This document is an English translation of the Final Report on the accident involving the Boeing 737-800 aircraft registered VQ-BJI that occurred on September 1, 2018 (UTC) at Sochi International Airport, Krasnodarsky Krai, Russian Federation.
The translation was done as accurate as a translation may be to facilitate the understanding of the Preliminary Report for non-Russian speaking people. The use of this translation for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.
In case of any inconsistence or misunderstanding, the original text in Russian shall be used as the work of reference.

INTERSTATE AVIATION COMMITTEE

AIR ACCIDENT INVESTIGATION COMMISSION

FINAL REPORT

Type of accident	Accident
Type of aircraft	Boeing 737-800, airplane
Registration	VQ-BJI
Owner	SB Leasing Ireland
Operator	UTAir Airlines
Aviation Administration	Rosaviatsia Tyumen ITO
Place of accident	Sochi airport, Krasnodarsky Krai, RF
	Coordinates: N 43°27′05.32″ E 039°57′36.53″
Date and time of accident	01.09.2018, 02:58 local time (31.08.2018, 23:58 UTC), nighttime

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LIST OF ABBREVIATIONS

A/C	–	Aircraft
AAI STSC	–	Air Accident Investigation Scientific and Technical Support Commission
AAIB	–	Air Accidents Investigation Branch, United Kingdom
AAIC	–	Air Accident Investigation Commission, IAC
AFM	–	Aircraft Flight Manual
AMC	–	Aviation Meteorological Center
AMC25	–	Acceptable Means of Compliance (Certification Specification) 25 (EASA document)
AOC	–	Air Operator Certificate
APU	–	Auxiliary Power Unit
ARFF	–	Aircraft Rescue & Fire Fighting
ASL	–	Above Sea Level
ATC	–	Air Traffic Control / Controller (depending on context)
ATIS	–	Automatic Terminal Information System
ATM	–	Air Traffic Management
ATPL	–	Airline Transport Pilot License
ATS	–	Air Traffic Service
CA	–	Civil Aviation
CAA	–	Civil Aviation Authority
CAWS	–	Civil Aviation Weather Station
CBM	–	Condition-based maintenance
CCTV	–	Closed-Circuit Television System
CME	–	Office of the Chief Medical Examiner
CRM	–	Crew Resource Management
CSN	–	Cycles Since New
CT	–	Compressor Turbine

CVR	–	Cockpit Voice Recorder (MC)
DA	–	Decision Altitude
DH	–	Decision Height
DME	–	Distance Measuring Equipment
E	–	Eastern Longitude
EASA	–	European Union Aviation Safety Agency
EGPWS	–	Enhanced Ground Proximity Warning System
EMERCOM RF	–	Ministry of the Russian Federation for Civil Defense, Emergency Management and Natural Disasters Response
ERT	–	Emergency and Rescue Training
F/O	–	First Officer
FAA	–	Federal Aviation Administration
FAP	–	Federal Aviation Rules of RF
FAP-128	–	*Preparation and Conduct of Flight in Civil Aviation of the Russian Federation*, approved by Order №128 of Ministry of Transport of RF as of July 31, 2009
FAP-262	–	*Specifications for Aerodromes dedicated for CA aircraft takeoff, landing and parking*, approved by Order №262 of Ministry of Transport of RF as of August 25, 2015
FC	–	Flight Cycles
FCTM	–	Flight Crew Training Manual
FDR	–	Flight Data Recorder
FH	–	Flight Hours
FIR	–	Flight Information Region
FL	–	Flight Level
FME	–	Flight Medical Expertise
FSBI	–	Federal State Budgetary Institution
FSUE	–	Federal State Unitary Enterprise

ft	–	Foot
GAMC	–	Main Aviation Meteorological Center
Geodinamika-M	–	Scientific Research Center within Moscow State University of Geodesy and Cartography
HF	–	High Frequency
HQC	–	Higher Qualification Commission
IAC	–	Interstate Aviation Committee
IAS	–	Indicated Airspeed
ICAO	–	International Civil Aviation Organization
ICAO	–	International Civil Aviation Organization
IFR	–	Instrument Flight Rules
ILS	–	Instrument Landing System
IPR	–	Intellectual Property Right
ITO	–	Interregional Territorial Office
JSC	–	Joint Stock Company
kt	–	Knot
LH	–	Left-hand
LLC	–	Limited Liability Company
LNAV	–	Lateral Navigation
LTD	–	Public Limited Company
MDA	–	Minimum Descent Altitude
MED	–	Aerodrome Medical unit
MEL	–	Minimum Equipment List
METAR	–	Aerodrome routine meteorological report
MFEC	–	Medical Flight-Expert Commission
MH	–	Mag Heading
min	–	Minute
MSN	–	Manufacturer Serial Number

N	–	North Latitude
NOSIG	–	No Significant Change
NTSB	–	National Transportation Safety Board, USA
OM	–	Operations Manual
PF	–	Pilot Flying
PIC	–	Pilot-in-Command
PJSC	–	Public Joint-Stock Company
PM	–	Pilot Monitoring
psi	–	Pound-force per square inch
QFE	–	Atmospheric pressure at aerodrome elevation
QNH	–	Altimeter sub-scale setting to obtain elevation when on the ground
RF	–	Russian Federation
RH	–	Right-hand
Rosaviatsia	–	Federal Air Transport Agency (RF CAA)
RPGSE	–	Recorders Portable Ground Support Equipment
RRCC	–	Regional Rescue Coordination Center
RSUE	–	Regional State Unitary Enterprise
RVR	–	Runway Visual Range
RWY	–	Runway
s	–	Second
SART ground	–	Ground-Based Search and Rescue team
SIGMET	–	Information concerning en-route weather and other phenomena in the atmosphere which may affect the safety of aircraft operations
SMS	–	Safety Management System
SNDB	–	Standalone non-directional beacon
SSCVR	–	Solid-State Cockpit Voice Recorder

SSFDR	–	Solid-State Flight Data Recorder
SW	–	Soft Ware
TAF	–	Aerodrome forecast
TBO	–	Time Between Overhauls
TC	–	Aviation Training Center
TEM	–	Threat and Error Management
TF unit	–	Task Force Unit
THR	–	Threshold
TOGA	–	Take-Off Go-Around
TSLO	–	Time Since Last Overhaul
TSN	–	Time Since New
TTSN	–	Total Time Since New
TWR	–	ATC tower
UHF	–	Ultrahigh Frequency
UK	–	United Kingdom
UTC	–	Coordinated Universal Time
V_{app}	–	Aircraft approach speed
VFR	–	Visual Flight Rules
VHF	–	Very High Frequency
VMC	–	Visual Meteorological Conditions
V_{ref}	–	Aircraft reference speed
WAFC	–	World Area Forecast Centre
WR	–	Weather Radar
WS	–	Winter Season
WSR	–	Weather Surveillance Radar

Synopsis

On 31.08.2018 Boeing 737-800 VQ-BJI operated by UTAir Airlines conducted the scheduled flight UT 579 from Moscow (Vnukovo airport) to Sochi (Adler airport).

On 01.09.2018, at 02:58 local time (31.08.2018, 23:58 UTC)[1], at nighttime, under heavy showers, with a presence of wind shear, during the landing at Sochi airport, the A/C overrun the runway threshold.

There were 2 flightcrew members, 4 cabincrew members, 166 passengers (164 – RF citizens, and 2 – Ukrainians), and 875 kg of luggage, 822 kg of cargo and 73 kg of mail onboard. In result of the accident 18 passengers asked for the medical assistance. The A/C was damaged. There were no on-ground damages.

The IAC received the information on the accident at 00:28 on 01.09.2018.

The investigation was conducted by the Investigation Team assigned by the IAC Vice-Chairman – Chairman of the AAIC by Order No. 31/889-P of 01.09.2018.

In accordance with Standards and SARPs of Annex 13 to the ICAO Chicago Convention (further "Annex 13"), Notification was sent to NTSB of the USA (the State of Design and the State of Manufacture of the aircraft) and to AAIB of the UK (the State of Registry), as the aircraft was included into the Aviation Register of Bermudas.

The investigation was started on 01.09.2018.

The investigation was completed on 12.12.2019.

A preliminary criminal investigation was being conducted by the Main Directorate for the Major Crimes Investigation of the RF Committee of Inquiry.

[1] Further in this Report the time is given in UTC format. Local time is UTC + 3 h.

1. Factual Information

1.1. Flight history

Fig. 1. View of the aircraft in flight

On 31.08.2018 Boeing 737-800 VQ-BJI operated by UTAir Airlines conducted the scheduled flight UT 579 from Moscow (Vnukovo airport) to Sochi (Adler airport).

During the preflight briefing (at 19:50) the crew was provided with the necessary weather information.

At 20:15, the crew had passed the medical examination at Vnukovo airport mobile RWY medical unit.

The Daily Check line maintenance (DY) was done on 30.08.2018 at Vnukovo airport by UTG aviation services, ZAO; job card # 11465742.

The A/C takeoff weight was 68680 kg and the MAC was 26.46 %, that was within the AFM limitations for the actual conditions.

At 21:33 the takeoff from Vnukovo airport was performed.

The flight along he prescribed route was performed on FL 350 in auto mode and without any issues.

The F/O acted as the pilot flying (PF).

When approaching the Sochi aerodrome traffic control area, the flight crew was provided by the aerodrome approach control with the approach and descending conditions, as well as with the weather conditions near the aerodrome. After descending to the height specified by Sochi Approach, the pilot contacted Sochi Radar, waited for the weather that met his minimum and was cleared for landing.

In course of the first approach to landing (from the altitude about 30 m) when RVR got down because of heavy showers, the PIC took controls and performed the go-around. In course of the second approach, the crew performed the landing but failed to keep the airplane within the RWY. The airplane had landed at about 1285 m from the RWY threshold, overrun the threshold, broke through the aerodrome fencing, and came to rest in Mzymta river bed. This ended with the fire outbreak of fuel leaking from the damaged LH wing fuel tank. The crew performed the passenger evacuation. The aerodrome alert measures were taken and the fire was brought under control.

1.2. Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	8	0
Minor/None	0	10	0

1.3. Damage to Aircraft

In course of the accident the aircraft was significantly damaged.

1.4. Other damage

The aerodrome fence, engineering and technical security equipment and some aerodrome electrical equipment was damaged.

1.5. Personnel Information

1.5.1. Crew Information

Position	**Boeing 737 PIC**
Age	51 years
Education	Aktyubinsk CA Flight School in 1991. Qualification: pilot-engineer

Pilot license	ATPL #0083008 issued by Rosaviatsia HQC on 27.02.2018. Rating: *"airplane B-737-NG, B-737 CL*[2]*"*
Pilot Medical Assessment	On 11.07.2018, hold by Rosaviatsia MFEC at Vnukovo International Airport medical unit. Valid till 11.07.2019
Weather minimum	CAT IIIA ICAO (15 m x 120 m, takeoff 150 m)
Total flying experience	13995 FH (Yak-18T, Yak-40, Boeing 737-300/400/500, Boeing 737-700/800)
Type experience on Boeing 737/ of which experience as PIC	6391 FH/ 5147 FH
FHs within the last calendar month	79 h 05 min
FHs within the last 3 days	08 h 12 min
FHs on the day of accident	02 h 39 min
Total work time on the day of accident	04 h 09 min
Breaks in flights within the last calendar year	Annual leave 16.01.2018 – 14.02.2018
Last check for piloting and navigation skills	20.09.2017, by pilot-examiner, International Flight Department, UTAir Airlines; "excellent"
Preliminary training	18.04.2018
Pre-flight briefing	31.08.2018, at Vnukovo Airport
Pre-flight rest, including sleep	At home/ 30 h
Pre-flight medical examination	Vnukovo Airport MED
ERT dry	29.05.2018
ERT wet	31.05.2018
Simulator Training	18.05.2018, SIM Service and Aviation Solutions (Paris, France); wind shear recovery at the landing phase was included into the training program
Last recurrent proficiency training	"Aeroflot Aviation Training School", Boeing 737-300/400/500/600/700/800, certificate # 038575, issued on 20.11.2017

[2] Here and further if not specified, the author's wording is kept is a quotation done in *Italic*.

Approval for SS operations	10.05.2018
CRM training	Certificate #153-099670 issued on 20.11.2015
Accidents and incidents in the past	None

PIC was graduated from Aktyubinsk Civil Aviation Flight School in 1991. He took a position of F/O for Yak-40 aircraft in Tyumenaviatrans Company, the Khanty-Mansyisk branch office. His experience as F/O on Yak-40 in period from 1991 to November 2000 is 4416 FH.

In November 2000, he took a position of PIC. His experience as PIC on Yak-40 in period from November 2000 to May 2005 is 3217 FH.

In May 2005, he took a position of F/O for Yak-40 aircraft in UTAir Airlines. His experience as F/O on Yak-40 in period from May 2005 to January 2007 is 757 FH.

In January 2007, he took a position of F/O for B-737 aircraft in Sky Express Airlines. The transition training for F/O of Boeing 737-300/400/500 he received at Flight Training International Inc. (Colorado, USA); Certificate # 575064393F3TX signed of 22.03.2007. His experience as PIC on B-737 in period from January 2007 to August 2009 is 1096 FH.

In August 2009, he took a position of PIC for B-737 aircraft. The transition training for PIC of B-737 he received at Amikon Aviation Training (Vilnius, Lithuania); Certificate # 480 08-13 signed of 30.04.2008. His experience as PIC on B-737 in period from August 2009 to October 2011 is 1209 FH.

In October 2011, he took a position of PIC for B-737 aircraft in Air Lines of Kuban, JSC. His experience as PIC on B-737 in period from October 2011 to December 2012 is 461 FH.

In period from December 2012 to August 2013 he had breaks in flights.

In August 2013, he took a position of PIC for B-737 aircraft in UTAir Airlines. His experience as PIC in period from August 2013 to September 2018 is 3423 FH.

The PIC's level of training and experience met the flight task.

Position	**F/O**
Age	53 years
Education	Sasovsk CA Flight School in 1986; qualification – pilot

Pilot License	ATPL #0091025 issued by Rosaviatsia HQC on 29.08.2018. Rating: *"B-737-NG, B-737 CL copilot"*
Pilot Medical Assessment	On 30.03.2018, hold by Rosaviatsia MFEC at Vnukovo International Airport medical unit. Valid till 30.03.2019
Total flying experience	12277 FH (Yak-18T, L-140UVP, An-24, Boeing 737-300/400/500, Boeing 737-600/700/800/900)
Type experience on Boeing 737	5147 FH
FHs within the last 30 days	76 h 50 min
FHs within the last 3 days	08 h 33 min
FHs on the day of accident	02 h 39 min
Total work time on the day of accident	04 h 09 min
Breaks in flights within the last calendar year	Annual leave 16.01.2018 – 31.01.2018, 15.05.2018 – 31.05.2018, 20.07.2018 – 29.07.2018
Last check for piloting and navigation skills	13.11.2017, by pilot-examiner, Flight Detachment #8, UTAir Airlines; "excellent"
Preliminary training	26.03.2018
Pre-flight briefing	31.08.2018, at Vnukovo Airport
Pre-flight rest, including sleep	At home/ 23 h
Pre-flight medical examination	Vnukovo Airport MED
ERT dry	20.02.2018
ERT wet	10.05.2018
Simulator Training	21.03.2018, SIM Service and Aviation Solutions (Paris, France); wind shear recovery at the landing phase was included into the training program
Last recurrent proficiency training	Center of personnel training (Tyumen), Boeing 737 CL/NG, certificate # 279-013604, issued on 18.06.2018
Approval for SS operations	10.05.2018
CRM training	Certificate #153-110427 issued on 10.09.2016

Accidents and incidents in the past	None

F/O was graduated from Sasovsk CA Flight School and from August 1986 till August 1994 took position of Co-pilot for L410UVP aircraft in Blagoveshchensk Flight Detachment[3]. His flight experience during this period is 5008 FH.

In period from August 1994 to January 1999 he had breaks in flights.

In January 1999, he took a position of pilot-instructor for Yak-18T aircraft in Blagoveshchensk unit of Voluntary Society for Assisting Army, Air Force, and Navy. His flight experience during the period from January 1999 to July 2003 is 460 FH.

In period from July 2003 to November 2007 he had breaks in flights.

From November 2007 to February 2010 he took position of F/O for An-24 aircraft in KatekAvia Airlines. His experience at An-24 is 1662 FH.

From 18.01.2010 to 30.04.2010 he received the transition training for B-737-300/400/500 aircraft in Aviation Training Center *S7 Training* (Certificate #10JI 008-13 issued on 30.04.2010).

In April 2010, he took a position of F/O for B-737 aircraft in SkyExpress Airlines. His experience in period from May 2010 to December 2010 is 296 FH.

In December 2010, he took a position of F/O for B-737 aircraft in UTAir Airlines. His experience in period from January 2011 to August 2018 is 4851 FH.

The F/O's level of training and experience met the flight task.

Wind shear recovery training was included into UTair training program on Boeing 737. The PIC received such training on 18.05.2018; the F/O – on 21.03.2018.

1.5.2. ATC Personnel Information

Position	**Flight Dispatcher**
Age	50 years
Education	High: Riga Aeronautical Institute (Latvia) in 1993
Work experience	Assigned to his position by the Order of Aeronavigation of South #330/ok of 20.06.2011
Rating	1 Class ATC controller assigned on 14.12.2001

[3] Comment in Russian here are two alike abbreviations.

License of ATC controller	CD #008366, valid 19.07.2020
Last recurrent training	In 2016 at Aviation Training Center of ATC personnel (flight dispatchers) in St. Petersburg State University of CA
Medical Certificate	Valid till 19.07.2020
Last Check for theoretical skills	02.07.2017
Last Check for practical skills	02.07.2018 at his working station

Position	**Air Traffic Controller + Ground Controller**
Age	28 years
Education	High: Ulyanovsk Higher Civil Aviation School in 2015
Works in current position	Assigned to the position as ATC by the Order of Aeronavigation of South #206 of 02.11.2015; assigned to the position as Ground Controller the Order of Aeronavigation of South #127 of 03.05.2017
Rating	3 Class ATC controller assigned on 22.10.2015
License of ATC controller	CD #016790, valid till 17.07.2019
Last recurrent training	In 2018 at Aviation Training Center of ATM in South Branch of Air Navigation Institute; 2 courses: ATC and English
Medical Certificate	Valid till 27.01.2019
Last Check for theoretical skills	22.05.2018
Last Check for practical skills	12.07.2018

Position	**Ground Controller**
Age	49 years
Education	High: Kirovograd Higher Civil Aviation School in 1992

Works in current position	Assigned to the position as Ground Controller the Order of Aeronavigation of South #73/ok of 19.02.2013
Rating	1 Class ATC controller assigned on 30.06.1998
License of ATC controller	CD #005407, valid 21.07.2019
Last recurrent training	In 2018 at Aviation Training Center of ATM in South Branch of Air Navigation Institute; Attended: senior ATC controller, instructor-controller and English
Medical Certificate	Valid till 23.04.2020
Last Check for theoretical skills	11.05.2018
Last Check for practical skills	30.08.2018

Position	**Ground Controller**
Age	25 years
Education	Vocational: ATC College of St. Petersburg State University of CA in 2016
Works in current position	Assigned to the position as Ground Controller the Order of Aeronavigation of South #269 of 01.12.2016
Rating	3 Class ATC controller assigned on 22.11.2016
License of ATC controller	CD #004541, valid till 08.11.2019
Last recurrent training	In 2018 at Aviation Training Center, senior ATC controllers
Medical Certificate	Valid till 08.11.2018
Last Check for theoretical skills	21.06.2017
Last Check for practical skills	03.03.2018

1.6. Aircraft Information

A/C data

Type of A/C	Boeing 737-800
Manufacturer, date of manufacture	19.11.2002, The Boeing Company (USA)
MSN	29937
Certificate of Registration	#3081 issued by Bermuda CAA on 10.05.2018
Registration	VQ-BJI
Assigned life (h/landings); and life limit	No calendar limitation; on condition
Assigned hours and life till first overhaul	CBM
Certificate of Airworthiness	#1643 issued by Bermuda CAA on 18.09.2017; valid from 05.10.2017 till 04.10.2018 (next scheduled Certificate was issued on 30.08.2018 for the period from 05.10.2018 to 04.10.2019)

Engines' data

Type of Engine	GE H80-200	
	Left	**Right**
Engine MSN	888119	876696
Date of manufacture	13.11.2000	27.10.2000
Manufacturer	General Electric (USA)	
Assigned life; life limit	CBM	
TSN/CSN (h/cycles)	49838 / 26485	49690 / 25535
TBO	CBM	
Engine overhauls	2	2
Last overhaul	16.05.2017, S7 ENGINEERING, Ltd (RF)	29.09.2017, Aero Norway AS (Norway)
SLO (FH/Cycles)	3877 / 1481	2867 / 1094

APU

Engine (type)	GTCP131-9(B)
MSN	P-8957
Date of manufacture, Manufacturer	31.05.2011, Allied Signal (USA)
Assigned life; life limit	CBM
TSN/CSN (h/cycles)	21116 / 7340

TBO	CBM
Number of overhauls	1
Last overhaul	25.02.2016, Triuph Aviation Services Asia, LTD (Thailand)
SLO (h/cycles)	3308 / 1263

7500FH+3YR+4YR+6YR+8YR periodical maintenance CHECK was performed by "TS Technik" LLC (Ufa, RF) on 01.12.2017; maintenance record # 10101638. On-line maintenance DAILY Check (DY) was performed by "UTG aviation services" (Moscow, RF) at Vnukovo airport on 30.08.2018 at 18:30; maintenance record # 11465742.

There were no MEL defects which could influence the aircraft performance recorded.

1.7. Meteorological Information

The meteorological support to the Boeing 737-800 VQ-BJI flight (31.08.2018) along the route Moscow (Vnukovo airport) – Sochi (Adler airport) was provided by the duty shift of Vnukovo unit of "GAMC of Rosgidromet", Federal Service for Hydrometeorology and Environmental Monitoring (license # P/2012/2035/100/ЛИ issued on 26.03.2012, open-ended) and by the CAWS duty shift of Sochi unit of FSBI "Aviamettelecom of Rosgidromet", Federal Service for Hydrometeorology and Environmental Monitoring (license # P/2017/3427/100/ЛИ issued on 06.10.2017, open-ended).

During the preflight weather briefing, the PIC of UTA 579 flight at 19:50 was provided with the meteo documents including the following:

– the METAR weather report made on 31.08.2018 at 19:30 for the following aerodromes: Moscow (Vnukovo), Moscow (Domodedovo), Nizhny Novgorod, Rostov-on-Don (Platov), Mineralnye Vody, and Sochi (Adler), as well as with the TAF forecast for Moscow (Vnukovo airport) for the period from 18:00 31.08.2018 to 18:00 01.09.2018, Moscow (Domodedovo) for the period from 18:00 31.08.2018 to 24:00 01.09.2018, Nizhny Novgorod, Rostov-on-Don (Platov), Mineralnye Vody, and Sochi (Adler) for the period from 18:00 31.08.2018 to 18:00 01.09.2018;

– information SIGMET #6 for Moscow FIR valid for the period from 1830 till 2030 on 31.08.2018 for embed thunderstorm;

– information SIGMET #10 for Rostov FIR valid for the period from 1930 till 2100 on 31.08.2018 for embed thunderstorm;

– fixed time prognostic charts FL 100 – 450 (issued by WAFC, UK Met Office) for ICAO Area Europe, valid for 21:00 on 31.08.2018;

– fixed time wind and temperature charts FL 180, FL 340 (issued by WAFC, UK Met Office) for ICAO Area Europe, valid for 21:00 on 31.08.2018.

On 31.08.2018, the weather at Sochi aerodrome and around it was determined by the stationary cold front waves where the cold front was located along the line Yeysk-Gelendzhik-Varna. Above the Black Sea and the coast, the cold center with high content of water, and that contributed into the development of the convective cumulonimbus with ceiling at 10-12 km and of the long term thunderstorm activity. During the day, according to the Sochi WR-5 data, above the Black Sea and the coast, the cumulonimbus with thunderstorm and heavy showers centers were observed.

Note: *In the area of Sochi airport, the thunderstorms are active throughout the year, and influence the flight operations significantly. Usually it is about 100 thunderstorms per year. It is mostly during the summer period (June – September), when about two-thirds of the total annual amount of thunderstorms occurs. According to the Sochi airport information, it is in August when most of summer thunderstorms occurs, sometimes it is 20 thunderstorms during the month. Half of them occurs at night (from 2100 to 0600, local time).*

The thunderstorm started in the vicinity of Sochi aerodrome at the cold front at 19:18 on 31.08.2018. At 21:07, the meteorological observer had recorded the origin of thunderstorm at Sochi aerodrome and issued the appropriate report. The thunderstorms in the vicinity of and above Sochi aerodrome were continuing till 01:25 on 01.09.2018.

Sharpening of thunderstorm activity at warm part of the cold front with waves showed itself in short-time increase of wind, periodical visibility reducing under the influence of heavy showers and developing of wind shear within the height from the ground up to circuit height (600 m). Under the heavy showers at Sochi aerodrome, the precipitation accumulated during 5 hours reached about 77.5 mm. Maximum precipitation depth was 58 mm during the period of from 23:15 to 23:50 on 31.08.2018.

UTair-579 flight contacted the Sochi-Approach ATC at 23:10 and reported that he has got ATIS (Y) information where the weather in Sochi for 23:00 on 31.08.2018 was broadcasted.

ATIS (Y) for 23:00: ILS approach to RWY 06. Somewhere the depth of water reaches 3 mm, breaking action 0.55, 0.55, 0.55. Surface wind 080°– 10 m/s, gusts 14 m/s, RWY 06 visibility 2000 m, halfway visibility 10 km, RWY 24, visibility 10 km, rain shower, thunderstorm in the vicinity of aerodrome, nonsignificant cloudiness with base at 390 m, continuous cumulonimbus with base at 990 m; temperature + 22 °C, dew point + 19 °C, RWY 06 QFE 759 mm of mercury / 1012 hPa, moderate wind shear in a layer from 200 m to the ground, forecast for landing without change.

At the same time the SIGMET № 11 was transmitted by VOLMET with period of validity from 21:00 till 23:30 on 31.08.2018, where embed thunderstorm with hail was forecasted with top up to FL 380, stationary, with no change tendency.

From 23:15 till 23:50 above Sochi aerodrome, the thunderstorm was accompanied by heavy showers with visibility degradation down to 1000 m.

As UTA 579 flight was governed by Sochi ATC, now and then directly from the controllers the crew received the weather information which was displayed at aerodrome meteorological remote indication monitors (AMIS-RF) and provided at their working stations. The said information was updated every minute.

At 23:35 Sochi-Circuit controller transmitted the following weather: "For RWY 06: wind 090 degrees, 7 m/s, gusts 19 m/s, visibility by the lighting system 3500, 1500, 3500".

At 23:42 Sochi-TWR controller transmitted the following information: "RWY 06, surface wind 130 degrees, 7 m/s, gusts 11 m/s, cleared for landing". At 23:45 UTA 579 flight crew performed a go-around.

When received and analyzed the updated forecast and actual weather and WSR data, the meteorologist on-duty at 21:06 developed and issued the amendment to forecast for Sochi aerodrome for the period from 21:00 31.08.2018 till 21:00 01.09.2018 about the visibility degradation down to 500 m under heavy showers with thunderstorm.

At Sochi aerodrome a meteorological observation usually are done by an assistant meteorologist of AMC of Sochi unit of FSBI "Aviamettelecom of Rosgidromet" from the observation main point with the aid of aerodrome meteorological remote indication monitors (AMIS-RF) with its sensors installed near SNDB, in landing areas and in area of artificial RWY 1 and RWY 2 midpoints (according to the meteorological aids' layout at Sochi aerodrome). Routine observations are to be done at 00 and 30 minutes of each hour. Based on these routine observations AMIS-RF system develops relevant messages and issues areal routine reports and METARs. Special observations are to be done in addition to the routine observations when aerodrome weather conditions are up or down; criteria to the special observations are agreed with Black Sea ATC Center.

Based on the results of the instrumental meteorological observations the area reports are automatically developed and issued (both on routine and special observations) and displayed at the monitors of ATC Automation system SINTEZ-A2 controller working stations. Every minute, the weather information is submitted also to aerodrome meteorological remote indication monitors (AMIS-RF), and provided at the Black Sea ATC Center controller working stations. Observations over weather phenomena, amount and shape of clouds are done by an assistant meteorologist from the observation main point. These data are inserted into AMIS-RF by hand with a view of further transmission.

At Sochi aerodrome, the area weather reports are on the air 24 hours by ATIS. It should be mentioned that ATIS (D) for 23:50 31.08.2018 contained the weather information for landing onto RWY 02, however the landing in question was performed to RWY 06 (the flight crew was cleared for landing to RWY 06 because the actual weather conditions at RWY 06 met the crew minima, but at RWY 02 did not meet). Therefore, the UTA 579 flight crew did not listen for ATIS (D) for 23:50, but received the weather conditions from ATC and Ground controllers in real-time mode. Let us repeat, than the weather information at the controllers' working stations is updated every minute.

Actual conditions for RWY 06 for 23:50: surface wind 210° 3 m/s, gusts 9 m/s, visibility 1900 m, visibility by the high-intensity lighting system 3300 m, heavy showers, thunderstorm above the aerodrome, vertical visibility 180 m, air temperature + 20 °C, dew point + 20 °C, ambient pressure 759 mm of mercury / 1013hPa, moderate winds hear in all layers, thunderstorm cells, mountains covered, on RWY 06 breaking action 0.5, 0.5, 0.5, depth of water 3 mm, fraction of surface covered from 26 up to 50% of artificial RWY. Forecast for landing for two hours: occasionally wind with moderate direction 10 m/s, gusts 22 m/s, visibility 500 m, heavy showers, thunderstorm, significant cloudiness at 180 m, significant cumulonimbus at 600 m.

At 23:54, UTA 579 flight crew received the following information from Sochi-TWR unit: *"RWY06, wind 200 degrees, 4 m/s, cleared for landing"*.

At 23:58 the accident with UTair Boeing 737-800 VQ-BJI aircraft occurred in course of the aircraft landing.

Following weather conditions were forecasted for the time of accident:

Amendment to forecast issued at 21:06 on 31.08.2018 for Sochi aerodrome:

TAF AMD URSS 312106Z 3121/0121 06005MPS 9999 SCT015 BKN030CB BKN100
TEMPO 3121/0108 VRB07G12MPS 0500 +TSRA BKN006 BKN020CB OVC100
FM010800 18005G10MPS 9999 SCT030CB BKN100 TEMPO 0108/0116
25005G10MPS –TSRA BECMG 0116/0117 05006MPS BKN020=

The validity of forecast from 21:00 31.08.20 till 21:00 01.09.2018: wind 060 degrees, wind velocity 5 m/s, visibility 10 km, scattered clouds with base at 450 m, significant cumulonimbus with base at 900 m, significant cloudiness with base at 3000 m, from 21:00 31.08.2018 till 08:00 01.09.2018, sometimes wind with moderate direction, wind velocity 7 m/s, gusts 12 m/s, visibility 500 m, heavy shower, thunderstorm, significant cloudiness with base at 180 m, significant cumulonimbus with base at 600 m, continuous cloudiness with base at 3000 m, from 08:00 01.09.2018 wind 180 degrees, wind velocity 5 m/s, gusts 10 m/s, visibility 10 km, scattered cumulonimbus with base at 900 m, significant cloudiness at 3000 m, sometimes from 08:00 till 16:00 01.09.2018 wind 250 degrees, wind velocity 5 m/s, gusts up to 10 m/s, light showers thunderstorm, in gradual mode from 16:00 till 17:00 01.09.2018 wind 050 degrees, wind velocity 6 m/s, significant cloudiness, base at 600 m.

At the time of the accident, the following storm warning #2 for the period from 20:00 31.08.2018 till 06:00 01.09.2018 was in force on Sochi aerodrome: moderate wind shear at RWY 02 and RWY 06.

Also the storm warning #4 – thunderstorm above the aerodrome – was in force for the period from 18:00 31.08.2018 till 06:00 01.09.2018.

On 31.08.2018 at Sochi aerodrome, the actual weather was as following:

23:56: surface wind 190°– 5 m/s, RWY 06 visibility 6000 m, halfway visibility 4300 m, RWY 24 visibility 7000 m, showers of slight rain, thunderstorm above the aerodrome, significant cloudiness with base at 180 m, significant cumulonimbus with base at 810 m, temperature + 21 °C, dew point + 20 °C, RWY 06 QFE 759 mm of mercury / 1013 hPa, moderate wind shear in a layer from 200 m to the ground, on RWY 06 breaking action 0.5, 0.5, 0.5, depth of water 3 mm, fraction of surface covered from 26 up to 50% of artificial RWY.

23:57: surface wind 190°– 5 m/s, RWY 06 visibility 6000 m, halfway visibility 5000 m, RWY 24 visibility 7000 m, showers of slight rain, thunderstorm above the aerodrome, significant cloudiness with base at 180 m, significant cumulonimbus with base at 810 m, temperature + 21 °C, dew point + 20 °C, RWY 06 QFE 759 mm of mercury / 1013 hPa, moderate wind shear in a layer from 200 m to the ground, on RWY 06 breaking action 0.5, 0.5, 0.5, depth of water 3 mm, fraction of surface covered from 26 up to 50% of artificial RWY.

23:58: surface wind 170°– 4 m/s, RWY 06 visibility 6000 m, halfway visibility 5000 m, RWY 24 visibility 6000 m, showers of slight rain, thunderstorm above the aerodrome, significant cloudiness with base at 180 m, significant cumulonimbus with base at 810 m, temperature + 21 °C, dew point + 21 °C, RWY 06 QFE 759 mm of mercury / 1013 hPa, moderate wind shear in a layer from 200 m to the ground, on RWY 06 breaking action 0.5, 0.5, 0.5, depth of water 3 mm, fraction of surface covered from 26 up to 50% of artificial RWY.

23:59: surface wind 170°– 3 m/s, RWY 06 visibility 7000 m, halfway visibility 8000 m, RWY 24 visibility 7000 m, showers of slight rain, thunderstorm above the aerodrome, significant cloudiness with base at 180 m, significant cumulonimbus with base at 810 m, temperature + 21 °C, dew point + 20 °C, RWY 06 QFE 759 mm of mercury / 1013 hPa, moderate wind shear in a layer from 200 m to the ground, on RWY 06 breaking action 0.5, 0.5, 0.5, depth of water 3 mm, fraction of surface covered from 26 up to 50% of artificial RWY.

No requests for the unscheduled weather search (against the signal "Emergency landing" or "Alert to rescue team") were sent to Sochi AMC unit from a flight dispatcher or from International Sochi Airport ATC operational center after the accident.

The aerodrome meteorological remote indication monitors (AMIS-RF) were installed at Sochi aerodrome as per the NGEA-92 (Standards for aerodrome operations) requirements. All measuring aids were verified by the State Scientific-Research Metrology Institute named after D. Mendeleev on 06.10.2017 (the next verification was planned for 05.10.2018).

Aerodrome meteorological aids were installed at Sochi aerodrome as per the NGEA-92 (with consideration of Amendment #25 of 2005) and Federal Aviation Rules 139 "Aerodrome certification" (volume II), as at the time of the accident were serviceable and properly verified.

Boeing 737-800 VQ-BJI meteorological support during its flight from Moscow (Vnukovo airport) to Sochi (Adler airport) was provided in accordance with effective regulations.

1.8. Navigation Aids, Landing Aids and ATC

The air navigation service for the aircraft at Sochi aerodrome was provided by Aeronavigation of South Black Sea ATC center.

The following aids were used at Sochi aerodrome on 31.08.2018:

- ILS radio beacon landing system SP-200.1 equipped by the DME radio beacon RMD-90NP, and deployed from magnetic direction of 058° of the runway to be used;
- azimuth Doppler VHF omnidirectional radio range DVOR 2000;
- 3 omnidirectional UHF radio beacons DME 2000;
- radio beacon RMP-200;
- radio beacon ARM-150MA;
- automated radio beacon system APR-7;
- local augmentation station LKKS-A-2000 (to be used for non-precise landing approach).

All aides were subjected to entry and periodical flight checks which were done within scheduled dates. All navigation, landing and ATC aids at Sochi aerodrome at the time of the accident were operating normally.

1.9. Communication Means

Sochi aerodrome is equipped by the following communication means:

- automated VHF transmit center APPC;
- VHF transmitters Fazan-19P50;
- HF transmitters PP-1000;
- VHF transmitters Fazan-19PRM;
- radio relay stations MIK-RL8;
- radio relay stations Radian-15;
- standalone retransmission station RP;
- VHF radio Fazan-19R50;
- VHF radio Fazan-19R5.

All aides were subjected to entry flight checks which were done within scheduled dates. All communication means at Sochi aerodrome at the time of the accident were operating normally.

1.10. Aerodrome information

Sochi aerodrome is located at the Black Sea coast about 2 km from Adler city to the North-East direction.

It is a joint civil and military aerodrome of international class B. The aerodrome is operated by "Sochi International Airport", LLC.

The field looks like a triangle outstretched in direction from North-East to South-West with its sides 3500 x 3000 x2000 meters. The surface is flat, loam soil with some pebbles covered by grass. The ground is soft, not usefully for aircraft landing.

There are two artificial RWY at the aerodrome, RWY 06/24 and RWY 02/20, both are artificial with concrete surface, they are crossing each other with 36º08′34″ angle.

RWY 06/24 with dimensions 2895 x 45 meters, concrete.

The radio beacon landing system is located at + 15.8 m above RWY 06 threshold.

The aerodrome surface class is PCN 63 R/B/W/T.

RWY 06/24 longitudinal gradients is 0.5 %, the crossfall gradients 0.01 %.

No braking strips are provided from either direction.

Strengthen part of RWY 06 threshold is 75 m, of RWY 24 – 55 m.

Free zone (SZ) near RWY 06 threshold is 150 x 150 meters, RWY 24 threshold doesn't provided with the free zone.

RWY 06 threshold: true angle of track is 064º50′44″, magnetic angle of track is 058º, landing MH is 058º.

THR 06 altitude is + 11.91 m.

THR 06 coordinates are: N 43º26′22.05″, E 039º55′32.77″.

RWY 24 threshold: true angle of track is 244º52′04″, magnetic angle of track is 238º, landing MH is 238º.

THR 24 altitude is + 26.35 m.

THR 24 coordinates are: N 43º27′01.91″, E 039º57′29.32″.

The acritical RWY is equipped by IDMAN lighting equipment.

White landing lights are located along RWY as two parallel lines situated at 3 m from RWY edge with interval of 60 m. At last 600 m the lights are yellow.

Dedicated aerodrome vehicles ATT-2 and ATT-2M measure the breaking coefficient at RWY.

1.11. On-board recorders

The aircraft was equipped with Honeywell on-board flight data recorder SSFDR 980-4700-042, L3 uQAR MODEL QAR200 and Honeywell cockpit voice recorder (CVR) SSCVR 980-6022-001.

All three recorders were found at their normal on-board locations, removed; they showed no damages.

The data downloading was performed in IAC Laboratory using the normal Honeywell SW RPGSE. In course of the performed work the following was found:

1. Honeywell SSFDR 980 4700-042 (FDR system) was found serviceable and contains the data related to Boeing 737-800 VQ BJI flight that had been performed on 31.08.2018 at Sochi airport and ended with the accident.
2. L3 uQAR MODEL QAR200 was found serviceable; the data related to the last Boeing 737-800 VQ BJI three flights was found, including the last flight along the route Moscow (Vnukovo airport) – Sochi (Adler airport) performed on 31.08.2018.
3. Honeywell SSCVR 980-6022-001 CVR was found serviceable; the recorded data was found as following five sound files: three of them each 30 min long and two of them (open mike and mixing signal) each 02 h 05 min long which meets the length of the last flight of Boeing 737-800 VQ BJI on 31.08.2018.

The downloaded data was used for the accident investigation purposes.

1.12. The A/C fragments' condition and location

The aircraft when overrun the threshold, broke through the aerodrome fencing and came to rest in Mzymta river bed. This ended with the fire outbreak of fuel leaking from the damaged LH wing fuel tank. The left and right half wings, both engines, the nose and RH main landing gear legs; the LH landing gear leg had been separated and was found under the LH half wing. The fuselage showed the significant deformation. All structure elements were found lying together within one spot (see Fig. 2).

Fig. 2. The aircraft at the accident site.

1.13. Medical and Pathological Information

All the crew members had the required medical certificates and were authorized for performing their functions with respect to their professional licenses.

Both PIC and F/O passed the medical examinations in the medical unit of "Sochi International Airport", LLC after the accident. No traces of alcohol or other intoxicants were found within the expired air or other biological matrix; the rapid test for the presents of drugs is negative.

There were no traces of ethyl alcohol found during the PIC and F/O bodies' forensic examination.

1.14. Survival Aspects

Nobody was killed in the accident. Some passengers received injuries: 18 persons called for the medical help, 8 of them were taken to hospital (among them 5 passengers and 3 kids). Nobody was killed on the ground.

1.15. Search and Rescue Operations

No search-and-rescue operations were conducted as the accident occurred at the aerodrome area.

At 23:58 31.08.2018 the fire-fighting launch unit officer right after the Boeing 737-800 VQ-BJI had landed saw the fire flash in the end of RWY 01; he alarmed the rescue fire squad.

At the same time the firefighter dispatcher received alert from GORN-2 system with the following voice annunciation: "Alert, an aircraft run out RWY 01 and got fire".

Then all additional information was transmitted and delivered in accordance with the alerting procedure.

At 00:00 01.09.2018 the first firefighting aerodrome vehicle arrived to the accident site, the personnel started to fight the fire and to evacuate the people from the Mzymta River.

At 00:01, three more fire-fighting aerodrome vehicles arrived and started to help.

At 00:15, the fire was brought under control; the fire-fighting personnel had finished the passengers' and crew members' evacuation from the Mzymta River.

At 00:28, all passengers and crew members had been taken to the airport terminal building. The firefighting personnel searched the airplane cabin for to be sure that no people had been left inside.

The fire-fighting team members provided the security of the accident site till the arrival of the Investigation team.

1.16. Tests and Research

1.16.1. Fuel and oil samples' analysis

Specialists of the Main Directorate for Major Investigations at the Public Prosecutor's Office of the Russian Federation have sent all fuel samples taken from the Boeing 737-800 VQ-BJI fuel tanks for the analysis to the crime laboratory of the Transport Department of the Russian Federation Ministry of the Interior within the Central Federal Region. The analysis was conducted.

No contaminations were found in the kerosene samples, such as hard particles, water, and other components which are representative for the light middle-distillate oil products (petroleum spirit type), gasoline, diesel oil, lubricants (petroleum-based) with consideration of the methods that were used during the analysis.

It was not possible to found the exact grade of the kerosene due to the absence of the necessary tools.

1.17. Organizational and Management Information

UTair Airlines, PJSC

UTair Airlines (the Company) was incorporated in accordance with the procedure established by Federal law on juridical person state registration; the enter #1028600508991 was made to the Unified State Register of Legal Entities, the license 86 № 002516358 was issued by Interdistrict Inspectorate of the Federal Tax Service No. 1 for the Khanty-Mansijsk (Yugra) Autonomous District.

The Company address is: airport, Khanty-Mansijsk City, the Khanty-Mansijsk (Yugra) Autonomous District, the Tyumen Region, 628012, RF.

The Company was established by the State Committee for State Property Management of the RF in accordance with the Edict of the President of the Russian Federation "On managerial procedure of transforming Public Enterprises into Joint-Stock Companies" of 01.07.1992 № 721.

The Company has the following airports of location: Moscow (Vnukovo), Surgut, Tyumen (Roshino), St. Petersburg.

The Company Charter stipulates its objectives and types of activity. The main objective is commercial.

The main types of activity are:

- commercial transportation of passengers, of cargo, luggage, mail with the air transport along the international and local airways;
- sales of the said transportations;
- flight operations and maintenance of the aircraft in accordance with the existing norms, rules and standards;
- flight operations' planning, establishing and supporting;
- air traffic control and management;
- radiotechnical and navigation aids' operation, and providing of aeronautical telecommunication;
- providing of maintenance and overhaul for aircraft in accordance with aviation norms, rules and standards;
- operation of aerodrome, aerodrome equipment, terminals and equipment, terminal buildings, vessels and treatment facilities;
- fuel, oil, dedicated liquids and gas storage and quality monitoring, aircraft ground service and refueling;
- aircraft purchase and sale, rent and lease in accordance with the existing legislation;

- protection of passengers from acts of unlawful interference, providing of aviation safety;
- pre-flight and post-flight inspection of passengers and luggage including cabin luggage of passengers, of crewmembers, civil aviation personnel, of aircraft onboard items, cargo and mail;
- providing of aerial works;
- providing of search and rescue flight support;
- providing of training for aviation personnel in accordance with the available license;
- providing of air transportation servicing;
- providing of medical service in accordance with the existing legislation;
- providing of flight medical expertise, medical examination in accordance with the existing legislation.

All the activities above are to be conducted in accordance with the RF legislation. Some types of activity (the list is stipulated by the RF Federal Laws) can be executed if the Company has got the special permission (license) for it only.

UTair Airlines conducts its activity based on the following documents:

- AOC #6, issued by Rosaviatsia on 23.06.2015 (the initial one was issued on 25.03.1992);
- operating license of air transport, passengers and cargo; operating license for execution
- of all types of airline charter and regular passengers flights (License # PP 0001, issued by Rosaviatsia on 27.04.2016, without time limits);
- operating license for air cargo transportation; operating license for execution of all types of airline charter and regular cargo flights (License # PP 0002, issued by Rosaviatsia on 27.04.2016, without time limits).

UTair Airlines performs the maintenance for its aircraft at maintenance organizations on base of the agreements with these organizations.

Sochi Aerodrome

Sochi Aerodrome is a common use aerodrome both for civil (RF Ministry of Transportation) and military (RF Ministry of Defense, Russian Federal Security Service, Ministry of Emergency Situations of RF) aviation by the Edict of the Government of RF # 1034-p of 10.08.2007.

Sochi Aerodrome is a Principle aerodrome by the Edict of the Government of RF # 726-p of 20.04.2016.

The aerodrome is operated on base of the compliance certificate for activity, issued by Rosaviatsia Directorate of airport management # АД00118 issued of 01.08.2018.

The class B aerodrome in Sochi is included into the State Register of RF CA aerodromes and helidromes and has the certificate of registration # 62 of 30.01.2014.

The authority which provides the supervision in accordance with the RF legislation for the CA is Ural Country Team of Administration of state aviation supervision and supervision over transportation security for Rostransnadzor Ural Federal District.

1.18. Additional Information

1.18.1. Known windshear cases

In course of the accident current investigation, the Investigation team has analyzed the go-around cases related to wind shear warning that were performed by UTair flight crews in period of 2017 - 2018 when they were flying Boeing 737 aircraft. There are 4 cases found; in two of them the crew performed the go-around right after the warning had been received (in 2-or-3 s), one go-around was performed in 18 s after the warning had been received (flight UTA 400, 26.04.2017, Vnukovo airport, Moscow) and the last one performed in 24 s after the warning had been received (flight UTA 247, 26.04.2017, Surgut airport). These four cases have been included into the flight operations SMS. The flight crew actions were assessed. However, as the current accident is already the third case when a crew does not react just after wind shear warning is received, do not perform the go-around maneuver, but continue descending and moreover – perform landing.

1.18.2. Documents that regulate the crew reporting to ATC procedures related to the wind shear

In course of the investigation it was found that the crews that received the wind-shear warning while they were approaching to landing performed the go-around procedures without reporting the reason of it to the ATM unit. However, in such case all crews belong to Russian airlines have to follow the requirements of national document FAP-128 item 3.117.

Note: ***FAP-128:***

«3.117. When possible, the crew has to inform the ATM unit (if necessary using priority alarm) in following challenging cases:

engine (engines) failure, if it is impossible to perform the flight at or above the safety altitude;

aircraft entered a zone with weather phenomenon hazardous…

3.118. As a hazard weather the following weather is considered:

active thunderstorm area, heavy rains, high atmosphere electrical activity, icing,

*turbulence, **wind shear**, volcanic ash, heavy sandstorm and duststorm."*

Crews belong to the airlines of other states have to follow the requirements of international documents: ICAO Annex 3 *Meteorological Service for International Air Navigation* and Doc 9817 AN/449 *Manual on Low-level Wind Shear*.

Note: *1. Manual on Low-level Wind Shear (**ICAO DOC 9817 AN/449**):*

"5.3.7 In view of the lack of remote-sensing equipment capable of detecting and measuring low-level wind shear, information on wind shear at most aerodromes is largely based upon air-reports, a situation acknowledged in Annex 3, Chapters 4 and 7. Such air-reports are to be made in accordance with Chapter 5, 5.6, of Annex 3. Because it may be the only source of information, the reporting of wind shear by pilots is of vital importance in helping to safeguard other aircraft. Ideally, pilots should give the maximum amount of relevant information to help other pilots assess the likely effect of the wind shear on their own aircraft."

*2. Meteorological Service for International Air Navigation (**ICAO Annex 3**):*

"5.7.2 Aircraft observations shall be reported during flight at the time the observation is made or as soon thereafter as is practicable."

1.18.3. Regarding the Procedures of Go-Around from below DH

UTair Airlines JSC didn't develop the recommendations (depending from the aircraft landing mass, available climb gradient, meteorological situation) for forced go-around performed after passing the decision height (DH) at the aerodromes with complicate navigating conditions for approach to landing, such as Sochi, Gelendzhik, Nalchik and so on, where the Company operates the aircraft.

1.18.4. Monitoring of RWY surface condition at Sochi airport

In course of monitoring of RWY surface condition at the Boeing 737-800 VQ-BJI landing on it, the Investigation team found that the aerodrome services made the surface assessment of RWY 06 in period from 23:00 to 23:10 31.08.2018. As it is shown in the extract of the radio communication record, the airport service officer reported to the ATC controller: *"START-1, Aerodromnaya-425, has just release RWY 06/24, the situation is similar as we have for RWY 02: wet, 0.5 at each third, 3 mm, 30 %."* According to Sochi AMC (booklog AB-6), there was rain shower at the aerodrome with visibility reduction to 250 – 800 m. According to measurements, the precipitation depth was 58 mm. In period after the rain passed away and before the Boeing 737-800 VQ-BJI landed at 23:58, there were no measurements at RWY 06 performed by the aerodrome services.

Note: *"**Procedure of cooperation** of aerodrome services with the "Aeronavigatsiya Yuga" unit of the Black Sea ATC and with other organizations that provide flight servicing for Sochi aerodrome",*

item 7:

7.1. Measurement of the surface friction values is to be performed by the person in charge of "Sochi International Airport", LLC, when the runway surface friction characteristics change due to the rain (snow/ice) and/or after the snow-removing works are completed at the runway.

7.2. If the weather conditions cause the alternating of friction coefficient (μ):

- *person in charge if sees that the weather reaches the conditions when may influence the surface conditions of runways, taxiways and high speed taxiways, is to report to the head of shift about the necessity for performing the aerodrome field surface assessment and friction coefficient measuring.*
- *flight supervisor issues the permission to a person in charge for the measuring of friction coefficient, precipitation depth and other surface measured parameters."*

1.18.5. Regarding the procedures of calculation of landing performance depending on RWY conditions

For the time being for calculating of the after landing braked stopping distance, one needs to use the normative braking friction coefficient value transmitted by ATIS or received from ATC controller. At landing, the Boeing 737-800 VQ-BJI flight crew used the transmitted by ATIS coefficient of μ = 0.55/0.55/0.5 measured by use of the aerodrome braking cart ATT-2M for the calculations.

In accordance with the Airlines OM, A-8 8.3.2.7.1 for landing performances including the correspondence between the required rolling distance and available field length by use of Boeing OPT (Onboard Performance Tool) calculating, the crew should have the following data available: RWY condition, wind speed and direction, OAT, and QNH.

For the landing performances calculating, the crew had no means to input the RWY friction coefficient into Boeing OPT as this possibility was not provided within the Tool. The crew had a choice: either they could have imput the braking efficiency or the RWY condition (however, it was possible to input just the RWY condition which was related to an amount and depth of water, slush or snow).

For the OPT data (related to a braking efficiency) input, it is recommended to use the tables published in Airlines OM, Part A, Part A-8 (Airplanes) *Operational Requirements and Procedures*, item 8.1.15.1 *Assessment of RWY surface conditions and braking efficiency indicators*, Table A-8.1.15.2, row one, where the following is stated: "*Normative friction coefficient is 0.57 – 0.42, estimated friction efficiency is GOOD."*

Table A-8.1.15.2.

Normative friction coefficient	**Estimated surface friction**	**Operational meaning**
0.57 – 0.42	Good	No undue directional control problems are expected
0.41 – 0.40	Medium to good	No undue directional control problems are expected
0.39 – 0.37	Medium	Directional control might be impaired
0.36 – 0.35	Medium to poor	Directional control might be impaired
0.34 – 0.30	Poor	Directional control will be poor
0.29 and below	Unreliable	Directional control is not monitored

These tables are also published in AIP Russia.

In 2007, Boeing issued FOTB (Flight Operations Technical Bulletin) *Landing on Slippery Runways*. In FOTB, Boeing following the FAA recommendations recommends for estimated landing distance calculation in addition to the friction coefficient measured by friction-measuring equipment to use the air reports related to the surface friction (good, medium, poor) and actual conditions (dry, wet, snow- or ice-covered).

In 2016, FAA published SAFO 16009 (Safety Alert for Operators) *Runway Assessment and Condition Reporting*. This document recommends changing the manner of RWY condition data providing so that to provide the data, that is related directly to the aircraft braking performance (category, amount and depth of the contaminants which are available at RWY).

Note: ***SAFO 16009*** *of 15.08.2016: "The FAA is implementing the use of the Runway Condition Assessment Matrix (RCAM) which will be used by airport operators to perform assessments of runway conditions and by pilots to interpret reported runway conditions. The RCAM is presented in a standardized format, based on airplane performance data supplied by airplane manufacturers, for*

> *each of the stated contaminant types and depths. The RCAM replaces subjective judgments of runway surface conditions with objective assessments tied directly to contaminant type and depth categories."*

Here we are talking about RCAM (Runway Condition Assessment Matrix) as of result of more than 10-years long work conducted by TALPA (Takeoff and Landing Performance Assessment) Advisory and Rulemaking Committee (ARC) that was established by FAA. Boeing includes RCAM in FCTM since 2015.

The similar approach to the estimated landing distance calculation is used for RRJ-95 airplanes. Sukhoi Civil Aircraft uses the wheel braking coefficient (tyre-to-ground) for calculation of the forces which affect the airplane when the later brakes in course of the after landing roll. For the actual friction coefficient (by FDR records) calculating, they use the method of measuring of braking torque in the moment when the wheel starts sliding. The method was verified by RRJ-95 airplanes flight test results, when the airplanes were equipped with dedicated braking torque measurement gauges. These tests helped to define the correspondence between the braking torque and hydraulic fluid pressure in the braking gears.

The value of the aircraft braking coefficient used for the flight simulation differs from the value of the normative friction coefficient which is measured by use of aerodrome braking carts because the design of aircraft landing gear tyres significantly differs from the aerodrome braking cart wheel tyres; there is a significant difference between a speed of aircraft (when braking during landing) and a speed of aerodrome braking cart (when measuring). Therefore, for calculation of the aircraft braking performance, it is better to convert the normative friction coefficient value into the wheel braking coefficient (tyre-to-ground). The conversion algorithm is unique for each aircraft type. Figure 3 shows the correspondence between friction coefficient and ground speed depending on the RWY condition.

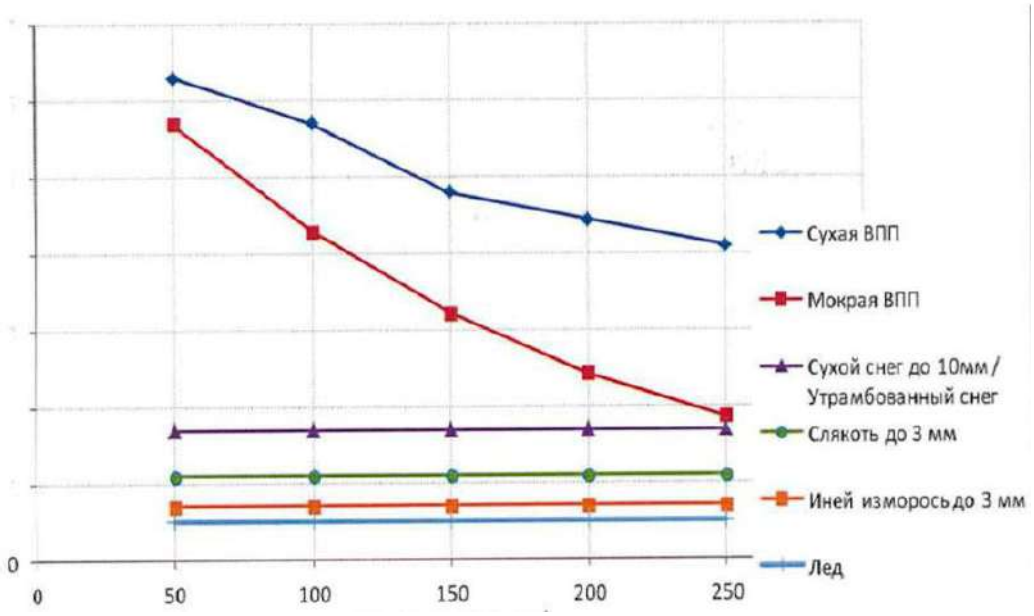

Fig. 3. Correspondence between the friction coefficient and the aircraft ground speed depending on the RWY condition

Legend to Fig 3:

axis Y	—	friction coefficient (units and their values of friction coefficient are not shown because this is the confidential property of IPR holder;
axis X	—	ground speed (km/h);
dark blue line	—	dry RWY;
dark red line	—	wet RWY;
violet line	—	dry snow with depth up to 10 mm, compacted show;
green line	—	slush with depth up to 3 mm;
scarlet-red line	—	rime icing, drizzle depth up to 3 mm;
light blue line	—	ice.

For calculating of the aircraft braking performance at RWY covered with precipitations, the RRJ0000-TC-02-148 recommendations (based on AMC 25.1591) agreed with GosNIIGA Certification Center were used.

Sukhoi Civil Aircraft methodology for friction coefficient calculating in a function of RWY length, as well as the method of use of the calculated friction coefficient for estimated landing distance calculating is somehow similar to FAA position according to which it is also required to use the actual RWY conditions for such calculations.

1.18.6. Sochi Aerodrome RWY inspection

In November 2017, LenAirProject Air Transport Pre-Project Planning and Scientific-Research Institute, LLC, performed the inspection of both RWYs at Sochi aerodrome. The artificial RWY surface evennes was estimated for each third of a runway in accordance with *Specifications for Aerodromes dedicated for CA aircraft takeoff, landing and parking* approved by Order №262 of Ministry of Transport of RF as of August 25, 2015 (further FAP-262). In accordance with FAP-262 provisions, the surface evenness can be described by R-index (surface evenness index). The index was calculated based on three elevation heads of three longitudinal sections of RWY 06/24 and RWY 02/20[4] which were measured by short-range step-by-step differential leveling by Geodinamika-M LLC experts. In result of the abovementioned work, the experts received the R-index value which represents the consolidated statistical measure of the mean RWY surface unevenness averaged over the RWY longitudinal profile. As result of the calculation, the minimum statistical R-index value was received over the total length of RWY 06/24. It was R = 4.7 (for RWY 02/20 the index value was R = 3.8). These values meet FAP-262 requirements.

Note: *In accordance with FAP-262 item 2.38: "For runways of aerodromes Class A, B, C, which are open for the international operations, the generalized surface evenness index (R-index) shall be determined. The value of R-index for the abovementioned runways shall be not less than 2.*

The runway surface evenness shall be inspected of the new constructed (re-constructed) aerodromes, and of the existing aerodromes after the re-construction (repair)."

The Geodinamika-M Report states that on RWY 06/24 at distance of 2206 m from the RWY 06 threshold and further, the profile with two sloping surfaces changes for the profile with one sloping surface (with left to right pitch) and keeps this shape up to RWY 24 end.

In period from 20.04 to 28.04.2019, the experts of the standalone subdivision (Central Test Laboratory of Administration of civil airports (aerodromes), FSUE) performed the inspection and monitor of RWY 1 rain removal and venting system with use of Rausch ECO-Star 400 Variable Control Unit for CCTV inspections equipped by push cameras. In course of the inspection it was found that the rain removal and venting system collecting canals 1 and 2 are serviceable, and water drainage from RWY 1, intersection of RWY 1 with RWY 2 and from the taxiways is being provided normally.

[4] Geodinamika-M experts have conducted the RWY 06/24 centerline profile calculation in increments of 0.5 m and the calculation of two parallel profiles spaced 3.9 m apart the centerline.

1.18.7. Horizontal Wind Shear

Consider an aircraft flying a 3deg ILS on a stabilized approach at 140 knots indicated airspeed (IAS) with a 20-knot headwind (Fig. 4).

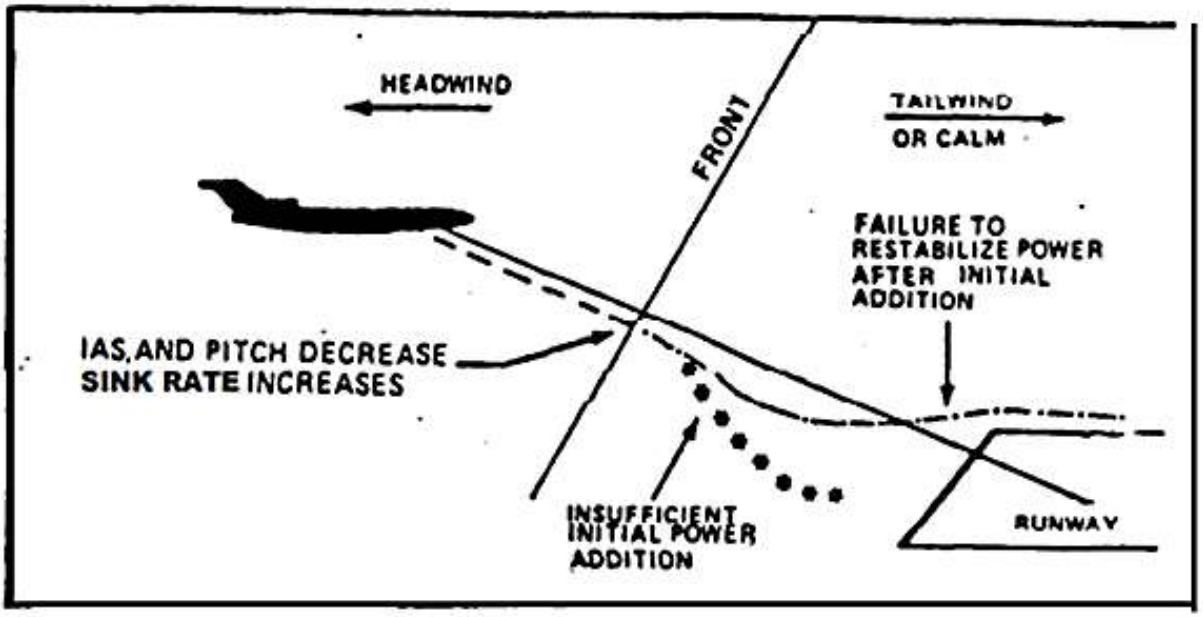

Fig. 4. Trajectory of the aircraft under the headwind influence

Assume that the aircraft encounters an instantaneous wind shear where the 20-knot headwind shears away completely. At that instant, several things will happen; the airspeed will drop from 140 to 120 knots, the nose will begin to pitch down, and the aircraft will begin to drop below the glide slope. The aircraft will then be both slow and low in a "power deficient" state. The pilot may then pull the nose up to a point even higher than before the shear in an effort to recapture the glideslope. This will aggravate the airspeed situation even further until the pilot advances the throttles and sufficient time elapses at the higher power setting for the engines to replenish the power deficiency. If the aircraft reaches the ground before the power deficiency is corrected, the landing will be short, slow, and hard. However, if there is sufficient time to regain the proper airspeed and glide slope before reaching the ground then the "double reverse" problem arises. This is because the throttles are set too high for a stabilized approach in a no-wind condition. So, as soon as the power deficiency is replenished, the throttles should be pulled back even further than they were before the shear (because power required for a 3deg ILS in no wind is less than for a 20-knot headwind). If the pilot does not quickly retard the throttles, the aircraft will soon have an excess of power: i.e., it will be high and fast and may not be able to stop in the available runway length.

When applying normal landing techniques, pilots who land their aircraft with a higher than normal approach speed tend to bleed off the speed by floating the aircraft. Floating the aircraft just off the runway surface before touchdown should be avoided because this will use a significant part of the available runway. In case of a tailwind operation the associated increase in ground speed will further increase the landing distance. As the aircraft comes closer to the ground the tailwind will normally decrease. This has a temporary lift increasing effect due to the increase in true airspeed (inertial effect) making it more difficult to put the aircraft on the ground, which amplifies floating of the aircraft.

1.19. New methods used in course of the investigation

No new methods have been used for the investigation.

2. ANALYSIS

Before Sochi terminal control area entering, the crew communicated to ATM Rostov Area Center controller and received the actual weather for Sochi aerodrome. The before landing briefing was conducted between 22:54:50 and 22:56:30 when the aircraft was at FL 350 and while F/O was piloting the aircraft (PF). Based on the briefing records one can see that the crew was planning to perform ILS landing to RWY 06, while the aircraft Vref was 147 kts, and Vapp 155 kt. The crew received the μ-coefficient = 0.55, therefore, they were planning to mode 3 of the automatic braking. The crew has set DA at 627 ft by QNH (by QFE DA was 588 ft), decided that in case of go-around they take FL 100, and determined the amount of fuel saying that: "we have fuel enough for flying to Vnukovo".

Note:

1. *The Operator (UTAir Airlines) requests to calculate minima for landing to aerodromes for the airplanes belonging to UTAir park by the Aerodrome operating landing and takeoff minima (OM, Part C, Attachment 1.2.1).*
2. *With this consideration the crew minimum for landing within the current QFE conditions was 180 x 2000 m.*

After completing of the before landing briefing, the crew read the Descent Checklist and requested the clearance for descending at the approved height. ATM Rostov Area Center controller cleared the aircraft for descending down to FL 210.

At 23:04:45, the aircraft was ready to descend. In course of descending, the crew was listening to ATIS (Y) broadcast.

Note: *1. SOCHI aerodrome ATIS (Y) for 23:00:*

"ILS approach to RWY 06. Somewhere the depth of water reaches 3 mm, normative breaking action 0.55, 0.55, 0.55. RWY 24 for landing, somewhere the depth of water reaches 3 mm, normative breaking action 0.55, 0.55, 0.55. Transition level 50. Reference point at 1513 m. TWY N is closed from TWY H till TWY M, TWY R is closed. In vicinity of aerodrome and final approach, birds can be detected.

RWY 06: wind 080° – 10 m/s, gusts 14 m/s. Circuit 160 degrees – 6, visibility 2000. RVR over 2000. Thunderstorm in vicinity of aerodrome, rain showers, scattered clouds 390, continuous cumulonimbus 990, temperature 22. Dew point 19, QFE 759 mm, 1012 hPa;

RWY 24: wind 070° – 6 m/s, gusts 14. Visibility over 10 km, QFE 758 mm, 1010 hPa.

Warning: moderate wind shear in the layer between the ground and 200 m. Cells of thunderstorm in vicinity of aerodrome NOSIG. Mountains are closed. Acknowledge receipt of information Y."

2. From 22:00 till 22:30 31.08.2018 above Sochi aerodrome, heavy rains were detected, which caused the RWY 02/20 covered with water up to 5 mm depth (it was shown in the airport service report on its inspection at 22:26). Therefore, by the flight dispatcher order, the RWY 02/20 was temporary closed; for operations, takeoffs and landings RWY 06/24 in use, however the airport services reported that it was at 25 % covered with water depth up to 3 mm, breaking action 0.55, 0.55, 0.55.

When the crew listen АТИС broadcast, they realized that the wind was high and therefore corrected the automatic braking mode changing it to "MAXIMUM".

At 23:10:34, the crew reported FL 210 reaching and was advised to communicate Sochi-Approach.

Note: *Here and further when descending from one flight level to another, the crew reported every level reaching beforehand and after the report, received every other clearance to descend further. Actually, the descent was performed continuously by the assigned vertical speed, and the vertical speed value was within the range from minus 2300 to minus 700 ft/min.*

At 23:11, the crew communicated Sochi-Approach reported of FL 210 keeping and of АТИС (Y) information availability on-board. Approach controller cleared for descent to FL 110 by MOBIT 4A arrival pattern and further for ILS approach to RWY 06 by the approach pattern (Fig. 5 and 6). Also, the approach controller informed that the previous airplanes had to avoid the thunderstorm cells.

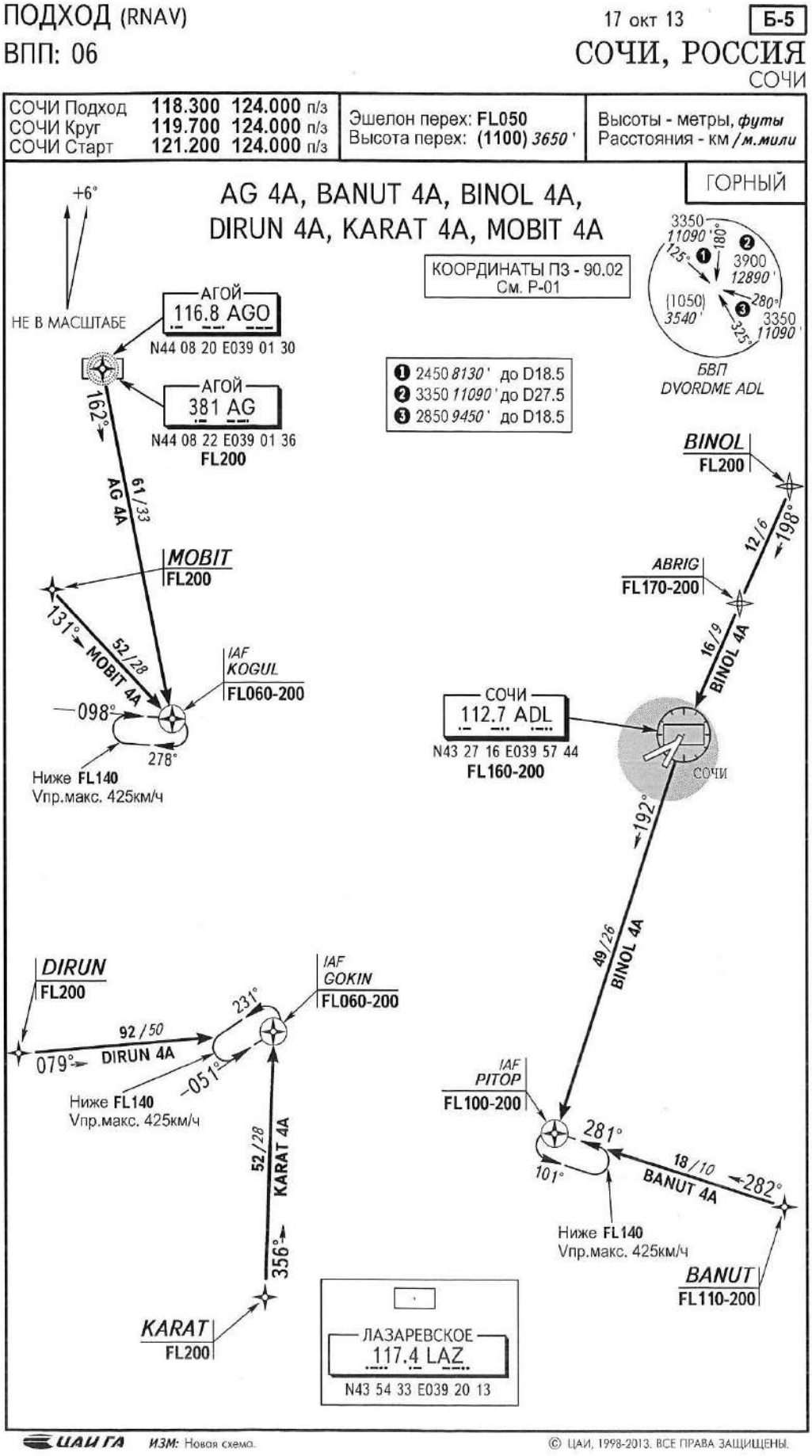

Fig. 5. Sochi aerodrome arrival chart

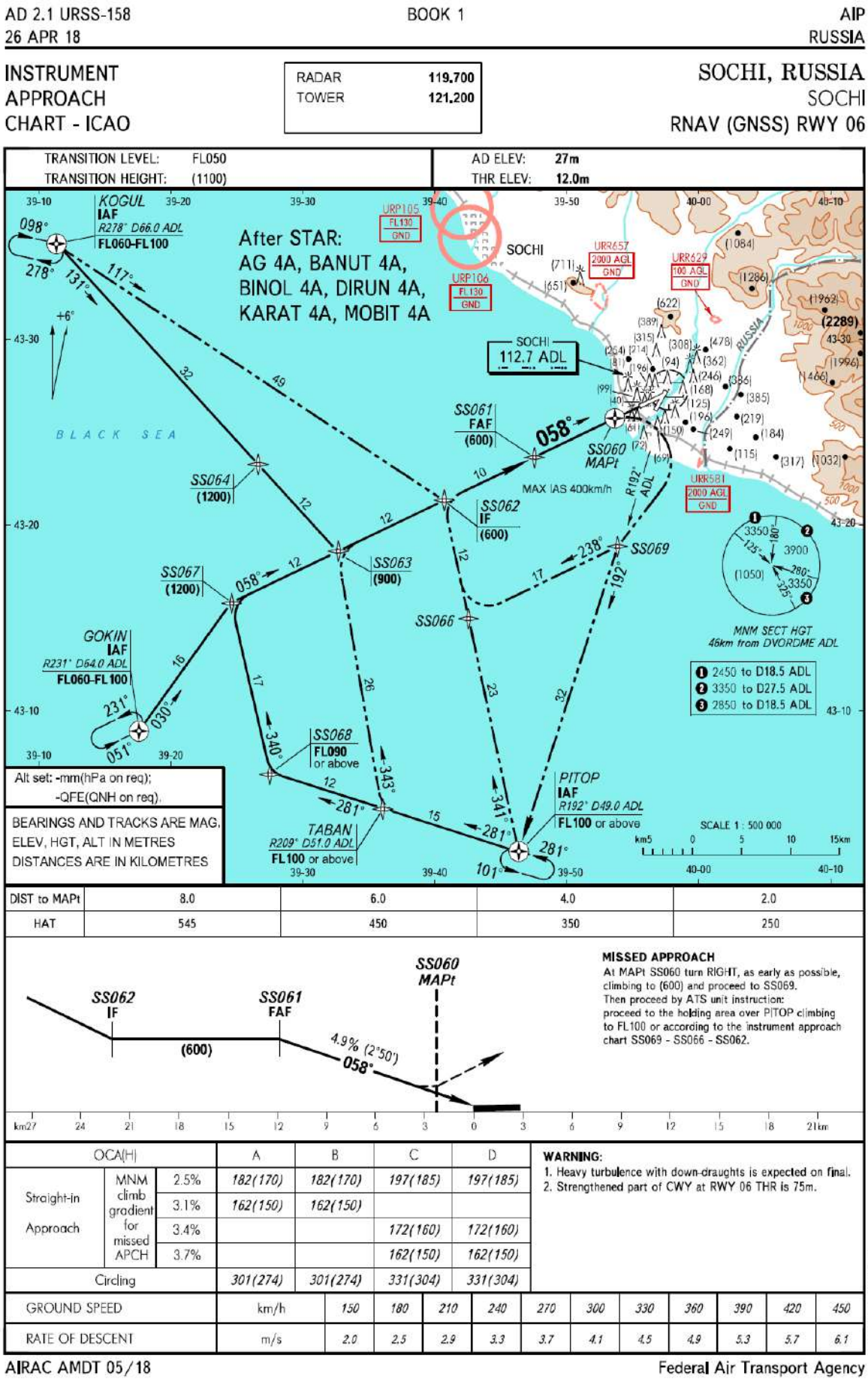

Fig. 6. Sochi aerodrome ILS approach chart

In respond to the PIC request, the controller cleared the aircraft for the thunderstorm cell avoidance by the onboard radar (Fig. 7 shows the aircraft trajectory when transiting from South Branch of Air Navigation area of responsibility to PITOP waiting area).

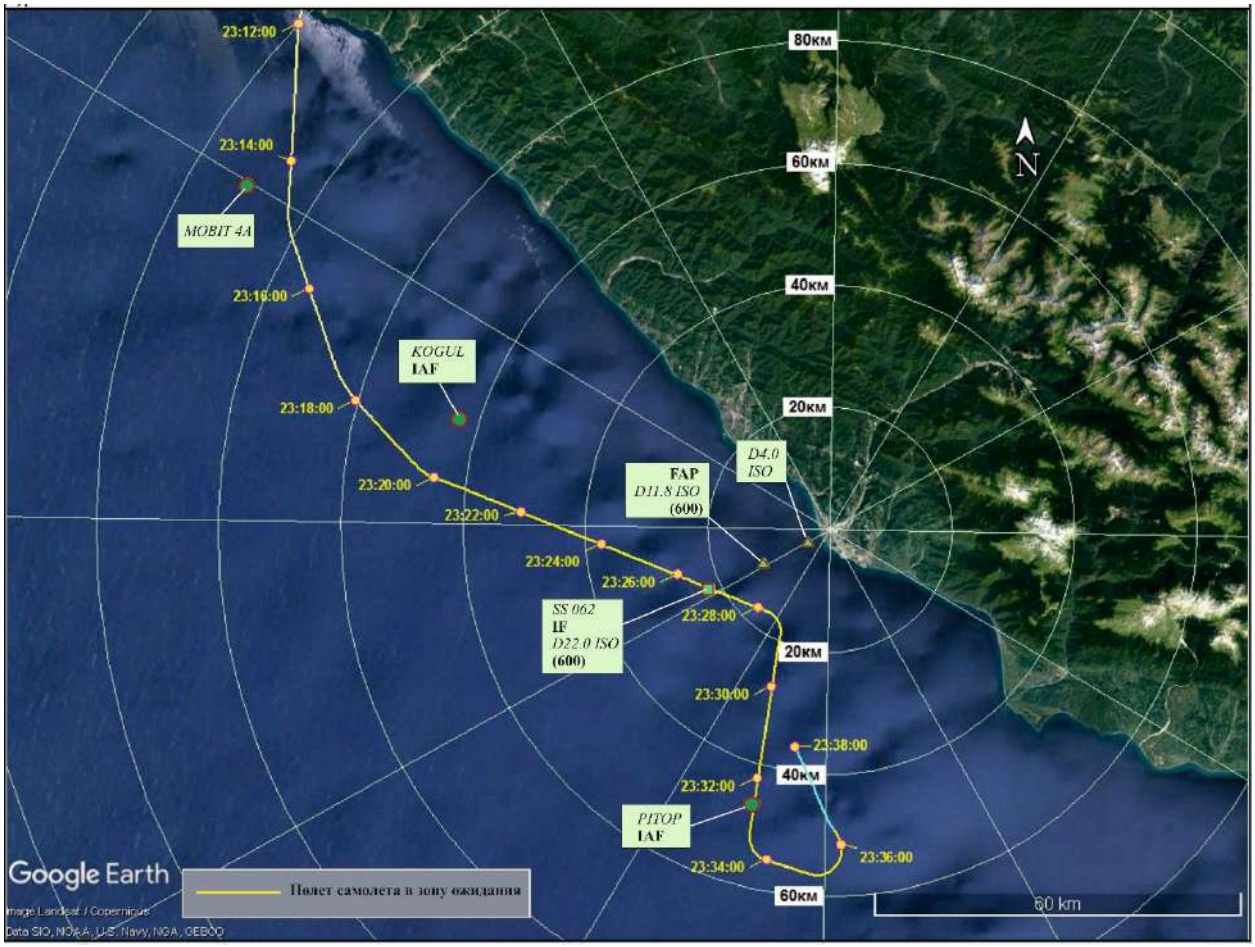

Fig. 7. Aircraft trajectory to PITOP waiting area before the approach to landing

At 23:15:50, the crew reported FL 110 reaching, and received the clearance for descending to FL 90. Because of a clutter over IAF KOGUL, PIC requested the clearance for avoiding it from the left. The controller issued the clearance.

When FL 100 approaching, the crew has performed all necessary procedures, including ILS frequency setting check.

At 23:16:45, Sochi-Approach controller informed the crew: "*UTAir-579, for runway 0-6: wind 80 degrees, 9, gust 18, RVR 3500, 2600, 1900, QFE 1012, and QNH is changed for 1014.*"

Weather conditions were sufficient for further approach and landing, therefore, the aircraft continued to FL 90 descending at the altered course for thunderstorm cell avoiding.

At 23:17:35, the crew reported FL 90 reaching; then the Approach controller transferred the aircraft to the communications with Sochi-Radar controller.

At 23:18, after contacting Sochi-Radar controller, the crew was cleared for FL 70 and for continuation of thunderstorm cell avoiding by his own means. At 23:19:03 the crew reported FL 70 reaching.

At 23:19:05, Sochi-Radar controller cleared for descent to 600 m by QFE 1012 hPa. In respond to the crew request to follow to SS062 way point (Fig. 6), the controller issued the clearance.

At 23:19:24, Sochi-Radar controller informed: "*UTAir-579, for your information, the aircraft that has landed now confirms all current information, the second one is on final now*".

At 23:20:08, being on transition altitude the crew set QNH 1014 hPa.

At 23:20:13, the crew started to perform APPROACH CHECKLIST.

At 23:23:08, Sochi-Radar controller informed: "*UTAir-579, for your information, RWY 06 visibility – 1000 m, 650 m, RVR 1400 and wind 90 degrees, 17 m/s, gusts 22; AIR BALTIC now is going around."*[5]

Note: *By Sochi AMC information (booklog AB-6) in the period from 23:10 to 23:50 31.08.2018 showers of heavy rain were recorded following with the visibility degradation down to 250 – 800 m. Precipitation depth was 58 mm as measured."*

These weather conditions did not meet the crew approach for landing requirements also. Further, the controller informed, that the forecast is not good enough, however the weather is fast-changing ("…*such weather is expected to stay until the morning, mostly it arrives to the coast with squalls*…"), the controller also informed that the weather is being monitored every minute.

The crew said that they hope "*to find their way between two squalls*", and agreed with the controller their decision to follow to PITOP waiting area. The minimum altitude the aircraft reached was about 2300 ft (700 m).

The controller commanded to take the waiting area at FL 70. Being at the transition level, the crew set the altimeter to standard pressure. The aircraft reached FL 70 at 23:29:35.

At 23:32:49, Sochi-Radar controller communicated the aircraft: "*UTAir-579, for your information, most probably 02, be ready for ILS approach, runway 02, and actual wind for the runway 02 is: 350 degrees 4 m/s, gust 15 m, visibility 1300, 600 m, 2800; the rest is without changing".*

[5] According the information received form Transport Accident and Incident Investigation Bureau of Latvia, AIR BALTIC aircraft performed the go-around because the warning system had issued two annunciations about entering a wind shear. The aircraft operated by AIR BALTIC Airlines are not equipped by the predictive windshear warning.

PIC reported: "*As per our information there is the best minimum there, visibility should be about 2400*"; the controller replied: "*UTAir-579, for the runway 02 visibility 160 to 2500, now the actual is 1800, 600, 4100. Meaning the runway lights".*

After that, the following conversation was recorded: PIC: "Will we play dumb and try approach?" – F/O: "*(just if) we won't have to go around*". Here, F/O passed the control to PIC and started to prepare the aircraft and systems for onto RWY 02 landing. When preparing the aircraft systems for onto RWY 02 landing, at 23:35:11, they received the following information from the controller: "*UTAir-579, for the runway 06 the actual weather is: 90 degrees, 7 m/s, gust 19 m, by runway lights visibility 3500, 1500, 3500*"; the crew replied, that the weather was fine with them and they perform approach to RWY 06.

At 23:35:45, Sochi-Radar controller communicated the aircraft: "*UTAir-579, roger, maintain the flight level 70, follow to SS062 directly. ILS approach you will have, runway 06".*

At 23:36:07, the controller cleared descending to 600 m by QFE (1013 hPa).

The aircraft started to descend to SS062 waypoint approaching to RWY 06 at 23:36:25 (see Fig. 8). The crew put the aircraft to descending mode and set the altimeters to QFE 1013 hPa. Once again, the crew started to prepare the aircraft systems for onto RWY 06 landing.

According to the record of the flight deck communications, F/O becomes to be PF again. In course of descending, the crew members discussed the go-around procedure once more (TO/GA flaps and landing gears retraction, right turn with to FL 100 climb). Also, PIC said: "*... if we will go around, let's keep our heads, will we?*", and F/O replied in the affirmative.

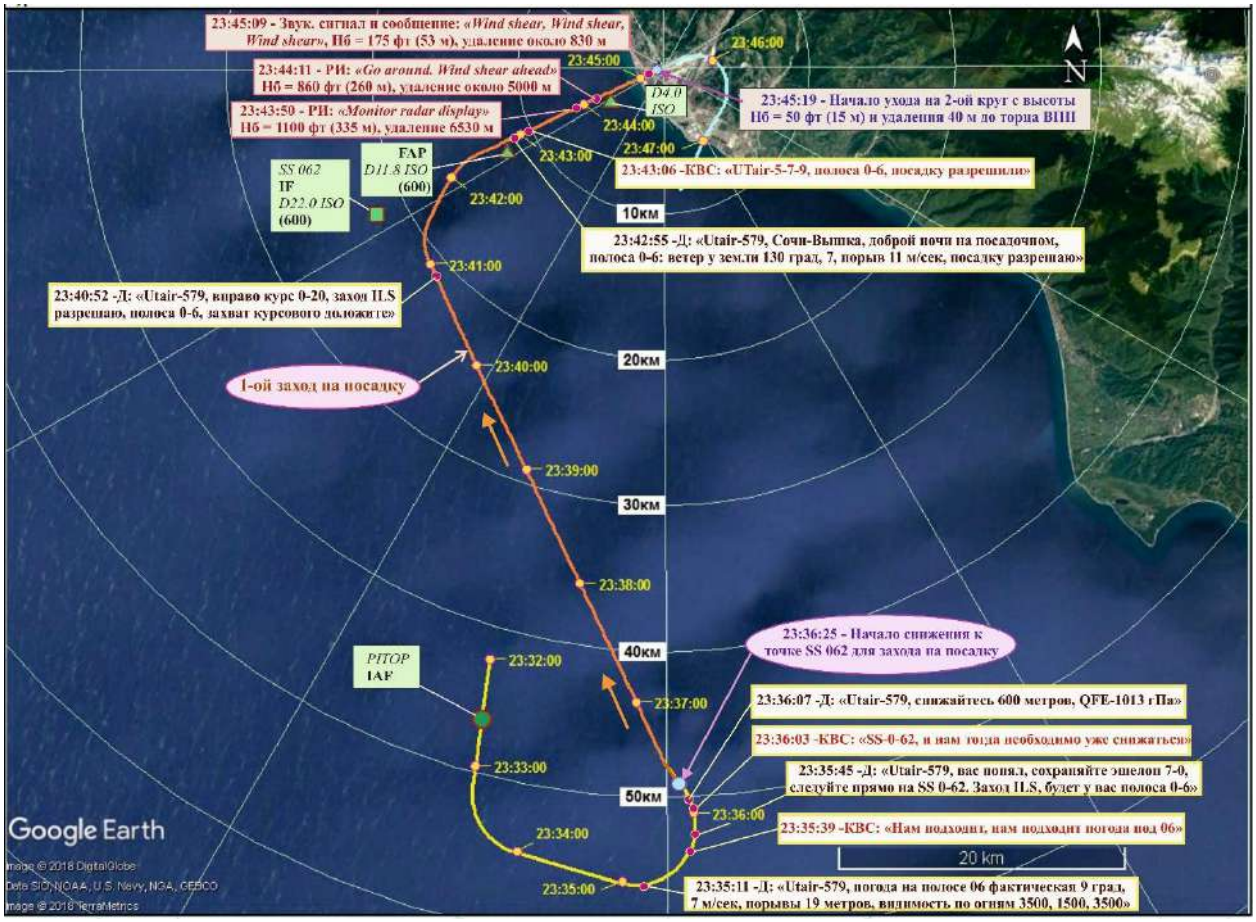

Fig. 8. Aircraft landing trajectory when landing from PITOT waiting area (orange line)

At 23:40:52, Sochi-Radar controller informed the crew: "*UTAir-579, turn right, heading 020, cleared for ILS approach, runway 06, report when established*". The crew confirmed the message received and started the flaps extension.

At 23:40:55, the aircraft reached the altitude of glide slope interception of 1976 ft (600 m)[6]. Reaching 600 m and the further flight at the altitude was performed with the following autopilot pitch modes: ALT ACQUIRE and ALT HOLD (see Fig. 9).

At 23:41:15, the flaps were extended to 5° and the aircraft started the turn for reaching the final.

At 23:41:38, the APPROACH button was pressed (here the single command APPROACH PB LITE was recorded), and it caused the autopilot approach mode activation (see Fig. 9).

[6] Here and further, if not other mentioned, all altitudes are shown from RWY level (by QFE).

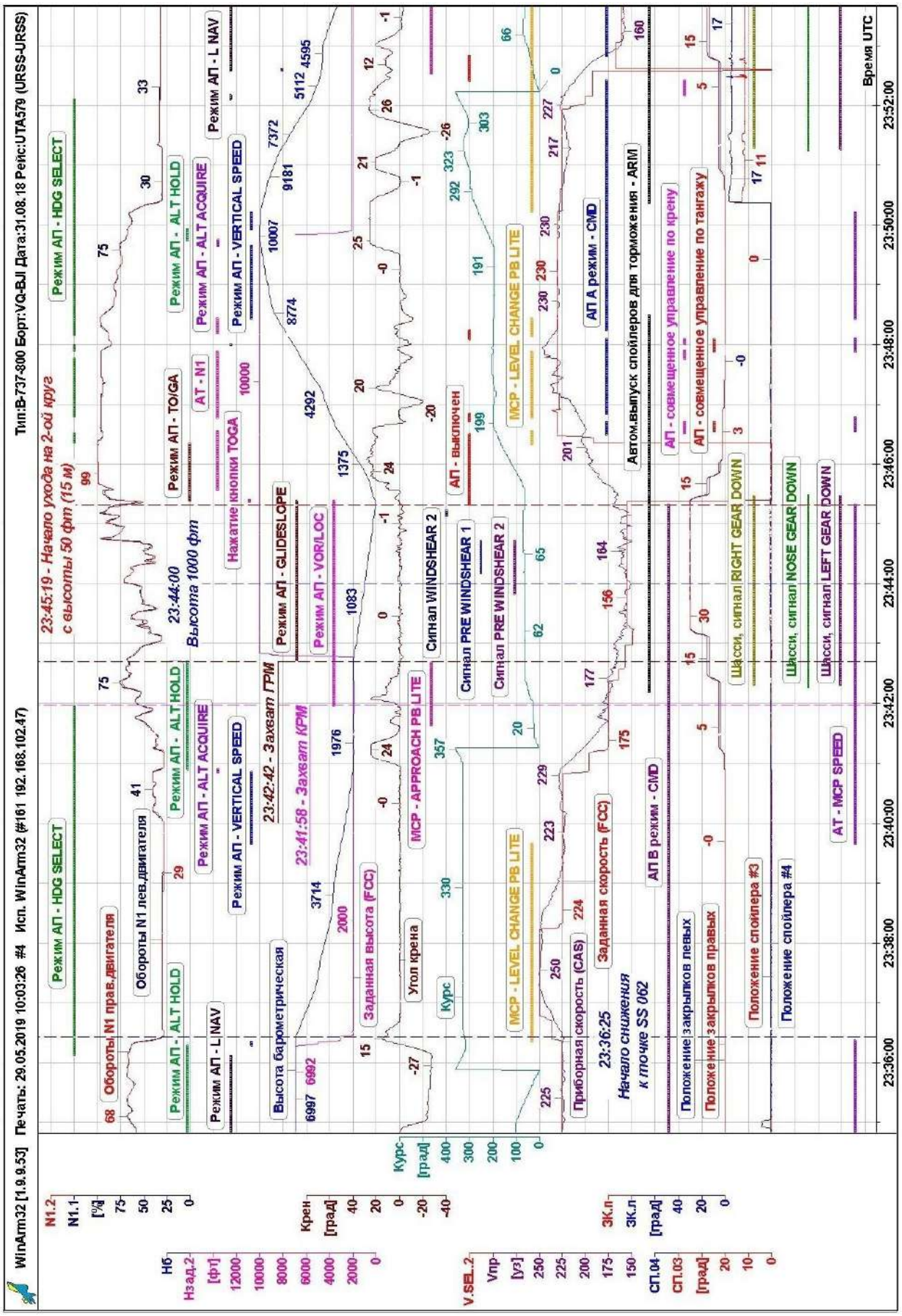

Fig. 9. Flight parameters during the first approach to landing and go-around

At 23:41:58, at height of 1800 ft (600 m) the localizer beam was captured and the automatic turn to the final was started.

At 23:42:19, with speed of 170 kts (315 km/h), the landing gears were extended by the pilot command.

At 23:42:28, the flaps were extended to 15° by the pilot command.

At 23:42:34 the Radar controller transferred the communication to Tower: "*UTAir-579, further communicate to Tower, by 119 decimal zero, good-by!*"

At 23:42:42, the glide slope beacon was captured, and the automatic descending started. The crew set the go-around altitude as 10000 ft.

At 23:42:48, the crew reported to Tower controller being on glide path and ready to landing: "*Sochi-Tower, UTAir-579, good night, established on final to glide path, ready to landing*."

At 23:42:55, the Tower controller provided the crew with wind information and cleared for landing: "*UTAir-579, Sochi-Tower, good night, on final, runway 06, surface wind 130 degrees, 7, gust 11 meters per second, cleared for landing."*

At 23:43:15 the crew set the flaps into the landing configuration and Vapp to 156 kts. In course of Landing Checklist reading, at 23:43:50, at height of 1100 ft (about 335 m) and distance of 6500 m before the threshold, the Predictive windshear system caution *"Monitor radar display"* was recorded.

PIC asked: *"What is this about?"* F/O replied: *"Suppose, about the wind shear it said" "We will try"* – said PIC; and the crew continued descending.

The aircraft was descending along the glide path with the autopilot and automatic throttle engaged. Down to 1000 ft (300 m) (see Fig. 9), the aircraft was descending with speed of 770 ft/min (4 m/s), and that was within the limits (maximum allowed speed was 1000 ft/min (5 m/s)). When reached 1000 ft (300 m), the aircraft was already stabilized (flaps extended to 30°, N1 was 50 %, and the vertical speed was under the allowed one).

Note: UTAir Airlines OM, Part A (Aircraft), subitem 8.3.2.8.25, *Procedure of stabilized approach*:

"The aircraft when does a commercial air transportation has to be stabilized at the calculated approach path before it reaches the height of 300 m (1000 ft) above the threshold if flying under IMC, and the height not less than 150 m (500 ft) if flying under VMC.

An aircraft can be considered as a stabilized one for further approaching if it is situated at the calculated glide path and landing course and:

- *just slight adjusting is of its yaw/pitch needed for maintaining of its glide path trajectory;*
- *its instrument speed is not above the calculated speed + 20 km/h (10 kts) and not under the calculated approach speed;*
- *the landing configuration requested by the aircraft AFM or OM is reached; and all actions under the checklists are fully completed;*
- *vertical descending speed is not above 5 m/s (1000 ft/min). In case the speed over 5 m/s is needed for final, it should be agreed in course of the preflight preparation;*
- *engine operation modes meet the aircraft landing configuration, approach speed and have to be under the nominal speeds or be below the speed which is prescribed for the current conditions."*

When the aural caution of reaching the 1000 ft was ON, PIC reported the stabilized approach; with this consideration, F/O made decision to descend to DH and informed PIC.

At 23:44:11, when the aircraft was at 850 ft (about 260 m) and at distance of 5000 m from the threshold, the Predictive Windshear System Warning "Go around. Windshear ahead" was recorded in the cockpit. It was confirmed by two GPWS signals: "PRE WINDSHEAR 1" and "PRE WINDSHEAR 2" recorded by FDR in the same time (see Fig. 9).

The crew ignored the wind shear warnings and continued to descend along the glide path.

Note: *According to QRH (Quick Reference Handbook), when such voice warning is heard, the crew has to perform a windshear escape maneuver or a standard go-around maneuver.*

The said voice warning was not discussed by the crew. When it appeared, PIC said to F/O: *"... the speed is the main issue*". F/O replied: "*Yes, yes*".

At 23:44:24, aural warning was heard in the cockpit "Plus hundred" (which means 100 ft to minimums), and then in 8 seconds (at 23:44:32) it was followed by the warning message "Minimums", which evidences that the aircraft descended to DH of 627 ft (190 m)[7] that had been previously set by the crew. However, PF failed to take one decision (CONTINUE) or another (GO AROUND), which does not meet requirements of Boeing 737NG UTAir Airlines OM, Part B-2 (Normal Procedures), Attachment B-2.1. In 9 seconds after the aural warning was ON, PIC said: "*Go, go. Control the speed*". And this was followed by the conversation within the crew:

PIC: "Are you monitoring the speed?"

F/O: "I am, I am monitoring… You monitor the ground."

PIC: "You – the speed, me – the ground."

F/O: "Yes."

PIC: "You – the speed, me – the ground."

F/O: "Yes."

At 23:45:03, F/O asked PIC: "*See the runway? I see.*" No respond came from PIC.

At 23:45:09, at the altitude of about 170 ft (≈ 50 m) and at distance of 850 m from the RWY threshold, the following aural warning was heard in the cockpit: "Windshear, Windshear, Windshear", which means that the wind shear conditions are encountered. It was confirmed by the GPWS signal "PRE WINDSHEAR 2" recorded by FDR in the same time (see Fig. 9). An again the crew ignored the wind shear warnings and continued to descend.

Note: *In accordance with the QRH, the crew if windshear conditions are encountered, has to accomplish the Windshear Escape Maneuver immediately.*

After the windshear warning was heard, PIC repeated "*You – the speed, me – the ground*", and F/O (being at the altitude about 110 ft (≈ 30 m)) responded: "*See the runway?*" After that PIC took control and started the normal (pushing TO/GA button and disengaging the autopilot, following with flaps and landing gears retraction) go-around procedure. According to the crew members' stating, they initiated the go-around as the RWY visibility was degraded because of the heavy shower.

[7] Here the QNH pressure is shown.

According to FDR records, the go-around was initiated at 23:45:19 from the altitude of 50 ft (≈ 15 m) at distance of 40 m from the RWY threshold.

The aircraft started the go-around maneuver, and in 10 s the START controller communicated the crew and advised: "*UTAir-5-7-9, go around as per published procedures, communicate the RADAR ATC at 119 decimal 7.*" F/O responded: "*Work at 119 decimal 7, UTAir-5-7-9.*"

Note: *The go-around SOP (till the pilots have completed the go-around) does not allow the pilot to conduct the radio communications with ATC. The ATC Working Instructions (in part where the crew reports the go-around initiated) required no special actions from controllers. However, the controller advises the crew to go around just in case some obstacles exist at RWY or near creating the hazard to the flight safety. It is not the first time when the IAC Investigation Team highlights (see the Boeing 737-500 VQ-BBN Final Report, Kazan airport, RF, 17.11.2013) that the radio communications with ATC during high-stress flight segments and a pilot distraction from his duties (if the pilot is acting as PM), is a violation of the Aviate – Navigate – Communicate concept and create additional risks to the flight safety.*

In the accident in question, the air situation was not heavy, the controller information did not contain anything new and significant for the pilot in frame of the go-around procedure. The pilots already reached the strained psychoemotional state caused the significant weather conditions and necessity of conduct the go-around from the height which was significantly lower than DH (considering that there was no procedure for the go-around from the height lower than DH in Sochi airport written in the Airlines OM). We consider as the evidence of the pilots' strained psychoemotional state, that PIC did not react to the situation when F/O did not respond the ATC advice, and just 1.3 minutes later, after the go-around was completed, he asked the clarification: "You didn't answer him, did you?" F/O said: "Yes, I've told him we go around." But based on the CVR records' transcript we can see that F/O didn't answer the controller, just confirmed the frequency for communications. However, almost immediately F/O communicated ATC (discussing the further flight direction), but using the old radio frequency; in answer ATC repeated that the aircraft should communicate with RADAR. In other words, in disregard of confirming of change of the frequency for

communications, F/O's mind did not register the fact of this change.

In 14 s after the go-around was initiated, in course of climbing, PIC put the aircraft into right bank turn of ≈ 30 ° and set heading to PITOP waiting area (see Figs. 8 and 9). At Fig. 10 you can see the trajectory of the aircraft go-around and second approach.

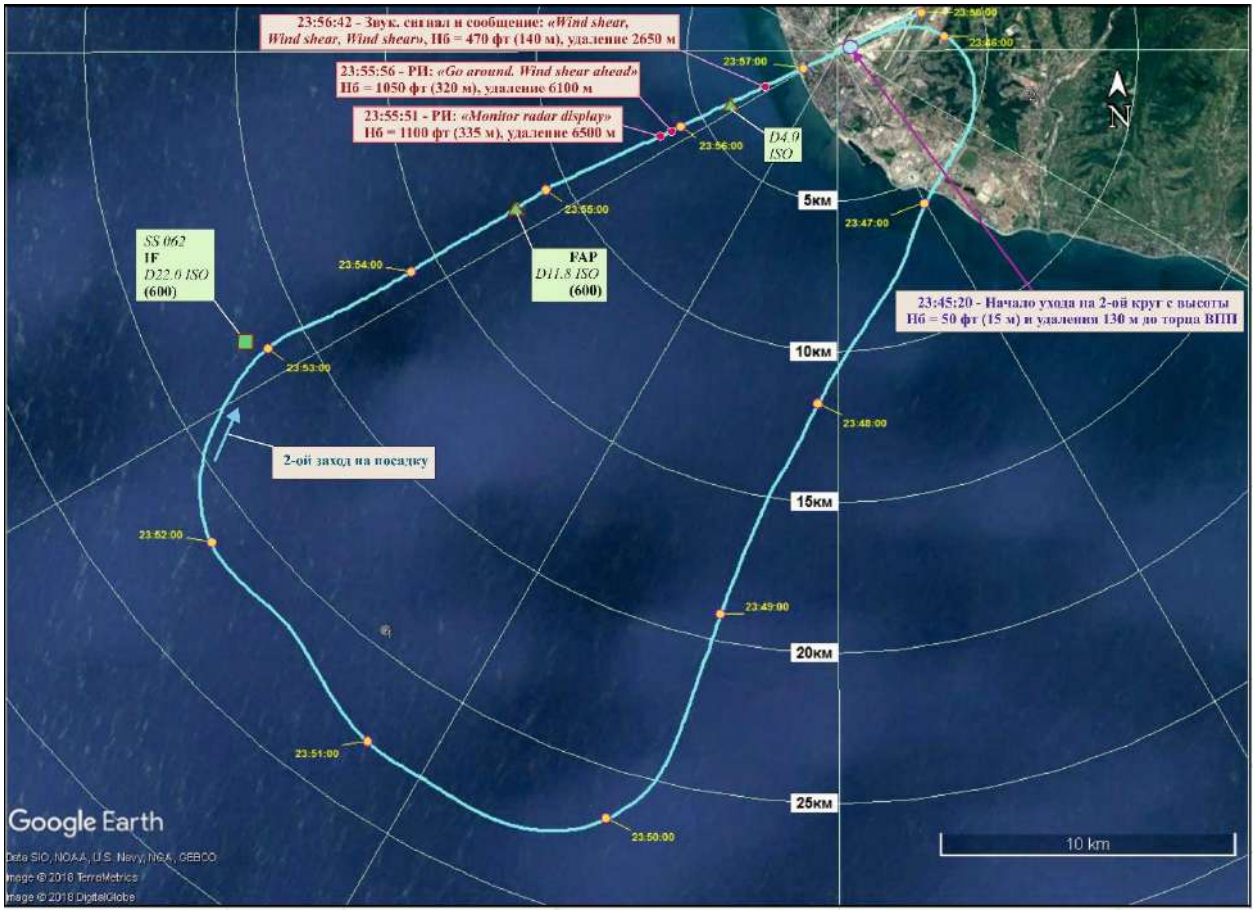

Fig. 10. The aircraft go-around and second approach trajectory

During the right turn, after the flaps were set to position "1", and the heading to about 180°, PIC twice (at 23:46:16 and at 23:46:22) said "*Autopilot*". Analysis of flight deck communications shows that the pilots tried to engage the autopilot being in modes LVL CHG and HDG SEL (longitudinal mode and lateral mode), but the autopilot failed to engage (at 24:46:28, PIC said: "*Autopilot is not engaged…*"). The analysis revealed that, most probably, the autopilot failed to engage because PIC had not removed the forces from the control column.

It is clear that the pilots continued their attempts to engage the autopilot, because at 22:46:30 at height of 3100 ft (≈ 950 m) after the forces had been released from the control column, the autopilot was engaged after all. Most probably, the pilots' mind did not register this fact. Because, at 23:46:35, F/O reported: *"Not engaged. Roll. Will roll out."* Actually, while the autopilot was already engaged, the roll and pitch control was conducting in cooperative mode (Control Wheel Steering). After the airplane was leveled off, at 23:46:43, the autopilot was disengaged with the dedicated aural alert. Then, the following conversation was recorded:

F/O: So, level change, heading select ᴜ flaps up available.

F/O: Engaged.

PIC: Flaps up.

F/O: So, up we go.

The analysis revealed that, in spite of F/O's report, the flaps were not retracted. F/O was concentrated at autopilot engaging (the autopilot was re-engaged at 23:46:52), so he missed the necessary action with setting the flaps to "UP" position (from position "1"), although he did report the flaps retraction. Just at 23:47:18, F/O realized the flaps are not retracted saying: "*That's it! Flaps, fucked*[8] *flaps we still have, fuck me!*" Following this emotionally charged talk, the pilots retracted the flaps.

All troubles the pilots had when trying to engage the autopilot, as well as missing the fact that the flaps are not retracted evidence that actual pilots' workload was beyond the capability. Most probably, the go-around acted as a significant distress for the pilots, therefore, they were not in the perfect working state.

Non-perfect pilots' working state can be confirmed by the fact that after the autopilot was re-engaged, the pilots several times changed its modes, also reaching the roll and pitch control cooperative mode. So, the autopilot was re-engaged at 23:46:52, 1 minute 14 second later it was disengaged, and at 23:48:15 re-engaged once more.

At 23:47:17, the altimeter was set for standard pressure.

In course of climbing and flying to the waiting area, the crew discussed the weather at destination:

23:48:11 PIC: Turn these fucking wipers off.

23:48:12 F/O: Yes.

23:48:17 F/O: Done.

23:48:19 F/O: The weather in Sochi is fucking; approach in such a weather is a hell, is it not?

[8] Here and further, the Investigation team keeps the initial wording intact, because it helps to demonstrate the pilots' psychoemotional state.

23:48:22 PIC: Fuck it.

23:48:24 F/O: Yes.

23:48:24 PIC: We cannot see anything there, anything at all, fuck.

23:48:26 F/O: Yes.

23:48:30 PIC: Nothing, no fucking thing.

At 23:48:33, the Radar controller informed the crew: *"UTair-579, for your information: after you've left, the wind – gusts does not go above 9. Visibility: 2500, 2600, 2400 by lights."*

In spite of the fact that they'd just discussed the weather conditions, received this information, the crew decide to conduct another approach to RWY 06 and reported this decision to ATC. At this moment the aircraft reached the altitude of about 8500 ft (≈2800 m) standard.

At 23:49:00, the Radar controller provided the conditions at landing: *"UTair-579, descend to 600 m, QFE – 1013 hPa, when ready. Sierra Sierra-0-62. Cleared for ILS approach, runway 06."* F/O responded: *"Sierra Sierra-0-62, when ready. Descend to 600 m, UTair-5-7-9."*

At 23:49:30, reaching the flight level 100, the right bank turn of ≈ 30° was initiated to SS062 (see Figs. 9 and 10). By this the aircraft was continuing to climb. PIC was PF. The crew prepared the aircraft systems for the second approach, however, did it hastily (for example, PIC at 23:49:31 said: "*Put there a kind of KOGUL for now, will change later. Go, go, go, go, go"*).

At 23:49:40, the autopilot started the airplane transition to the targeted FL 100; the flight level was reached at 23:49:46 (the time of the autopilot altitude stabilizing mode engagement). F/O did not report targeted flight level approaching and reaching.

At 23:49:41, CVR recorded the following F/O sentence: "*Pressure 14.*" FDR recorded the setting of this pressure QNH (1014 hPa) just at the F/O working station. As for PIC, his altimeter was set to standard (1013 hPa). We must say, that this fact did not affect the result of the flight, but illustrates the pilots' non-perfect psychoemotional state, insufficient level of interaction and failure to follow the standard operation procedures.

At 23:49:52, the controller issued the clearance: *"UTair-5-7-9, ILS approach, runway 0-6."* The crew acknowledged the clearance receipt.

At 23:50:00, the controller informed: *"UTair-5-7-9, wind at RWY 06 – 200 degrees per second, gust 9 meters per second; visibility 3500, 2800, 2800 by lights."*

At 23:49:56, the aircraft in course of the right turn proceeded to descend.

By 23:51:15, the crew in order to increase the descent gradient one-by-one extended spoilers, then flaps to 5°, then landing gears (see Fig. 11). However, at that time the airplane had the excess height; at 23:51:28, F/O (himself without PIC's command) communicated the controller: *"UTair-5-7-9, we are somewhat high, can we be vectoring slightly to the left?"* The controller advised to take heading 290°. At the same time PIC said to F/O: "*There, there, we'll take it, will approach the final*" and initiated the right turn to final. F/O reported to the controller: "*Right away, we approach the landing profile, approach the final 5-7-9*"; after that the controller asked if the crew is ready to approach. The crew acknowledged the readiness, and the controller cleared for approach to RWY 06.

The airplane still had the excess power (both height and speed). The crew realized this fact:

23:52:02 F/O: 16 miles. 1000 above, Ok, approaching the profile. Closing.

23:52:06 PIC: LNAV.

23:52:07 F/O: Approaching the profile, lay the speed off. Check.

LNAV mode was activated and the airplane roll went down. PIC interfered the control (it could be seen by the autopilot turning into the roll cooperative mode (Control Wheel Steering), however, possibly he had done this reflexively. F/O reported: *"It is Control Wheel Steering again"*, PIC responded: *"Fuck me, what is it now? Heading. Heading. What does it mean?"* After these words the autopilot was disengaged.

At 23:52:28, the Radar controller informed the crew: *"UTair-579, for 52nd minute wind 200 degrees 4, gusts 8. Visibility 6000, 3500, 3100."*

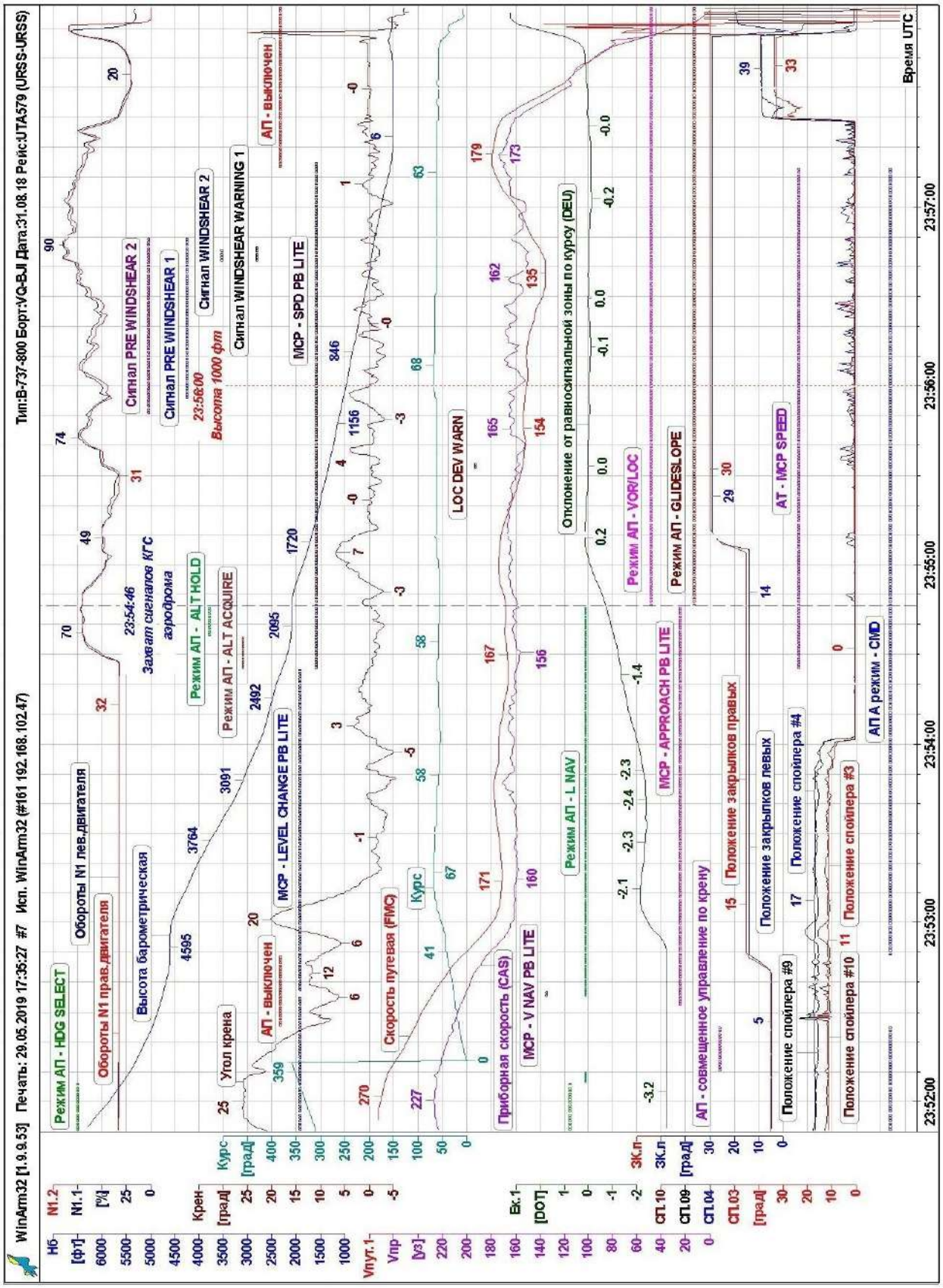

Fig. 11. Flight parameters during the second approach to landing

At 23:53:10, in course of descending, at altitude of 4500 ft (≈1300 m) and distance of 21 km from RWY threshold, the aircraft reached the heading close to the final one, the crew corrected the flaps to 15°, and engaged the autopilot once more.

At 23:53:49, the controller informed: *"UTair-579, a preceding [aircraft] goes around."* PIC was interesting to know the reason of this go-around. He twice asked the F/O: *"The reason?"* and *"Did he say why?"* F/O didn't respond, probably, because at this moment he was talking with ATC clarifying the weather. The weather provided for the crew was following: *"...visibility 6000, 3600, 3500, wind 200 degrees, 4 meters."* Later, PIC didn't come back to the reason of the preceding aircraft go-around.

Note: *When other aircraft do the go-around (including because of the wind shear warning), the crews did not inform ATC about the reasons. International documents, such as ICAO Annex 3, Doc 9817 AN/449 (sub-item 4.3.59), and Russian Regulations (FAP-128) recommend report the wind shear encounter to the tower. The Radar controller also did not clarify the issue with the preceding crews. It is known that the pilots reports may be the only source of the wind shear information, therefore these reports are vitally important for the flight safety of the subsequent aircraft.*

At 23:54:07, the Radar controller advised the crew to communicate with Tower ATC. The airplane was almost on final at distance of 15 km from the RWY 06 threshold; in course of descending it crossed the height of 2600 ft (≈800 m).

Despite the fact that the aircraft did not reached the altitude of the glide slope intersection (600 m), F/O at 23:54:14 reported to the Tower controller: *"Tower, UTair-579, at intercept point 600"*, and the Tower controller respond: *"UTair-579, Sochi-Tower, on final, the runway to the right from the final, RWY 06, continue approaching."*

Although the pilot pressed the APPROACH button, the localizer capture did not occur. At 23:54:18, PIC said: *"No VORLOC, fuck it." At* 23:54:25 F/O asked the Tower if ILS if available and receive the positive answer. The analysis revealed that most probably, the localizer capture did not occur because the aircraft was flying in LNAV mode almost parallel to the RWY centerline slowly approaching the equisignal leg, which means that the on-board systems did not recognize the necessary approach gradient. The crew did not recognize the reason why they cannot capture the localizer and check the ILS setting (ILS was set correctly).

At 23:54:35, at distance of 13 km, the autopilot stopped aircraft descending at height of the glide slope intersection (600 m).

At 23:54:46, almost simultaneously the automatic capturing of the localizer and glide slope beacon occurred, and the automatic descent along the glide slope was initiated.

At 23:54:48, the crew reported the localizer capture, and receive the clearance for landing: *"UTair, Roger, runway 06, surface wind 200 degrees, 4 meters per second, cleared for landing."*

The crew one by one did the following actions: set the TOGA altitude (10000 ft), set the flaps to 30°, and set the approach speed (157 kts) on MCP; then the crew read the Landing Checklist.

When descending along the glide path (see. Fig 11), at 23:55:51 at height of 1100 ft (≈ 340 m) and distance of 6500 m from the RWY threshold, the aural warning was heard: *"Monitor radar display"*, then in 5 second at height of 1050 ft (≈ 320 m) distance of 6100 m from the RWY threshold, the aural warning was heard: *"Go around. Windshear ahead."* At the same time two single signals were recorded: "WINDSHEAR 2" and "WINDSHEAR 1" (see Fig. 11). The crew did not discussed these warnings and continued to descend. At the same time (when the aural warning was ON), PIC commanded to F/O: "*When I tell you. Will you read me [checklist] full steam, ok?*" F/O agreed to do, then PIC added: "*And altitudes, if you can, ok?*"

At 23:56:05, the aural alert informing that the aircraft had reached 1000 ft was heard. Pilots did not report if the approach was stabilized or not, PIC just said: "*… to minimum.*" Exactly at the moment when the warning was ON, the instrument speed was close to the target one. However, 3 seconds before it was by 5 kts (≈ 9 km/h) less that the target one, and 4 seconds later it was by 12 kts (≈ 22 km/h) higher that the target one, which does not meet the Airlines determined by OM requirements for the stabilized approach (see NOTE at page 50).

At Fig. 12, we can see that in course of descending along the glide path, the wind speed and direction were changing significantly. The autothrottle in attempt to maintain the aircraft target speed was changing the engines' rotation speed (N1) within the range from 30 to 90% to counteract the wind influence. The aircraft explains that this autothrottle behavior was caused the wind speed and direction fast changes.

At 23:56:21, the aural information *"Plus hundred"* was recorded. Starting from this time F/O was calling out speeds and altitudes continuously. This callout with consideration of the fact that F/O voice was rather tense emotionally produced a significant acoustic overhead within the cockpit. It should be mentioned that at that time the descending along the glidepath was conducted in automatic mode (both the autopilot and autothrottle were ON), it means that PIC was not engaged in the aircraft piloting so deep. Based on PIC's note: *"If I do not see… the runway I, fuck me, will not land"*, that was said to F/O after the latest receive his command to call speeds and altitudes out, one can conclude that PIC was concentrated at the outside view entirely. At 23:56:40, at altitude of 485 ft (150 m) the instrument speed achieved the value of 157 kts (while the target speed was 150 kts), and F/O called this value aloud. At that, the single event "AT-MIN SPEED" was short-time recoded which means that the speed had fallen down to 1.23 Vstall. Later the instrument speed went up.

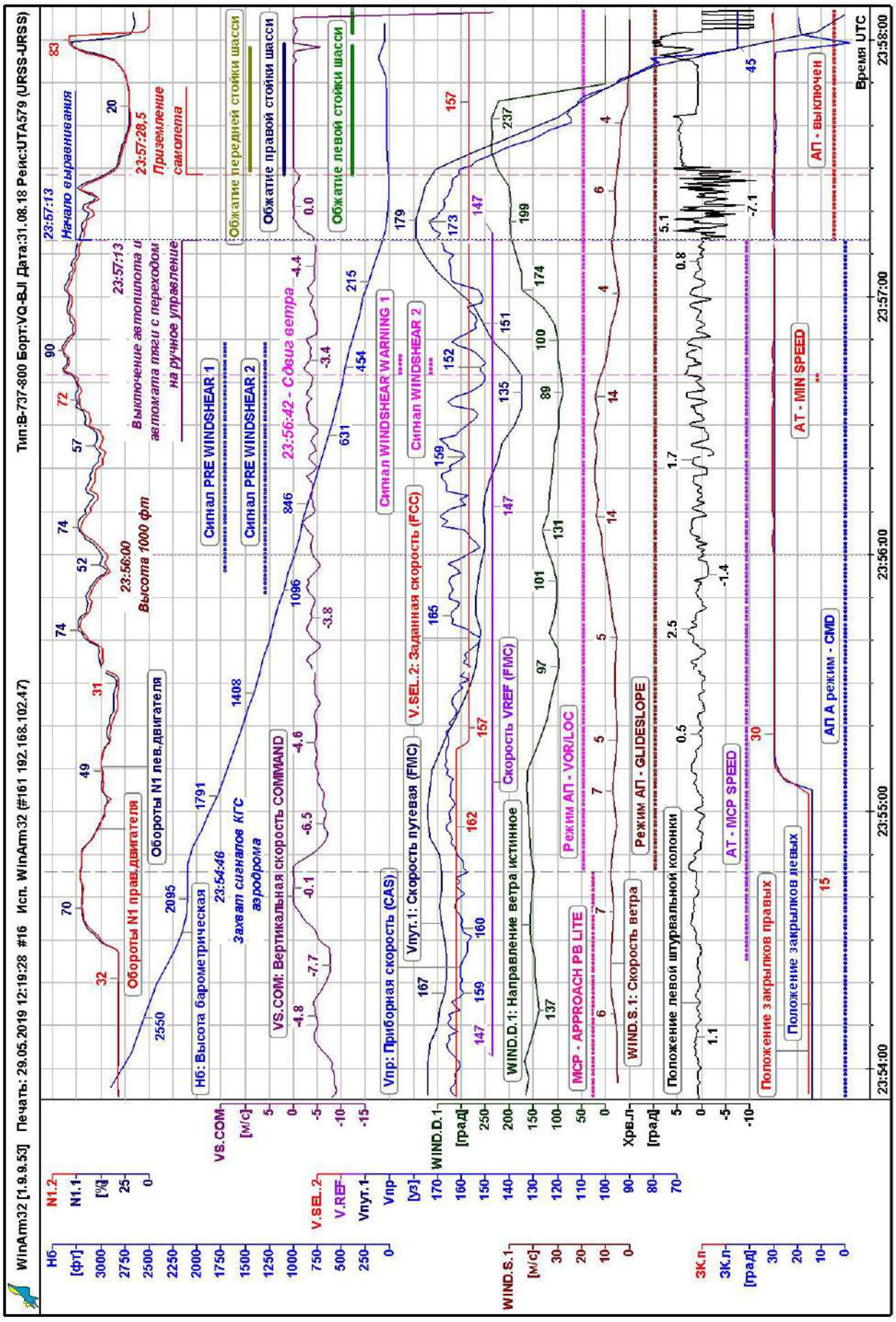

Fig. 12. Flight parameters on the glide path descent

At 23:56:42, at height of about 470 ft (145 m) and distance of 2650 m to RWY threshold, the chime sound and three-time aural warning *"Windshear, Windshear, Windshear"* were heard in the cockpit, evidencing the aircraft had entered the windshear zone. Both GPWS signals: "WINDSHEAR 2" and "WINDSHEAR 1" was also recorded. However, the crew, in spite of these warnings, continued to descend.

Note: *According to PIC's explanation, as he was PF: "The wrong decision to land was caused by [my] emotional state: I just did not hear the windshear warning, my mind had added it to the flight deck unwanted acoustic overhead (it worked so loudly during the first approach and was keeping me off my work, therefore, it turned to be an unwanted acoustic overhead instead of a necessary warning system that alarm you)."*

At 23:57:13, at height of 75 ft (≈ 25 m) and distance of 150 m to RWY threshold, PIC had disengaged the autopilot and autothrottle, and took the control manually. At this time, the aircraft was in the wind shear "epicenter". Exactly before that, the autothrottle started to reduce the engine rotation speed as the instrument speed to this moment had reached the value of 170 kts (≈315 km/h). Autothrottle disengaging caused "freezing" of the mode which was rather excessive for the actual flight conditions. It resulted in the instrument speed increase up to 173 kts (≈320 km/h). The instrument speed increase in combination with PIC control inputs caused a significant vertical speed decrease and flight profile flattering (see Fig. 13, 14). At that, the ground speed was about 178 kts (≈330 km/h) as a result of tail wind influence. The aircraft when passed the RWY threshold was at height of about ≈ 54 ft (15 m). The total flight time left to the landing was 14 s.

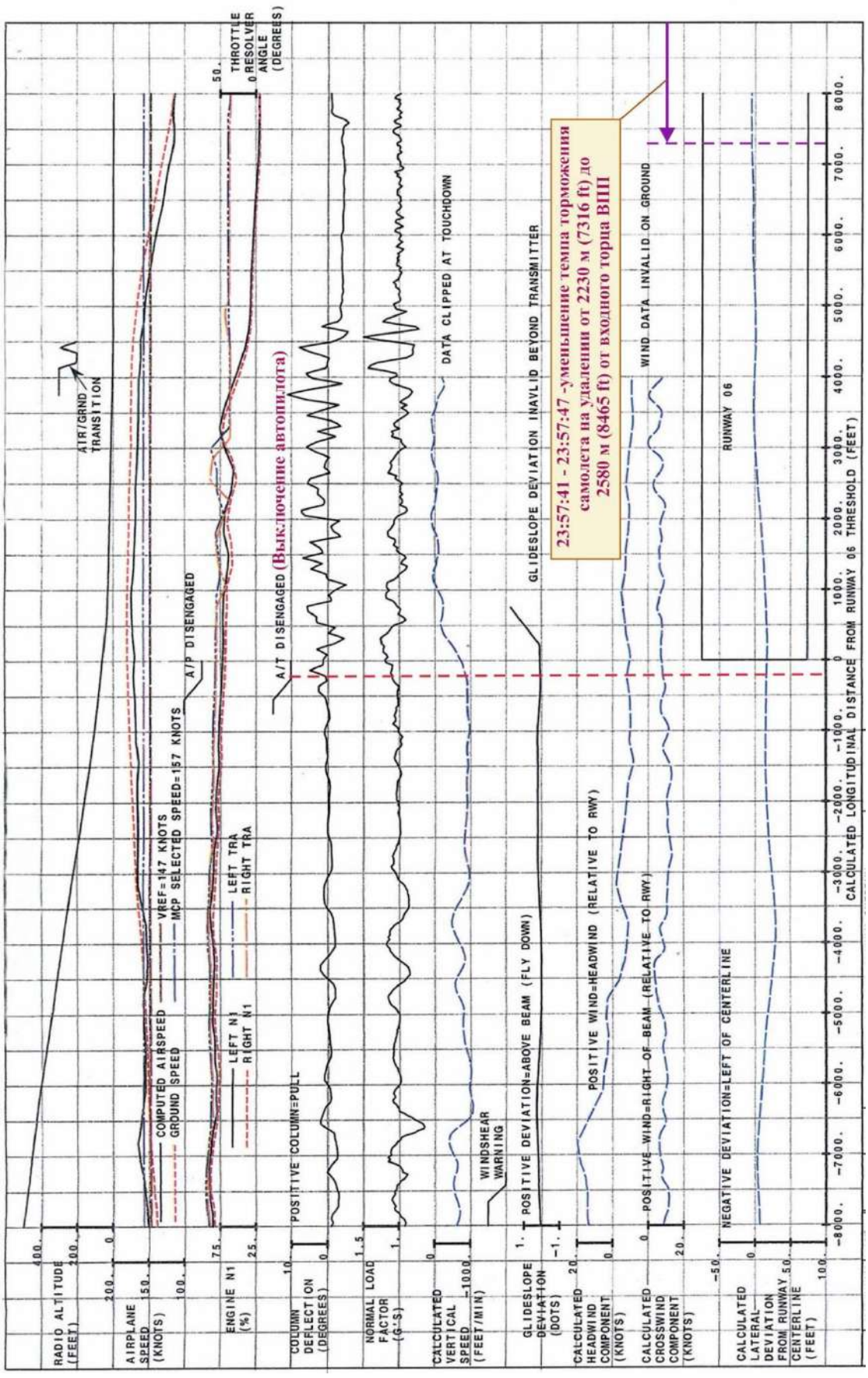

Fig. 13. On landing – simulation of the aircraft movement

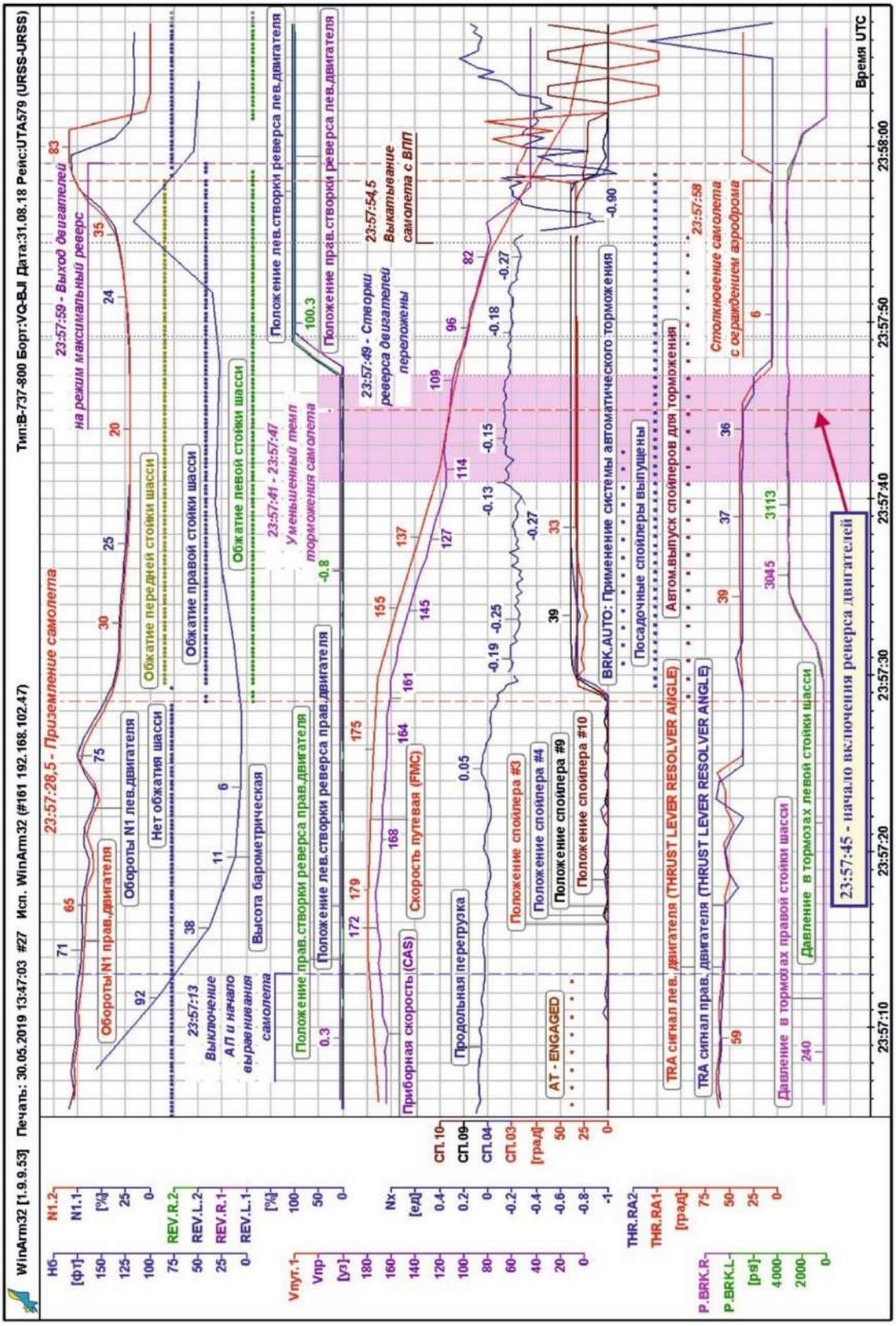

Fig. 14. Landing run – aircraft movement

The aircraft landed at 23:57:28 behind RWY 06 threshold (see Fig. 15)at about ≈ 1285 m (it is according to FDR records) when the instrument speed was 160 kts (≈ 300 km/h) and ground speed was 170 kts (≈ 315 km/h).

Fig. 15. Aircraft on landing trajectory

Therefore, the increased instrument speed on final flight (after the control was changed to the manual one) and the influence of tail wind component led to landing at distance of 1285 m from the RWY threshold (about 385 m overshoot).

Right after the aircraft had landed spoilers were extended automatically and autobrake was initiated (the autobrake mode was set to MAXIMUM). When landed between 23:57:30 and 23:57:34, two F/O's reports were heard. Firstly: *"Speedbrake up, Reversers maximum"*, and 2 s later: *"...autobrake maximum in use."* In fact, the reverse mode was not ON at that time. It was engaged about 20 s later that the aircraft had landed. At 23:57:45, PIC said: "[expletive!] Reverser!", and at 23:57:49 the thrust reverser deployment was recorded (see Fig. 14). At this time, the aircraft was already at a distance of 2690 m from the RWY threshold. At the time of the thrust reverser deployment, engines' rotation speed was already at ground idle, therefore, the thrust lag had increased significantly, and when the engines reached "maximum reverse" mode the aircraft had already overrun the runway.

Note: *According UTair OM, Part B-2, Boeing 737 NG, Normal Procedures, Attachment B-2.1, subitem 4.9.7, all actions related to thrust reverser should be performed without delay: "Without delay, move the reverse thrust levers to the inter-locks and hold light pressure until the interlocks release. Then apply reverse thrust as needed."*

F/O's report on the "maximum reverse" mode engagement when in fact the reversers were not engaged at all, shows the crew failure to comply with Airlines OM in part of Part B-2, Normal Procedures, subitem 2.3.1, *Standard Phraseology*, and lack of CRM training.

Note: *In accordance with subitem 2.3.1, Standard Phraseology:*

PM executes callouts based on instrument readings or surveillance over a current event oriented environment. PF shall verify the received information and ***confirm it by the instrument readings and controls' positions****.*

If PM missed a callout, PF shall execute it. One of the CRM underlying principles is that every crew member is capable of substituting another crew member partially or completely.

The strict abidance of the recommended callouts is one of the keystones of the correct and efficient flight crew management."

At 23:57:39, PIC asked F/O: "*Is the autobrake working? Sure?"* F/O replied: *"Fuck you, apply braking! Yes! Manually!"* At 23:57:43, it means 13 s after the autobrake was initiated, PIC applied manual braking; this could be proved by the end of "BRK AUTO" single event recording (see Fig. 13).

The CVR data analysis revealed that the crew applied max manual braking; this could be proved by the fact that the brake pressure (recorded upstream of the antiskid valves) was equal to the autobrake system full available hydraulic pressure (≈ 3000 psi). The airplane designer explained, that in this case (for purposes of the efficiency of landing) the braking performance is no different whether the brake command is from the autobrakes or manual input from the crew.

At 22:57:43, F/O reported to the controller: *"5-7-9 landing"*; the controller asked: *"5-7-9, Roger, [able to] stop?"* No reply from the crew was recorded.

At 23:57:54, 26 s after touchdown, the aircraft with ground speed of about ≈75 kts (≈140 km/h) overrun RWY, broke through the aerodrome fencing and came to rest in Mzymta river bed. This ended with the fire outbreak of fuel leaking from the damaged LH wing fuel tank. The crew performed the passenger evacuation. The aerodrome alert measures were taken and the fire was brought under control.

The FDR recorded data analysis revealed no single events during the Boeing 737-800 VQ-BJI flight and landing which could suggest any equipment failures.

For the purpose to determine the effective brake pressure at the wheels of Boeing 737-800 VQ-BJI aircraft, the Boeing specialists provided the dynamic simulation of the flight in question on the landing roll. At Fig. 16, the result of this simulation are shown.

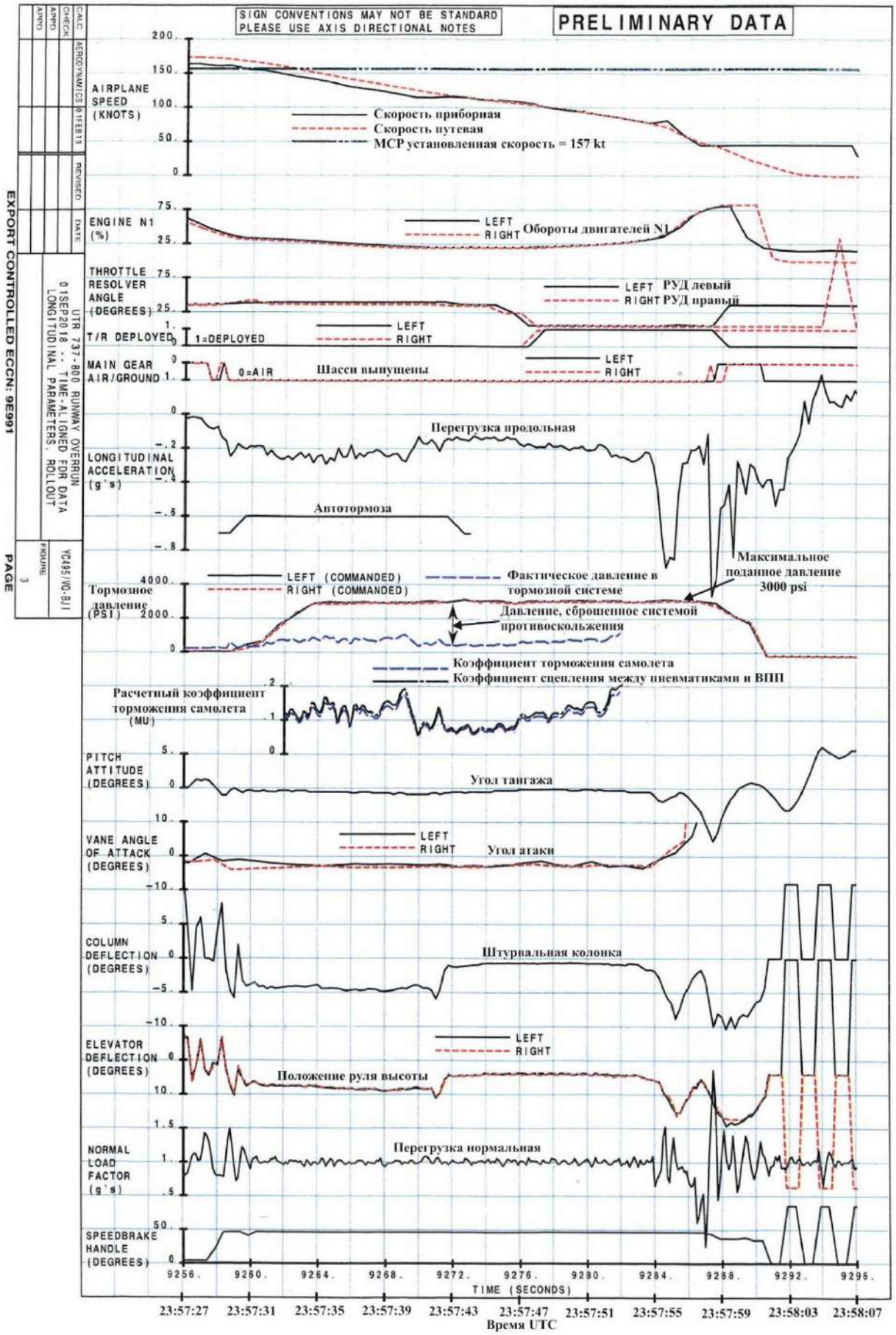

Fig. 16. Landing run – simulation of the aircraft movement

As was mentioned above, the crew selected autobrake max. Boeing explained, that for autobrake max the target deceleration for Autobrake max is 14 ft/s/s when above 80 kts and 12 ft/s/s below 80 kts.

If autobrake worked as per design, the autobrake system will be commanding the full available hydraulic pressure of 3000 psi (≈ 210 kg/cm^2), but the actual pressure at the brakes will be lower due to antiskid activity. The antiskid system will lower the brake pressure to achieve optimum wheel braking based on available friction.

The simulation revealed that in this case the actual brake pressure decreased upon the auto- and manual brake application (3000 psi), and in course of the aircraft rollout was changing from 390 psi (≈ 27 kg/cm^2) to 1040 psi (≈ 73 kg/cm^2), while deceleration varied around approximately 9 ft/s^2, and the tyre-to-ground coefficient varied around 0.05…0.18. As Boeing explained, the low brake pressure and tyre-to-ground coefficient indicate that there was insufficient tyre/runway friction available to achieve the target deceleration rate.

Based on the simulation result, the autobrake system was working as designed, for the given situation where friction is limited (RWY was covered by water). Within the distance of 2230 to 2580 m from the RWY 06 threshold, there was a RWY section with the most low available runway friction.

As it was already said in subitem 1.18, at distance of 2206 m from the RWY 06 threshold and further, the profile with two sloping surfaces changes for the profile with one sloping surface (with left to right pitch). Most probably, this caused some water accumulation and degradation of the tyre-to-ground adherence.

The actual braking performance did not meet the RWY condition with normative friction coefficient value of 0.5 – 0.55, that the crew received in ATIS (Y) at 23:07:12.

As it was already said in subitem 1.18, Sukhoi Civil Aircraft (for RRJ-95 airplanes) uses the wheel braking coefficient (tyre-to-ground) for calculation of the forces which affect the airplane when the later brakes in course of the after landing roll. For the actual friction coefficient (by FDR records) calculating, they use the method of measuring of braking torque in the moment when the wheel starts sliding. The method was verified by RRJ-95 airplanes flight test results. For the calculation of the aircraft braking performance when landing at the slippery runway, there is the conversion table to use for obtaining the wheel braking coefficient (which is unique for each aircraft type) against the measured friction coefficient. Here we are not able to determinate the actual normative friction for the covered by water runway because Boeing does not publish an explicit nomogram relating the normative friction to runway conditions. It would be safe to assume that the estimated wheel braking coefficient corresponds to the measured friction coefficient. Based on the dynamic simulation of the aircraft rollout movement (see Fig. 16), average wheel braking coefficient was about 0.12. In accordance with requirements of AIP of the Russian Federation, the runway surface condition should be evaluated by the normative friction coefficient (braking efficiency). By the published in AIP Table (AIP, Book 1, item 2.4 *Measuring of braking efficiency*), for the measured friction coefficient of 0.12, the normative friction coefficient shall be about ~ 0.27. This value is lower than 0.3 – min allowed (for landing) friction coefficient. Therefore, this brings us to the reasonable assumption that the runway actual condition failed to meet the requirements for safe landing.

By use of Boeing OPT, the field length for Boeing 737-800 VQ-BJI was calculated for different runway surface conditions. Based on the calculations the following field lengths are needed:

- for surface friction 0.5 (surface condition is good) if the thrust reversers are deployed after the touchdown – 1145 m;
- for surface friction 0.5 (surface condition is good) if the thrust reversers are not deployed – 1325 m;
- if a runway is covered with water and the thrust reversers are deployed after the touchdown – 1720 m;
- if a runway is covered with water and the thrust reversers are not deployed – 2580 m.

The calculations show that if an aircraft lands at distance of 1300 m from the RWY 06 threshold (friction coefficient is 0.5) the aircraft shall not overrun the runway (RWY length is 0.5). In case the runway is covered by water and the thrust reversers are deployed after the touchdown the aircraft shall overrun the runway by 125 m. If the thrust reversers are not deployed immediately, the aircraft shall overrun the runway by 985 m. This fact is confirmed by Boeing specialists.

Boeing believes that given the actual friction conditions that existed (with consideration that the aircraft had landed 1285 m to the threshold), it likely was not possible to stop on the runway even if the thrust reversers had been deployed immediately.

If the Boeing 737-800 VQ-BJI aircraft had landed without the overrun at distance of 380 m from the leveling initiation (OPT airborne part of a landing distance), the overrun might have occurred if the crew had not being applying the reversers. In this case the aircraft would had stopped at distance of 2960 m of the RWY 06 threshold. In case the use of reversers the aircraft would had stopped at distance of 2400 m of the RWY 06 threshold.

The Investigation team makes point that during the second approach the crew was in non-perfect working state and was not able to conduct the comprehensive assessment of the situation. Some examples are included into the Final Report. As, for example, F/O's report to the ATC controller: *"5-7-9 landing"* (see above). Another example: when F/O saluted PIC with *"Good boy!"* right after they had landed and reported the spoilers' and reversers' deployment, he was not recognizing that landing was not completed yet safe.

Most probably, the non-perfect working state was by inconsistency between the actual landing conditions and the received training as well as the psychological limit which was determined by the individual psychological constitution of each member which resulted in the strained psychoemotional state close to stressing. We must add that the crew run themselves ragged with nonoptimal decisions they took related to the flight continuation and to landing to the destination airport despite the bad weather forecasts they had received from different sources and their own estimation the weather conditions around Sochi airport as very adverse ones. This fact shows insufficient crew CRM and TEM training.

The Investigation team also makes point that there were individual features of the psychological constitution of each member which were estimated by an experienced psychologist[9] on base of the relevant documentation that had been provided by the Investigation team. Based on the psychologist conclusion, both pilots' personality profiles (considering the quantitative readings) may be actually assessed as "normal" ones. The similar conclusions were made during the mandatory psychological tests. However, the psychologist highlighted that the pilots' rather high level of intelligence allows them to manipulate the testing (in verbal methodology) and eliminate the answers which could show them to disadvantage.

[9] The psychologist work experience is over 25 years, mostly in the clinical psychodiagnosis, as well as in legal expertise and personnel appraisal.

At the same time, the psychologist assessed the pilots' personality profiles as maladaptive ones in a view of the clinical practice and qualitative researches, despite their good quantitative readings. F/O's personality was assessed as a hyper-risk-taking one.

In extreme (stress) conditions, a psychological maladaptiveness might show itself as a perception (space and/or time) disorder, memory problems, attentional disturbance; some unusual states of mind could be presented; and might be accompanied by unusual evident vegetative retreats. Such abnormalities affects the behavior and efficiency of a professional activity. The range of the presentation is rather wide: starting with the wrong actions range increase, proneness to conflict escalation, activity slowdown, and ending with the impossibility of the safe duty continuation which is typical for the accident in question.

In this respect, the fact that a personality profile is within limits (by the quantitative readings) is not a reasonable ground for the conclusion of aptiveness/maladaptiveness level. Also, the personality profile qualitative measurement should be done with a risk group detection; for the risk group the additional testing using a non-verbal methodology, and if necessary, relevant corrective measures. Psychologists did the similar conclusions earlier, for example, during the investigation of accident with Tu-154M (2006, Donetsk, Ukraine) and B 737-500 (2008, Perm, RF). The recommendations issued by psychologists and related to updating of flying personnel psychological testing were not implemented in full.

3. Conclusion

The aircraft overrun, destroying and damage by fire were caused by the following factors[10]:

- repeated disregarding of the windshear warnings which when entered a horizontal windshear (changing from the head wind to tail one) at low altitude resulted in landing at distance of 1285 m from the RWY threshold (overrunning the landing zone by 385 m) with the increased IAS and tail wind;
- landing to the runway, when its normative friction coefficient was less than 0.3 that according to the regulations in force, did not allow to land.

The factors contributed the accident:

- the crew violation of the AFM and Operator's OM requirements in regards to the actions required a forecasted or actual wind shear warning;
- use of the automatic flight mode (autopilot, autothrottle) in the flight under the windshear conditions which resulted in the aircraft being unstable (excess thrust) when turning to the manual control;
- lack of prevention measures taken by the Operator when the previous cases of poor crew response to windshear warning were found;
- insufficient crew training in regards to CRM and TEM that did not allow to identify committed mistakes and/or violations in good time;
- the crew members' high psychoemotional state caused by inconsistency between the actual landing conditions and the received training as well as the psychological limit which was determined by the individual psychological constitution of each member;
- insufficient braking both in auto and manual mode during the aircraft rollout caused by the insufficient tyre-to-ground friction aiming to achieve the specified rate of braking. Most probably the insufficient tyre-to-ground friction was caused by the significant amount of water on the RWY surface;

[10] As per ICAO Doc 9756 AN/965 the factors are listed without the priority assessment. The contributing factor identification is done not for the purpose of to apportion blame or liability.

– the aerodrome services' noncompliance of Sochi International Aerodrome Manual requirements related to the RWY after heavy showers inspection which resulted in the crew provision of wrong normative friction coefficients.

In obtaining of the increased overrun speed of about ≈75 kt (≈140 km/h) the later setting of engines into reverse mode was contributed (the engines were set into reverse mode 16 s later than the aircraft landed at distance of about ≈200 m from the runway end).

4. Other shortcomings revealed in the investigation

4.1. The normative friction coefficient determined by an airport service and provided to a crew for the operational landing distance calculation in case of wet runway landing does not meet the expected braking efficiency and therefore is to be recalculated by a methodology developed for each aircraft.

4.2. The aerodrome responsible staff failed to inspect the runway condition after heavy showers as required by provisions of Sochi International Aerodrome Manual, Part 4.5, item 7.1.

4.3. In the Runway Condition log encoded (by ICAO code) entries related to the fraction of runway surface covered by water do not reflect the measured values.

4.4. Taking into consideration the individual natural and climatic characteristics of the territories around Sochi airport (all-year thunderstorm activity with significant precipitations mostly in summer time), it is necessary to mention the insufficient RWY Safety Group activity in regards to hazard factors identification and response for instance prevention of cases of landing to the runways which surface condition does not meet the normative requirements.

4.5. The "Alarm" signal was not provided to the AMC of Sochi meteorologist on duty, no requests on the special meteorological observations were issued by the Flight/Shift Supervisor or by controller of Sochi International Airport Flight Operations Control Center.

4.6. The Operator had the cases when crews delayed with the go-around after they had received windshear warning in course of landing, it is evidence that the taken measures on the flight safety improvement are insufficient.

4.7. In violation of the requirements of national document FAP-128 (item 3.117) and recommendations of ICAO Annex 3, Doc 9817 AN/449 *Manual on Low-level Wind Shear*, crews when went around due to windshear warning failed to inform the ATM unit on the windshear zone at landing existence. As they might be the only source of information, therefore air-reports are very important from the viewpoint of the flight safety provision to other aircraft.

5. Safety Recommendations[11]

To Civil Aviation Administration (CAA) of the Russian Federation[12]

5.1. To provide the airports' management, airlines' management, flying and maintenance personnel, and ATC personnel with the results of the Boeing 737-800 VQ-BJI accident investigation. To pay special attention on performing of flight operations in accordance with the AFM and airlines' OM requirements.

5.2. To consider the reasonability of implementation of the new methodology of crews' provision of runway surface actual conditions' information on base of TALPA (Takeoff and Landing Performance Assessment) Advisory and Rulemaking Committee (ARC) in the form of the Runway Condition Assessment Matrix (RCAM).

5.3. With consideration of the insufficient runway conditions after heavy showers precipitations to conduct the evaluation of conformance of Sochi aerodrome design documentation to climatic conditions and norms in regards to the water drainage, as well as the evaluation of conformance of the actual runway design to the approved project documentation. To pay special attention to the runway section which is located within the distance of 2230 to 2580 m from the RWY 06 threshold.

5.4. To consider the reasonability of developing the List of runways, the overrunning of which might be hazardous for flight safety, and to install to these runways the dedicated brake covering as for example EMAS (Engineered Materials Arresting System) or other speed brake devices.

5.5. To consider the reasonability of implementing the additional (special) requirements and methodologies intended to the determination of flying personnel psychological testing on the matter of aptiveness/maladaptiveness level with use of the qualitative readings (in addition to the quantitative ones) of the personality profile analysis, and to detect risk groups where its members should be subjected to additional testing using non-verbal methodology, and if necessary, relevant corrective measures.

To Certification Authorities

5.6. To consider the reasonability of updating the airworthiness standards for large transport category aircraft with the conversion tables for each type of aircraft where a braking parameter

[11] In accordance with ICAO Standards and Recommended Practices, these Safety Recommendations (SR) have been issued with the sole objective of aircraft accident prevention. It is not the purpose of these SRs to apportion blame or liability.

[12] CAAs of other States-members of The Agreement on Civil Aviation and the Use of Airspace to consider the applicability of the above SRs with consideration of the actual situation in the State-member.

will be indicated as a function of a RWY state, measured friction coefficient and a type of measuring equipment used.

To UTair Airline

5.7. Within the Airline SMS, to take well-timed and effective measures providing of the crew members with the revealed hazard factors and measures taken on the risk mitigation.

To airlines' Executives

5.8. To update the airlines' Safety Management Systems with consideration of the shortcomings revealed in course of the investigation. To pay special attention to the measures that should be taken for C of the hazards that can affect the flight safety.

5.9. To identify the aerodromes with adverse navigational conditions for approaching, and to develop the recommendations for go-around procedures from the altitudes below DA(H).

5.10. To provide training for the flying personnel on the following items:

- flight operations, including decision making aspects under the thunderstorm in the aerodrome area;
- actions required when windshear warnings received and procedures for ATC reporting on the windshear availability;
- actions required when failed to follow the requirements for stabilized approach after a reference height fly-over;
- CRM policy when landing performing;
- importance of informing ATC on adverse weather conditions.

To airports' Executives

5.11. To CA airports' operators, RWY Safety Groups together with State ATM Corporation for the purposes of hazard factors identifying and preventive measures developing for preventing landing to unprepared runways, to use the accident investigation materials which are issued for the flight safety purposes and published at the IAC website, as well as other relevant documents stored in Rosaviatsia AMRIPP[13].

5.12. To provide additional training for the aerodrome and ATC staff on the following items:

- requirements for frequency of the airfield condition inspections in dependence to the weather conditions and seasons;
- acceptance criteria of runway related to operation elements and procedures of an airfield condition assessment.

[13] Rosaviatsia Archive of Incident and Accident Investigation Materials.