pilot used the values of the cross component of the wind from the FMC screen ("progress page"), which did not exceed the maximum permissible values at the flight altitude.

**Note:** *During communication with the aircraft crew, the ATS controllers of the OVT sectors and Tower provided the crew with the averaged data on the wind direction, while the ATS controllers' weather display receives the data on the wind direction for a certain sector. In addition, paragraph 2.4.1.3 of the Instruction No. 01/i dated 11.01.2018 on meteorological servicing of the aircraft at «Odesa» Aerodrome states that, at report generation by the automated station AMAS-Avia, in particular, the averaged values of wind direction and speed, as well as their significant deviations, if any, measured along the runway, shall be included into local regular reports MET REPORT and special reports SPECIAL.*

*In general, during the first landing approach, flight in the holding area and repeated landing approach, the ATS (ACC and Tower) informed the crew 10 times about the values of the wind direction and strength. Of these 10 times, only once did the controller give the crew information about the wind direction (at 18:45:30, approximately 10 minutes prior to the landing). The other 9 times, the controller gave the crew only the averaged value of the wind direction, which differed from the information transmitted by the aerodrome meteorological authority (without the indication that the wind direction is constantly changing.)*

The aircraft crew confirmed receipt of the information.

At 18:29, the crew performed a go-around. Observing the maneuver of the aircraft, at 18:29:16, the Tower controller asked the crew to confirm the go-around: "TURKISH two Uniform Tango, confirm go-around".)

**Note:** *According to Statement of the ATC controller of the Odesa Tower, he visually observed the aircraft and noticed, according to the aircraft movement, that the*

aircraft began to climb in front of the Runway 16. For this reason, he made a request to confirm the go-around.

At 18:29:20, the crew reported the go-around, "Going around", and, at 18:31:31, indicated that the reason was a non-stabilized aircraft attitude.

**Note:** according to the FDR data, the aircraft attitude was non-stabilized by the instrument speed, which was 171 knots (exceeding the estimated one by 18 knots.)

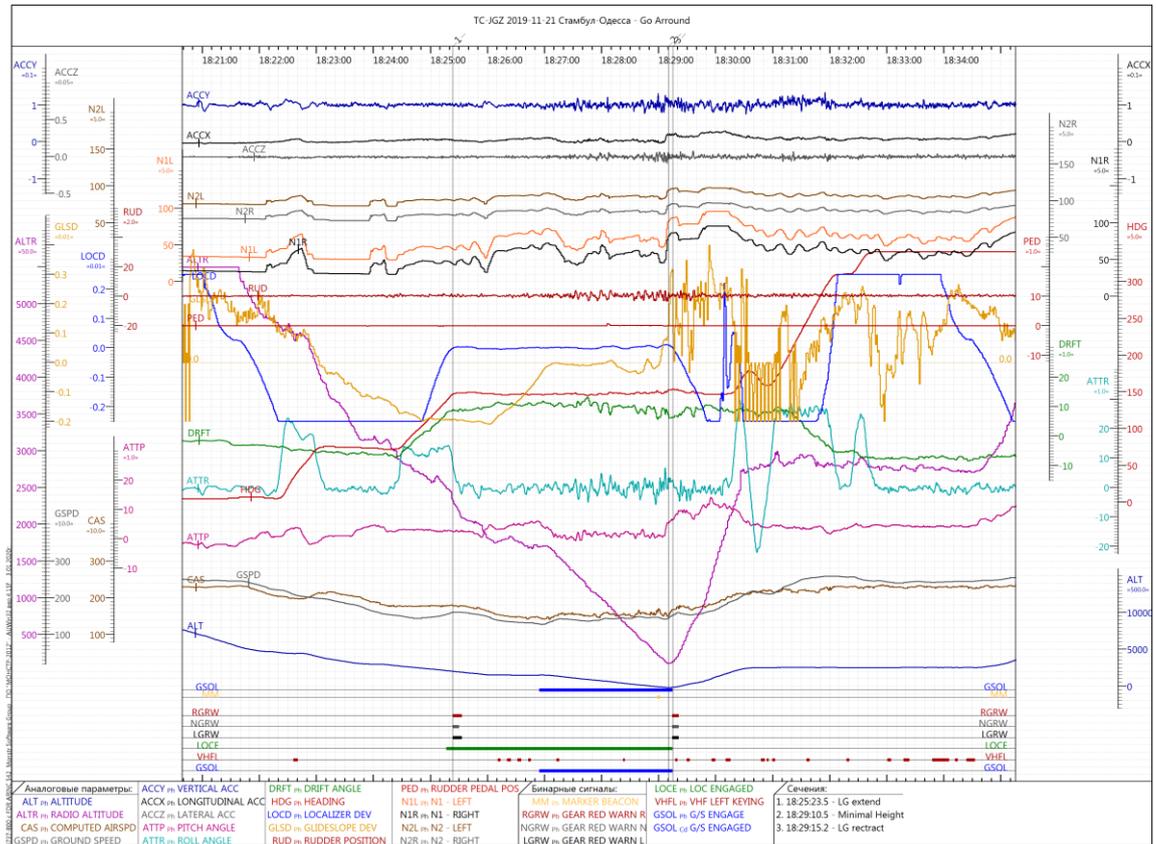


Fig. 3. Graphs of flight parameters at the time of go-around

The ATC controller of the Odesa TWR instructed the aircraft crew to initially gain the altitude of 3,000 feet with the heading of the runway-in-use and instructed to switch communication to the ATC controller of the TMA Odesa OVT sector on the frequency of 120.9 MHz.

The aircraft crew confirmed the control instruction.

At 18:29:57, the aircraft crew contacted the ATC controller of the TMA Odesa OVT sector on the frequency of 120.9 MHz and reported the go-around: "Hello Odesa, TURKISH two Uniform Tango, we are going around."

At 18:30:03, the ATC controller of the TMA Odesa OVT sector informed the aircraft crew about establishment of radar identification and instructed to climb to the altitude of 3,000 feet and rely on the radar vectoring for ILS approach to Runway 16. Following the controller's instructions, the crew climbed to the altitude of 3,000 feet and set at first heading 310°, and then 340°.

From 18:32:34 to 18:34:21, on the frequency of 133.1 MHz, ATIS "ROMEO" information was broadcasted in English:

*Odesa ATIS Information «ROMEO» 18:30. ILS Approach, NDB Approach, runway in-use one six. Runway surface condition report at one eight zero five: dry clear, measured coefficient decimal six, decimal six, decimal six. Estimated surface friction-good. Transition level- one one zero. Turns on the runway should be made at the end of the runway on abeam taxiway three. Caution: construction works in progress seven zero meters to the north of the threshold runway one six. Caution: large flocks of birds in the vicinity of aerodrome and on final. Present weather: wind touchdown zone - zero eight zero degrees one two meters per second, gusts maximum one five, minimum zero six meters per second. Varying between zero four zero and one one zero degrees, stopend - zero nine zero degrees one two meters per second, gusts maximum one seven, minimum zero seven meters per second. Varying between zero four zero and one zero zero degrees. Visibility one zero kilometers. Light snow, cloud overcast five one zero meters. Temperature – zero two, dew point – minus zero one. QNH one zero three zero Hecto Pascals, QFE one zero two four Hecto Pascals. Trend: NOSIG. Acknowledge information «ROMEO».*

In relation to the previous ATIS "QUEBEC" information, the ATIS "ROMEO" information provided different values of the wind and its changes, which the crew did not listen to.

At 18:33:02, the aircraft crew made a request for the latest wind values.

At 18:33:09, the ATC controller of the TMA Odesa OVC sector, at the request of the crew, provided the up-to-date information about the wind direction and speed: 100°, 12 m/s, gusts 18 m/s.

**Note:** wind gusts exceeded the maximum permissible values for the given conditions at «Odesa» Aerodrome (calculation of the cross component of the wind:

MHland = 157°,  $\sin 60^\circ = 0.866$ ,  $18 \cdot 0.866 = 15.59 \text{ m/s} \approx 31.2 \text{ knots}$ , the maximum wind component for a wing with a winglet is 30 knots.)

Having received the wind data, the PIC took the decision to wait for the wind gust force decrease in the holding area above OOW01 waypoint with climb to the altitude of 8000 feet, as icing was observed at the altitude of 3000 feet. The controller checked with the crew, which wind was right for the crew, to which he received the answer that the wind speed should not exceed 15 m/s.

At 18:38:56, the ATC controller of the TMA Odesa OVC sector provided the crew with information about the wind – 090°, 10 m/s, maximum 14 m/s, in response, the crew announced its decision to hold more. During transmission of the wind data, the controller did not indicate to the crew that there were significant changes in the wind direction.

*Note: The ATC controller of the TMA Odesa OVT sector and ACC controller of TWR use the weather display of the automated meteorological aerodrome station "AMAS Avia-1" at their workplaces. In accordance with paragraph 2.4.1.3 of the Instruction for Meteorological Service of Flights at «Odesa» Aerodrome, the weather display shows the current data on average values of the wind speed and direction, significant changes in the wind direction with an averaging period of 2 minutes, maximum speed values observed in the last 2 minutes.*

At 18:43:02, the ATC controller of the TMA Odesa OVC sector again provides the crew with the information about the speed and direction of the surface wind - 080°, 9 m/s, maximum 12 m/s.

At the request of the controller, whether the crew is ready for the landing approach, the crew once again requests the latest information about the wind.

At 18:45:30, the ATC controller of the TMA Odesa OVC sector informs the crew of the current information about the wind:

*"070°, 9 m/s, maximum 13 m/s, changes in sector 050° to 110°, after which the crew reports its readiness to descend and approach for landing."*

At 18:51:23, the controller provides the crew with the updated information about the wind 080°, 11 m/s, maximum 15 m/s. During transmission of the updated information, the controller no longer draws the crew's attention to significant changes in the wind direction.

At 18:52:00, the crew reported to the ATC controller of the TMA Odesa OVC sector about the localizer beam capture.

At 18:52:27, the crew switches communication to the Tower controller.

At 18:52:32, the Tower controller informed the crew about the wind: 080°, 12 m/s, maximum 15 m/s and gave clearance to land on the Runway 16.

*Note: in the process of landing approach and on final, the co-pilot shall monitor and constantly inform the PIC about the cross component of the wind, which at this time, at the flight level, ranged from 23 to 28 knots.*

At 18:53:18, the crew started to perform the Landing Check List, during which the landing gear extension, spoiler arming and flap deployment to 30° were checked.

At 18:53:56, after the "One thousand" sound signal, the PIC and co-pilot said that the plane was stabilized.

*Note: according to the FDR data, the aircraft was indeed stabilized by all parameters.*

At 18:53:59, the controller provided the crew with the information about the wind: 090°, 11 m/s, maximum 13 m/s.

At 18:54:56, after the Minimums sound signal, the PIC announced his decision to continue the landing approach.

From 18:55:10 to 18:55:14, the aircraft synthetic voice was calling out the altitude ("Fifty, forty, thirty, twenty, ten".)

At 18:55:15, the plane reduces the pitch from + 3.5° to + 2.6°.

At 18:55:16, the touchdown took place first by the right landing gear at a distance of 444 m from the threshold of the Runway 16 and to the left of the centerline at the distance of 0.4 m with heading 151° and right roll of 3° (according to FDR data.) PIC deflects the right pedal to the angle of 5.6° (out of possible 12°.) The magnetic heading increased by 2° and reached 153°, the aircraft pitch decreased from + 2.6° to -0.7°, which caused the left landing gear touchdown at the distance of 454 m of the threshold and 6 m to the left of the centerline of the Runway 16, and nose landing gear touchdown at the distance of 552 m from the end and 1.5 m to the left of the centerline of the Runway 16.

At 18:55:17, the co-pilot confirmed that the spoilers were deployed automatically ("Speed brake up".)

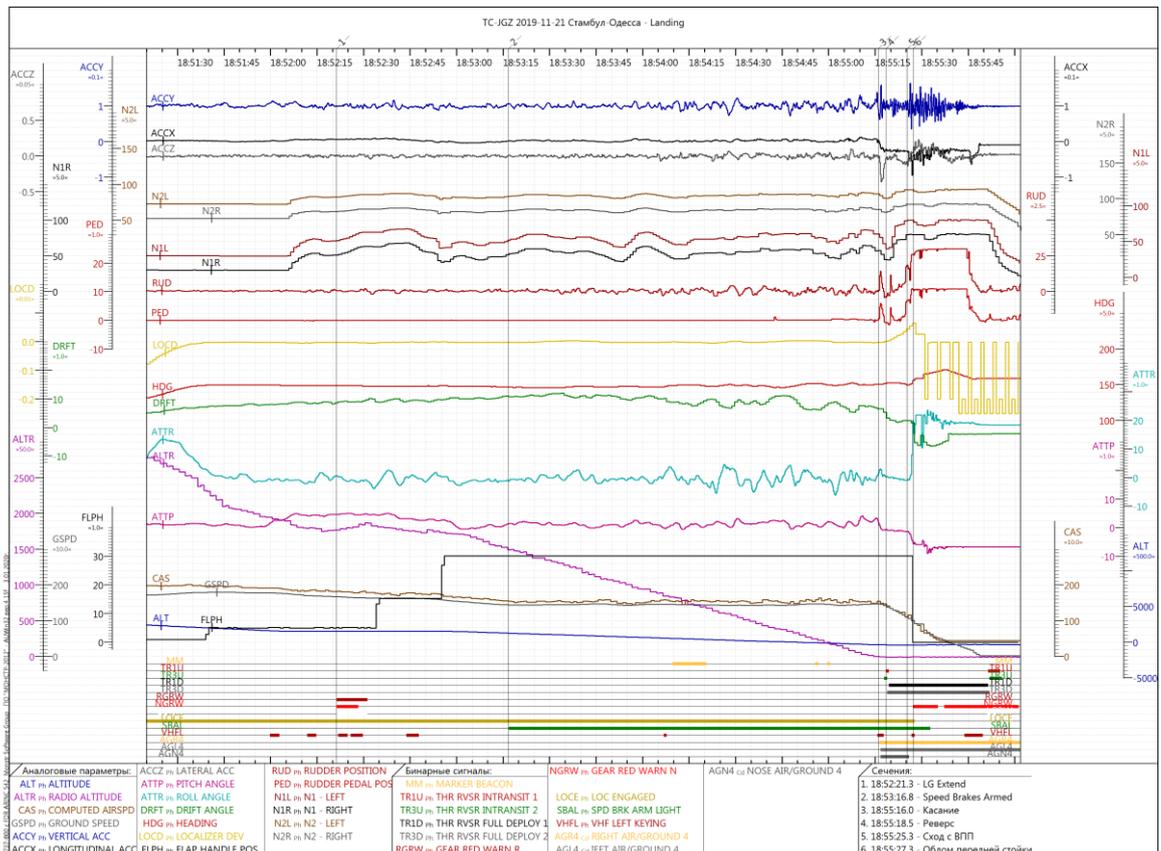


Fig. 4. Charts of flight parameters during landing approach and landing

At 18:55:18, the PIC switched the reverse thrust to position "2" and again, for 2 seconds, displaced the right pedal to 4.6° (out of possible 12°), but it had no effect because the aircraft heading remained 153°. The co-pilot did not report that the reverse thrust was unlocked ("REVERSE UNLOCK"), the automatic braking system started operation ("AUTOBRAKE IN USE"), the reverse thrust was switched to position "2" ("REVERSE NORMAL"), as required by the crew operation technology. In addition,

when the aircraft deviated from the centerline of the Runway 16 during the landing run, the co-pilot should have warned the PIC ("DRIFTING TO THE LEFT".)

*Section 6 on p. 6.32 of B-737NG FCTM "Directional Control and Braking during Landing Roll" contains the recommendation to use a combination of rudder, differential braking, and ailerons input to maintain runway centerline during strong crosswinds, gusty wind conditions or other situations. According to the flight recorders, the rudder input was insufficient and was equal to 15° at a possible input to the maximum angle of 30°.*

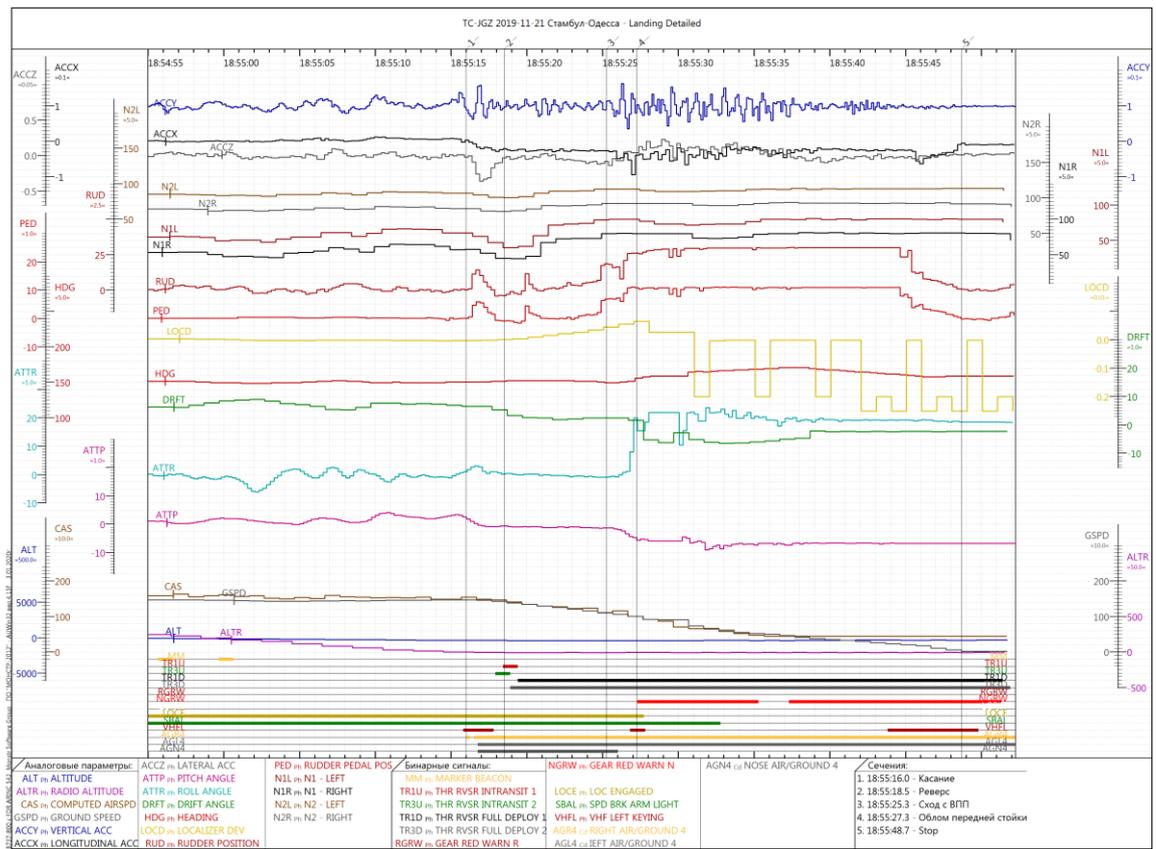
At 18:55:21, the PIC, at the speed of 130 knots, turns the wheels of the front landing gear to the right through large turn angles up to 78°. As a result, the wheels of the front landing gear began to skid on the runway, as evidenced by a clear solid black mark from the wheels of the nose landing gear on the runway, which also indicates that the PIC turned the wheels of the nose landing gear through large turn angles. At this speed, the aircraft weighing 63,000 kg at the distance of 848.76 m from the runway threshold and 13.53 m to the left of the centerline of the Runway 16 with MH 153° at landing heading 157° continued to drift to the left. At that, the tires of NLG wheels begin to crumble to pieces. However, the FCOM warns against using large wheel turn angles (78°) until the landing run speed is reduced to the steering speed.

At 18:55:25, with MH 151° at a speed of 111 knots with the pedals deflected to the right by 7° (out of maximum 12°), the rudder was deflected to 18.7° (out of the maximum 30°), NLG entered the soil. At this point, the flight recorders recorded almost the maximum deflection of the right pedal, which lasted until 18:55:43 (speed was 27 knots, distance was 1638 m from the entrance threshold.) At 18:55:44, the deflection of the right pedal decreased to 8°, and then to 0°.

Subsequently, after collapse of the nose landing gear, for 23 seconds, the ground speed began to decrease from 107 to 2 knots.

At 18:55:27, the pitch of the aircraft was -5.6°; right roll +20°, MH 152°, maximum pedal deviation to the right 11.2° (out of the maximum 12°), rudder 27° (out of the maximum 30°) and speed 101 knots, which evidenced NLG collapse in the direction opposite to the movement.

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**Fig. 5. Graphs of flight parameters during aircraft landing and runway excursion**

At 18:55:28, the plane completely rolled out of the runway onto the soil and moved with MH 158°-159° for 3 seconds.

At 18:55:31, the aircraft increased its heading to 165° at a distance of 1360 m from the entrance runway threshold. Over the next 8 seconds, the aircraft increased its heading up to 171°.

From 18:55:39 to 18:55:50, the aircraft heading decreased from 170° to 159°.

The aircraft came to rest at 18:55:51 at a distance of 1683 m from the entrance threshold of the Runway 16 and at 27 m from the runway centerline to the left.

**B737-800 TC-JGZ Istanbul-Odesa 2019-11-21**

Analog parameters:

Tag	Name
ATTP	Pitch Angle, deg
ATTR	Roll Angle, deg
PED	Pedals position, deg
RUD	Rudder position, deg

Analog parameters:

Tag	Name
HDG	Heading, deg
CAS	Airspeed, kts
GSPD	Ground Speed, kts
L	RWY Distance, m

Time	ATTP	ATTR	HDG	RUD	PED	CAS	GSPD	L	Marker
18:55:09	1.6	1.8	152	4.2	0.4	155	144	-50	
18:55:10	4	-2.3	150	0.6	0.3	153	145	20	

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18:55:11	4.2	-2.5	151	2.7	0.3	154	146	100	
18:55:12	3	-0.9	150	1.9	0.2	153	146	170	
18:55:13	2.5	-0.7	150	-0.8	0.4	155	146	250	
18:55:14	2.8	-0.9	150	-1.5	-0.5	149	147	330	
18:55:15	3.5	-1.1	151	1	0.3	149	147	400	
18:55:16	2.6	3.2	151	14	6	155	147	480	Right Landing Gear Touchdown
18:55:17	-0.7	2.8	151	11	5.6	149	146	550	Nose and Left Landing Gear Touchdown
18:55:18	-0.7	1.1	152	-3.9	-0.8	147	143	630	Reverse Thrust
18:55:19	-0.9	0.5	153	-2.7	-0.8	142	139	700	
18:55:20	-0.9	0.2	153	12	4.6	135	135	770	
18:55:21	-1.1	0	153	1.9	0.2	130	130	830	
18:55:22	-1.1	-0.4	153	5.6	0.6	128	126	900	
18:55:23	-1.1	-0.7	153	5.1	1.1	123	121	960	
18:55:24	-1.2	-0.9	152	7.3	2.3	124	116	1020	
18:55:25	-1.4	-0.9	151	19	7.1	112	111	1080	Exit from Runway
18:55:26	-3.3	1.2	151	26	10.9	116	107	1130	
18:55:27	-5.6	20	156	27	11.2	101	101	1180	Nose Landing Gear Destruction
18:55:28	-5.8	22	159	29	11	92	92	1230	
18:55:29	-5.8	22	159	29	11	87	91	1280	
18:55:30	-5.8	22	159	30	11.1	71	91	1320	
18:55:31	-6.5	21.4	166	30	11.1	66	74	1360	
18:55:32	-9	23.7	166	30	11.2	65	67	1400	
18:55:33	-8.6	23.2	167	30	11.2	58	62	1430	
18:55:34	-6.9	22	168	30	11.1	53	56	1460	
18:55:35	-7.2	20.6	169	30	11	48	53	1480	
18:55:36	-7	19.3	170	30	11.1	45	51	1510	
18:55:37	-7.2	20.2	171	30	11.1	45	47	1530	
18:55:38	-6.9	19.5	171	30	11.1	45	42	1560	
18:55:39	-6.7	19.9	170	30	11.1	45	38	1580	

Table. 1. Decoded FDR data for the final stage of landing approach since the time of flight over the Runway 16 threshold till the aircraft came to rest after runway excursion



Photo 22. Continuous track of NLG wheels



Photo 23. The beginning of the track of the right main landing gear after landing



Photo 24 Point of the left main landing gear exit from the runway.



Photo 25. Double track of the nose landing gear



Photo 26. The beginning of a continuous track of the nose landing gear tires  
(beginning of the aircraft skidding)

Section 6 (p. 6.45) of the FCTM B-737NG provides three techniques for landing in strong crosswinds on a dry runway. The values of the flight parameters during landing, such as roll, magnetic heading and rudder deflection, indicate that the crew performed the landing and landing approach using the Touchdown in crab technique (landing with an angle of allowance till touchdown), which is not recommended by FCTM B-737NG document for dry runways with strong crosswinds. At the time of touchdown of the main landing gears, it is very important to maintain with the rudder the aircraft longitudinal axis parallel to the runway centerline until the front landing gear is lowered, simultaneously deflecting the ailerons against the wind. However, the crew did not do so and lowered the NLG at the heading  $151^\circ$  at  $MH_{land} = 157^\circ$ , which caused a gradual deviation of the aircraft from the runway centerline to the left. After NLG lowering, it was difficult to the crew to turn the aircraft to the heading  $157^\circ$ , having a turn angle from the nose landing gear just only  $7^\circ$ . A significant landing weight of the aircraft (63,000 kg) and its landing speed during the landing run caused emergence of forces that contributed to the aircraft veering off. These forces, together with the cross wind force component, reverse thrust force component, as well as an insufficient rudder deflection angle, prevented the aircraft from returning to the runway centerline or, at least, to a position parallel to the runway centerline.

In his Statement, the PIC notes that, having realized ineffectiveness of the rudder deflection, he took decision to apply "Nose wheel steering" to large angles up to  $78^\circ$ , although FCTM does not recommend using this mode at speeds higher than the steering speed. Despite the fact that the nose landing gear was hydraulically rotated through a significant angle (almost perpendicular to the aircraft movement), this did not allow the aircraft reaching the centerline or position parallel to it. The turned wheel of the nose landing gear began to skid, as seen in the photo, when two black stripes from the tires of the nose landing gear merge into one continuous stripe (Photo No. 26.)

### **3. Conclusions:**

1. PIC and co-pilot have valid transport pilot licenses and medical certificates according to the established requirements.
2. PIC is an experienced pilot and has a significant number of flight hours on this type of the aircraft.
3. Co-pilot has a little flight experience on this type of the aircraft.
4. During landing, the PIC was a Flying Pilot, and the co-pilot was a Monitoring Pilot. The training level of PIC and co-pilot was in conformity with the flight task.

5. The maintenance of the aircraft was carried out in accordance with the Turkish Airlines Maintenance Program and other guiding documents of the aircraft manufacturer and Directorate General of Civil Aviation of Turkey.

6. Controllers of the OVT sector of Odesa ACC and Odesa Tower provided the crew several times with only averaged data on the surface wind direction, but not informing about its significant deviations.

7. During the approach briefing, the PIC did not discuss with the co-pilot, which crosswind landing technique should be used after touchdown, at what time he would turn on the reverse thrust, whether he would turn it on separately, or in the normal mode, whether he would use separate braking, or in the automatic mode, whether he would deploy ailerons against the wind, or not. In spite of the fact that there are no requirements to apply the above actions in the FCTM and airline guidance documents, the Investigation Team considers it appropriate to recommend aircraft crews to discuss during the approach briefing the specific features of the landing performance depending on the conditions at the aerodrome.

8. During landing at «Odesa» Aerodrome, the crew carried out approach and landing using the Touchdown in Crab technique, which is not recommended by the FCTM B-737NG document for use on dry runways in the conditions of strong crosswinds.

9. During landing, the crew applied the reverse thrust ahead of time, not having turned the aircraft nose part parallel to the runway centerline.

10. The Paved Runway pavement of «Odesa» Aerodrome is operated by B-737-800 aircraft with restrictions on traffic intensity and mass.

11. The Paved Runway status met the requirements of subparagraph "a" paragraph 6.9.1 Certification Requirements for Civil Aerodromes of Ukraine, approved by the Order of the State Aviation Administration of Ukraine dated 17.03.2006 No. 201.

12. The take-off and landing weights did not exceed the maximum permissible for the given conditions.

13. Take-off and landing Center-of-Gravity positions had mean values and did not exceed the maximum permissible ones.

14. As a result of the runway excursion, the aircraft suffered significant damage to the structural elements.

15. Aerodrome is equipped with lighting equipment of high intensity lights.

16. Radio beacon landing system at «Odesa» Aerodrome does not meet the established requirements (the technical operating life of the localizer expired.)

17. Recording of the communication via radio communication channels during the emergency rescue operations was not conducted by ground live monitoring and recording equipment.

### **3.1. Causes**

The cause of the accident, i.e. runway excursion, which caused significant damage to the structural elements of the aircraft B-737-800 TC-JGZ of Turkish Airlines, which took place on 21.11.2019 during landing at «Odesa» Aerodrome, was failure to maintain the direction of the aircraft movement during the landing run in the conditions of a strong crosswind of variable directions.

Factor: human (crew), environment.

Occurrence Category: RE.

### **3.2. Contributing Factors:**

- Use by the crew of the landing approach method using the Touchdown in Crab technique, which is not recommended by FCTM B-737NG document for use on dry runways in the conditions of a strong crosswind;

- Untimely and insufficient actions of the crew to maintain the landing run direction;

- Presence of a significant cross component of the wind;

- Effect of an omnidirectional wind – from cross-headwind to cross-tailwind directions – during the landing run.

## **4. Safety Recommendations**

### **To: ME "Odesa International Airport"**

1. Conduct additional inspections of the pavements surfaces with documenting any deterioration of their condition in cases of take-off and landing operations of the overloaded aircraft. Stop flights and perform necessary repairs in case of detection of new defects (through cracks, chipped edges and panel corners, subsidence, etc.), which can cause unacceptable damage to the pavement and pose a threat to the flight safety.

2. Provide aircraft operators, which perform flights to «Odesa» Aerodrome, with the up-to-date information on operating restrictions in terms of traffic intensity and aircraft weight.

3. During operation of the aerodrome, monitor a number of takeoff and landing operations per day and follow the recommendations of the scientific-research organizations that conduct relevant studies of aerodrome pavement status, as regards the modes of operation of the aerodrome components pavements.

4. Bring into conformity with the current aviation legislation of Ukraine: the Instruction on Lighting Equipment Operation of «Odesa» Aerodrome from Tower Controllers' Workplaces Using Remote Control Equipment "ID-6.2", approved by the general director of ME "Odesa International Airport" on 12.05.2011.

5. In accordance with paragraph 4.11 of the Regulations of Emergency Rescue and Fire Safety Support of Flights, ensure recording of the voice communication through direct communication and radio exchange channels during emergency and rescue operations, using the live monitoring and recording system.

6. Establish the frequency of assessment of braking action characteristics on the runway surface according to paragraph GM1 ADR.OPS.C.010(b)(3) (c) of Acceptable Means of Compliance (AMC) and Guidance Material (GM), which clarify the provisions of the Aviation Regulations of Ukraine "Technical Requirements and Administrative Procedures for Certification of Aerodromes."

### **To: UkSATSE**

1. During the radio exchange, ATS controllers should comply with the requirements of Instruction No. 01/i dated 11.01.2018 on Meteorological Service of Aircraft Flights at «Odesa» Aerodrome and provide aircraft crews with the information on significant changes in the wind direction, not just its averaged values.

2. Supplement the Operating Instructions of the ATS control units with clear requirements for providing the crews with the information on significant wind direction changes, for example, of the following content: “During the aerodrome control/ approach control service, upon a crew's request, an ATC controller shall transmit to the crew an average direction and speed of the surface winds, including their significant changes, regardless of whether the crew has previously listened to this information.”

### **To: Aircraft Operators Jointly with Aerodromes Operators**

Analyse in advance the compatibility of an aerodrome with operation of a certain aircraft type according to the recommendations set out in Chapter 4 Doc 9981 ICAO “Procedures for Air Navigation Services — Aerodromes”, namely, assess the compliance of the aircraft's flight practice with the aerodrome infrastructure in case, where the aerodrome is servicing an aircraft, which characteristics exceed the aerodrome certification characteristics.

### **To: Turkish Airlines**

1. Conduct theoretical training of aircraft flight crews in choosing a type of landing on dry runways at limit values of the cross component of the wind.

2. Introduce into the simulator-based training program, as regards landing with the maximum permissible crosswind, the following:

- taking decision on landing in the conditions of the maximum crosswind and tailwind of variable directions;

- correctness of choice of landing approach method versus runway status and crosswind strength;

- timely and effective actions to maintain the landing run direction;

- specific features of the reverse thrust application.

3. Consider the three types of landings on a dry runway, which are recommended by FCTM, their positive and negative aspects.

4. Supplement the airline's guidance documents with the requirements obliging aircraft crews to discuss during the approach briefing the specific features of the landing performance depending on the conditions at the aerodrome.

**To: State Aviation Administration of Ukraine**

During inspections of the ground aids of radio technical flight support at the aerodromes of Ukraine, take into account the requirements set out in the regulation on their operation, as provided by the manufacturer of such means.

**To: NBAAI**

Provide the relevant NBAAI units with FDR/CVR read-out devices.