INTERSTATE AVIATION COMMITTEE
AIR ACCIDENT INVESTIGATION COMMISSION

INTERIM REPORT
(PRELIMINARY REFERENCE INFORMATION)
ON ACCIDENT INVESTIGATION

Type of occurrence	Accident
Type of aircraft	RRJ-95 (RRJ-95B)
Registration	RA-89098
Owner	JSC «VEB-Leasing»
Operator	«Aeroflot » PJSC
Aviation authority	Federal Air Transport Agency (Rosaviatsiya)
Place of occurrence	Russia, Moscow region, Sheremetyevo airport, coordinates: 55°58′06.20″ N, 37°24′07.20″ E.
Date and time of occurrence	05.05.2019, 18:30 local time (15:30 UTC), daytime

The preliminary report has been issued before the end of the investigation in compliance with 7.4 of Annex 13 to the Convention on International Civil Aviation (ICAO) and 2.4.12 of the Rules of investigation of air accidents and incidents with civil aviation aircraft in the Russian Federation. The preliminary report contains the actual information, currently received by the investigation team, conducting the accident investigation (further referred as "the investigation team") as well as the results of the data decoding of the onboard and ground data recorders, video records, results of the examinations, which have been currently completed, and other materials. The report may be updated upon the receipt of additional information.

The investigation team is currently examining the technical condition of the aircraft, analyzes its certification and technical documentation, examining the data of the onboard weather radar and the air traffic control radar, assessing the fire occurrence causes and the rescue operations; studying the information on the training and qualification of the flight crew and the cabin crew and the respective training programs, the training and qualification of the air traffic control and the emergency rescue team specialists and analyzing their actions during the occurrence and the development of the accident.

The information provided in the report is preliminary and may be specified and supplemented based on the results of the conducted examinations and study of all the associated materials. After the completion of all the associated works, the Final Report on the results of the investigation of the accident is to be provided.

In compliance with 2.2.7 of the Rules of investigation of air accidents and incidents with civil aviation aircraft in the Russian Federation, earlier the investigation team has prepared the follow-up report, containing, inter alia, the recommendations for the flight safety level enhancement, and has provided it to the Federal Air Transport Agency (Rosaviatsiya) and to the Ministry of Industry and Trade of the Russian Federation. Upon consideration of the preliminary report, the investigation team members have decided that there will be no additional recommendations provided at this stage of the investigation. Within the framework of further work, the technical team may provide additional recommendations.

The Report is published in the Russian and English languages. If there is a difference in interpretation between the Russian and English versions, the Russian version will prevail.

LIST OF ABBREVIATIONS

AMIS	–	Aerodrome meteorological information system
AMC	–	Aviation meteorology center
AC	–	Aircraft
AR-25	–	Aviation Rules, Part 25
ATIS	–	automatic terminal information service
RWY	–	runway
GosNII GA	–	State Research Institute of Civil Aviation
BEA	–	French Civil Aviation Security Investigation and Analysis Bureau
BFU	–	German Accident Investigation Bureau
CAT	–	category
CCTV	–	closed circuit television
CRM	–	Crew Resource Management
CVR	–	Cockpit Voice Recorder
EMERCOM	–	Ministry of the Russian Federation for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters
FATA	–	Federal Air Transport Agency
FCOM	–	Flight Crew Operations Manual
FDR	–	Flight Data Recorder
FFS	–	Full Flight Simulator
FO	–	First Officer
FMS	–	Flight Management System
ft	–	feet
ft/min	–	feet per minute
IAC	–	Interstate Aviation Committee
ICAO	–	International Civil Aviation Organization
JSC	–	Joint stock company
iDMU	–	Integrated data management unit
kt	–	knots
MEL	–	Minimum Equipment List
METAR	–	regular meteorological weather report
MSN	–	manufacturer serial number

NOTAM	–	notice about changes in the rules of flight conducting and aeronautical information (eng. NOtice To AirMan)
NTO	–	Normal Takeoff
NTSB	–	National Transportation Safety Board (USA)
PCMCIA	–	International Association of Personal Computer Memory Cards
PIC	–	Pilot-in-Command
PJSC	–	public joint stock corporation
PNR	–	Part number
QFE	–	atmospheric pressure at runway threshold
QNH	–	atmospheric pressure reduced to mean sea level in a standard atmosphere
QRH	–	Quick Reference Handbook
RWS	–	Reactive Windshear
RWY	–	Runway
SID	–	Standard Instrument Departure
SIGMET	–	Meteorological information about the actual or expected occurrence of special weather phenomena along the flight route that may affect aircraft safety
SPECI	–	special meteorological weather report
STAR	–	standard terminal arrival route
TAF	–	aerodrome weather forecast (in meteorological code)
TAWS	–	Terrain Awareness and Warning System)
TO/GA	–	Takeoff / Go-Around
TWY	–	Taxiway
UTC	–	coordinated universal time
V1	–	decision speed
Vr	–	nose gear wheel lift up speed
V2	–	safe takeoff speed
VCSS	–	voice communication switching system
VDR	–	VHF data radio
WS	–	wind shear

SYNOPSIS

On 05.05.2019, at 18:30 local time (15:30 UTC)[1], during the landing to RWY 24L of the Sheremetyevo airdrome, an accident occurred, involving the Aeroflot RRJ-95B RA-89098 aircraft. The aircraft was performing a scheduled SU – 1492 passenger flight from the Moscow Sheremetyevo Airport (UUEE) to Murmansk Airport (ULMM). At the 6th minute of the flight, after the atmospheric electricity impact, the crew decided to return to the Moscow Sheremetyevo Airport. There were 2 flight crew members, 3 cabin crew members and 73 passengers onboard. As the result of the aviation accident, 1 cabin crew member and 40 passengers (39 of them being Russian citizens and 1 USA citizen) were killed, 1 cockpit crew member and 2 passengers were seriously injured, 1 flight crew member and 2 cabin crew members, and 4 passengers suffered minor physical injury. As the result of several touchdowns with the significant vertical g-force and the fire that occurred afterwards, the aircraft was significantly damaged.

The information about the accident was received by the IAC at 15:53 on 05.05.2019.

The investigation of the accident is being conducted by the investigation team, appointed by the orders of the Chairman of the Air Accident Investigation Commission of the IAC, dated 05.05.2019 No. 8/909-p and dated 14.05.2019 № 8/910-p.

According to ICAO Annex 13, Aircraft Accident and Incident Investigation, to the Convention on International Civil Aviation, the notifications on the accident were sent to the BFU, Germany, as to the accredited investigation organization of the State of Design and the State of Manufacture of the aircraft flight control system; to the NTSB, the USA, as to the accredited investigation organization of State of Design and the State of Manufacture of a number of components and parts and as to the State whose citizen was killed as the result of the accident; to the BEA, France, as to the accredited investigation organization of the State of Design and the State of Manufacture of the engines and a number of components and parts. The above-mentioned states appointed their accredited representatives for the purpose of participation in the investigation.

The representatives of the Federal Air Transport Agency (Rosaviatsiya), of the aircraft designer (JSC "Sukhoi Civil Aircraft"), of "Aeroflot Russian Airlines" PJSC and other specialists are participating in the investigation.

[1] Further the time is provided in the UTC format, if not indicated otherwise, the local time is UTC time + 3 h.

The initial activities at the accident site (the passenger evacuation, the provision of security of the accident site) were carried out by the EMERCOM of Russia, JSC "Sheremetyevo International Airport" and "Aeroflot Russian Airlines" PJSC. An investigation team has taken into consideration the information provided by these organizations.

At the moment, the fragments of the aircraft are under the custody at the Moscow Sheremetyevo Airport.

The investigation was launched on 05.05.2019.

In order to investigate accident, involving the "Aeroflot Russian Airlines" PJSC Superjet RRJ-95B (Registration Number RA-89098), that occurred in the Moscow Region on 05.05.2019, to provision of assistance to the injured and to the families of those who passed away and to assist in the disaster consequences elimination, by Decree No. 890p of the Chairman of the Government of the Russian Federation, dated 06.05.2019, the Government Commission headed by the Minister of Transport of the Russian Federation was established.

The preliminary criminal investigation is being carried out by the General Directorate for Highly Important Cases of the Investigative Committee of the Russian Federation.

1. FACTUAL INFORMATION

1.1. Flight history

On 05.05.2019, Aeroflot Russian Airlines PJSC's flight crew consisting of the PIC and the First Officer, on the RRJ-95B RA-89098, performed scheduled passenger SU – 1492 flight on the route from The Moscow Sheremetyevo Airport (UUEE) to the Murmansk Airport (ULMM). The aircraft had arrived from the previous flight performed by another flight crew at 10:41.

The crew arrived to the airport approximately 2 hours before the flight. After performing the required preflight procedures (medical examination, briefings etc.) at 14:17[2], the flight crew started performing the preflight procedures in the cockpit.

According to the CVR data, in particular, the crew noted that: "There are no MEL restrictions, there are no NOTAM restrictions" , "No special weather phenomena" Further on, the crew determined their actions under possible abnormal situations after the takeoff: "…engine out SID to the holding area…"[3] and "In case of immediately return … TALUK, Mayday"[4].

During the time period from 14:25:40 to 14:27:20, the crew received the ATIS Alfa information, then during the period from 14:28:00 to 14:31:22, they received the ATIS Bravo information: "…Departure RWY 24 centre, wet, braking action good measured by SFT. Friction coefficient 0.45, transition level 60, procedure of the reduced runway separation minima in progress., caution birds. Weather: surface wind 140 degrees 3 gusting 6. Visibility 10 km or more, few cumulonimbus 1800 m, temperature 17, dew point 13, QFE 7-4-2 millimeter, 989 hectopascal, QNH 1-0-1-1 hectopascal, RWY 24 centre, QFE 0989 hPa 7-4-2 mm, no significant changes".

At 14:35:35, the Sheremetyevo Delivery traffic controller on the request of the flight crew assigned the SQUAWK and instructed on the departure sequence: "Aeroflot 1-4-9-2 Sheremetyevo - Delivery, good evening, clear to Murmansk, runway 2-4 Central, Kilo November 2-4 Echo departure, SQUAWK 2-1-4-7".

During the discussion on the received departure sequence KN 24E[5] (Fig. 28) the PIC said that there were flashes: "All the same, to the right, there is such flashing behind. It will be even faster for us".

The passengers embarked through the left front door. By 14:40, all the doors had been closed.

[2] According to the timetable, the SU – 1492 flight was scheduled at14:50.
[3] In case of engine failure, SID to the holding area.
[4] In case of immediate return, TALUK and MayDay.
[5] Previously, the crew discussed another departure sequence.

By 14:42:48, upon receipt of the information from the ground maintenance personnel on the readiness to the engine start, the FO contacted the Sheremetyevo Apron air traffic controller: "*Sheremetyevo - Apron, good evening, Aeroflot 14-92, parking 107 Whiskey, information Bravo, requesting start-up clearance".*

Due to the fact that there were many aircraft at the holding point, the air traffic controller instructed to contact him again in 2 minutes.

At 14:45:30 after the repeated request, the controller cleared for the start-up. The crew accomplished the "BEFORE START" section of the checklist (during the check list section performance, it was confirmed that all the doors were locked and armed) and performed the engines' start-up: first for the right engine, then for the left engine.

After the engine start-up, during the period from 14:48:30 to 14:49:25, the crew performed the rudder and elevator check and the "AFTER START" section of the checklist. At 14:49:29, the FO reported to the controller that they were ready for taxiing.

The controller informed the crew about the route of taxiing to the RWY: «*To the left via BRAVO 1, BRAVO 2 to Taxiway 10*».

At 14:50:15 the crew started taxiing. The taxiing was performed at the speed not above 20 kt (37 km/h). During the taxiing, the brakes and the weather radar were checked.

At 14:51:05 the crew contacted the taxiing controller. On establishing the contact, the crew received the instruction for taxiing to the holding point of RWY 24C.

At 14:51:40 the crew started to perform the «BEFORE TAKEOFF» section of the checklist, and the calculated speeds were announced V_1 – 129 kt (240 km/h), V_R 135 kt (250 km/h), V_2 - 140 kt (260 km/h), as well as the takeoff configuration of FLAPS 2 (slats 24°, flaps 16°).

According to the loadsheet, the takeoff weight of the aircraft was 43 545 kg, the fuel onboard was 7330 kg, the calculated center-of-gravity was 26.43%, the stabilizer position was at 2.2° pitch-up.

At 14:54:25, after the FO report that the aircraft was at the holding point, the communication was transferred to the Sheremetyevo Tower controller.

At 14:57:20, on receiving the air traffic controller's clearance, the crew lined up at RWY 24C, where they were holding for about 5 minutes to receive the takeoff clearance. At the line up the crew observed the flashes at the weather radar: the PIC reported at *14:58:27: "The flash, do you see it (illeg.). Yes, holy crap".*

At 15:02:23, the controller issued a clearance for takeoff. The crew confirmed the receiving the clearance. At 15:02:49 via pressing the TO/GA switch, the PIC engaged the auto throttle. The thrust levers were automatically set to the «NORMAL TAKEOFF" mode» (the thrust levers were at

48°, the N_1 was 92%). Simultaneously with the auto throttle engagement, the flight director bars were engaged in the in «TAKEOFF» («TO») mode in the automatic control system.

At the speed of 154 kt (285 km/h) the aircraft lifted off the RWY, after the *«Positive climb»*[6] *callout*, upon the command from the PIC, the FO retracted the landing gear.

At 15:03:36 at 1250 ft (380 m), according to the QNH pressure (the altitude according to the radioaltimeter was 690 ft (210 m)) and at the indicated speed of 160 kt (296 km/h), the PIC engaged the autopilot. The "TO" mode was engaged in the longitudinal control channel, the "LATERAL NAVIGATION" / "LNAV" mode was engaged in the lateral control channel.

At 15:03:41, "CLIMB"/"CLB" was in the longitudinal control channel. The auto throttle system engaged in the «THRUST» mode and the engine power was decreased (the thrust levers were set to 31°, the N1 was 91%). The climb was performed at the vertical speed of ≈3500 ft/min (≈18m/s).

At 15:03:56, the Sheremetyevo-Radar controller cleared the crew to climb to 1200 m (according to the QFE pressure) in accordance with the standard departure sequence.

At 15:04:33, there the "FMS SPEED CONTROL" mode was activated in the automatic control system, and the selected speed was set at 250 kt (463 km/h). The autopilot continued in the climb mode, and the aircraft speed was increased by means of decreasing the pitch angle of climb, and consequently, by the vertical speed decrease.

At 15:04:56, when reaching the indicated air speed of 185 kt (343 km/h) (which corresponds to the "F" speed, prescribed for the beginning of the flap retraction, to the middle post-takeoff position), the crew started to retract the flaps in the FLAPS 1 position (slats 18°, flaps 3°).

At 15:05:00, the "ALTITUDE CAPTURE" / "ALT*" mode was activated, because the aircraft was close to H_{ssel}=4608 ft (1405 m), selected before the takeoff. The auto throttle switched to the "SPEED"/"MACH") *mode.*

At 15:05:18 the Sheremetyevo-Radar controller gave an instruction to climb to FL 60.

At 15:05:22, the aircraft reached the selected flight altitude of 4608 ft (1405 m) and after that the "ALTITUDE HOLD" / "ALT" was engaged. At the same time, when the indicated air speed was increased to 224 kt (415 km/h) (which corresponds to the "Green Dot" speed, recommended for the beginning of the flaps retraction to the cruise position), the crew started to retract the flaps to the FLAPS 0 position slats 0°, flaps 0°).

[6] Positive vertical speed.

At 15:05:24 the selected altitude was set to 5984 ft (1824 m), and almost immediately after that the «VERTICAL SPEED» / «VS» mode was activated in the automatic control system with the selected vertical speed of Vsel=0 m/s. This combination of the recorded parameters may be associated with pressing "LEVEL OFF" of the automatic flight control system control panel. The trust levers were set to the thrust decreasing mode (to the position of 26°), as at this stage, the aircraft almost reached the selected speed of 250 kt (463 km/h)).

At 15:05:32, the crew engaged the "CLIMB" / "CLB" mode. The auto throttle was switched to the «THRUST» mode and the trust levers were set to 29.4°, which corresponds to the engine «CLIMB» mode.

At 15:05:33, the crew set the standard pressure of 760 mm Hg/1013 hPa.

At 15:05:42, the crew engaged the "VERTICAL SPEED" / "VS" mode and set the selected vertical speed to 937 ft/min (4.76 m/s). Simultaneously, in the "LATERAL NAVIGATION" / "LNAV" mode, the aircraft started to develop the right turn to the heading of 268° in accordance with SID KN 24E.

During the period from 15:05:44 to 15:05:53, the crew performed the «AFTER TAKEOFF / IN CLIMB» section of the checklist.

At 15:06:30, the "ALTITUDE CAPTURE" / "ALT*" mode was engaged and the aircraft reached the selected altitude of ≈6000 ft (1830 m), and after that the mode "ALTITUDE HOLD" / "ALT" mode was activated. The indicated air speed was 250 kt (463 km/h).

At 15:06:57, the Sheremetyevo-Radar controller instructed the crew to climb to FL 70 and to contact the Approach controller. The crew set the new selected altitude of 7008 ft (2136 m) and activated the «VERTICAL SPEED» / «VS» mode. The selected vertical speed was 938 ft/min (4.75 m/s).

At 15:07:10, the «HEADING» / «HDG» mode was engaged in the lateral control channel, and the selected heading was set to 327°. According to the Vnukovo[7] doppler weather radar, the aircraft was flying through the active thunderstorm area (Fig. 3), that was moving from the south-west to north-east with the speed of 40-45 km/h. The transition to the selected heading mode caused the aircraft to initiate the right turn earlier than it is prescribed by SID KN 24E (Fig. 4). The crew did not requested the active thunderstorm area avoidance clearance. Section 1.18.1 of the present

[7] Because of the peculiarities of the Vnukovo doppler weather radar operation and data registration, for the figures provided, it is possible only to indicate the period of time when they were taken. The indications on the display of the onboard weather radar could be different.

Report provides the consolidated table of the other aircraft following and preceding the SU – 1492 flight, which crews requested the active thunderstorm area avoidance clearance.

On contacting the Approach controller, the crew was instructed to climb to FL 90. At 15:07:21, the crew set the new selected altitude of 8992 ft (2741 m) and activated the "CLIMB" / "CLB" mode.

During the period from 15:07:30 to 15:07:33, there is the following conversation in between the crew members was recorded: PIC*: "We are going to get shaken"*, FO*: "Damn it."*, *PIC: "Nothing to worry about"*.

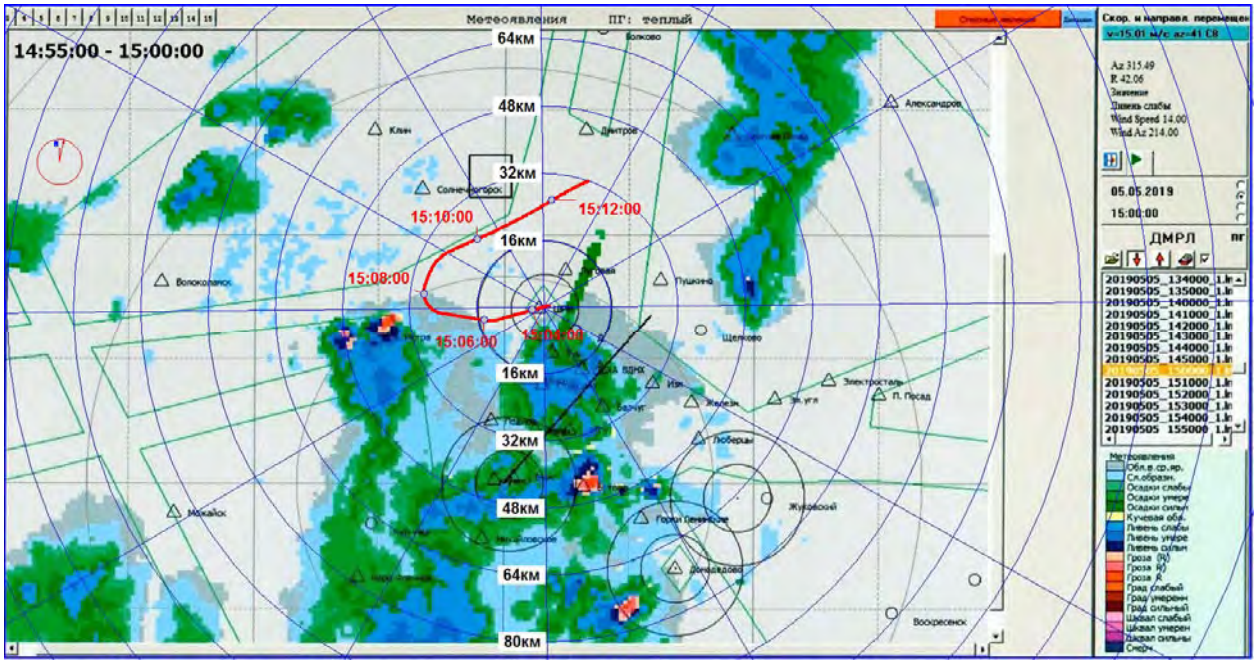

Fig. 1. Flight path combined with the DMRL-C Vnukovo weather radar for the time 14:55 – 15:00

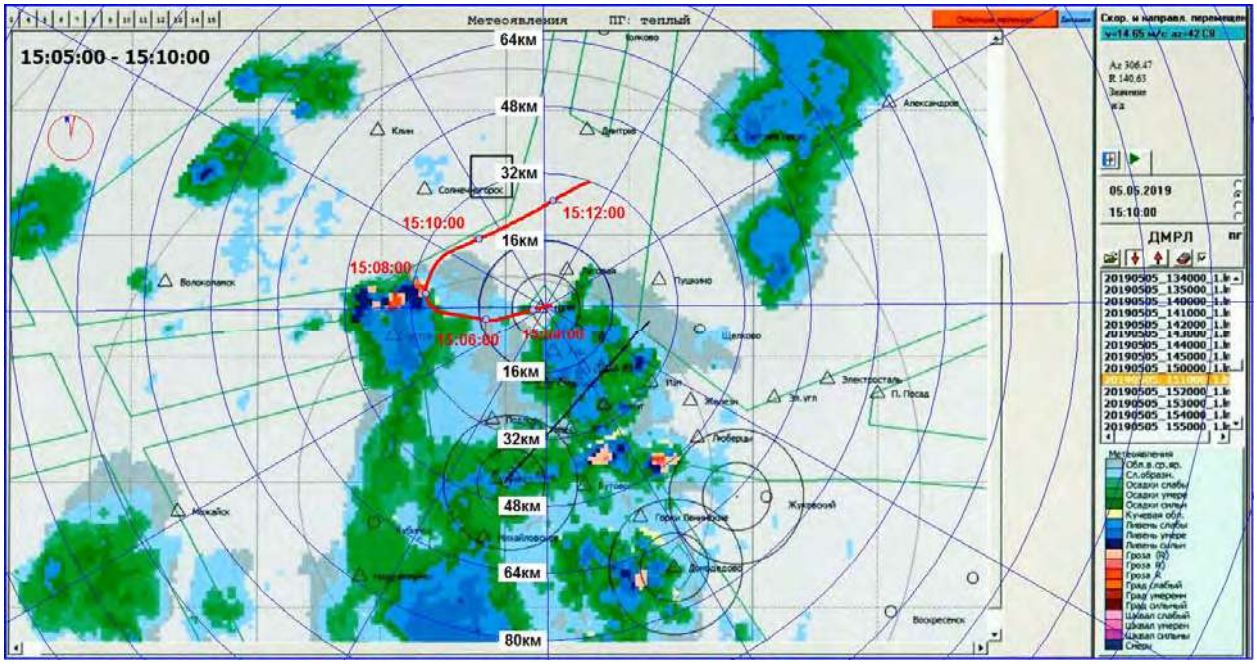

Fig. 2. Flight path combined with the DMRL-C Vnukovo weather radar for the time 15:05 – 15:10

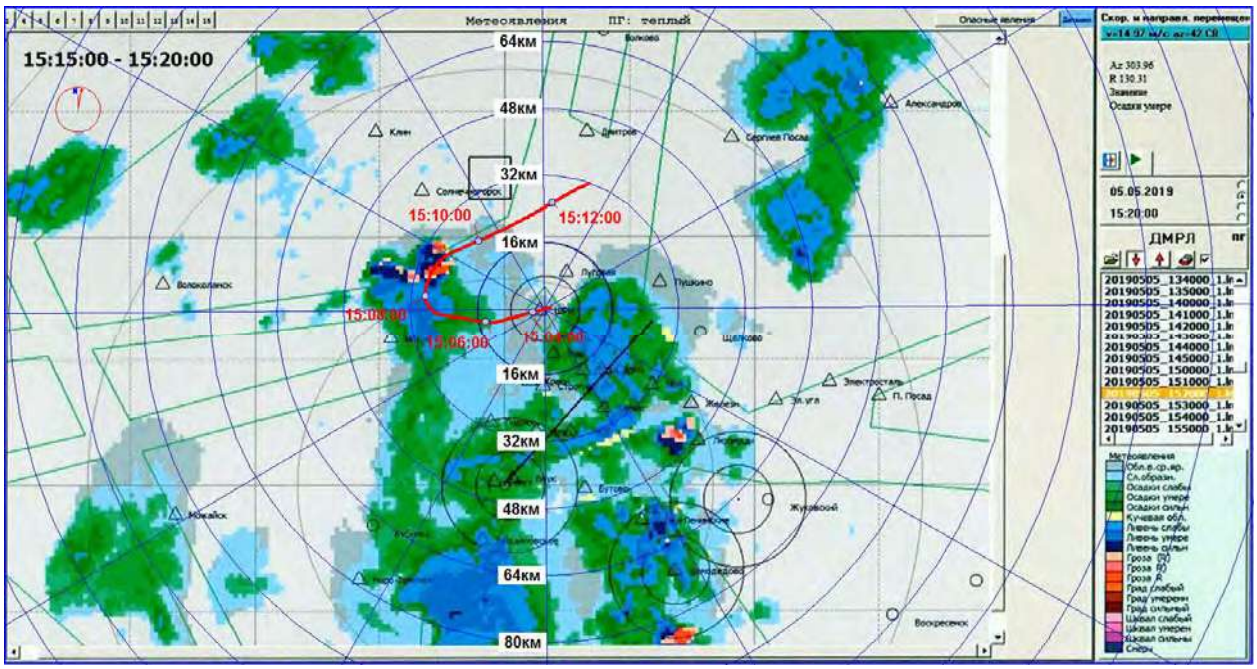

Fig. 3. Flight path combined with the DMRL-C Vnukovo weather radar for the time 15:15 – 15:20

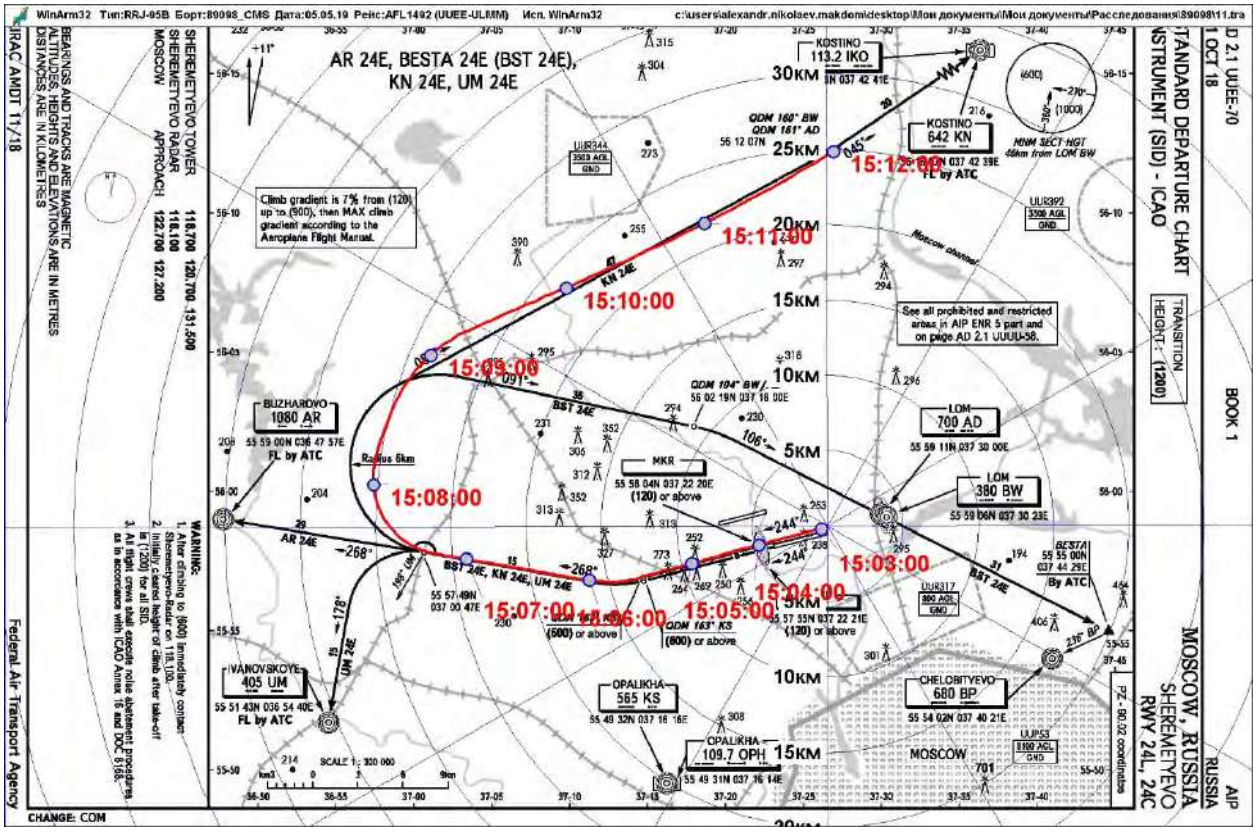

Fig. 4. Flight path combined with the SID KN 24E chart

At 15:07:34, the Approach controller instructed the crewto climb to FL 100. At 15:07:39, the selected altitude was 9984 ft (3043 m), with "CLIMB" / "CLB" mode continued to be engaged in the longitudinal control channel.

At 15:07:43, the "LATERAL NAVIGATION" / "LNAV" mode was engaged again in the horizontal plane. By that time, the aircraft was flying with heading of 317°, the right roll of 24° and the indicated speed of 250 kt (463 km/h).

At 15:08:03, the Approach controller instructed the crew to climb to FL 110. When the FO confirmed receiving the instruction, recorded by the CVR, the sound effect lasting for 1.5 seconds, starting from 15:08:09.7, was recorded. Most probably, at this stage, an atmospheric electricity impact affected the aircraft. 3 seconds prior, the FDR started to record the single commands, indicating the engagement of the permanent ignition on the both engines.

Note: ***Aeroflot Operations Manual, Part A, Chapter 8, Working procedures, Section .3.9 Flights under different weather conditions, Subsection .8.3.9.2 Flights in thunderstorm and heavy rain areas***

…

(2)In case there are towering cumulus clouds and cumulonimbus clouds around the airport of departure ,the crew must examine the take-off and departure zone by means of the onboard weather radar and determine the manner of avoiding the towering cumulus clouds and cumulonimbus clouds and the heavy rain area.

(3) Upon approach to the area of the thunderstorm and the heavy rain , the PIC must assess the possibility to continue the flight ,make a decision on avoiding the active thunderstorm area and the of heavy rain area and coordinate his actions with the ATC unit. If necessary, the PIC may request the aircraft vectoring from the ATC unit in order to avoid the thunderstorm area.

It is prohibited to deliberately enter the (thunderstorm) towering cumulus clouds and cumulonimbus clouds and the heavy rain area.

(4) The IFR flights in the thunderstorm and heavy rain area without the radar station onboard or without ground radar assistance are prohibited.

Upon detection of the (thumderstorm) towering cumulus clouds and cumulonimbus clouds by the onboard radar it is allowed to fly around them at the distance of no less than 15 km from the closest boundary of the cloud marking at the radar display.

Aeroflot Flight Operations Manual, Part B (C), Chapter 3, Additional Procedures, Section 3.13, Weather radar

The basic provisions of the flight operation in the thunderstorm and heavy rain conditions are provided in Operations Manual, 8.3.9.2.

The RRJ-95 is equipped with an RDR-4000 weather radar, the weather radar manufacturer recommends is case of the thunderstorm cell detection to do as follows:

- *to plan avoidance no less than 40 nautical miles away from the thunderstorm cell in order to timely coordinate the avoidance route with the ATC controller*
- *to avoid the thunderstorm cell from the upwind side instead of the downwind side (as thus the probability to get into the turbulent descending flow or hail is less)*
- *while planning to avoide the thunderstorm cell, the crew must consider to the thunderstorm cell altitude and apply the following*
    - *to fly-around amber, red and magenta zones at a distance of 20 nautical miles as a minimum*

At 15:08:11, the crew set new selected altitude of 11008 ft (3355 m) and the new selected vertical speed of 3281 ft/min (16.7 m/s), and the "VERTCIAL SPEED" / "VS" mode was engaged.

At 15:08:11.9, the disengagement of the autopilot occurred, accompanied by the corresponding aural alert and the switching of the automatic flight control system into the "DIRECT MODE" (see Section 1.18.% of the present Report) with the audio alert "DIRECT MODE. DIRECT MODE". After the sound effect, simultaneously with the autopilot disengagement, the emotional exclamation of one of the crew members was recorded: *"Wow!"*. The auto throttle continued to be engaged. The aircraft was in 20° right roll, crossing FL 89 (2700 m) in climb.

Starting from 15:08:12, during 15 seconds, the FDRs incorrectly recorded single commands and the analog parameters, which are usually recorded via the electronic interface unit, EIU-100. Two single commands and , "EIU1 FAULT" and "EIU2 FAULT", were recorded simultaneously

The conducted examinations (Section 1.16.2 of the present Report) have shown that, most probably, at that stage, a reboot of the data concentrator units occurred, which caused the switching of the automatic flight control system into the «DIRECT MODE». According to the "List of special situations for the RRJ-95B aircraft" during the certification this event had been classified as a "complicated situation" (Section 1.18.14)

After the switching to the "DIRECT MODE", the "FLAPS ICE" configuration (slats 0°, flaps 1°) was engaged automatically.

Starting from 15:08:16, the aircraft control was switched to manual control of from the left-hand side pilot station. During the period of approximately 4 seconds, starting from the moment of the autopilot disengagement and till the PIC took over the aircraft control, the right roll decreased to

13°, pitch attitude increased (from 11° to 12°). The PIC's first control input from was affecting the roll channel, the sidestick was declined to 11.7° to the left (which is for more than half of its travel range), after that the sidestick was advanced to 6.8° (which corresponds to the half of its pitch-down travel range). Further sidestick control movements both in the roll and in pitch channels was of an abrupt and intermittent character. At 15:08:22, the aircraft was turned to the right via multiple impulse deflections of the sidestick ranging from 30% to 65%. To set the roll of ≈20° the pilot performed more than 10 roll deflection movements of the sidestick during the period of 18 seconds. Moreover, at different moments of the further flight the PRIORITY / APOFF[8] button was pressed momentarily (for approximately 1 second) on the left sidestick 6 times.

The aircraft continued to develop the right turn in accordance with the KN 24E chart and continued to climb. At 15:08:47, the auto throttle was disengaged by the overriding movement of the thrust lever. At 15:09:17, the aircraft was put out of the right roll mode and was set to the heading of about 60°.

After short discussion with the FO, the PIC made the decision to return to Sheremetyevo and ordered the FO to report PAN-PAN. After several failed attempts to contact the controller on the working frequency via VHF-Station 1 (the one that was used from the beginning of the flight), at 15:09:32, after the discussion, the crew set the 7600 squawk code (for the lost radio communication).

At 15:09:35 radio-contact was restored at the emergency frequency (121.5 MHz) via VHF-Station 2. After that, at 15:09:39, the FO reported the Approach controller: *"Moscow-Approach, request return of 14-92, radio lost, aircraft in direct mode"*. The controller issued an instruction to descend to FL 80. Maximum altitude the aircraft gained was 10600 ft (3230 m) (QNE). The crew responded: "Aeroflot *14-92, heading 0-57, descending to FL 8-0"*. The controller confirmed the clearance for the descent with the maintained present heading. Further flight till the moment of the glideslope capture was performed by means of vectoring.

At 15:09:52, the crew set the selected altitude of 8000 ft (2438 m) and disengaged the FMS speed control mode, set the selected speed of 250 kt (463 km/h) and put the aircraft into the descent mode. In descending, the PIC maintained the indicated air speed by changing the pitch angle and the thrust levers' positions.

Upon each receipt of the controller's instructions, the crew set the new selected altitude (at 15:10:51 it was set to 7008 ft (2136 m), at 15:12:01 –it was set to 5984 ft (1824 m)).

[8] Hereinafter the actual actions of the flight crew are provided. The reasons for these piloting peculiarities are to be analyzed in the Final Report.

At 15:12:32, the PIC explained to the purser that the aircraft was returning to the airdrome of departure and emphasized: *"No emergency, we are simply going back"*.

At 15:12:43, the controller instructed the crew to turn right to the heading of 140° and to descend to FL 900m QFE. The descent and approach trajectory is shown in Fig. 5.

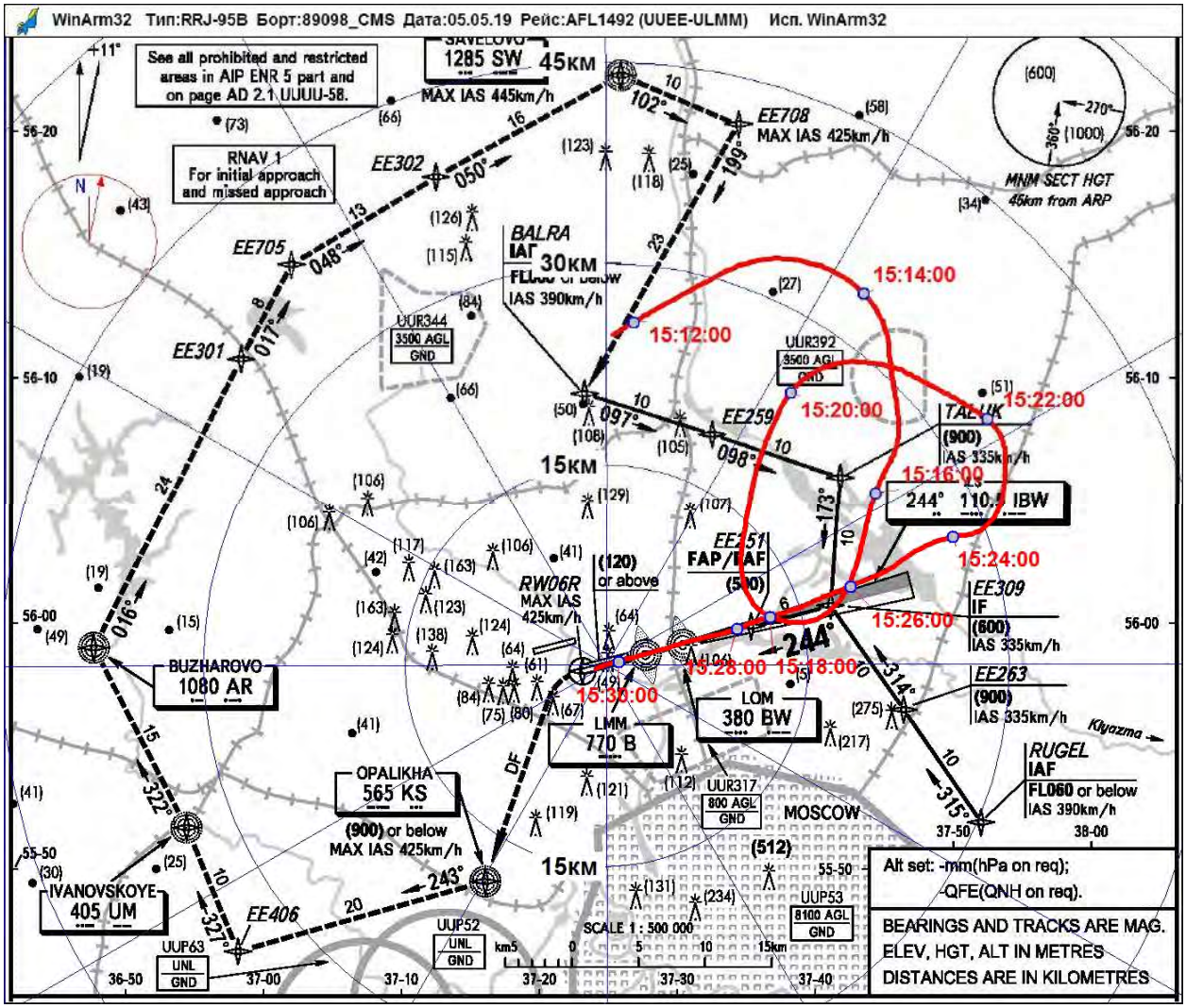

Fig. 5. Flight path combined with the STAR chart

At 15:12:47, the selected heading of 140° was set, and the PIC set the aircraft into the right turn. The turning was performed with the roll, changing within the range of 13° to 22°. In the process of turning, when receiving the corresponding instruction from the controller, the selected heading was set to 160°.

Upon the controller ' request: "*Any assistance required?"*, the crew responded: *"No, so far everything is normal, standard"*. Upon the controller's request for clarification, the crew responded that they were having problems with the radio communication and that the automatic flight control had been lost.

At 15:13:11, the PIC ordered to perform the QRH «F/CTL DIRECT MODE» section (1.18.6). The FO initiated the performance of the QRH «AUTO FLT AP OFF» section two times,

because these actions were interrupted by his communication with the controller. At 15:14:25, the PIC corrected the FO.

At 15:14:36, the aircraft was put on heading of ≈170°.

At 15:15:05, the controller instructed the crew to turn right to the heading of 180° and to descend to 600 m QFE.

At 15:15:10, the selected heading was set to 181° and at 15:15:27 the selected altitude was set to 2592 ft (790 м)[9] and did not change till the end of the record.

At 15:15:34, the controller cleared the crew for the ILS Yankee approach, RWY 24 left. After the permission confirmation, the FO started reading section QRH "F/CTL DIRECT MODE", inter alia: "… Auto throttle should not be used, fly smoothly. … Balance manually. … Speed brake no less than a half. … use Flaps 3. TAWS, landing gear, Flaps 3 on. V approach, V reference plus 10. Landing distance – increase by 1-34. … Speed brake set to full after touchdown. Go-around lever to NTO".

At 15:16:54, the controller instructed: "… proceed right heading 210 till localizer capture …".

At 15:17:39, the FO, after the command from the PIC, reported to the controller that the crew was not ready to perform landing approach and requested an «orbit», but then corrected himself: "the circuit" and the controller responded: "… heading 360 to the right".

At 15:18:53, the PIC tried to contact the controller himself: «Aeroflot 14-92, holding area above Kilo November, if possible». The message was not recorded by the controller's recorder. The PIC did not raise this question again.

When performing an orbit flight at 600 m QFE, the PIC could not maintain the altitude precisely. During right turns with roll up to 40°, the deviation from the selected altitude exceeded ±200 ft (60 m), and that triggered multiple aural alerts. The PIC was aware of that, at 15:22:53: "How come… plus-minus 200 feet".

During the orbit flight performance, the FO was reading out the QRH "OVER MAXIMUM LANDING WEIGHT LANDING" section (1.18.7). The weight of the aircraft was about 42 600 kg which exceeded the maximum landing weight by 1600 kg. To gain the maximum thrust in order to be able to perform the go-around, the crew switched off the engine air bleed supply to the conditioning system. The FO also read out that the maximum vertical speed of descend before the touchdown must be no more than 360 ft/min (1.8 m/s). During the standard approach and landing

[9] The height of the pressure QNH, corresponding to an altitude of 600 m QFE, given by the controller.

(the Standard Procedures)) the vertical speed recommended by FCOM is 150-200 ft/min (from 0.76 to 1 m/s).

Note: ***FCOM RRJ-95, Standard operation procedures, Section 04-80 LANDING***

During the manual landing, the vertical speed at the moment of touchdown must be 150-200 ft/min (0.76 to 1 m/s).

At 15:20:41, the crew started the APU.

At 15:21:38, at 225 kt (415 km/h) the crew initiated the flaps deployment to FLAPS 1 (slats 18°, flaps 3°).

At 15:23:03, after the PIC's order, the FO reported the controller that the crew was ready for landing.

At 15:23:19, at 190 kt (350 km/h) the crew initiated the flaps deployment to FLAPS 2 (slats 24°, flaps 16°).

At 15:23:58 the crew started the landing gear extension.

At 15:24:02, the crew armed the speedbrake system.

Note: *Automatic speedbrake deployment mode which can be engaged during the landing and which is inactive when the Remote Control system is in the "DIRECT MODE"».*

At 15:24:20, at 170 kt (315 km/h), the crew set the flaps into the landing configuration, FLAPS 3 (slats 24°, flaps 25°).

During the landing gear and flaps deployment, the PIC performed stabilizer trimming manually. When the aircraft was set to the landing configuration, the stabilizer deflection angle was ≈3.5° pitch-up and it almost did not change until landing (one short pitch-up pressing was recorded during the glideslope descent).

The aircraft was put to the landing heading at the distance of more than 20 km from the RWY 24L threshold. The final approach fix is located at the distance of 9.3 km.

At 15:24:38, the crew responded to the controller's request that they would perform the ILS approach (the QRH the ILS approach is required with the use of the instrument-landing horizon-director indicator). By 15:25:57, the crew had finished the "DURING LANDING" section checklist. The crew performed neither the before-landing briefing nor the "APPROACH" checklist.

At 15:26:05, the crew had the following conversation: the FO *"Should I set the transponder to 7700? Or leave as it is? Ok, roger."*. The PIC: *"We could have done it long before, actually."* The CVR record does not provide us with clear understanding of the PIC's decision. Nevertheless, at 15:26:31 the crew set the transponder to 7700.

At 15:27:20, the glideslope descent was initiated. The go-around altitude was not set by the crew. The flight parameters during the glideslope descent are provided in Fig. 6 and Fig. 7.

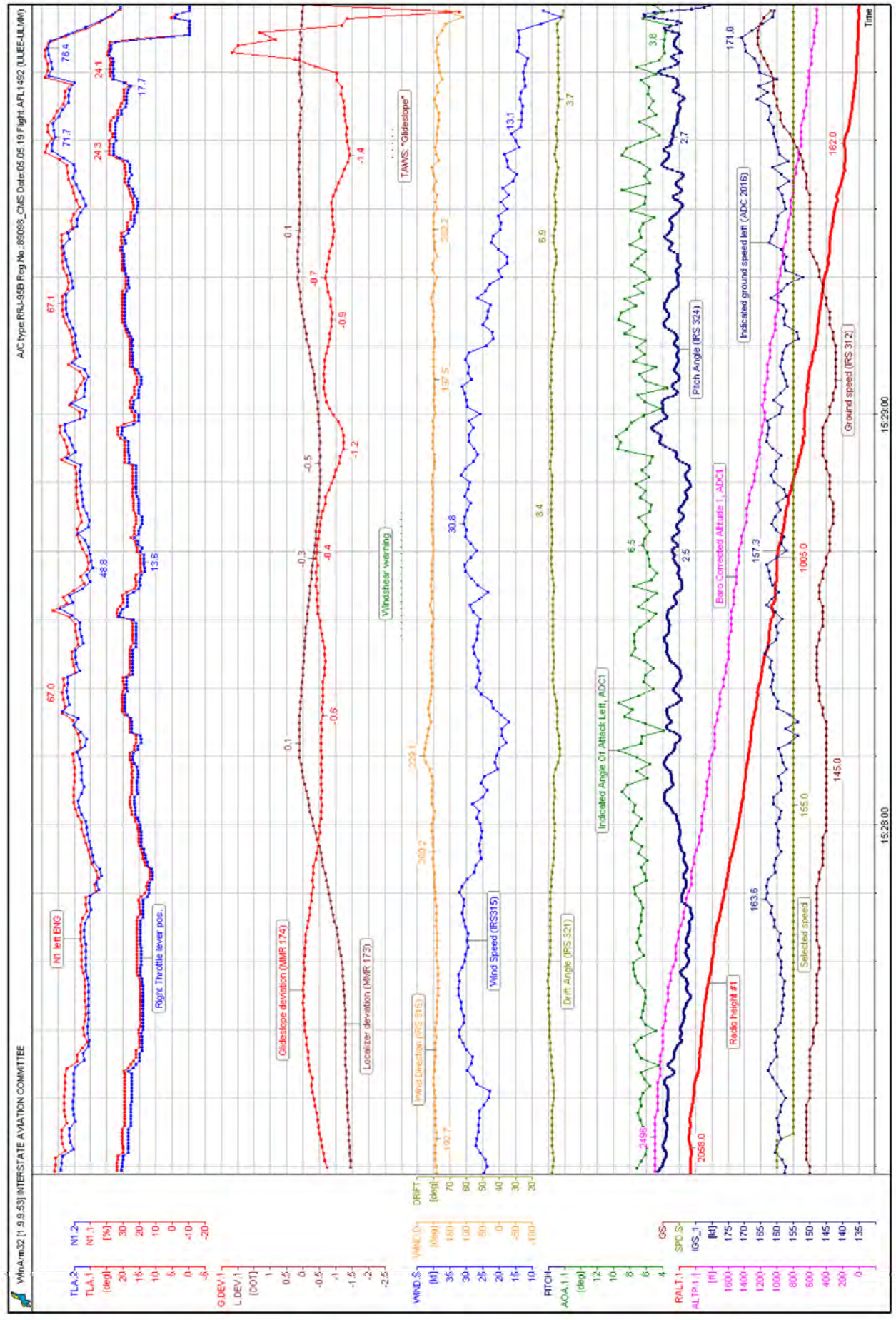

Fig. 6. Flight parameters while approach at the glide path

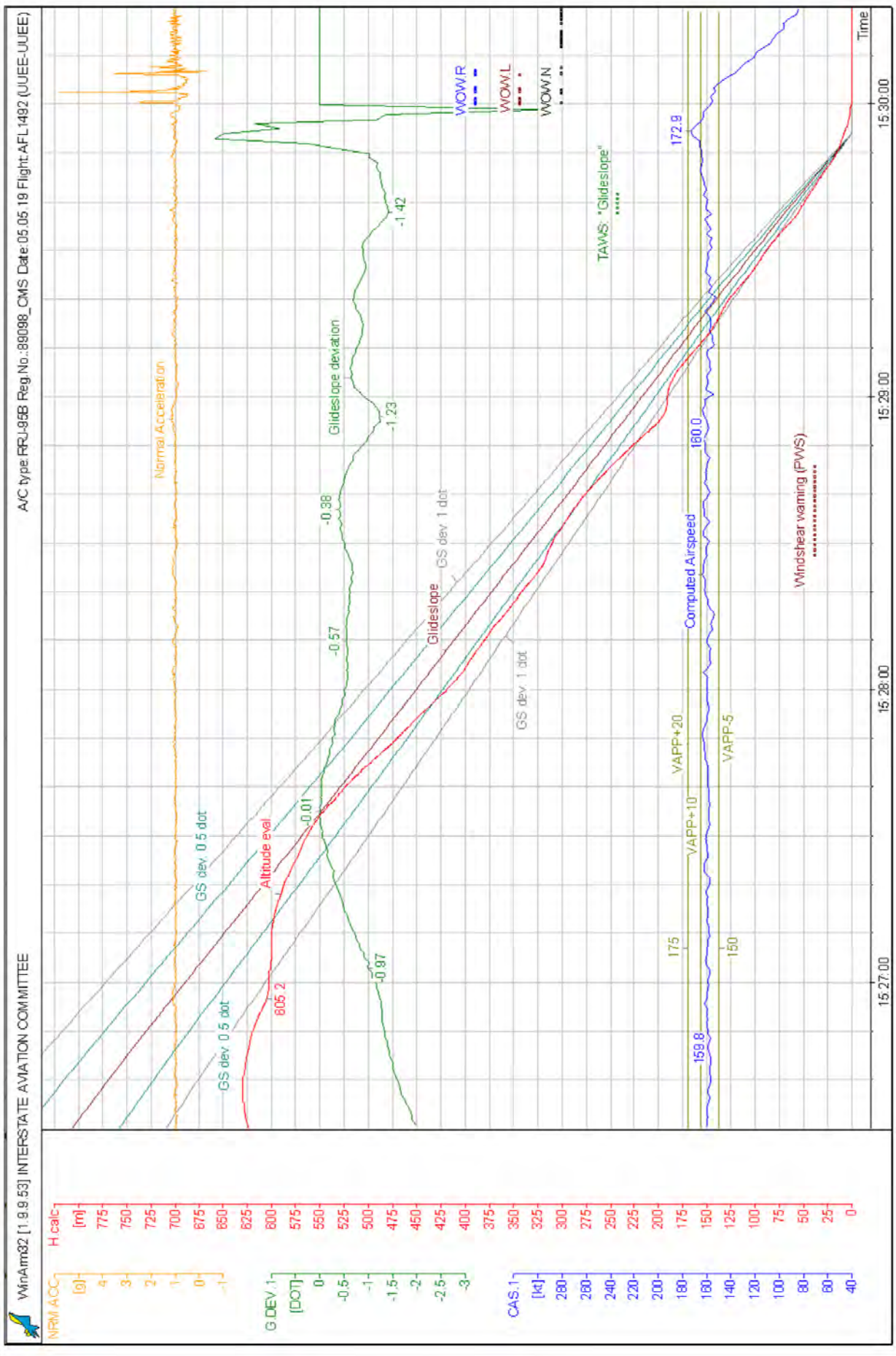

Fig. 7. Vertical approach profile via the glideslope

The descent was performed at the indicated air speed of 155…160 kt (287...296 km/h) parallel to (lower) the prescribed glideslope (Fig. 7). The heading deviation did not exceed 0.5 dot.

The elevator followed the pitch commands from the sidestick, which was regularly declined by the PIC in for the pitch-up by 2…3° (i.e. for 15…20% of its travel range). When the sidestick was released and returned to its neutral position, the pitch was tending to decrease: thus, the aircraft was balanced (trimmed) by the pilot via residual backward pressure. The thrust levers positions were changing within the range of 11° to 20.5°, the engine N_1 was changing within the range of 43% to 69%. The wind at the glideslope was up to 30 kt (15 m/s), 190° to 200°. The crab angle was up to ~8°.

Note: *Comparative analysis of the sidestick pitch inputs of the PIC as far during this flight and a number of flights performed before, when the landing was performed manually in the «NORMAL MODE», is provided in Section 1.16.3. The same section provides the compared parameters for other landings, performed in the «DIRECT MODE».*

At 15:27:51, the controller provided the crew with the meteorological information and cleared for landing: *"Aeroflot 14-92 wind at the ground 160 degrees 7, gusts 10 meters per second, runway 24 left, landing cleared for"*. The crew confirmed the landing clearance.

At 15:28:26, at 1600 ft (490 m) QNH (at the radio altitude of 1100 ft (335 m)) the "*WINDSHEAR" warning* was recorded, it is generated by the crew alerting system based on the wind shear forecast data of the weather radar, accompanied by the voice message *"GO-AROUND, WINDSHEAR AHEAD"*. This warning informs the crew about the possible wind shear enroute. The alert lasted for 11 seconds and included 2.5 warning cycles (5 voice messages, each cycle consisting of 2 messages one after another, with the 1 second interval in-between). The crew had no discussion of this warning triggering.

Note: ***In the QRH «W/S AHEAD» Section (1.18.8)*** *states that the triggering of this warning during the approach indicates that the crew must initiate the go-around procedure. At the same time in the beginning of the section, there is the notice that if the crew is sure that there is no wind shear hazard and there are no other signs of wind shear, and the RWS is operative, this warning may require no responsive actions from the crew. The same provisions are incorporated into the Flight Operations Manual.*

In 0.5 second, the voice message informed the crew that the aircraft had reached the height of 1000 ft (305 m). The PIC decided to continue the approach and informed the FO on it by saying: *"Proceed"*, the FO responded: *"Check"*.

Note: ***Aeroflot Operations Manual, Part B, Chapter 2, Standard Operation Procedures, Page 2.3.24,*** *contains the indication, that during the ILS approach, at 1000 ft above RWY, the crew must check the criteria for the stabilized approach. The criteria of the stabilized approach in accordance with Flight Operations Manual and in accordance with FCOM are provided in Section 1.18.9 and Section 1.18.10 of the present Report respectively.*

At 15:29:22, the FO called out that the landing decision height was close. The PIC confirmed continuing the approach.

At 15:29:31, at 270 ft (82 m) the aural annunciator system informed the crew on reaching the landing decision height minimum, it was repeated by the FO. Starting from that moment, there was noted fast increase of the downward glideslope deviation (up to minus 1.4 dots), which caused the TAWS "*GLIDESLOPE*" alert triggering to indicate the glideslope deviation The alert was on for 4 seconds. The PIC confirmed hearing the alert by saying *"Advisory"*.

Note: ***1. Aeroflot Operations Manual, Part B (C), Chapter 2 Standard Operation Procedures, Page 2.3.24*** *states that «GLIDESLOPE» aural alert during the flight below the landing decision height is advisory. And there is the requirement to monitor the angle of attack to be ≈6°.*

2. FCOM Part 1, Chapter 1.04, Standard Operation Procedures, Section 1.04.72 ILS approach, Page 5 *prescribes to perform the go-around in case of any alert of the warning or caution level (except for the engine failure alert) at within the height range of below 1000 ft and above 100 ft. The "GLIDESLOPE" alert is a caution annunciation. Same page contains warning that the "diving" under the glideslope is forbidden and that it is required to maintain the stabilized descent angle till flare.*

3. QRH, Emergency and special procedures, navigation equipment, A-12, 534, Pages 19-20, TAWS alerts:

Caution*: During night flight or in case of instrument meteorological conditions, the procedures, required by the warning annunciation triggering must be performed immediately without any delay caused by the attempt to find out of the causes for the warning annunciation triggering activated.*

During the day flight, in case of visual meteorological conditions, the warning annunciation may be considered a caution, if the cause of its triggering is immediately found out by the crew.

…

"GLIDE SLOPE":

Forbidden downward glideslope deviation

- GLIDESLOPE PATH RECOVER"

Simultaneously with the warning triggering, the PIC increased engines power (the trust levers were set to 24° to 23°, which caused the N_1 increase up to 77 to 74%). The increase of the engine power caused the increase of the indicated air speed: when the aircraft was passing RWY threshold: at 40 ft (12 m) it was up to 164 kt (304 km/h), and by 16 ft (5 m) it was up to 170 kt (315 km/h). According to FCOM, the required landing approach speed for the actual conditions was 155 kt (287 km/h). This speed was set by the crew as the selected speed. The airline's Flight Operations Manual contains the value plus 20 kt as the criterion for the stabilized landing approach (Section 1.18.9).

Over the RWY threshold, the glideslope deviation was minus 0.9 dot (i.e. below the glideslope). After passing the RWY threshold, the the vertical speed of descent was decreased. The flight parameters during landing are provided in Fig. 8.

At 15:29:54, at 17 ft (5.2 m) aural alert "RETARD. RETARD" informed the crew on reaching the height recommended for the thrust levers to be set to "IDLE" during the flare. The PIC started to change thrust levers positions simultaneously with the alert triggering.

Almost simultaneously with the thrust levers positions changed to "IDLE", the PIC initiated the flare by pulling the sidestick by 8.8° (65% of its travel range). Further on, the PIC's ever-amplitude increasing pitch sidestick inputs were recorded up to the both maximum advanced and maximum retarded positions with a relatively long holding period in the both maximum positions. These inputs caused counter-reversal pitch change (+6…-2º). At 15:30:00, at a distance of ≈900 m from the RWY threshold at indicated air speed of 158 kt (293 km/h), first touchdown occurred. The touchdown occurred at the pitch angle close to zero (7 pitch up rate; at the moment of the touchdown, the sidestick was in the maximum retarded position; and during the landing within 0.4 seconds, its position was changed for the maximum advanced), for "threedots", with vertical g-force of no less than 2.55 g.

Note: ***1. According to the "Landing technique" Bulletin for the cockpit crew, Section "Flare" (FCOM 1.09.11, Pages 6-7),*** *in order to prevent the "late flare", after the beginning of the flare, the sidestick advancing is not allowed.*

According to the information, provided in Aircraft Maintenance Manual Section 17-51-00, Task 200-801, Page 606, *the aircraft landing with exceeded maximum landing weight and the vertical g-force of 1.94 to 2.25 g are classified as hard landing, landing with vertical g-force exceeding 2.25 g are classified as very hard landing.*

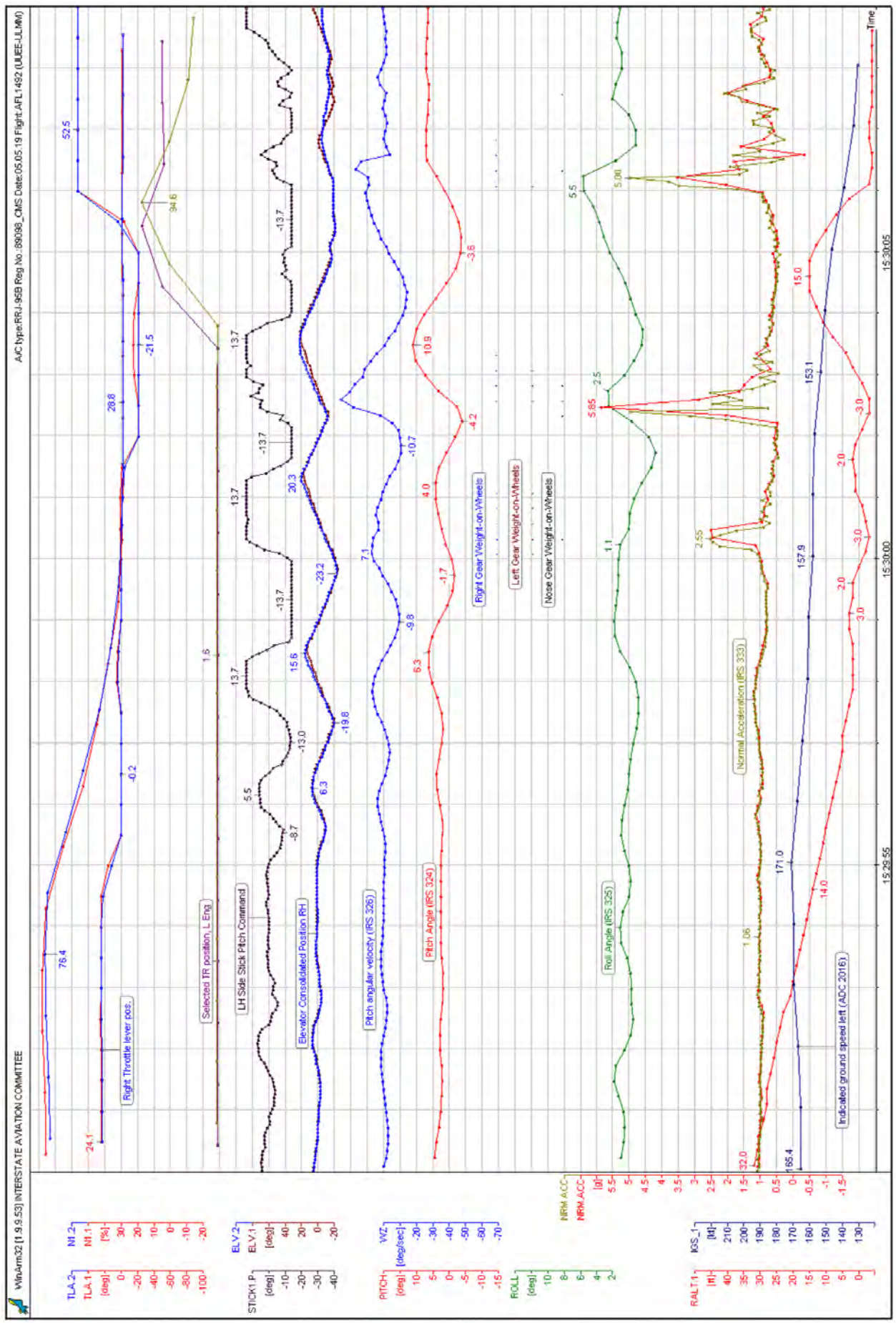

Fig. 8. Flight parameters while landing

In "DIRECT MODE", the automatic deployment of the speedbrakes (spoilers) is not provided by the design, and the manual speedbrakes deployment was not engaged by the crew. After the touchdown, the aircraft bounced up for the he height of no more than ≈ 5-6 ft (2 m).

Note: ***According to the "Landing technique" Bulletin for the cockpit crew, Section, "Aircraft bouncing off the RWY during landing"(FCOM 1.09.11, Page 18),*** *in case of insignificant bouncing (of less than 5 ft) after the touchdown, it is necessary to fix the sidestick at the position it was at the touchdown, not allowing any pitch angle change, and, holding the thrust levers in "IDLE" positions, and complete the landing procedure. The pitch angle must not be increased, especially after the hard landing with high pitch rate.*

In case of high bouncing (of more than 5 ft), after the touchdown, it is necessary to fix the sidestick at the position it was at the touchdown and without further changing of the pitch angle, perform the go-around.

After the aircraft was bounced up, the sidestick continued to be held in the maximum advanced position, which caused the pitch downward rate of up to 10.5°/s, the rapid downward pitch angle decrease to 4° and the repeated touchdown with the nose landing gear touching the ground first.

The second touchdown occurred 2.2 seconds after the first touchdown, at the indicated air speed of 155 kt (287 km/h).

Landing performed with the nose gear touching the ground first, with the high vertical speed and the fully retarded sidestick immediately before touchdown, caused the intensive pitch-up rotation of the aircraft. The maximum pitch rate recorded was ≈25°/s and the vertical g-force was no less than 5.85 g. As the result, the angle of attack and the pitch angle increased, which, due to the remaining significant value of the indicated air speed, caused the repeated bouncing ("progressing bouncing"), despite the sidestick fully advanced position at bouncing up.

During the first bouncing up, when the aircraft was in the air, the PIC switched the thrust levers to the "Maximum Reverse" mode but the thrust reverser doors did not deployed, as there were no weight-on-wheel (WOW) signals. Upon receipt of the left and right main landing gears WOW signals, the reverser doors started to deploy, which was completed after the second aircraft bouncing up movement off the RWY. There was no engine power increase as at this moment, there was no WOW signals again.

During the second bouncing up, the aircraft reached the height of ≈ 15 - 18 ft (5-6 m). In 2-3 seconds after this repeated bouncing up, the thrust levers were set to "Takeoff" mode and the sidestick was pulled to the maximum retard position. This actions may be interpreted as an attempt

to perform the go-around, as before that the thrust reverser system was engaged (the reverser doors were in the open position, though starting to close), the engine thrust did not increase.

At 15:30:05, with the indicated air speed of 140 kt (258 km/h), the third touchdown occurred with vertical g-force of no less than 5 g. The type of the markings, left on the RWY after the third touchdown, indicate that the main landing gears were by that moment already partially destroyed ("weak links" were cut off, see Sections 1.3, 1.12 and 1.18.12 of the present Report). The main landing gears collapsed, further on, the aircraft structural disintegration with fuel spillage and fire occurred.

After the third touchdown, the flight data recorders recorded the information which indicates the possible loss of the engines' control (full or partial). In order to analyze this issue, the investigation team is planning to examine the DECU. The engines were operating until the end of the record.

At 15:30:15, the thrust levers were repeatedly switched to the "MAXIMUM REVERSE". The ground speed at that moment was 107 kt (198 km/h). This action did not cause any changes, the engines continued to operate in the "IDLE" mode, the reverser doors were in the transit positions.

At 15:30:18, "Aft cargo compartment fire" event was recorded. The aircraft ground speed was ≈ 100 kt (185 km/h).

Note: *In fact, taking into consideration the type of the sensors, the alert indicates the smoke detection, not fire detection.*

At 15:30:24, the CVR recorded the controller's command: *"Emergency service to the runway"*.

At 15:30:30 and at 15:30:34, the flight attendants' reporting's of fire were recorded.

At 15:30:34, the "APU fire" event was recorded. The aircraft ground speed 25 kt (46 km/h).

At 15:30:38, the aircraft stopped its movement. Immediately before that, the aircraft turned left, nose upwind».

At the same time, the two call-outs of the flight crew addressing the cabin crew were recorded: *"Attention crew! On station. Attention crew! On station*"

At 15:30:44, the PIC called out: *"Emergency evacuation checklist"* (Section 1.18.11 of the present Report). The CVR did not record the checklist performance.

At 15:30:49, the flight attendants' command was recorded: *"Undo the seatbelts, leave everything, evacuate…*"

At 15:30:52, the PIC called out: *"Evacuation"*.

At 15:30:53.3, the CVR stopped recording.

At 15:30:58, "APU fire extinguisher discharged" event was recorded, however, no event of the fire extinguisher bottle discharge input was not recorded.

At 15:31:06, FDR stopped recording.

At about 15:31:34, according to the sound data of the video record, engines' shutdown occurred.

1.2. Injuries to persons

Injuries to persons	Crew	Passengers	Others
Fatal	1	40	0
Serious	1	2	0
Minor/none	3/0	4/27	0/0

1.3. Damage to Aircraft

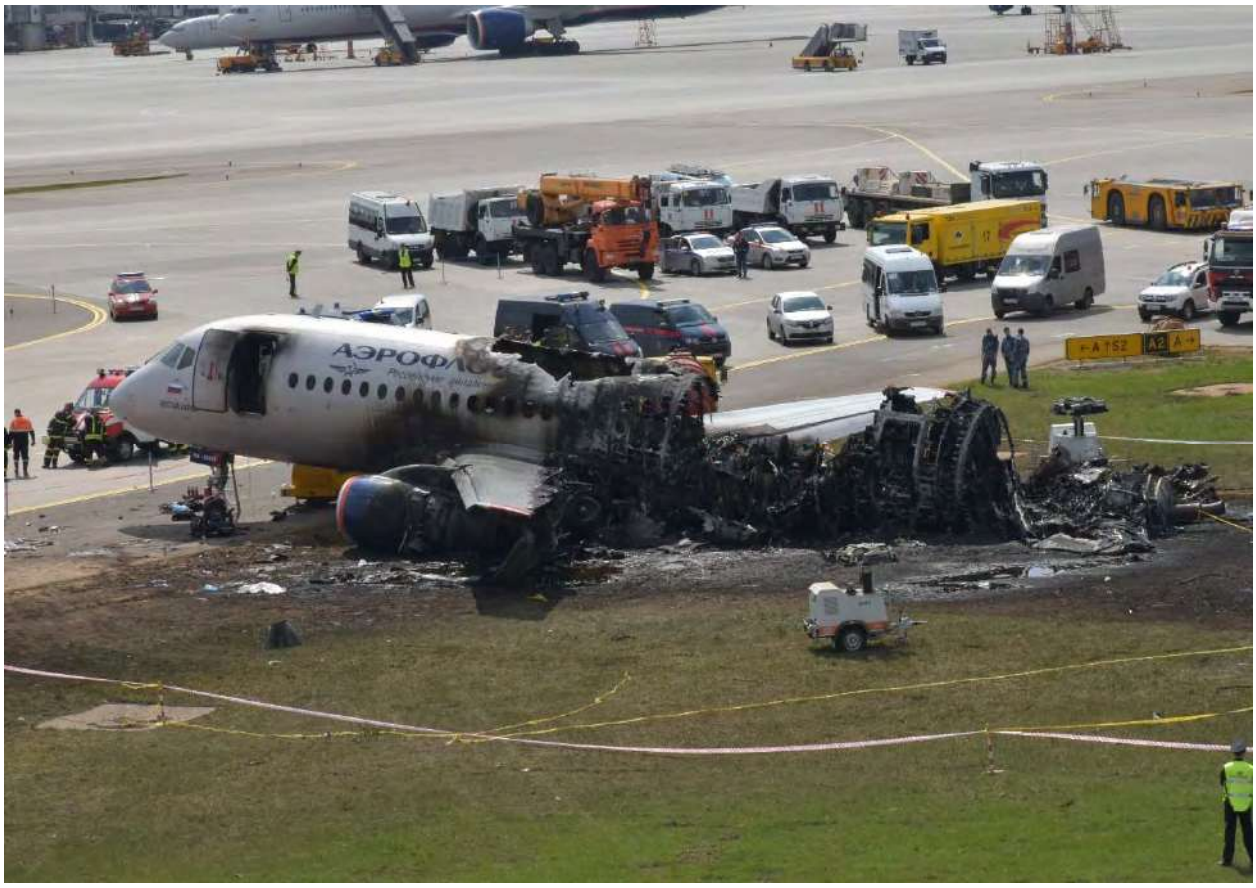

Fig. 9. Aircraft RRJ-95B RA-89098 after the accident

Examination of the aircraft performed on 06.05.2019 during daylight.

This section provides the description of the airframe and systems condition after the accident.

Fuselage sections F1, F2 (ribs 1-24) do not have external structural damage (Fig. 10)..

Fig. 10. External view of the fuselage front part after the accident

F3 and F4 (ribs 24-51) burned up completely after rib 29 from the floor level and have substantial skin burnout below the floor level (Fig. 11).

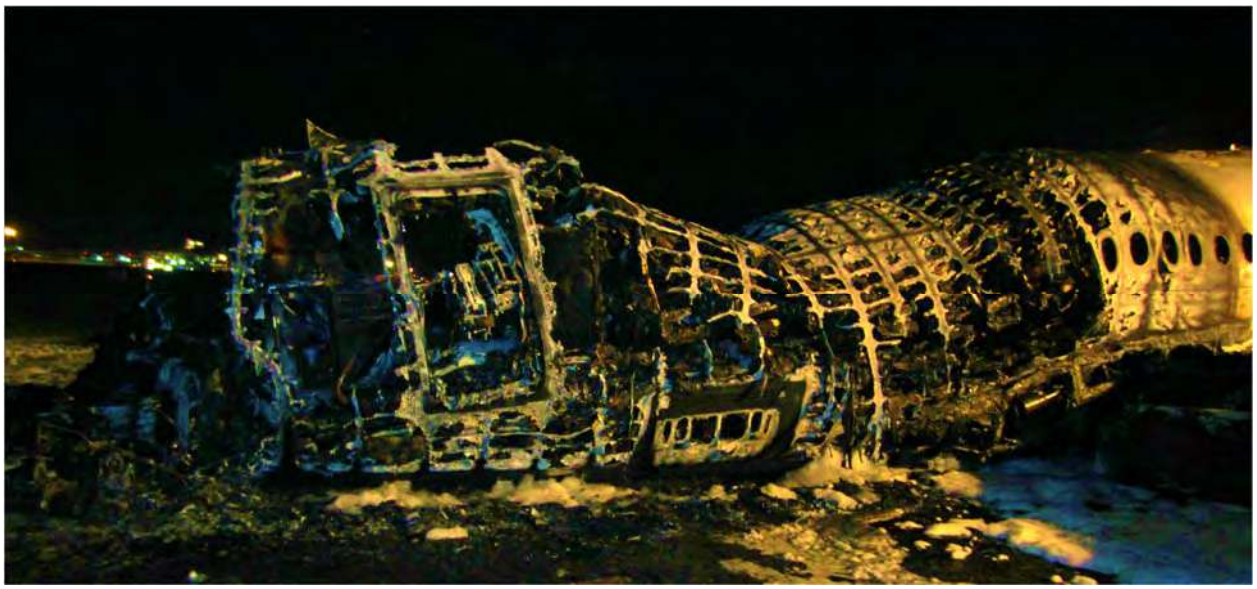

Fig. 11. External view of the middle and rear part of the fuselage after the accident

F5 burned out completely, framework and components fragments situated on the floor and around rib 51 on the ground (Fig. 12).

Fig. 12. External view of the F5 section

F6 burned despite the details made of steel and Ti-alloys (Fig. 13), framework and components fragments situated on the floor and on the ground.

Fig. 13. External view of the F6 section

Vertical and horizontal stabilizers burned down (Fig. 14), remaining elements situated on the ground.

Fig. 14. External view of the vertical and horizontal stabilizers after the accident

Outerwing panels with engines connected to the fuselage. List of wing damage:

– lower panels of the right-side wing burned out apart from the root segment;

– rear pylon fairing of the right-side wing burnt, flap fairing burned out;

– cylinder bracket of the right main landing gear separated from the rear spar and is situated under the console panel hanging (Fig. 15). After the separation of the cylinder bracket of the right main landing gear there occurred a hole in the spar web, and the fuel spilled through it from the fuel tank of the right-side wing (Fig. 16);

Fig. 15. External view of the cylinder of the right main landing gear

Fig. 16. The hole in the right-side wing spar web (pointed with an arrow)

– external section of the flap of the right-side wing is extended position;
– aileron of the right-side wing is up, no visible damage;
– lower panels of the front part of the left-side wing is burnt and damaged;
– cylinder bracket of the left main landing gear is separated from the rear spar and is situated under the console panel hanging (the kind of separation and damage same to the right main gear);
– aileron of the left-side wing is put down;
– back wall of the centre-section has multiple through holes with curled edges.

Doors, hatches, transparencies

Front right and left doors of the cabin are opened, bars of the safety slides connected to brackets of door beams (Fig. 17).

Fig. 17. External view of the front doors (left, right)

Right apt cabin door is absent together with the hinge lever. Safety slide bar is connected to the brackets of the door beams. The bulkhead to which the door is hanged, was removed during

the rescue work. According to the picture analysis, after the accident the door was closed. The door with the hinge lever was found in debris under the aircraft.

Left apt cabin door is absent (burnt down). The hinge lever is open. Safety slide bar found in debris on the ground.

Apt cargo door is closed, burnt severely and has external panels burnt-through. Front cargo door is closed and has no visible damage.

The escape hatch of the cockpit door is open. The door has no visible damage.

The right sliding window of the cockpit is open, the left sliding window of the cockpit is closed.

Rear baggage compartment damaged partially, there are no signs of open fire in the compartment. There is soot on the front wall of the compartment and the baggage of the passengers (Fig. 18). The access to the rear baggage compartment after the accident was carried out through the upper hatch with no mechanical damage (Fig. 19).

Fig. 18. Passenger baggage from the rear baggage compartment after the accident

Fig. 19. External view of the rear baggage compartment after the accident

Fuel system

- fuel pumps are situated in nominal locations and have the sings of the high temperature impact;
- fuel system charging gears are melted, fuel locks, set on the wall of the second spar, are in nominal locations;
- in the landing gear compartment (the area with the severest impact of the fire) twin-engine lock burnt completely;
- fuel tanks breather system units are situated in nominal locations, with no mechanic damage;
- fuel supply pipes to the APU are disconnected;
- no traces of fire detected in the fuel tanks;
- fuel system units are not available for examination in the F5 because the section is destroyed completely.
- Landing gear
- nose gear is deployed, no visible damage, no hydraulic fluid spill detected;
- left and right main landing gears are deployed and significantly damaged;

– nose gear dressing damaged (wiring and hydraulic hoses);
– nose brace strut and its locks mechanically damaged;
– break spring of the rear strut of the right main landing gear is destroyed, the fragment found on the RWY, also gear fragments, demolished as the result of the impact of off-design loads and further main gear struts deformation;
– shear ties of the front assembly of the main gear are destroyed, the bodies of the shear ties remained in the bearing box and heads remained in hinge brackets of the box bearing.

Control system

– slats and flaps are deployed, FLAPS 3 (slats 24°, flaps 25°) position;
– the elements of the control system situated in F5, rudder and horizontal stabilizer suffered most severe damage;
– transmission shafts and gears in the area of the gear beam are destroyed and detached;
– mechanical damage to the control system elements results from the destruction of the airframe structure. In the intact areas there is only temperature impact to the flap gears detected.

Powerplants

The examination of the engines showed that the gas-air path does not have any damage and the traces of ingestion that could have lead to the engine stop inflight or resulted in the system failure or fire on the ground. The signs of the unlocalized engines destruction (cowl, body or blade (in the visible part of gas-air path) and so on) were not detected.

Thermal damage of the engines is typical for the external fire on the ground and localized in the area of mixing nozzles. The fire points were most likely situated above the nozzles of the right and the left engines in the central part of the fuselage.

Locks of the doors of both reverses of both engines are «Open».

APU

APU separated from the structure and damaged.

Avionics (control panels)

The examination of the cockpit showed that control panels are covered with combustion products, there is no visible mechanical damage or signs of fluid impact is not detected.

The following position of engine start switch (Fig. 20), electrical battery control and fire extinguish systems set.

Fig. 20. Engine control switch after the accident

On the figure	Element	Position	Description
Engine start CP			
1,2	Switches ENG MASTER L ENG MASTER R	OFF	ENG MASTER L and ENG MASTER R open and close fuel valves supplying fuel to the engines. When ENG MASTER L (ENG MASTER R) is ON the valve is open and the fuel runs to the left(right) engine. When ENG MASTER L (ENG MASTER R) is OFF the valve is closed, the fuel does not run to the left(right) engine. The screen of ENG MASTER L (ENG MASTER R) shows FIRE L (R) when there is fire in the left (right) engine detected.
3	ENG START switch	OFF	Sets the following ingition modes: CRANK – ignition is off. It is used for dry motoring and false start; OFF – ignition is off; IGN/ON – ignition is on.
Throttle			
6		IDLE	IDLE

The examination of the cockpit equipment after the accident showed that APU FIRE (APU fire protection system, Fig. 21, position № 84), L ENG FIRE (left engine fire protection system, Fig. 21, position № 87) and R ENG FIRE (right engine fire protection system, Fig. 21, position № 91) were «Activated».

The fire extinguish system containers were weighted in order to determine whether they were used during the last flight. It was determined that all the containers were full. The APU fire extinguish system container was not detected.

Fig. 21. Engines and APU fire extinguish systems switch condition after the accident

The buttons of all the for electrical batteries are off. (Fig. 22, positions №№ 52, 53, 54, 55).

Fig. 22. Electrical batteries buttons condition after the accident

During fuselage examination, including the nose part, after the evaluation of the antennas, transducers (ice detector, temperature probe, angle-of-attack sensor) the exit lights and the cockpit windows there were the traces typical for lightning impact detected (Fig. 23, Fig.24, Fig. 25).

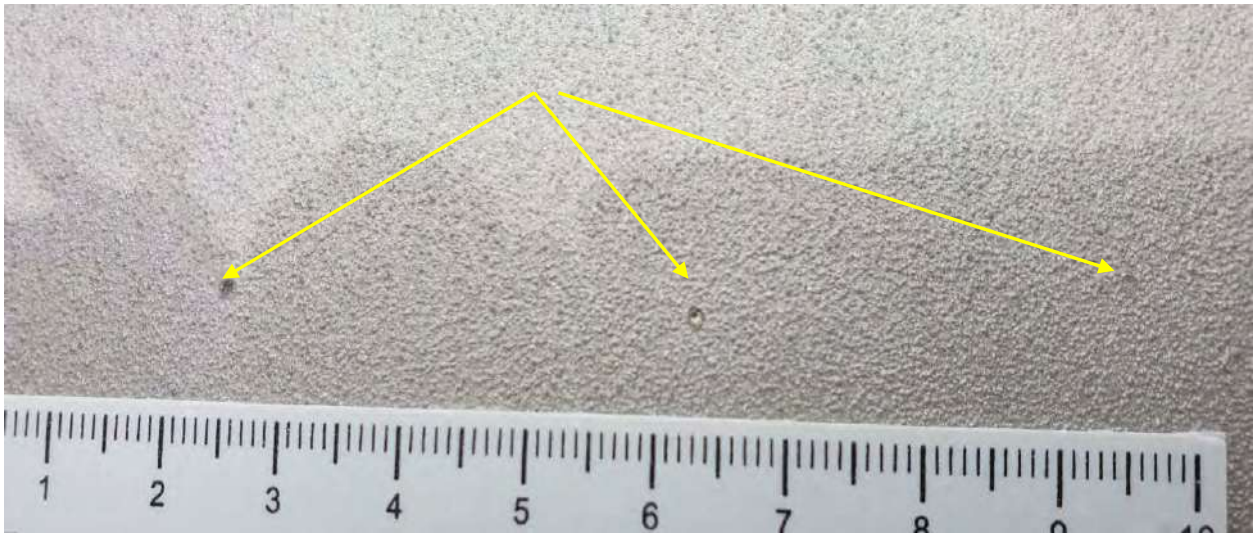

Fig. 23. The external view of the damage caused by the lightning strike to the upper front part of the fuselage

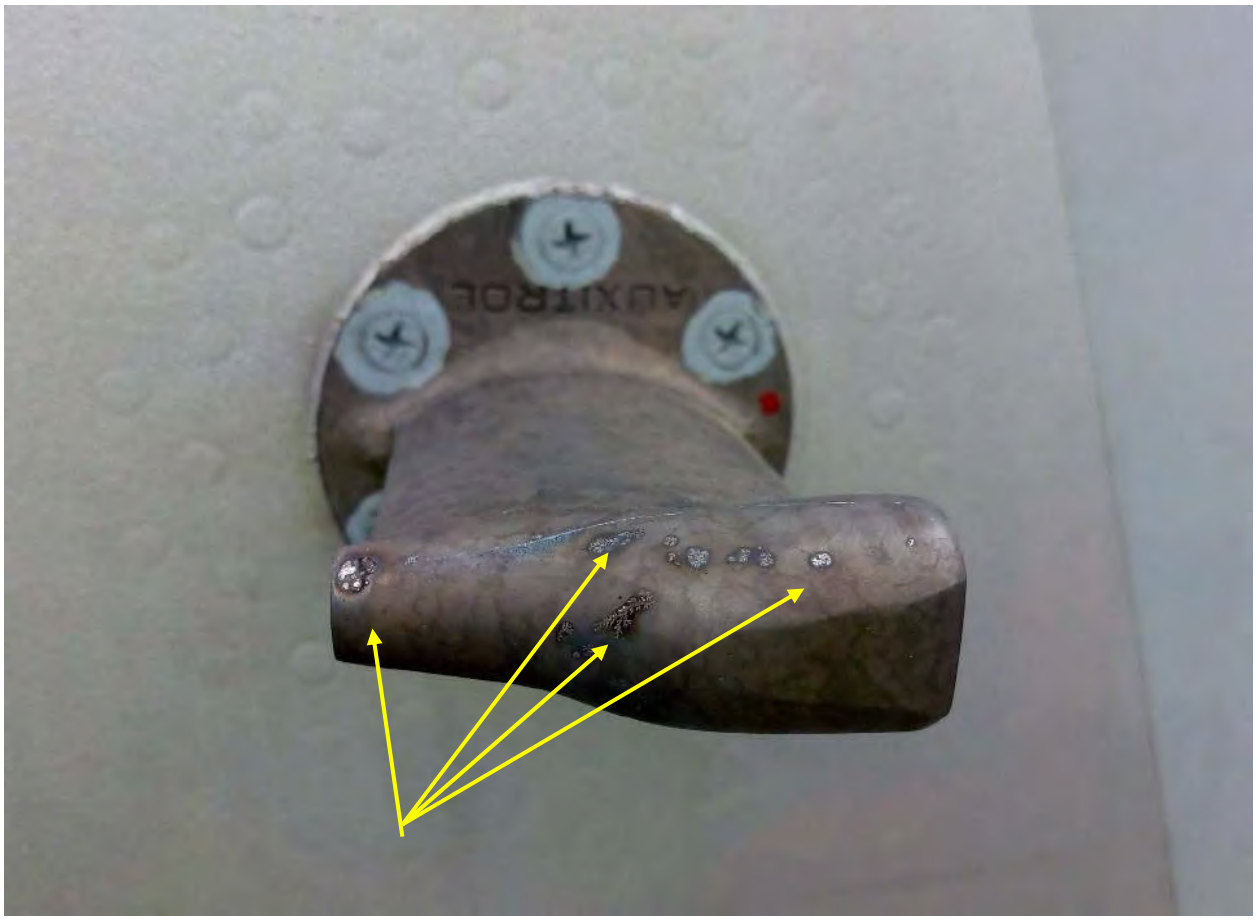

Fig. 24. Lightning strike traces on the right temperature probe

Fig. 25. Lightning strike traces on the right ice detector

Besides, there are traces of the lightning strike at the angle-of-attack sensor on the right of the aircraft.

1.4. Other damage

No other damage detected.

1.5. Personal information

Pilot-in-command

Position	RRJ-95B pilot-in-command
Gender	Male
Age	42
Education	Balashov Air Force Higher Flight College, 1998, «Tactical aviation, air operations», the engineer-pilot qualification
The RRJ-95 transition training	at the Aeroflot, PJSC aviation personnel training department (Moscow), license No 092881 of 29.06.2016
Civil pilot license	ATPL No 0080723, issued by North-Western FATA interregional territorial department on 13.06.2018
Qualification mark	RRJ-95
Pilot medical certificate	issued on 18.04.2019, by the Aeroflot medical flight-expert commission, the I class certificate BT № 100782, valid till 18.04.2020
Weather minimum	ICAO CAT III 15 x 175 m

Total flying time	6800
The RRJ-95 type flying time	1570
The RRJ-95 type flying time as a PIC	1428
Flying time within 30 days	42 h 15 min
Flying time within 3 days	09 h 25 min
Flying time on the day of the accident	00 h 28 min
Total duty time on the day of the accident	02 h 20 min
The intervals in flights within the last year	Leave periods: 21.05.2018 - 03.06.2018, 26.07.2018 - 08.08.2018, 15.10.2018 - 21.10.2018, 15.01.2019 - 31.01.2019
The date of the last line check	on 31.10.2018, by the flight instructor-examiner – the Aeroflot, PJSC squadron commander, the excellent mark
Land emergency-rescue training	on 08.04.2019, at the Aeroflot, PJSC aviation personnel training department
Water emergency-rescue training	on 12.04.2018, at the Aeroflot, PJSC aviation personnel training department
Simulator training	on 22.02.2019, at the Aeroflot, PJSC aviation personnel training department
Professional advanced training	On 19.02.2019
Authorization for summer season air operations	05.04.2019
CRM training	29.03.2019 (according to the reference, issued on 22.05.2019 by the head of the CRM department– the leading flight inspector of the Aeroflot, PJSC aviation personnel training department)
Preliminary training	on 19.02.2019
Preflight check	on 05.05.2019 at the Sheremetyevo airport
The Crew rest	More than 50 h at home
Medical preflight check	at the Aeroflot flight crews preflight check medical post at 13:20 on 05.05.2019

The incidents and accidents in the past	None
The English language proficiency	ICAO Level 4, valid till 25.05.2021

After graduation from the Balashov Air Force Higher Flight College , the PIC[10] served in the Federal Security Service aviation as a flight personnel The total flying time during the period of education and service amounted to 2320 hrs, the operated aircraft types: Yak-52 (42 hrs of flying time), L-410 (78 hrs of flying time), Il76 (2200 hrs of flying time, of which as a PIC - 1488 hrs).

After the retirement, within 18.10.2011 - 03.11.2011, he had undergone the 96 hrs training at the Ulyanovsk Higher School for Civil Aviation under the Program «The training of another types of aviation flight crews to be authorized for the different (new) civil aircraft types transition training and the helicopter pilots to be authorized for the civil aircraft transition training» Upon the training completion the PIC was issued the CPL without any rating (the Ulyanovsk Higher School for Civil Aviation High Qualification Commission No 6 working group minutes of meeting No 77 of 24.11.2011).

Within 26.12.2011 - 04.03.2016 the PIC was successively employed by the “Transaero” airline as the Boeing 737 aircraft F/O and PIC; the total flying time amounted to 2022 hrs, of which 1905 hrs as aa PIC.

On 04.03.2016, he was fired due to the “Transaero” airline downsizing.

According to the labor contract No 431 of 25.04.2016 and the Order No 5396/л by the Deputy Director of the Aeroflot HR Department of 27.04.2016, the PIC was employed into the Aeroflot flight training group to the pilot's position.

Within 27.04.2016 - 29.06.2016 the PIC as a F/O underwent the training at the Aeroflot, PJSC aviation personnel training department under the Program “Flight crew personnel RRJ-95 transition training”, approved by the FATA Flight Operations Department on 26.01.2015. Upon the completion of the training he was issued the license No 092881 of 29.06.2016.

The type transition training program, under which the PIC underwent the training for the RRJ-95 aircraft, incorporates the F/CTL DIRECT MODE at the simulator session 4.

[10] In this section the «pilot-in-command» term refers to the same person even for the periods when heoccupied different positions.

Note: *FAR-128, p. 5.84*

"The Operator does not allow the crew members to perform their functions until they receive full training according to the program elaborated by the operator that provides proper training of the cockpit crew members and:

…

e) requires:

…

at least once in 36 months there should be an FFS training with all systems faults that do not refer to the emergency, including the check."

The ground training was carried out within 04.07.2016 - 07.07.2016. According to the training task of 04.07.2016 «The F/O preflight preparation», the pilot started to prepare for the task № 1 «Ground training» on 04.07.2016 (the time of preparation amounted to 04 hrs 00 min). According to the document issued by the Head of CRM - flight inspector of the Aeroflot, PJSC aviation personnel training department on 22.05.2019, on the same date (04.07.2016) the pilot underwent the CRM training («Module 3.1») out of 08 hrs 00 min.

On 06.07.2016, the flight instructor authorized the pilot for exercise 1 task 2 section 1. On 17.07.2016, the pilot started the line training.

According to the Order No 125.11/1-1097/y by the Deputy Director General – Aeroflot Flight Director of 18.07.2016 № 125.11/1-1097/y, the PICauthorized for commissioning as the RRJ-95 F/O as per the Flight Crew Training Program for the RRJ-95 at Aeroflot (approved by FATA on 25.11.2015). The program determines the training out of six variants depending on the previous training and experience. Variant I is applicable for the most experienced pilots and variant VI is designed for the pilots who do not have any flying experience on the aircraft with maximum takeoff weight ≥ 5700 kg and the pilots-graduates of the institutions for civil aviation.. The PIC underwent his training as per variant II.

According to the amendment to the labor contract of 04.08.2016 and the Order № 125.11/11406/л by the Deputy Director General – Aeroflot Flight Director of 04.08.2016, the PIC was transferred to the position of the SSJ100[11] F/O at the Aeroflot SSJ-100 air squadron.

According to the Order No 290 by the SSJ-100 squadron Commander of 04.08.2016 upon the completion of training under the RRJ-95 (SSJ100) Flight Crew Training Program the PIC was

[11] SSJ-100 – RRJ-95 marketing name.

authorized to perform solo flights as a F/O in the fixed crew under ICAO CAT I standard (60x550, takeoff 200 m with the high intensity lights).

Within 22.08.2016 - 25.08.2016 the PIC underwent the theoretical training course at the Aeroflot, PJSC aviation personnel training department, designed for the pilots about to be commissioned as PICs, the program is approved by FATA (Rosaviatsiya) on 14.02.2014 (24 pages), after the end of training the license № 093819 was issued of 25.08.2016.

According to the Order No 335 by the SSJ100 squadron commander of 31.08.2016, the PIC was authorized to perform flights as a F/O in a non-fixed crew.

According to the Order No 125.11/1-1595/y by the Deputy Director General – Aeroflot Flight Director of 05.10.2016, the first officer was authorized for commissioning as the PIC of SSJ100 according to the variant III.

As a matter of fact as the first officer, he took training starting from 05.10.2016 till 16.11.2016 according to variant V of the program for cockpit crew training for RRJ-95

On 14.10.2016 at the FFS SSJ-100 in Aeroflot Department for cockpit crew training the examiner pilot instructor evaluated the performance of the special procedure F/CTL DIRECT MODE by the first officer, score «five» (without commentary)[12].

According to the decree of the SSJ100 Squadron Commander dated 17.11.2016 № 468, the first officer admitted to perform flights on SSJ100 as the first officer as part of fixed crew.

According to the additional agreement to the labor contract dated 17.11.2016 and the decree of the Deputy Director General – Aeroflot Flight Director dated 17.11.2016 № 125.11/11637/л, transferred to the position of the first officer of the Aeroflot SSJ-100 Squadron.

According to the Order No 125.11/1-1862/y by the Deputy Director General – Aeroflot Flight Director of 21.11.2016, on 16.11.2016 the PIC's commissioning for SSJ-100 operations had been actually completed.

According to the Order No 94 by the SSJ100 squadron commander of 15.02.2017 the PIC was authorized to perform flights under ICAO CAT IIIA (15 x175, takeoff 150 with high-intensity lights.

According to the Order No 120 by the SSJ100 squadron commanderof 28.02.2017 the PIC was authorized to perform flights in the non-fixed crew.

[12] The investigation team does not dispose of any supporting documents, directly confirming that during the training course there had been the go-around in DIRECT MODE performed.

According to the Order No 125.11/1345/л by the acting the Deputy Director General – Aeroflot Flight Director of 09.06.2017 the PIC was transferred to the position of the PIC of the Aeroflot SSJ-100 squadron No 1.

Within 21.02.2019 - 22.02.2019 the PIC under the authority of the simulator flight instructor pilot and the SSJ-100 squadron flight instructor underwent the simulator training and check at the SSJ100 FFS at the Aeroflot, PJSC aviation personnel training department. In compliance with the Guidance on pilot training and check at the RRJ-95 FFS (approved by the Deputy Director General – Aeroflot Flight Director on 26.11.2018 (for instructors, the period of January – July 2019)), on 22.02.2019 the first officer underwent the LOFT training. There is the corresponding mark in the first officer's record of the regular FFS training.

Note: *Guidance for pilot training and check at the RRJ-95 FFS.*

2.2 LOFT

Exercise list

…

5.1. L Unreliable speed indication[13]*.*

According to the decree of the SSJ100 Squadron Commander dated 05.04.2019 № 124, was authorized for the flights during Summer season of 2019 upon the undergo of the full training of seasonal preparation at the “Aeroflot” PJSC aviation personnel training department, with the weather minimum, earlier determined, unchanged.

The First Officer

Position	RRJ-95 first officer
Gender	Male
Age	36
Education	Sasovo Flight School UVAU CA Branch, 2016, «Flight operation of an aircraft», qualification – pilot
The RRJ-95 transition training	Private professional institution «Aeroflot Flight School» (Moscow), diploma № 00905 dated 14.06.2018
Civil pilot license	Commercial pilot license № 0079551, issued by Komi MTA of FAVT (Rosaviatsiya) on 26.07.2018
Qualification mark	RRJ-95 First Officer. Nonvisual flight – aircraft

[13] Unreliable speed indication cause DIRECT MODE transition.

Pilot medical certificate	15.06.2018, Aeroflot medical flight-expert commission, I class BT № 053484, valid till 15.06.2019
Weather minimum	CAT III ICAO 15 x 175 м
Total flying time	765 h
The RRJ-95 type flying time	615 h
Flying time within 30 days	70 h 13 min
Flying time within 3 days	05 h 24 min
Flying time on the day of the accident	00 ч 28 min
Total duty time on the day of the accident	02 h 20 min
The intervals in flights within the last year	No breaks between the flights
The date of the last line check	20.03.2019, examiner - training pilot – Aeroflot, score «5»
Land emergency-rescue training	25.02.2019, Aeroflot, PJSC aviation personnel training department
Water emergency-rescue training	19.07.2018, Aeroflot, PJSC aviation personnel training department
Simulator training	11.12.2018, Aeroflot, PJSC aviation personnel training department
Professional advanced training	03.12.2018
Authorization for summer season air operations	05.04.2019
CRM training	Certificate № 102344 dated 26.06.2018
Preliminary training	03.12.2018
Preflight check	05.05.2019 in Sheremetyevo, under the PIC’s control and guidance
The Crew rest	More than 46 h at home
Medical preflight check	Aeroflot crew pre-flight check medical post at 12:57 05.05.2019
The incidents and accidents in the past	None
The English language proficiency	ICAO level 4, valid till 22.05.2019

In 2016 the FO graduated from Sasovo Flight School UVAU CA Branch, Flight operation of an aircraft», qualification – pilot. Diploma № 106224 1449446 dated 27.05.2016. Total flight hours 150 h, the aircraft types: Cessna-172 (105 h), L-410 (45 h).

During the period starting from 23.05.2017 till 09.06.2017 received training in the private professional institution «Aeroflot Flight School» (Moscow), the training program «Cockpit crew members international flights training» lasted for 126 academical hours. Certificate № 026679 dated 09.06.2017.

From 03.07.2017 till 01.08.2017 took the course of «Aviation technical English for the cockpit crew members» in «Aeroflot Flight School» (Moscow), it lasted 130 academical hours. Certificate № 030282 dated 01.08.2017.

According to the minutes of the Aeroflot cockpit crew recruiting commission dated 31.01.2018 № 149 and recommendation for additional education and professional training in line with the SSJ-100 FO training program, by the Deputy Director General – Aeroflot Flight Director the pilot was recommended for retraining and further recruitment to Aeroflot.

From 15.02.2018 till 16.02.2018 took training course for «Aviation safety» (initial training and advanced training for cockpit crew members in «Aeroflot Flight School» (Moscow) that lasted 16 academical hours. Certificate № 045143 dated 16.02.2018.

From 20.02.2018 till 20.05.2018 took training course «Cockpit crew without the experience of the operation of the aircraft equipped with display (digital) indication for retraining for other aircraft types» in «Aeroflot Flight School» (Moscow) that lasted 107 academical hours. Certificate № 053220 dated 20.05.2018.

From 12.03.2018 till 14.06.2018 took professional retraining as a FO in «Aeroflot Flight School» (Moscow), the program «RRJ95 training for cockpit crew», it lasted 282 academical hours. The program was approved by FAVT (Rosaviatsiya) on 15.02.2016. Diploma № 00905 dated 14.06.2018.

According to the program of the professional retraining which the FO took for the RRJ-95 type, in FFS session 5 there is the F/CTL DIRECT MODE.

From 03.07.2018 till 10.10.2018 took flight training as a FO according to the variant VI of the Aeroflot RRJ-95 cockpit crew training program according to which the training is for the pilots with no experience on the aircraft with maximum takeoff weight more than 5700 kg and the graduates of the commercial flight schools.

According to the labor contract dated 23.05.2018 № 946 and the decree of the Aeroflot HR Deputy Director dated 28.05.2018 № 7748/л, was introduced to the Aeroflot training squadron to the pilot's position.

According to the additional agreement to the labor contract dated 11.10.2018 and the decree of the Deputy Director General – Aeroflot Flight Director dated 11.10.2018 № 125.11/л690/л, transferred to the position of the FO of the Aeroflot SSJ100 Squadron №1.

According to the decree of the SSJ100 Squadron Commander dated 11.10.2018 № 334, after finishing the RRJ-95 cockpit crew training program was permitted to perform solo flights as a FO in fix RRJ-95 crew according to ICAO category I (60x550, takeoff 200 m ОВИ).

According to the decree of the SSJ100 Squadron Commander dated 19.10.2018 № 354, was permitted to perform solo flights as a FO in fix RRJ-95 crew according to ICAO category IIIA (15x175, takeoff 150 m high-intensity lights).

According to the decree of the SSJ100 Squadron Commander dated 22.04.2019 № 148, was permitted to perform flights in unfixed crew.

From 10.12.2018 till 11.12.2018 under the control of the simulator instructor and SSJ-100 Squadron pilot instructor the pilot took the training and the test at the FFS SSJ100 in Aeroflot Department for cockpit crew training in compliance with the Guidance for pilot training and check at the RRJ-95 FFS (approved by the Deputy Director General – Aeroflot Flight Director on 26.11.2018 (for instructors, the period of January – July 2019)). The pilot performed the exercise «unreliable speed indication».

According to the decree of the SSJ100 Squadron Commander dated 05.04.2019 № 124, was admitted to the flights during Summer season of 2019 upon receipt of the full training of seasonal preparation in the Aeroflot Department for cockpit crew training, with preservation of the weather minimum set beforehand.

Cabin crew

Position	RRJ-95 chief steward
Gender	Female
Age	27
Rate	1
Education	Graduate degree
RRJ-95 training	16.03.2015 – 09.06.2015 «Aeroflot Aviation School», the program «initial training for cabin crew for A320, RRJ-95, A330»
Commercial flight attendant certificate	№ 0010526, issued by FATA (Rosaviatsiya) North-West MTA on 08.09.2015
Valid for the aircraft types	A320 25.09.2015, A330 25.02.2016,

	B737 01.12.2017, RRJ-95 28.04.2016
Valid access permit	A320 06.03.2017, B737 07.12.2017, RRJ-95 19.10.2017
Advance training	02.04.2019
Advance training for safety	04.04.2019
Check flight on B-737 NG	17.07.2018, B-737 NG, instructor flight attendant Aeroflot, score «five»
Check flight on RRJ-95	19.10.2017, instructor flight attendant Aeroflot, score «five»[14]
Ground emergency-rescue training	01.04.2019 «Aeroflot Aviation School»
Water emergency-rescue training	02.04.2019 «Aeroflot Aviation School»
Summer season flights permit	29.04.2019
Medical assessment	26.01.2015, Aeroflot medical flight-expert commission, 2 class PA № 175773, valid till 26.01.2020
Total flight hours	2644 h 51 min
RRJ-95 flight hours	150 h 51min
Flights hours during the last month	78 h 38 min
Flight hours on the day of the accident	00 h 28 min
Preflight rest	More than 48 h at home
Total working time on the day of the accident	02 h 20 min
Medical check before the flight	Aeroflot crew pre-flight check medical post on 05.05.2019

[14] According to 5.6.7 part A of the Operations Manual of the airline, check-up for civil flight attendant qualification confirmation in line flights is carried out not less than once a year. The Operations Manual does not contain any information if the check-up should be carried out on each type of the aircraft the flight attendant has access permit to.

Accidents and incidents in the past	None

According to the labor contract dated 15.09.2015 № 729 and the decree of the Aeroflot Client Service Deputy Director dated 21.09.2015 № 10720/л, recruited to the Aeroflot Onboard Service Department № 5, cabin crews to the position of the flight attendant.

Position	RRJ-95 flight attendant
Gender	Female
Age	34
Rate	3
Education	Secondary education
RRJ-95 training	16.07.2012 – 01.08.2012 in «Aeroflot Aviation School», «Flight Attendant Retraining for A320, RRJ-95»
Commercial flight attendant certificate	V БП № 018529, issued by ТКК МТА VT CR 03.08.2011
Valid for the aircraft types	A320 11.08.2012, RRJ-95 23.08.2016
Advance training	15.02.2018
Check flight on A320	07.12.2018, A320, Aeroflot instructor flight attendant, score «five»
Check flight on RRJ-95	23.08.2016, Aeroflot instructor flight attendant, score «five»
Ground emergency-rescue training	15.02.2018 in «Aeroflot Aviation School»
Water emergency-rescue training	14.02.2019 in «Aeroflot Aviation School»
Summer season flights permit	29.04.2019
Medical assessment	10.02.2016, Aeroflot medical flight-expert commission 2 class РА № 223701, valid till 10.02.2021
Total flight hours	2466 h 21 min
RRJ-95 flight hours	520 h 26 min
Flights hours during the last month	43 h 58 min
Flight hours on the day of the accident	00 h 28 min

Preflight rest	More than 12 hours at home
Total working time on the day of the accident	02 h 20 min
Medical check before the flight	Aeroflot crew pre-flight check medical post on 05.05.2019
Accidents and incidents in the past	None

According to the labor contract dated 05.07.2012 № 274 the decree of the Aeroflot Client Service Deputy Director dated 10.07.2012 № 5665/л, recruited to the Aeroflot Onboard Service Department № 2, cabin crews, to the position of the flight attendant.

Position	RRJ-95 flight attendant
Gender	Male
Age	21
Rate	3
Education	Secondary
RRJ-95 training	14.02.2018 – 17.02.2018 «Aeroflot Aviation School», «Flight Attendant Retraining RRJ-95»
Commercial flight attendant certificate	№ 0070140, issued by FAVT (Rosaviatsiya) on 23.02.2018
Valid for the aircraft types	A320 19.04.2018, B737 13.06.2018, RRJ-95 12.11.2018
Advance training	09.02.2018
Check flight on RRJ-95	02.10.2018, Aeroflot instructor flight attendant, score «good»
Ground emergency-rescue training	20.12.2017 in «Aeroflot Aviation School»
Water emergency-rescue training	18.10.2018 in «Aeroflot Aviation School»
Summer season flights permit	29.04.2019
Medical assessment	10.10.2017, Aeroflot medical flight-expert commission, 2 class BT № 036392, valid till 10.10.2022
Total flight hours	651 h 41 min
RRJ-95 flight hours	50 h 31min

Flights hours during the last month	None
Flight hours on the day of the accident	00 h 28 min
Preflight rest	More than 12 hours at home
Total working time on the day of the accident	02 h 20 min
Medical check before the flight	Aeroflot crew pre-flight check medical post on 05.05.2019
Accidents and incidents in the past	None

According to the labor contract dated 07.03.2018 № 303 and the decree of the Aeroflot Client Service Deputy Director dated 27.03.2018 № 4318/л, recruited to the Aeroflot Onboard Service Department № 9, cabin crews, to the position of the flight attendant.

1.6. Aircraft information

Fig. 26. Aircraft RRJ-95B RA-89098 before the accident

Type of A/C	RRJ-95 (RRJ-95B)
Manufacturer	JSC «Sukhoi Civil Aircraft Company»
Date of manufacture	17.08.2017
MSN	95135

Registration	RA-89098
Certificate of A/C Registration	№ 8245 dated 14.09.2017, issued by FATA (Rosaviatsiya) Flight Safety Inspection
Owner	JSC «VEB-leasing», leased out to the JSC «Aeroflot» (certificated dated 18.09.2017)
Airworthiness Certificate	№ 2021170075 dated 27.09.2017, issued by FATA (Rosaviatsiya), valid till 27.09.2019
Design service life Current stage of the service life	70000 flight hours, 54000 flights, 25 years 15000 flight hours, 10000 flights, 15 years
Total time since new	2710 h, 1658 cycles
Overhaul information	Operation in compliance with the technical condition
Last repair	None
Last base maintenance check	05.04.2019 flight preparation maintenance, including the «A-check» («A01») + 375 FH (maintenance release dated 05.04.2019 № 148/1, H01154794)
Last line check	05.05.2019 before departure from Sheremetyevo by “Aeroflot” PJSC experts performed «T+DY» (maintenance release dated 05.05.2019 № 212/6)

SaM-146-1S-17 manufactured by POWERJET S.A. and APU RE220[RJ] manufactured by HONEYWELL installed to the aircraft.

Engines	Powerplant № 1	Powerplant № 2	APU
Type of Engine	SaM-146-1S-17	SaM-146-1S-17	RE220[RJ]
Engine MSN	146377	146397	P-1127
Date of manufacturing	31.05.2017	31.07.2017	23.16.2016
Power plant overhauls	Operation in compliance with the technical condition	Operation in compliance with the technical condition	Operation in compliance with the technical condition
Total time since new FH/cycles	1886/1155	1829/1161	2039/3055
Repairs	0	1 (local)	0

After the last repair, FH/cycles	-	154/112	-
Last repair date and location	-	07.06.2018, NPO SATURN (Rybinsk)	-

Aircraft maintenance

In compliance with the Maintenance Certificate dated 24.10.2016 № 285-16-148, issued by FATA (Rosaviatsiya), JSC «Aeroflot» is allowed to perform line and base RRJ95 maintenance.

Aeroflot Maintenance Control Manual is approved by the FATA (Rosaviatsiya) Aircraft Continued Airworthiness Department on 12.02.2016, Bermuda Department for Commercial Aviation in European region on 01.06.2016 and approved by PJSC «Aeroflot» Director General on 09.08.2016.

During RRJ-95B RA-89098 operation all line and base maintenance was performed by PJSC «Aeroflot» personnel.

The maintenance of the aircraft was performed in compliance with the RRJ-95B Aeroflot Maintenance Program (issue 14) approved by FATA (Rosaviatsiya) Aircraft Continued Airworthiness Department on 26.11.2018.

Base maintenance

According to 2-3-2-5 of Maintenance Program, the «A-Check» («A01» and «A02») consists of Maintenance Program tasks to be performed each 750 FH and/or each 100 DY, and 1500 FH and/or 200 DY.

Line maintenance

According to 2-3-2-1 of Maintenance Program, «TRANSIT» - «T» consists of a number of actions to be performed after each return to base airport. All the tasks of the Maintenance Program being part of this form, have the corresponding notice in the description of the task of Section 3 of the Maintenance Program (section 3 consists of Maintenance Program tasks concerning functional systems, power plants, structure examination, examination of specific areas and airworthiness restriction).

According to 2-3-2-2 of Maintenance Program, «DAILY» - «DY», typically, is to be performed at least once a day for the serviceable aircraft being under operation. If necessary, (for example, in order to return to base airport), it is allowed to perform another DAILY, not later than after 48 hours from the time of the previous work.

Base maintenance of the aircraft included in «A01»+375 FH and «A02», was performed correspondingly:

- 05.04.2019, maintenance release № 148/1, H0154794, upon achievement of 2556 FH, 1546 cycles. «A01»+375 FH work performance was combined with actions aimed at flight preparation after the aircraft was grounded since 08.01.2019 and aircraft preparation for summer season. During the period of grounding (on 31.03.2019) SaM 146-1S17 № 146397 (right) was installed to the aircraft;

- on 11.04.2019, maintenance release № 034/1, H0184546, upon achievement of 2580 FH, 1563 cycles.

During «A01»+375 FH there were 75 additional tasks performed, including the evaluation of the condition of the fueling point access hatch on the right-side wing (work order № 15826434 (№ 156) for portable fire extinguishers (№ 222 и 223)).

According to the results of the evaluation of the condition of the fueling point access hatch on the right-side wing (work order № 15826434 (№ 156) the deformation of the hinge loops; hatch alinement checked; lock fixation in closed position checked.

During «A02» there were 3 additional tasks performed, including the evaluation of fueling point access hatch on the right-side wing condition (work order № 16161931, (№ 111)). The work was to be performed because of lock defect. The lock adjustment was performed and the alinement of the hatch checked.

In the annexes to the maintenance releases for «A01» and «A02» there are marks that the actions according to the Maintenance Program were performed.

Before the last flight on 05.05.2019 on the aircraft there were T+DY (maintenance release № 212/6) performed. There were no commentaries from the crew as far as the systems performance is concerned after the previous flight. Additional tasks and the list of tasks delayed were not performed. During maintenance the check of the emergency and safety equipment was carried out.

During the examination of the aircraft at the site of the accident it was noticed that the blanks and covers used during the grounding were removed during the process of the preparation for the flight. Full set of the guard pins was detected at the nominal location in the cockpit.

On 05.05.2019 before departure from Sheremetyevo the aircraft was fueled with 4438 kg of TC-1 fuel, with the remaining fuel of 3000 kg the total fuel weight comprised 7438 kg.

In the course of the investigation there were the samples of fuel taken from the inner and the medium sections of the right fuel tank and from points 1 and 2 of the inner sections of the left fuel tank. The samples are put at tests.

During the period of grounding (from 30.12.2018 till 24.03.2019) because of engine absence, 06.01.2019 and 12.03.2019 the EIU100 concentrators were relocated (p/n КИВШ.466525.019) (work order № 15840297 (№ 182) and № 16050060 (№ 208) in order to restore the airworthiness of RRJ-95B RA-89111 and RA-89105. Among the actions to be taken before the relocation it was also necessary to make certain that there are no traces of lightning strike. There were no commentaries.

At the moment of the accident on RA-89098 there were EIU-100 № 575084410 и № 3640820134.

During the operation there was one commentary dated 25.01.2018 about the defect of the lifting and locking device: door 1L is difficult to close, it creaks. In compliance with the Maintenance Manual 52-10-00-010-801 (automatic service door opening with the emergency slide deployment) and 52-71-00-710-801.iss.02.ch.02 (service door gas spring charge control). There were no commentaries.

Since 15.04.2019 the flights were performed with one defect delayed till 05.05.2019: the dismantled fueling point access hatch (622CB). The possibility of flights with such defect is allowed by MCDL 0828, p. 3 D-15 (category DD). Fueling point access hatch noted 11 times since 04.01.2018.

During operation there were no defects connected with control system or lightning strike or static electricity impact. Among the damage reordered before the accident there were no damage typical for the damage caused by lightning strike or static electricity.

There were the following external panel damage:

- air intake toe СУ № 1. 30.03.2017 repaired;

- separation of air intake channel of the engine № 1 protective cover 6-8 o'clock position in the area of riveting. Repaired on 20.11.2017;

- paint coating defect of the compression hatch of the door 1R. Paint restored on 15.09.2018;

- paint coating defect of the upper front slats without, base cover remains intact. Paint restored on 06.11.2018;

- paint cracks on panel 713. Paint restored on 08.04.2019.

The listed damage do not coincide with the kind of the damage typical for the lightning impact traces that were discovered in the course of the investigation on the front right part of the fuselage

1.7. Meteorological Information

Weather conditions on the European part of the Russian Federation and on the Moscow airfields on 05.05.2019 were determined by the influence of the front part of the Mediterranean cyclone trough, its center was located over the central part of Italy and was outlined by the 995th isobar, the pressure at the center was 994.3 hPa. Cyclone is a slow high pressure formation, and it was traced throughout the entire thickness of the atmosphere. The trough of the cyclone on the ground spread from southwest to northeast. According to the weather map at 12:00 its axis went to the West from Lvov through Minks and Velikiye Luki where the cold front with the waves was situated. The Moscow air zone was influenced by the warm sector of the cyclone and the front of the occlusion, which shifted from the southwest to the northeast at a speed of 40–60 km/h and determined the weather of Moscow airfields.

The front of occlusion caused the development of cumulonimbus clouds with a 8–10 km height of the upper boundary, thunderstorm activity with an increase of the south-west surface wind up to 15–19 m/s, and the rainfall, reducing visibility in some areas till 1500–2000 m.

At 13:38 till 13:49 there was thunderstorm in Sheremetyevo, the pouring rain with visibility worsening till 1700 m and the southwest wind up to 15 m/s. In Vnukovo at 14:18 till 14:35 there was thunderstorm with light rain, visibility 5-7 km, during thunderstorm, the wind of the south-west direction increased to 15m/s.

At 15:01 till 15:13 at the Domodedovo airfield there was thunderstorm with light rain and the visibility of 10 km, southwest wind up to 19 m/s.

At 09:54, the forecaster on duty, because of the predicted and the actually observed gusty surface wind at a speed of 11-14 m/s, issued warning 1 about the wind shear at the Sheremetyevo airfield from 10:00 to 14:00 on May 05, 2019: wind shear on the approach.

UUEE WS WRNG 1 050954 VALID 051000/051400 WS IN APCH FCST.

On 05.05.2019 the crews transmitted the inflight weather data via ATM to the meteorologist on the main observation point: at Sheremetyevo at 10:33 – mild wind shear, mild turbulence (AFL 2107), at 13:41 – strong wind shear (AFL 261).

At 13:47 wind shear warning 2 for Sheremetyevo for the period from 14:00 till 18:00 on May 05 2019 issued: wind shear in the approach forecasted: UUEE WS WRNG 2 051347 VALID 051400/051800 WS IN APCH FCST.

In the daily plan of departures on 05.05.2019 flight SU-1492 on the route Moscow (Sheremetyevo) - Murmansk was scheduled for 14:50.

During the preflight preparation at 13:11 at the Briefing the crew received the flight documentation with the meteorological information from the automatic pre-flight information system of the Federal State Budgetary Institution “GAMC Rosgidromet”, it consisted of TAF code for departure aerodromes, scheduled landing and a spare: period of operation starting from 12:00 05.05.2019 till 12:00 06.05.2019 for the airports of Murmansk, Pulkovo, Naryan-Mar, Syktyvkar, Nizhny Novgorod, Sheremetyevo, from 12:00 05.05.2019 to 21:00 05.05.2019 for Arkhangelsk and from 12:00 05.05.2019 to 18:00 06.05.2019 for the airfield Domodedovo, actual weather in the METAR code for 13:00 for the airfields of Murmansk, Arkhangelsk, Pulkovo, Naryan-Mar, Syktyvkar, Nizhny Novgorod, Domodedovo and in the SPECI code for 13:01 for the Sheremetyevo airfield, SIGMET 1 information on FIR Moscow validity with 12:30 to 16:30; FL 100-450 weather forecast maps for the London WAFC Europe region, valid at 12:00 and 18:00 05.05.2019. The meteorological package included a wind speed and direction map: Route chart WX:05MAY 16:06 UTC FL352.

The crew met again at a briefing at 13:39, during which they received a new form with TAF forecasts with a validity period from 12:00 05.05.2019 to 12:00 06.05.2019 for the airfields of Murmansk, Pulkovo, Naryan-Mar, Syktyvkar, Nizhny Novgorod, Sheremetyevo, from 12:00 05.05.2019 to 21:00 05.05.2019 for Arkhangelsk and from 12:00 05.05.2019 to 18:00 06.05.2019 for the Domodedovo airfield and updated actual weather data in the METAR code for 13:30 for the airports of Murmansk, Arkhangelsk, Pulkovo, Naryan-Mar, Syktyvkar, Nizhny Novgorod, Domodedovo, in the SPECI code for Sheremetyevo for 13:38, and information SI GMET 1 for FIR Moscow valid from 12:30 to 16:30.

Moscow (Sheremetyevo) take-off aerodrome forecast in TAF code released on 05.05.2019 at 10:59 with a period of validity from 12:00 05.05.2019 to 12:00 06.05.2019:

TAF UUEE 051059Z 0512/0612 18008G15MPS 9999 BKN030 TX23/0612Z TN06/0602Z

TEMPO 0512/0518 -TSRA BKN015CB BECMG 0518/0519 18003MPS SCT030=

Surface wind 180 ° - 08 m/s, gust 15 m/s, visibility more than 10 km, significant cloudiness, height of the lower boundary 900 m, maximum temperature +23°C at 12:00 on May 6, minimum

temperature +06°C at 02:00 May 6, sometimes from 12:00 to 18:00 05.05.2019 thunderstorm, rain, significant cloudy cumulonimbus, the lower limit is 450 m, gradually from 18:00 to 19:00 05.05.2019 ground wind 180 ° - 03 m/s, scattered clouds, height of the lower border 900 m.

The actual weather for the take-off aerodrome, Moscow (Sheremetyevo), SPECI on 05.05.2019 at 13:38:

SPECI UUEE 051338Z 24008G15MPS 7000 -TSRA BKN053CB 15/13 Q1013 R24L/290045 R24C/290045 NOSIG=

Surface wind 240 ° - 08 m/s, gusts of 15 m/s, visibility 7000 m, thunderstorm, light rain showers, significant cumulonimbus clouds, height of the lower boundary 1590m, air temperature + 15°C, dew point temperature +13°C, atmospheric pressure QNH 1013 hPa, condition of runway 24L: wet, braking 0.45, condition of runway 24C: wet, braking 0.45, without significant changes.

SIGMET 1 for Moscow flight area on 05.05.2019, period from 12:30 till 16:30:

UUWV SIGMET 1 VALID 051230/051630 UUWV-

UUWV MOSCOW FIR EMBD TS FCST S OF N57 TOP FL360 MOV N 30KMH INTSF=

SIGMET 1 message, issued by Moscow meteorological watch office (UUWV-) for MOSCOW FIR (UUWV-), valid from 12:30 05 May till 16:30 05 May, masked thunderstorm is projected south of 57°C. sh. vertical length up to FL 360, shifted to the north at a speed of 30 km/h, increasing.

In addition to the above meteorological information, the crew, before departing at the Briefing, were familiarized with a cloud image of Meteosat-8 satellite on 05.05.2019 and data from the doppler weather radar Vnukovo at 1:30 pm on 05.05.2019 at the remote weather displays; warning No. 1 at Sheremetyevo airfield: 05.05.2019 a thunderstorm is predicted from 15:00 to 17:00 MSK and warning No. 1 about wind shear at Sheremetyevo airfield: 05.05.2019 from 13:00 to 17:00 MSK, a wind shift is forecasted on paper.

At 14:35 the SU-1492 crew reported to the Delivery controller that they received local weather data automatically transmitted by «Bravo» for 14:30: surface wind 140 ° - 03 m/s, gusts 06 m/s, visibility more than 10 km, cloudiness slightly cumulonimbus 1800 m, air temperature 17°C, dew point temperature 13°C, QFE 742 mm Hg. Art. / 989 hPa, QNH 1011 hPa, without significant changes.

At 15:03 RRJ-95B RA-89098 performed takeoff from the Sheremetyevo aerodrome.

At 15:08 at 8700 feet (2700 m) according to standard pressure, the development of a special situation began. According to the evidence from the crew, lightning strike hit the plane. According to the data of Vnukovo doppler weather radar, at 15:00, 15:10 05.05.2019 in the west, 30-40 km from Sheremetyevo airport, in the area of the Istrinsky reservoir, cumulonimbus cloudiness was noted with an upper limit of 8-9 km occlusion, thunderstorm, the direction was to the northeast (azimuth 41-42 °), at the the speed of ~ 15 m/s.

According to the atmospheric radio sounding data of the aerological (weather) station Moscow (Dolgoprudny) on 05.05.2019 at 12:00, the wind parameters (direction, speed) in the layer from the Earth to the AP level 700 hPa (height 2848 m) were analyzed. In the layer from 390 m to 211 m (from 1280 ft to 692 ft) the wind speed varied from 10 m/s to 5 m/s, which implies the presence of a wind shear in this layer.

At 15:31 via the service phone of the main observation point there was received the «Alarm» code «red» signal (circular call system) from the head of the airport Sheremetyevo. The meteorologist of the main observation point with the help of the system AMIS-RF formed the weather report and transmitted it to KSA «TOPAZ OVD», AFRS «Popugai», RK «Moskva – Reserv», ATC «SINTEZ-AR4» and to meteo-displays.

The actual weather at the Moscow airport (Sheremetyevo), released upon the “Alarm” signal, issued with a local special weather report for 15:31: surface wind of 160º - 7 m / s, gusts of 10 m / s, visibility in the landing zone of 10 km, in average the runway point is 10 km, at the far end of the runway is 10 km, scattered clouds are cumulonimbus, the height of the lower boundary is 1800 m, air temperature is + 17º C, dew point temperature is + 11 ° C, atmospheric pressure QNH is 1012 hPa, QFE is 742 mm Hg. Art. / 990 hPa, runway condition 24L wet, clutch 0.45, forecast for landing: no significant changes.

1.8. Aids to Navigation, Landing and ATC

At the time of the accident the following means of radio support for flights were engaged at the aerodrome: SP-90, radar of the TERMA SCANTER 2001 and KSPI “Ladoga”.

Landing system on runway-24 L SP-90 as part of the LOC (SP-90), OM and IM (RMM-95), Landing Systems Equipment Outer NDB and Inner NDB (RPA-Parsec) worked without comment, were remotely controlled, no signals of failures and deterioration were recorded, no complaints from aircraft crews nor before, neither the accident were reported, there were no transfers to backup power sources. The system provided ILS approach for the ICAO category II.

In accordance with the data of means of objective control, radio means of landing worked according to the regulations. There were no comments from the controllers team.

1.9. Communications

At the Moscow Sheremetyevo airport, the aeronautical mobile telecommunications to contact the aircraft crews, the radio communications to transmit the meteorological information in the VHF band, the back-up radio communication with the aircraft in distress, as well as the ground communications between the air operations supervisor and the ATM authorities, service providers, radio aids operators and the alternate aerodromes are ensured.

The means of mobile and fixed radio communications at the Moscow Sheremetyevo aerodrome were functioning as assigned. The VCSS “Megafon” voice communication system ensured the management of the main and standby radio stations, as well as the loudspeaker communications. There were no comments neither by the ATC controllers, nor the aircraft crews.

The RRJ-95 RA-89098 aircraft was equipped with the three Thales VDR. From the point of the engines start up and in the progress of the flight until 15:08, the crew contacted the ATM controllers at the main/primary frequency with the use of VDR No. 1. After the aircraft was exposed to the impact of the atmospheric electricity, there communication via VDR No 1 was not available anymore.

At 15:09 the crew contacted the Sheremetyevo Tower controller at the 121.5 MHz emergency frequency of via VDR No. 2. Further on, the radio communication with the ATC controllers was conducted on this frequency. The analysis of the quality of the radio communication will be provided in the Final Report.

1.10. Aerodrome information

The Moscow Sheremetyevo is an A category, I class civil aerodrome. The aerodrome is in the area of responsibility of the Ministry of Transport of Russian Federation. The aerodrome is located 28 km north-west off Moscow. The aerodrome reference point is 55º58′20.63″ N, 37º24′46.99″ E. The aerodrome reference position elevation (the true altitude) is 190.1 m. The elevation (the aerodrome true altitude) is + 192 m. The geodesic height (as per Geodetic Parameters-90.02/ПЗ-90.02) is + 206.3 m. The magnetic variation is + 11°. The time zone number – 2 (UTC+3 hrs). The Geodetic Parameters-90.02/ПЗ-90.02 is the coordinate system used. The flights are authorized in IFR/VFR.

The certificate of conformity No АД 00033 is issued by FATA on December 30, 2015 and valid until December 30, 2020.

The aerodrome is qualified for international operations. Then aerodrome is approved for H24 operations under the established minima.

The aerodrome location index is Moscow (Sheremetyevo) - УУЕЕ/UUEE (in Russian Federation/the ICAO code), the IATA code – ШРМ/SVO.

The senior air officer of the Moscow Sheremetyevo aerodrome is the general manager of the Sheremetyevo international airport, JSC (the FATA Order No 65/1 of February 24, 2012).

The aerodrome integrates two rectangular airfields with the dimensions 4500 x 1830 m and 3800 x 500 m., interconnected with the D TW. The aerodrome surface is even, the soil is a silty loam with grass cover, the ground is soft, unfit for the landing operations.

The aerodrome integrates three side-by-side artificial RWYs: the A class RWY-6C/24C (RWY- 1), the A class RWY-06R/24L (RWY-2) and the A class RWY-06L/24R (RWY-3). The distance between the RWY-1 and RWY-2 centerlines is 280 m; between RWY-1 and RWY-3 centerlines is 2130 m. The centers of the RWY-1 and RWY-2 are not shifted to each other. The centers of the RWY-1 and RWY-3 are shifted to each other by 3375 m. RWY-3 is inactive (closed for operations) (the first NOTAM A1976/18 of April 26, 2018, the last NOTAM A0930/19 of February 26, 2019).

The dimensions of RWY-24L/06R are 3700 x 60 m, magnetic track angle = 244° (true track angle = 255°06′), magnetic track angle = 064° (true track angle 075°04′). PCN is 64/R/A/W/T, the RWY surface is a reinforced concrete (the upper layer of 30 cm), the cement concrete (the lower layer of 25 cm). The 24 threshold reference position: 55°58′32.53″ N., 37°26′37.69″ E., the 24 threshold elevation – + 189.34 m.

The RWY equipment ensures:

– with the 064° landing magnetic heading the CAT I, II, IIIA precision approach;

– with the 244° landing magnetic heading the CAT I, II precision approach.

The RWY cleared and graded areas run 90 m off the RWY-1 and RWY-2 centerlines on either side. The RWY cleared and graded area soft surface at the areas of intersection with the artificial surfaces is level with them.

The Guidelines on the Air Operations at the Moscow Sheremetyevo aerodrome area is approved by the Sheremetyevo International Airport, JSC general manager on September 28, 2015 and registered by the FATA central interregional territorial department No ЦИ1-419 of September 01, 2015.

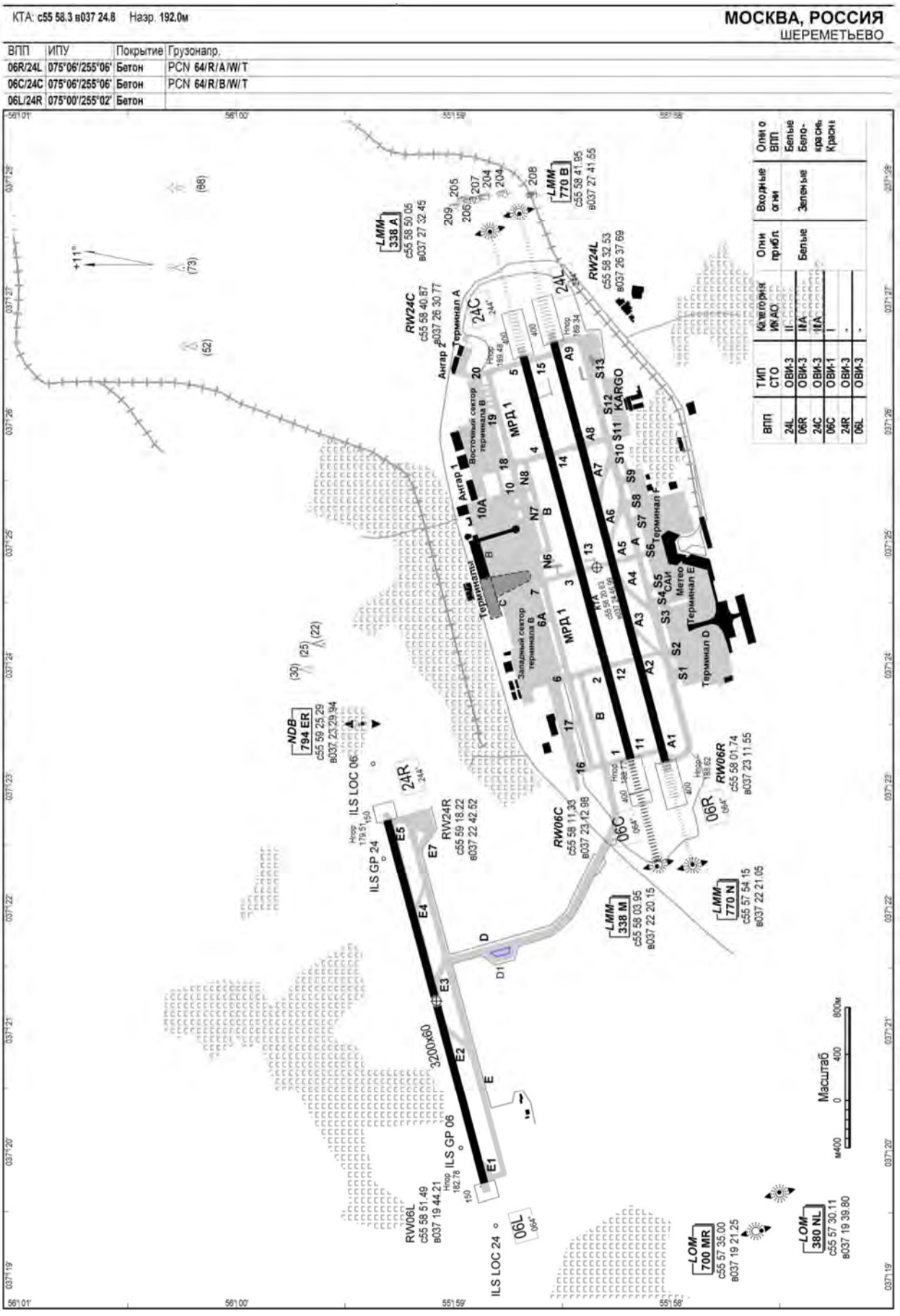

Fig. 27. Moscow Sheremetyevo aerodrome chart

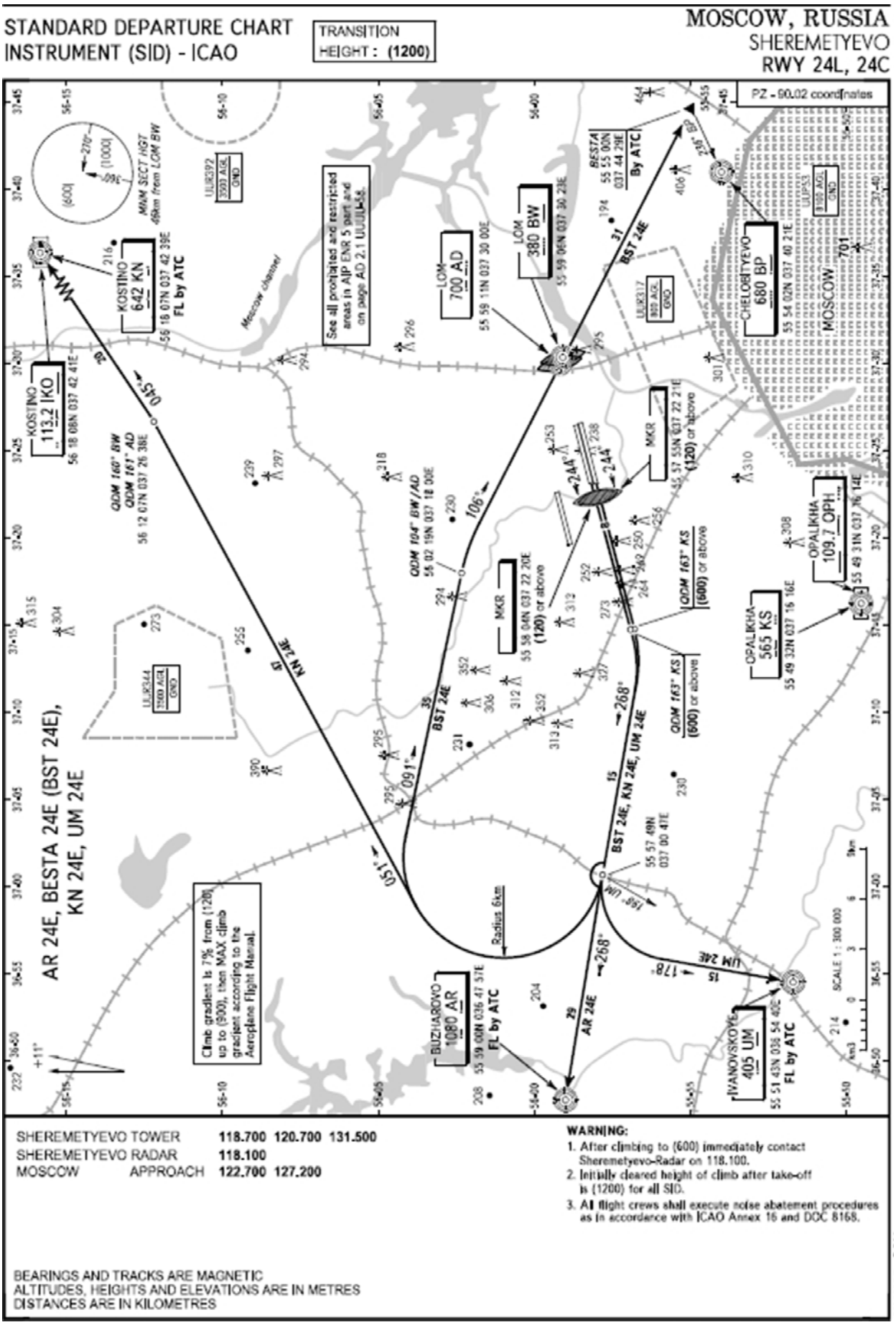

Fig. 28. Sheremetyevo SID KN 24E chart

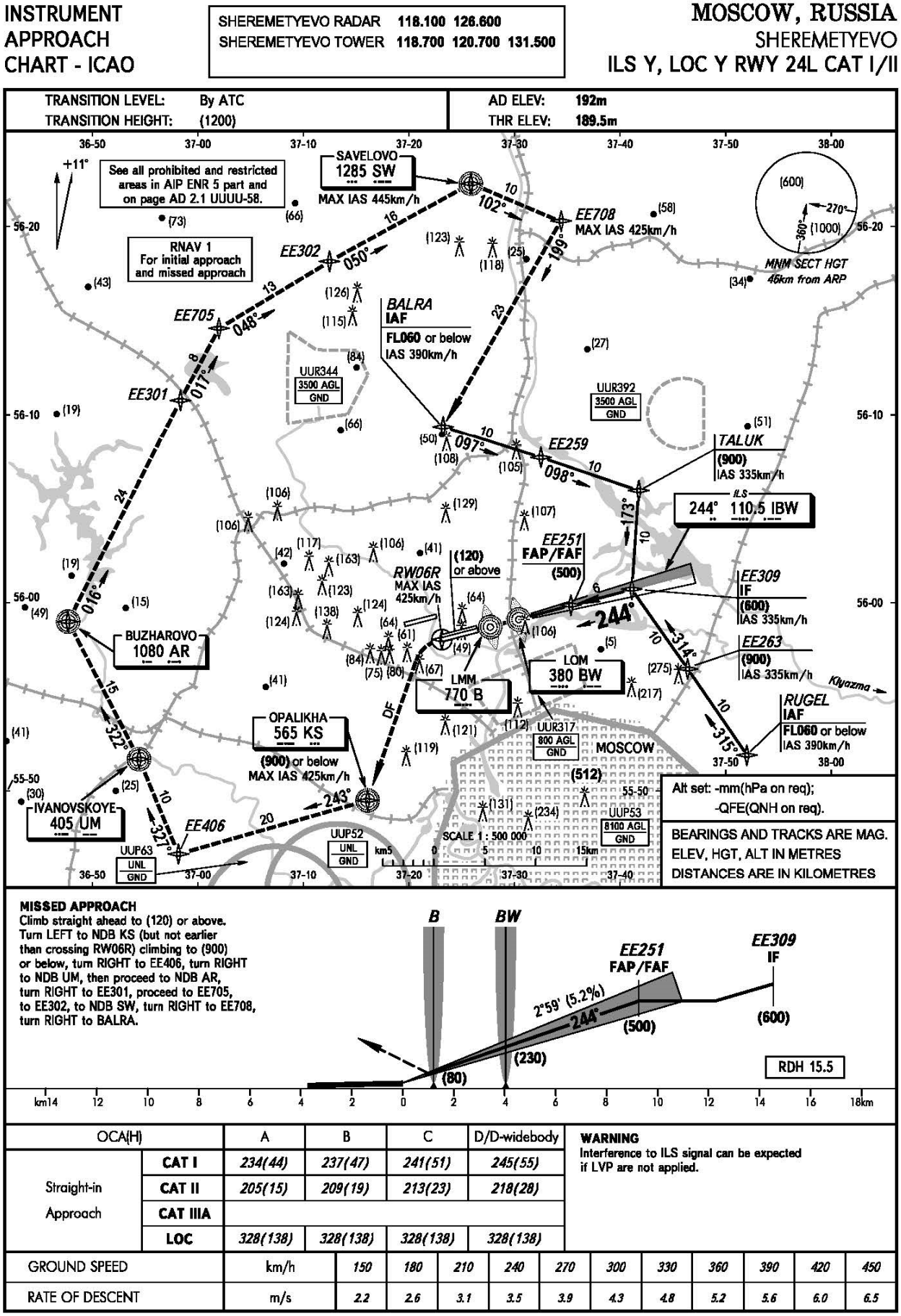

Fig. 29. An ICAO Sheremetyevo ILS Y LOC Y RWY 24L SVO STAR chart

1.11. Flight recorders

RRJ-95 RA-89098 was equipped with the following flight recorders:

- FDR L3 FA2100;
- CVR L3 FA2100;
- Integrated Data Management Unit (iDMU) with Flash-card Personal Computer Memory Card International Association (PCMCIA).

The condition of the recorders received from the accident site:

- FDR L3 FA2100 PNR 2100-2043-12 was damaged, as a result of the heat exposure, the body of the recorder unit was partially destroyed (Fig. 30);

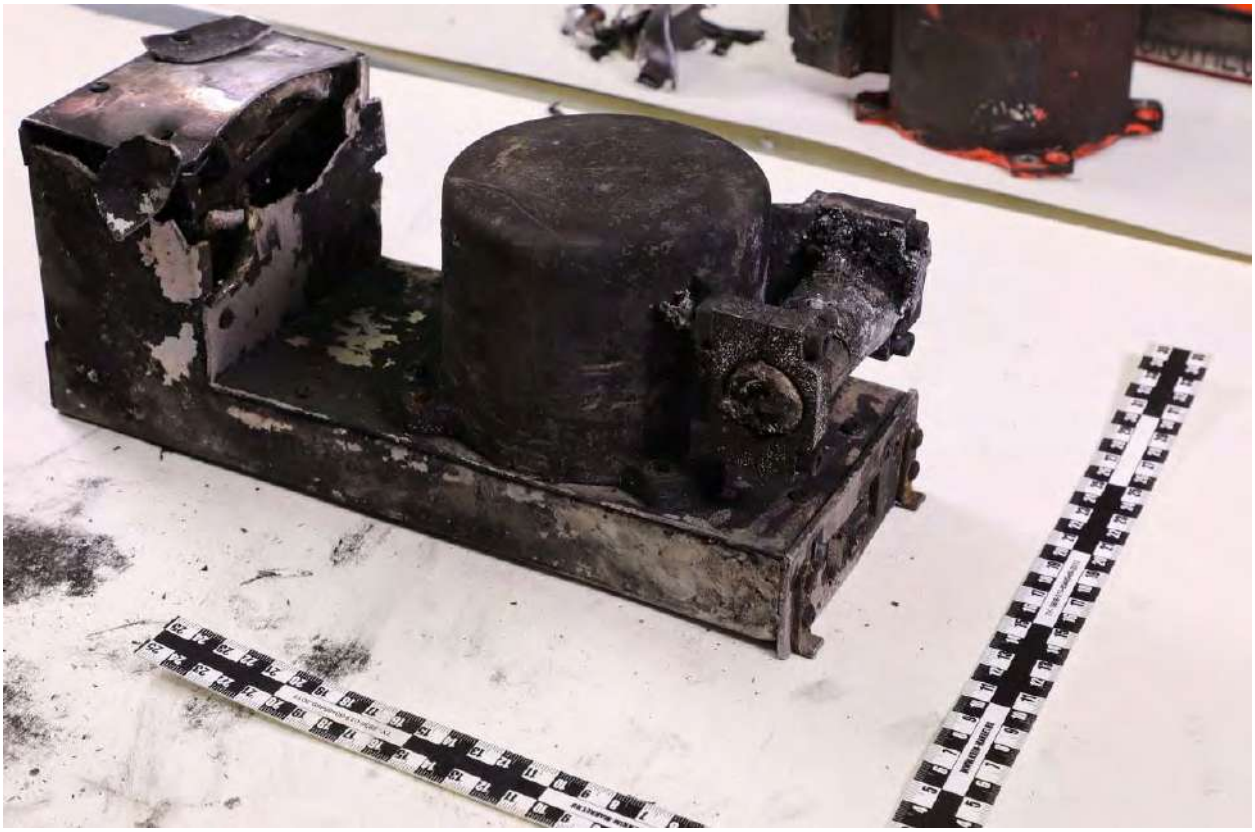

Fig. 30. General view of the FDR L3 FA2100

– CVR L3 FA2100 PNR 2100-1025-12 was damaged, its housings and protected memory module are covered with soot, no deformation (Fig. 31);

– Integrated Data Management Unit (iDMU) PNR 223560006 with a PCMCA Flash-card s/n 2088-51M. The body of the iDMU is not damaged, was not exposed to fire, is in satisfactory condition (Fig. 32).

The decoding of the recorders was carried out in the laboratory of the IAC.

The flight information is safe. The quality of the records is fine.

The results of the decoding of the flight information are used to find out the causes of the accident.

Fig. 31. CVR L3 FA2100: a) general view, б) device label

Fig. 32. Integrated Data Management Unit (iDMU) with Flash-card PCMCIA №2088-51M: a) general view of the unit; b) device label; c, d) Flash-card PCMCIA №2088-51M

1.12. 1.12. Wreckage information

The examination of the accident site was performed on May 06, 2019. By the time of the examination the first and second points of impact on the runway had not been visible. In order to design the wreckage map of the accident site, the materials, provided by the Sheremetyevo International Airport, JSC flight safety inspection and the photo and video shots, taken immediately after the accident, had been additionally used. The video records by the Sheremetyevo airport CCTV had been used as well.

The flight of the RRJ-95B RA-89098 aircraft on 05.05.2019 should have been proceeded en-route Moscow (Sheremetyevo) - Murmansk. After takeoff the crew returned to the departure airport, performed the approach and landed on RWY 24L with 244 ° magnetic heading.

As per the records of the Sheremetyevo CCTV the first touchdown occurred with all the three landing gear legs at once at the A8 TWY at a distance≈ 890 m off the RWY 24L threshold (Fig. 33), the aircraft bounce off the RWY occurred afterwards (Fig. 34).

Fig. 33. First touchdown point

The second touchdown occurred at the distance of ≈ 1070 m from the RWY 24L threshold, first by the nose gear leg with the further main gear legs impact with the RWY (Fig. 35), another bounce off the RWY occurred afterwards (Fig. 36). At the area of the second impact there were no fuel traces or aircraft fragments found.

The third touchdown occurred at the area of the A7 TWY, at the distance of about 1360 m from the RWY 24L threshold, first with the right main gear leg, then with the left one (Fig. 37).

Fig. 34. The bounce after the first touchdown

Fig. 35. The place of the second touchdown

Fig. 36. The aircraft bounce after the second touchdown

Fig. 37. The place of the third touchdown

In the progress of the impact the main landing gear legs collapsed (most probably in the progress of the second impact the right and left main landing gear legs weak links safety pins had been sheared along the “A” joint with the further successive contact of the right engine nacelle - aircraft tail segment-left engine nacelle with the RWY surface.

The examination of the RWY right after the accident was the evidence that at the distance of ≈1360m off the RWY 24L threshold, to the right of the RWY centerline, there are traces of the right engine nacelle, the right main landing gear leg, the inner wheel disc of the left main landing gear leg and the rear part of the fuselage.

Then the aircraft proceeded its movement along the RWY on engine nacelles and the rear part of fuselage with the destruction of the structural elements of the aircraft, which fragments are scattered on both sides along the aircraft motion path at the distance of not more than 60 m.

As per the CCTV records, at the distance of about 130 m from the third impact point the aircraft caught fire.

Initially the aircraft moved straightforwardly along the runway centerline on the right side. At the area of TWY A5, the onset of the left shift of the aircraft and its deviation off the RWY centerline was detected (Fig. 38).

Fig. 38. The onset of the left shift traces off the RWY centerline at the area of the A5 TWY

The aircraft excursion of the RWY occurred at the area of the A3 TWY (2460 m off the RWY 24L threshold) (Fig. 39).

Fig. 39. The aircraft motion traces, the point of the RWY excursion at the area of the A3 TWY

The AC stopped in between the TWYs \2 and 3, at the 55°58′06.20″ N., 37°24′07.20″ E at the height of 185 m, the true heading of 128° (Fig. 40). The distance from the RWY 24L threshold was ≈ 2720 m, the lateral deviation amounted to about 110 m to the left off the runway centerline.

Fig. 40. The RRJ-95B RA-89098 aircraft at the accident site

Fig. 9 presents the external view of the aircraft after the stop and the fire extinguishment. The wreckage map of the accident site is given on Fig. 41.

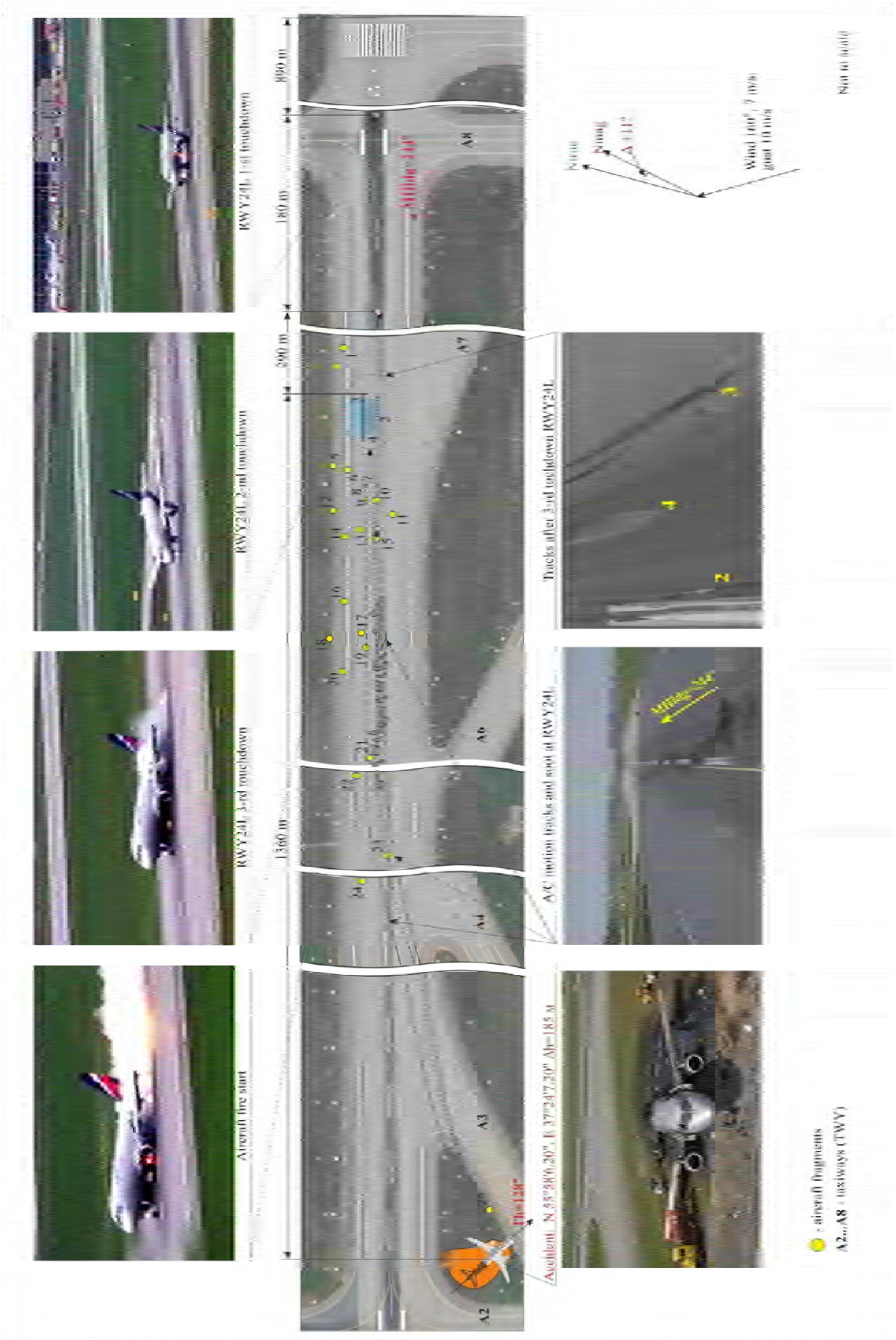

Fig. 41. The wreckage map of the RRJ-95 RA-89098 at the Sheremetyevo airport on May 05, 2019

1.13. Medical and Pathological Information

Medical and pathological have not been finished yet. They are to be provided in the Final Report.

1.14. Survival Aspects

Are being analyzed. To be provided in the Final Report.

1.15. 1.15. Search and Rescue. Fire Fighting Operations

Are being analyzed. To be provided in the Final Report.

1.15.1. Condition and sequence of the rescue equipment application

All portable rescue and oxygen equipment (except of oxygen cylinders that were in the destroyed rear luggage compartment on the right side of the cockpit, and two lights for cockpit crew members) found at regular places.

The front emergency slides (left and right) opened up when the doors opened. The rear left emergency slide did not open up.

The FO used the rope for evacuation through the right sliding window of the cockpit.

Work on analyzing the performance of rescue equipment continues.

1.16. Tests and Research

1.16.1. Fuel test

Samples of fuel were taken from the wing of the aircraft and from the fuel station for further research. Fuel samples were sent to the Scientific Center of Airport Activities and Aviation Fuel Support (SC-28) of the Federal State Unitary Enterprise GosNII GA.

1.16.2. Electronic Interface Units Research

The first stage of the EIU-100 (Electronic Interface Unit) is finished. The work was carried out in the scientific and technical center of the IAC together with the experts of the designer of the units - JSC "Ulyanovsk Instrument Design Bureau".

EIU-100 provide information exchange between the aircraft systems; the aircraft kit includes two interchangeable units. Information exchange between the blocks is not carried out.

The units are designed to provide information exchange between aircraft systems that have no direct links.

The units transfer outputs to the following aircraft systems:

- Engine control system ATA 76-00-00;
- AC power supply system ATA 24-20-00;
- External lighting system ATA 33-40-00;
- Air conditioning system ATA 21-00-00;
- Cockpit glazing electrical heating system ATA 30-41-00;

- Heating system for full and static pressure receivers ATA 30-31-00 (avionics);

- Desk and control panels systems ATA 31-11-00;

- Multifunctional transponder system ATA 34-57-00.

The results of the research:

1). Channels «B» of both units performed fine till the end of flight and landing.

2). Channels «A» of both units till landing do not contain the fault codes.

3). In channels of both units during 15:08:06 - 15:08:24 (time resolution 6s) there was a transition (reboot)[15] to the new sector of the long-term memory device with end of processor functioning for the period of ~ 18s. This transition could be caused by the lack of power at the input or a short-term failure of the channels of the units.

4). According to the RRJ-95B safety systems analysis it was established that, during fault (including reboot) of the units, inter alia, the control system transits to DIRECT MODE happens.

The research of the units continues.

1.16.3. Approaches comparative analysis

The Commission carried out preliminary comparative analysis of the approaches performed by the PIC manually (with disengaged autopilot) in «NORMAL MODE», with the emergency flight (Fig. 42). The figure shows that the sidestick movements for the pitch in the emergency flight are characterized by significantly wider amplitude, and are oscillatory, which caused significant changes of longitudinal motion parameters.

Similar "sweeping" movements were observed during landing performed in «DIRECT MODE» by other crews of the airline (Fig. 43). Reasons of these peculiarities are being analyzed.

[15] According to the explanations granted by the units designer, the reboot is one of the working modes, it is not the sign of fault (failure or defect).

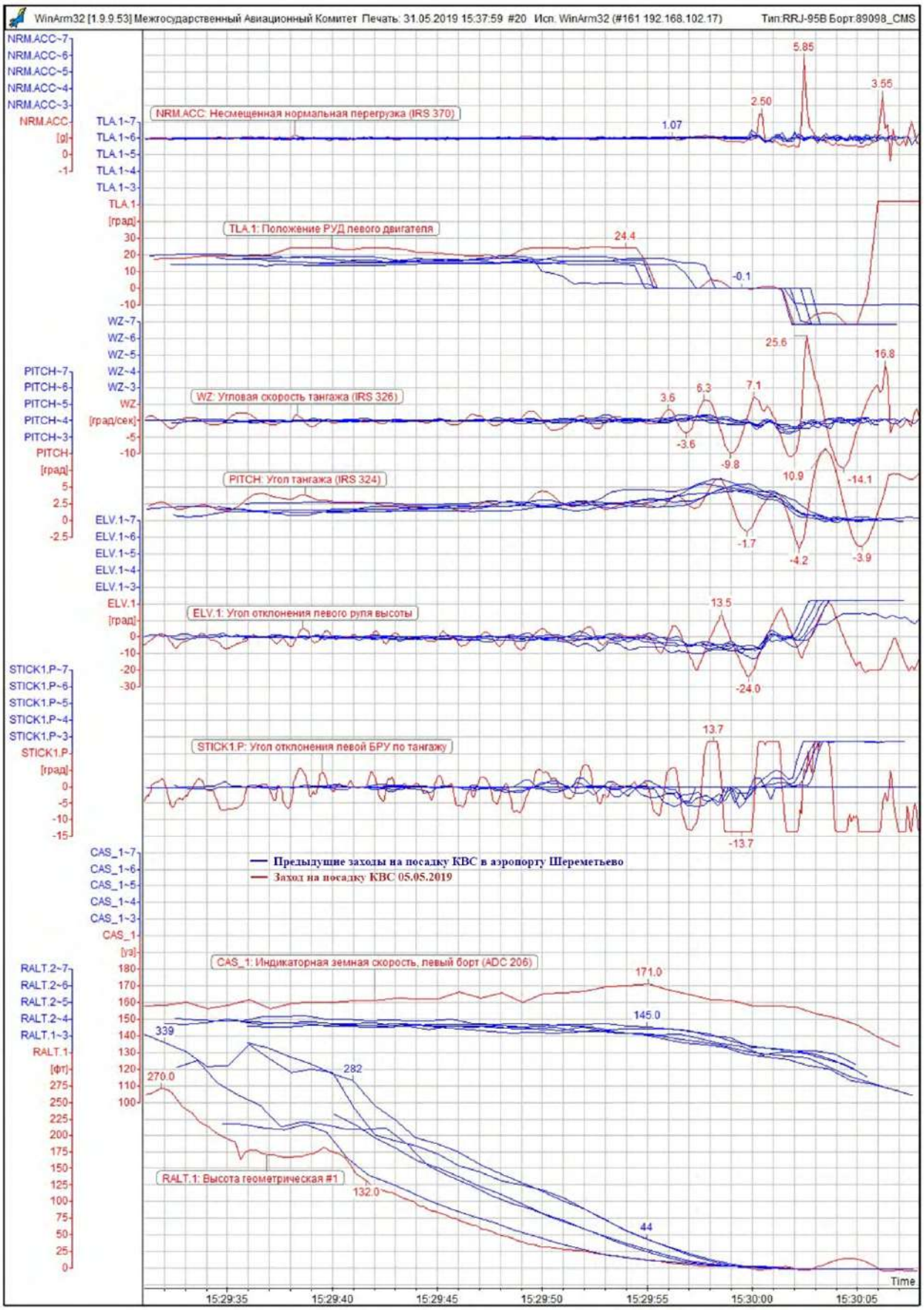

Fig. 42. PIC approach comparative analysis

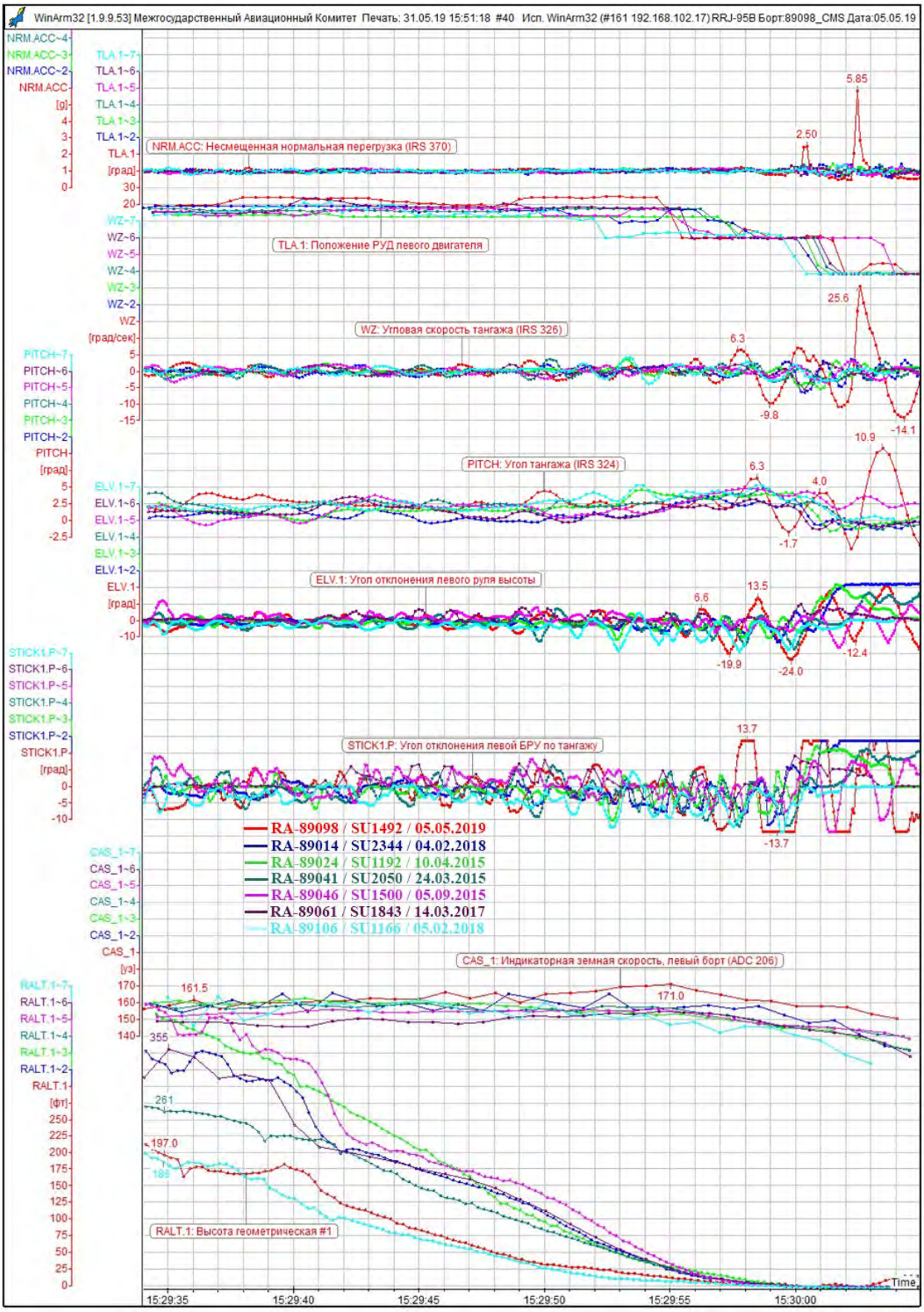

Fig. 43. Approach comparative analysis performed in DIRECT MODE

1.16.4. Other research planned

The units of various aircraft systems (remote control (fly-by-wire) system, weather radar, engine control units (DECU), central calculator of avionics and VHF transceivers) were dismantled in order to read data from the internal non-volatile memory (NVM) and to study their condition and determine their operability. The work is planned to be carried out together with the designers and manufacturers of these units, as well as with the authorized representatives of Germany, the USA and France.

Following the investigation commission assignment the designer of the aircraft carries out the mathematical modeling of the flight in order to assess the compliance of the characteristics of the aircraft in an emergency flight with the characteristics of the aircraft-type, as well as the possible influence of external disturbances.

To assess the actions of the crew in an emergency flight, the commission plans to conduct experiments on the full flight simulator (FFS).

The commission analyzes the previous cases of transition to DIRECT MODE in flight (section 1.18.3) and cases of hard landings (section 1.18.4).

1.17. Information about organizations and administrative activities related to the accident

To be provided in the Final Report.

1.18. Additional Information

1.18.1. Table of flights performed before and after SU – 1492

Depart. time	Flight	AC type	Country	Departure procedure	Request for fly over
14:53	NVS377	B738	Russia	BST24E	Did not request
14:54	AFL1130	A320	Russia	BST24E	Did not request
14:55	AFL2164	SU95	Russia	AR24E	14:57 heading 270^0, 14:57:45 heading 290^0, 14:59 heading 270^0
14:57	AFL1364	SU95	Russia	BST24E	Did not request
14:59	CSA895	B739	Czech Republic	AR24E	15:01 heading 290^0
15:00	AFL274	A333	Russia	BST24E	15:03:26 heading 290^0, 15:03:44 heading 300^0
15:03	AFL1492	СУ95	Russia	KN24E	Did not request

15:04	AFL1426	СУ95	Russia	BST24E	15:08:17 heading to the right at BESTA for fly over
15:06	AFL2138	Б738	Russia	BST24E	15:07:46 heading 300^0
15:08	AFL2352	A321	Russia	AR24E	15:08:27 heading 220^0
15:09	AFL2468	A320	Russia	AR24E	15:10:28 heading 220^0
15:11	AFL2474	A320	Russia	AR24E	15:12:06 heading 230^0
15:12	AFL261	A321	Russia	AR24E	15:13:43 heading 220^0
15:14	AFL2382	A321	Russia	AR24E	15:14:45 heading 220^0
15:17	CAR389	E190	Russia	BST24E	15:18:52 heading 330^0
15:20	AFL1260	A320	Russia	BST24E	15:21:23 heading to the right
15:24	AFL2002	A320	Russia	AR24E	15:25:18 heading 230^0

1.18.2. Previous cases of lightning strikes to RRJ-95

№ п/п	MSN	Date	Circumstances	Consequences
1.	95024	20.11.2013	Lightning strike to the left part of the AC	No damage
2.	95028	27.05.2014	Lightning strike	No damage
3.	95046	22.10.2015	Lightning strike	No damage
4.	95046	03.12.2015	Lightning strike	No damage
5.	95085	11.05.2016	Lightning strike	No damage
6.	95029	04.06.2016	Lightning strike at the parking point	No damage
7.	95054	08.07.2017	Lightning strike to the nose cone	No damage
8.	95048	12.07.2017	Lightning strike to the stabilizer	Lightning protection tape change
9.	95100	23.11.2017	Lightning strike to the door fasteners of the nose landing gear	Soot, fasteners replacement
			RAT area R6-F6H	Soot, fasteners replacement
			To the right part of the fuselage	Soot, paint job
			To stabilizer	Soot, paint job
			To the upper part of the fuselage	Soot, paint job

10.	95100	29.11.2017	Lightning strike to RAT area R6-FGH	Soot, fasteners replacement
11.	95024	27.01.2018	Lightning strike	No damage
12.	95100	09.02.2018	Lightning strike to the fuselage	Fasteners replacement
13.	95103	04.05.2018	Lightning strike to the rudder	Replacement of the static discharge wick and rudder hatch crew
14.	95025	23.05.2018	Lightning strike to the VHF-2 antenna and the wing panel	VHF-2 antenna replacement
15.	95118	27.05.2018	Lightning strike to the nose cone	Nose cone replacement
16.	95043	05.01.2019	Lightning strike to the VHF-2 antenna	VHF-2 antenna replacement

1.18.3. Previous cases of transition to DIRECT MODE on RRJ-95

Date	Tail number	Flight stage
24.03.2015	RA-89041	On the route
10.04.2015	RA-89024	Approach
05.09.2015	RA-89046	On the route
13.01.2016	RA-89011	Climb
03.08.2016	EI-FWA	Approach
14.03.2017	RA-89061	Approach
04.02.2018	RA-89014	Takeoff
05.02.2018	RA-89106	Takeoff

1.18.4. Previous cases of hard landings on RRJ-95

Date	Type	Tail number
30.03.2015	RRJ-95B	RA-89043
16.05.2015	RRJ-95LR-100	RA-89031
24.10.2017	RRJ-95LR-100	RA-89029
03.05.2018	RRJ-95LR-100	RA-89037
15.01.2019	RRJ-95B	RA-89061
25.01.2019	RRJ-95B	RA-89023

1.18.5. Fly-by-wire control system modes description

Fly-by-wire control system (FBWCS) is a control system designed so that there is no mechanical connection of the aircraft controls located in the cockpit with the aerodynamic control surfaces.

Pilots, using the controls in the cockpit, control the aircraft by pitch, roll and yaw.

The computing part of the FBWCS processes the signals, received from the FBWCS sensors and the collaborating systems of the aircraft, calculates control commands, and in accordance with them, the executive actuators of the controls in the cockpit via the control channel sets the aerodynamic control surfaces to the position specified by the pilots in order to fly along the calculated trajectory, ensuring the following:

- optimal characteristics of the stability and controllability of the aircraft along the entire allowable flight area, including automatic pitch trimming;

- automatic limitation of the limit flight modes for angle of attack, speed and acceleration;

- automatic stabilization of the roll and pitch achieved by the time of removal of effort from the side control stick of the aircraft in the process of manual piloting the aircraft.

FBWCS has three modes: NORMAL MODE, Simplified mode[16] and DIRECT MODE. The transition from one mode to another happens automatically and smoothly.

Normal mode

It is implemented subject to the availability of all necessary data from the interacting systems of the aircraft and the correct operation of at least one PFCU calculator. The FBWCS system has three dual-channel calculators PFCU, which independently form the signals of the NORMAL MODE mode. These signals are sent to the ACE blocks, where one control signal is generated from three signals, which is fed to the appropriate drive. Control of the aircraft is carried out in manual and automatic mode. On the ground, in the NORMAL MODE mode, the auto-balance between roll and pitch is disabled, the stabilizer is controlled manually.

Direct mode

FBWCS transits to DIRECT MODE upon losing all ADC or IRS signal or three PFCU fault.

In DIRECT MODE RSU signals are used to ensure the specified damping characteristics of the aircraft. It provides the acceptable level of the aircraft stability and controllability sufficient to complete the flight safely.

[16] Is not considered in this Report.

FBWCS restrictive functions and the stabilization functions of the current roll and pitch do not work. Trimming is done manually. Control of the aircraft is carried out manually only. At the same time, the electrical signals proportional to the angles of deviation of the sidestick and pedals, via ACE blocks, enter the corresponding actuators of the steering surfaces, bypassing the PFCU calculators.

2 rate sensor units (RSU) give data to ACE to provide the specified damping characteristics of the aircraft in DIRECT MODE.

When the system transits to the DIRECT MODE, it is not possible to perform the transit back to the NORMAL MODE in flight.

1.18.6. QRH «F/CTL DIRECT MODE»

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F/CTL DIRECT MODE

Сопровождается речевым сообщением «DIRECT MODE» и автоматическим перемещением механизации крыла в положение FLAP ICE.

- МАКСИМАЛЬНАЯ СКОРОСТЬ.....280 KT / 0.8 M
  Скорость ограничена из за неработоспособности функции ограничения максимальной скорости в текущей конфигурации.
- A/T .....НЕ ИСПОЛЬЗОВАТЬ
- ПИЛОТИРОВАТЬ.....ПЛАВНО
  Функция ограничения по углу атаки неработоспособна.
- БАЛАНСИРОВАТЬ.....ВРУЧНУЮ
  Функция автоматического триммирования неработоспособна.
- SPEED BRAKE.....НЕ БОЛЕЕ 1/2
  Интерцепторы выпускайте и убирайте поэтапно для исключения чрезмерных изменений угла тангажа, с балансировкой в каждом положении.
- РАСХОД ТОПЛИВА.....УТОЧНИТЬ
  Уточните план полета, учитывая увеличение расхода топлива на 6% при полете на скорости более 0.72M в конфигурации FLAP ICE.

	СТАТУС
– МАКСИМАЛЬНАЯ СКОРОСТЬ.....280 KT / 0.8 M	ОТКАЗАВШИЕ СИСТЕМЫ
– A/T.....НЕ ИСПОЛЬЗОВАТЬ	NORMAL MODE
– ПИЛОТИРОВАТЬ.....ПЛАВНО	AP
– РАСХОД ТОПЛИВА.....УТОЧНИТЬ	FD
– SPEED BRAKE.....НЕ БОЛЕЕ 1/2	
ЗАХОД НА ПОСАДКУ И ПОСАДКА:	
– ЗАХОД НА ПОСАДКУ.....ПСП	
– ДЛЯ ПОСАДКИ ИСПОЛЬЗУЙТЕ FLAPS3	
– TAWS LDG FLAP3.....ON	
– СКОРОСТЬ V_{APP}.....VREF+10 KT	
– ПОСАДОЧНАЯ ДИСТАНЦИЯ.....УВЕЛИЧИТЬ В 1.34	
● **После приземления:**	
– SPEED BRAKE.....УСТАНОВИТЬ FULL	
УХОД НА ВТОРОЙ КРУГ:	
– РУД.....NTO	
Нажмите кнопку TO/GA и вручную установите РУД в положение NTO	

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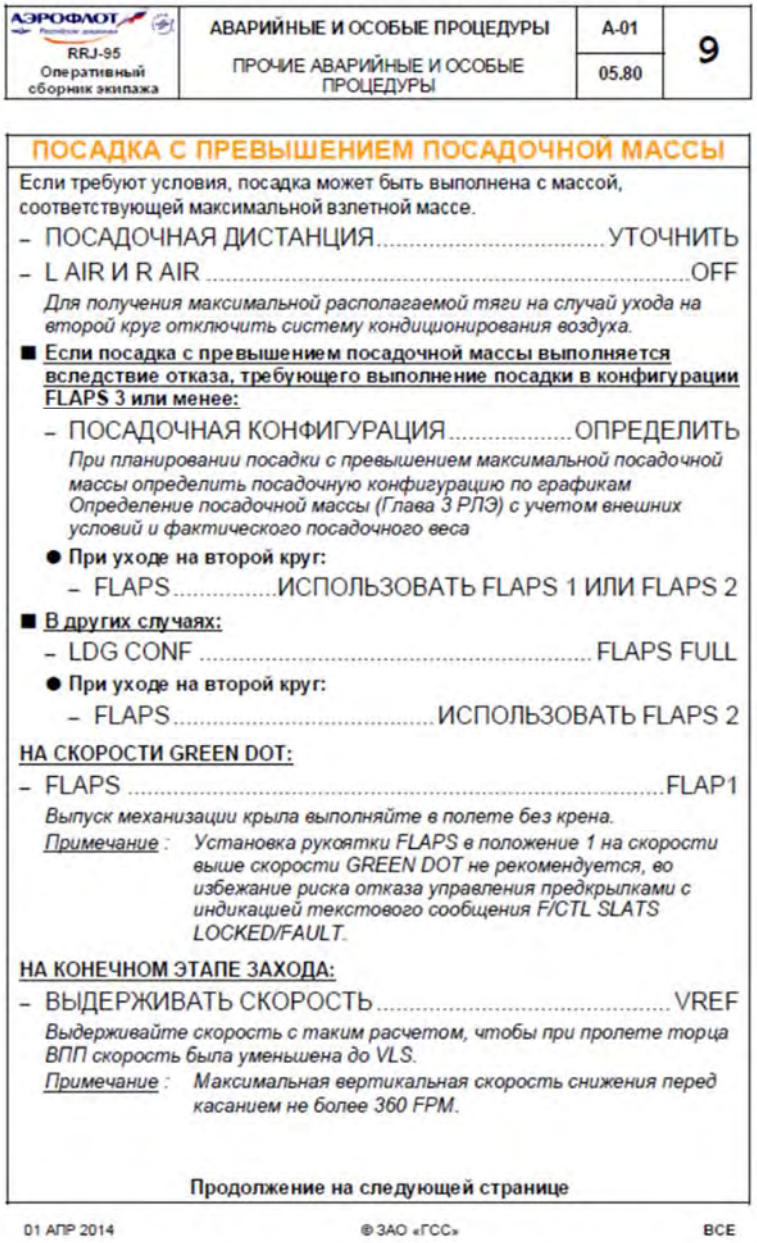
1.18.7. QRH «LANDING WITH EXCESS LANDING WEIGHT»



АЭРОФЛОТ
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ПОСАДКА С ПРЕВЫШЕНИЕМ ПОСАДОЧНОЙ МАССЫ

Если требуют условия, посадка может быть выполнена с массой, соответствующей максимальной взлетной массе.

- ПОСАДОЧНАЯ ДИСТАНЦИЯ ..... УТОЧНИТЬ
- L AIR И R AIR ..... OFF

Для получения максимальной располагаемой тяги на случай ухода на второй круг отключить систему кондиционирования воздуха.

■ **Если посадка с превышением посадочной массы выполняется вследствие отказа, требующего выполнение посадки в конфигурации FLAPS 3 или менее:**

- ПОСАДОЧНАЯ КОНФИГУРАЦИЯ ..... ОПРЕДЕЛИТЬ

При планировании посадки с превышением максимальной посадочной массы определить посадочную конфигурацию по графикам Определение посадочной массы (Глава 3 РЛЭ) с учетом внешних условий и фактического посадочного веса

● **При уходе на второй круг:**

- FLAPS ..... ИСПОЛЬЗОВАТЬ FLAPS 1 ИЛИ FLAPS 2

■ **В других случаях:**

- LDG CONF ..... FLAPS FULL

● **При уходе на второй круг:**

- FLAPS ..... ИСПОЛЬЗОВАТЬ FLAPS 2

НА СКОРОСТИ GREEN DOT:

- FLAPS FLAP1

Выпуск механизации крыла выполняйте в полете без крена.

Примечание : Установка рукоятки FLAPS в положение 1 на скорости выше скорости GREEN DOT не рекомендуется, во избежание риска отказа управления предкрылками с индикацией текстового сообщения F/CTL SLATS LOCKED/FAULT.

НА КОНЕЧНОМ ЭТАПЕ ЗАХОДА:

- ВЫДЕРЖИВАТЬ СКОРОСТЬ ..... VREF

Выдерживайте скорость с таким расчетом, чтобы при пролете торца ВПП скорость была уменьшена до VLS.

Примечание : Максимальная вертикальная скорость снижения перед касанием не более 360 FPM.

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ПРОЧИЕ АВАРИЙНЫЕ И ОСОБЫЕ ПРОЦЕДУРЫ
АЭРОФЛОТ RRJ-95 Оперативный сборник экипажа

Продолжение

ПОСЛЕ ПРИЗЕМЛЕНИЯ НА ОСНОВНЫЕ ОПОРЫ:

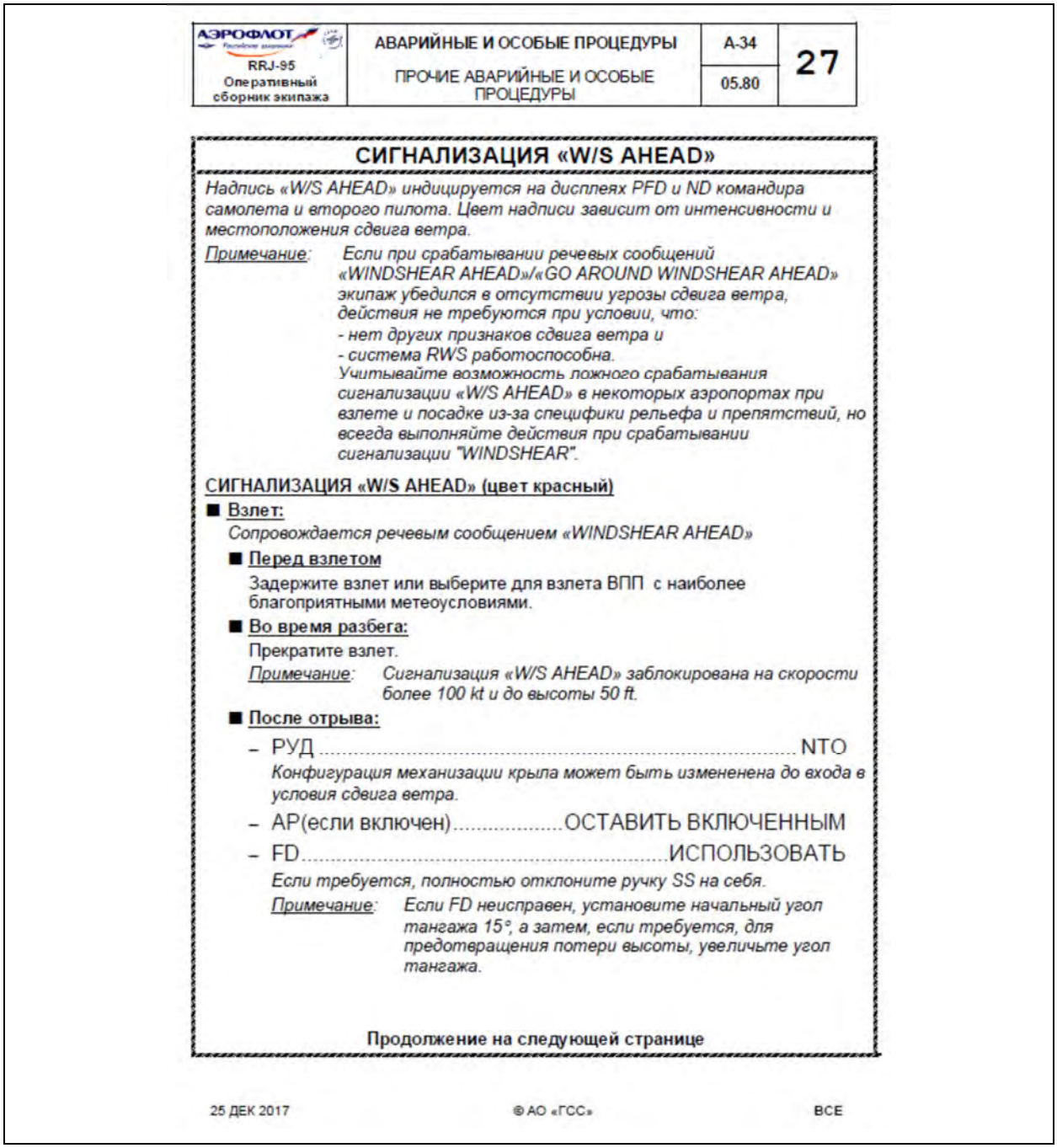
- РЕВЕРС ТЯГИ ..... MAX
- SPEED BRAKE ..... ПРОВЕРИТЬ/FULL

ПОСЛЕ ОПУСКАНИЯ КОЛЕС ПЕРЕДНЕЙ ОПОРЫ:

- ТОРМОЗА ..... ПРИМЕНИТЬ

Максимальное торможение рекомендуется применить после опускания колес передней опоры и в соответствии с длиной ВПП выбрать интенсивность торможения.

1.18.8. QRH «W/S AHEAD»



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СИГНАЛИЗАЦИЯ «W/S AHEAD»

Надпись «W/S AHEAD» индицируется на дисплеях PFD и ND командира самолета и второго пилота. Цвет надписи зависит от интенсивности и местоположения сдвига ветра.

Примечание: Если при срабатывании речевых сообщений «WINDSHEAR AHEAD»/«GO AROUND WINDSHEAR AHEAD» экипаж убедился в отсутствии угрозы сдвига ветра, действия не требуются при условии, что:
- нет других признаков сдвига ветра и
- система RWS работоспособна.
Учитывайте возможность ложного срабатывания сигнализации «W/S AHEAD» в некоторых аэропортах при взлете и посадке из-за специфики рельефа и препятствий, но всегда выполняйте действия при срабатывании сигнализации "WINDSHEAR".

СИГНАЛИЗАЦИЯ «W/S AHEAD» (цвет красный)

■ **Взлет:**

Сопровождается речевым сообщением «WINDSHEAR AHEAD»

■ **Перед взлетом**

Задержите взлет или выберите для взлета ВПП с наиболее благоприятными метеоусловиями.

■ **Во время разбега:**

Прекратите взлет.

Примечание: Сигнализация «W/S AHEAD» заблокирована на скорости более 100 kt и до высоты 50 ft.

■ **После отрыва:**

– РУД ..... NTO

Конфигурация механизации крыла может быть измененена до входа в условия сдвига ветра.

– AP(если включен) ..... ОСТАВИТЬ ВКЛЮЧЕННЫМ

– FD ..... ИСПОЛЬЗОВАТЬ

Если требуется, полностью отклоните ручку SS на себя.

Примечание: Если FD неисправен, установите начальный угол тангажа 15°, а затем, если требуется, для предотвращения потери высоты, увеличьте угол тангажа.

Продолжение на следующей странице

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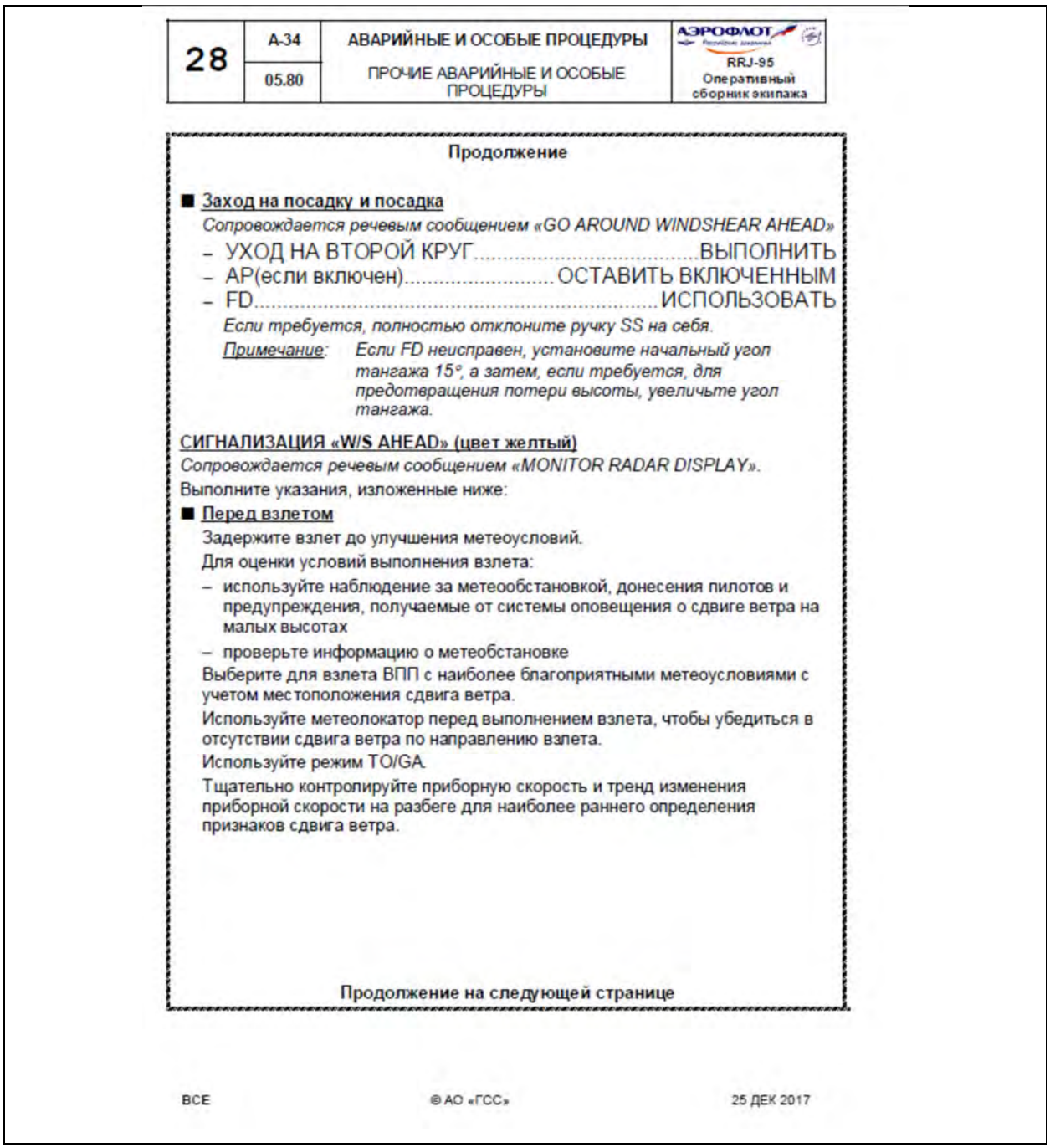

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Продолжение

■ **Заход на посадку и посадка**

Сопровождается речевым сообщением «GO AROUND WINDSHEAR AHEAD»

- УХОД НА ВТОРОЙ КРУГ.....ВЫПОЛНИТЬ
- АР(если включен).....ОСТАВИТЬ ВКЛЮЧЕННЫМ
- FD.....ИСПОЛЬЗОВАТЬ

Если требуется, полностью отклоните ручку SS на себя.

Примечание: Если FD неисправен, установите начальный угол тангажа 15°, а затем, если требуется, для предотвращения потери высоты, увеличьте угол тангажа.

СИГНАЛИЗАЦИЯ «W/S AHEAD» (цвет желтый)

Сопровождается речевым сообщением «MONITOR RADAR DISPLAY».

Выполните указания, изложенные ниже:

■ **Перед взлетом**

Задержите взлет до улучшения метеоусловий.

Для оценки условий выполнения взлета:

- используйте наблюдение за метеообстановкой, донесения пилотов и предупреждения, получаемые от системы оповещения о сдвиге ветра на малых высотах
- проверьте информацию о метеобстановке

Выберите для взлета ВПП с наиболее благоприятными метеоусловиями с учетом местоположения сдвига ветра.

Используйте метеолокатор перед выполнением взлета, чтобы убедиться в отсутствии сдвига ветра по направлению взлета.

Используйте режим TO/GA.

Тщательно контролируйте приборную скорость и тренд изменения приборной скорости на разбеге для наиболее раннего определения признаков сдвига ветра.

Продолжение на следующей странице

1.18.9. Stabilized approach criteria according to the Flight Operations Manual of the operator

(b) в полете аэродром назначения выбран в качестве запасного, при этом:
- аэродром имеет независимые рабочие ВПП;
- последняя фактическая и прогнозируемая метеорологическая информация свидетельствует о том, что в течение времени использования аэродрома нижняя граница облаков (вертикальная видимость) и видимость на ВПП, выбранной в качестве запасной, будут соответствовать требованиям подпункта (a) пункта 8.1.3.2(2), а направление и скорость ветра (включая порывы) с учетом состояния ВПП соответствует установленным эксплуатационным ограничениям.

(13) Заход на посадку считается стабилизированным (*См. Таблицу 8.3-1-2*), если:
- до высоты 1000 ft над уровнем аэродрома создана необходимая посадочная конфигурация ВС; или
- при выполнении захода на посадку с применением визуального маневрирования – маневра «Circle-to-Land» посадочная конфигурация ВС создана до высоты не ниже 500 ft над уровнем аэродрома;
- угол наклона траектории и вертикальная скорость снижения соответствуют схеме захода на посадку, а вертикальная скорость снижения не превышает 1000 ft/min. Если конечный этап захода на посадку требует выдерживать вертикальную скорость снижения более 1000 ft/min, это необходимо оговаривать при проведении предпосадочной подготовки;
- режим работы двигателей соответствует посадочной конфигурации ВС, а приборная скорость не превышает значения Vapp + 20 knots и не менее Vapp - 5 knots при достижении высоты 500 ft над уровнем аэродрома;
- отклонения ВС от расчетной траектории снижения в пределах допустимых значений для выбранной системы захода на посадку, установленных по типам ВС в части В РПП;
- для выдерживания траектории снижения требуются небольшие корректирующие движения органов управления ВС;
- до высоты 500 ft над уровнем аэродрома экипаж полностью проинструктирован и выполнены в полном объеме карты контрольных проверок.

Таблица 8.3-1-2

Условия стабилизированного захода на посадку

Приборные метеорологические условия - IMC	Визуальные метеорологические условия – VMC (*)	Визуальное маневрирование – «Circle-to-Land»
1000 ft AAL	1000 ft AAL	MDH, но не ниже 500 ft
Посадочная конфигурация	Посадочная конфигурация	Посадочная конфигурация
Vy ≤ 1000 ft/min	Vy ≤ 1000 ft/min	Vy ≤ 1000 ft/min
Δ траектории снижения-норма	500 ft AAL	500 ft AAL
Небольшие корректирующие движения органов управления	Δ траектории снижения-норма	Δ траектории снижения-норма
500 ft AAL	Небольшие корректирующие движения органов управления	Небольшие корректирующие движения органов управления
Режим работы двигателей соответствует посадочной конфигурации	Режим работы двигателей соответствует посадочной конфигурации	Режим работы двигателей соответствует посадочной конфигурации
Vapp ≤ Vapp + 20 knots	Vapp ≤ Vapp + 20 knots	Vapp ≤ Vapp + 20 knots
Vapp ≥ Vapp - 5 knots	Vapp ≥ Vapp - 5 knots	Vapp ≥ Vapp - 5 knots
Брифинг + КК	Брифинг + КК	Брифинг + КК

1.18.10. Stabilized approach criteria according to the FCOM

АЭРОФЛОТ Российские авиалинии RRJ-95 Руководство по летной эксплуатации	СТАНДАРТНЫЕ ЭКСПЛУАТАЦИОННЫЕ ПРОЦЕДУРЫ	1.04.72 СТР. 5	
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– **ПАРАМЕТРЫ ПОЛЕТА ..... КОНТР/ОБЪЯВИТЬ**

- *ПП объявляет любые изменения FMA*
- *НП объявляет:*
  - *«SPEED», если скорость полета меньше чем заданная на (-5 kt), или больше чем заданная на (+10 kt)*
  - *«PITCH», если угол тангажа меньше чем (-2,5°), или больше чем (+10°)*
  - *«BANK», если угол крена становится больше чем 7°*
  - *«SINK RATE», если вертикальная скорость снижения больше чем 1 000 ft/min*
  - *«LOCALIZER», если отклонение более 1/2 точки*
  - *«GLIDE SLOPE», если отклонение более 1/2 точки*

Выполните уход на второй круг:

■ **На высоте менее1000 ft и до высоты 100 ft**

При срабатывании любой сигнализации уровня Warning и Caution (кроме сигнализации об отказе двигателя) , TRIPLE CLICK

■ **На высоте менее 100 ft:**

Только при срабатывании сигнализации APPROACH LOST, AUTO FLT AP OFF, AP OFF

НА ВЫСОТЕ ПРИНЯТИЯ РЕШЕНИЯ+100 FT:

– **«APPROACHING DECISION HEIGHT» ..... ОБЪЯВИТЬ ИЛИ КОНТР**

НА ВЫСОТЕ НЕ НИЖЕ ВЫСОТЫ ПРИНЯТИЯ РЕШЕНИЯ:

– **«DECISION HEIGHT» ..... ОБЪЯВИТЬ ИЛИ КОНТР**

– **ОБЪЯВИТЬ ..... «CONTINUE» ИЛИ «GO AROUND, FLAPS»**

Не допускайте «подныривание» под глиссаду, сохраняйте стабилизированный угол снижения до выравнивания.

1.18.11. Emergency evacuation procedure according to operator's FOM

АЭРОФЛОТ	РУКОВОДСТВО ПО ПРОИЗВОДСТВУ ПОЛЕТОВ ЭКСПЛУАТАНТА. ЧАСТЬ В **Глава 4. Аварийные процедуры**	**РД-ГД-002** Изд. 2 | Рев. 04

4.6. ПРОЦЕДУРЫ АВАРИЙНОЙ ЭВАКУАЦИИ

Общие принципы процедуры «АВАРИЙНАЯ ЭВАКУАЦИЯ» изложены в 11 главе

EMERGENCY EVACUATION CHECKLIST
AIRCRAFT (CM1) ..... **STOP**
PARK / ALTN BRAKE (CM1).....**ON**
ATC (CM2)..... **NOTIFY**
"MAYDAY, MAYDAY, MAYDAY, AFL ___, EMERGENCY EVACUATION, EMERGENCY EVACUATION RWY ___"
CABIN CREW (CM1)..... **ALERT**
Если не был проинформирован: *«ATTENTION CREW! ON STATION, ATTENTION CREW! ON STATION.»*
ENG MASTERS (L+R) (CM2 W/O CONFIRM) ..... **OFF**
ENG FIRE (L+R) и APU FIRE (CM2 W/O CONFIRM)..... **PUSH**
ENG FIRE AGENTS (1L+2R) и APU (CM2 W/O CONFIRM) .....**AS RQRD**
Использование кнопок-табло AGENT требуется в случае, когда индицируется сообщение ENG L (R) FIRE или APU FIRE
Если MODE в положении MAN:
MAN RATE (CM2 W/O CONFIRM)..... **FULL INCR POSITION**
Перед открытием дверей убедитесь в том, что значение ΔP = 0
Если требуется эвакуация:
EVACUATION (CM1) ..... **INITIATE**
«PASSANGER EVACUATION. PASSANGER EVACUATION»
BAT 1, 3, 2, 4 (CM2 W/O CONFIRM) ..... **OFF**
Если эвакуация не требуется:
CABIN CREW (CM1).....**NOTIFY**
«CANCEL ALERT, CANCEL ALERT»
ATC (CM2)..... **NOTIFY**
«AFL ___, CANCEL DISTRESS, CANCEL DISTRESS»

1.18.12. Flight attendant guide, the peculiarities of the evacuation on the ground

АЭРОФЛОТ Российские авиалинии	РУКОВОДСТВО ДЛЯ БОРТПРОВОДНИКОВ Специальная часть ВС RRJ-95	РД-ГД-027 Часть 2 Изд. 02 Рев. 02

7.3. Проведение эвакуации

Особенности эвакуации на сушу

1. После остановки ВС и команды КВС **PASSENGER EVACUATION!** членам кабинного экипажа подать пассажирам ***первый блок команд*** (допустимо использовать мегафон):

ПЕРВЫЙ БЛОК КОМАНД	
РАССТЕГНУТЬ РЕМНИ!	SEAT BELTS OFF!
ОСТАВИТЬ ВСЕ!	LEAVE EVERYTHING!
НА ВЫХОД!	GET OUT!

Подойти к аварийному выходу, оценить ситуацию снаружи ВС, проверить положение двери (ARMED), принять решение об использовании выхода.

- Если выход использовать можно и аварийный трап наполнился, подать ***второй блок команд***:

ВТОРОЙ БЛОК КОМАНД	
КО МНЕ! ПРЫГАЙТЕ!	COME THIS WAY! JUMP!
СЪЕЗЖАЙТЕ! УБЕГАЙТЕ!	SLIDE! RUN AWAY!

- Если выход использовать нельзя – необходимо направить пассажиров к используемым выходам:
  - повернуться лицом к пассажирам;
  - заблокировать выход и подать команды:

ВЫХОДА НЕТ!	EXIT BLOCKED!
БЕГИТЕ К ДРУГОЙ ДВЕРИ!	USE OTHER EXIT!

  - держать пассажиров на расстоянии вытянутой руки, чтобы не ограничивать свою свободу движения.

2. Начать эвакуацию через противоположный аварийный выход, если:
   - член кабинного экипажа отвечает за две двери;
   - член кабинного экипажа, отвечающий за противоположный выход, не в состоянии это сделать.
3. После эвакуации пассажиров проверить пассажирскую кабину и убедиться, что на борту ВС никого не осталось (СБ и бортпроводник 1R проверяют кабину летного экипажа).
4. Взять необходимое для организации выживания аварийно-спасательное оборудование (мегафон, фонарь, аптечку, радиобуй).
5. Эвакуироваться, собрать пассажиров на безопасном расстоянии от ВС, оказать первую помощь раненым.

1.18.13. Weak links of the airframe design[17]

Ensuring compliance with the Aviation Rules 25.721 (a), (2), (c), (c) refers to constructive measures aimed at fuel leakage prevention in an amount sufficient to cause fire hazard in the event of the main landing gear destruction in the situation when the design load over the main landing gear was exceeded.

There are safety pins in the RRJ-95 landing gear design which are the elements of a certain level of strength, and they are the first to be destroyed upon the impact of a single design load, determined basing on the load application conditions given in aviation regulations, it is proved by calculations and tests. Destruction of the safety pins causes the gear to move up and backwards and does not cause the damage to the wing box.

The RRJ-95 safety analysis concerning the fuel leakage from the wing box upon the main landing gear destruction was carried out during design studies by modeling of the process of gear destruction when the calculated loads on the landing gear are exceeded. The conditions of application of the load listed in the certification requirements were considered. The certification report was issued.

Basing on the calculations the strength and design requirements for safety pins in the gear hinge fitting were determined.

In production the safety pins are particularly important parts, the blanks are under special control, and the parts themselves undergo periodic testing.

During operation, the confirmation of the compliance of the serial design to the design parameters was established as a result of an investigation of a serious incident - a very rough landing of the aircraft MSN 95032 with a vertical acceleration of about 4g, as a result of which the safety pins of the right main landing gear were destroyed. The corresponding report has been issued on this incident.

In the course of the accident with RA-89098 there were three consequent touchdowns to the RWY with accelerations not less than 2.55g, 5.85g, 5.0g.

The airframe endurance design vertical acceleration is 3.75 g.

The acceleration of 2.55 g did not exceed the value, calculated for the cut off of the safety pins of the main landing gear hinge brackets on the rear spar, so at the acceleration of 5.85 g the cut off of the safety pins of the right and the left main landing gear to the rear spar of the wing

[17] This section is given in compliance with the materials provided by the aircraft designer. The commission continues to analyze the issue.

occurred. During the repeated aircraft lift of the landing gear were in the loose position towards the rear spar. The wing box was not destroyed, according to the records and the fuel gauge data, there were no fuel leakages, there were no structure fragments found on the RWY. At the third runway touchdown, with the allowable vertical loads exceeded, the structure condition did not allow the gear to absorb the loads of the landing hit and they broke down, wing structure was destroyed in the areas of the hinges of the hydraulic cylinders. The aircraft went low and moved on the nacelles and the rear part of the fuselage.

The situation described above is not provided for in the current airworthiness standards. In accordance with the certification rules, the evaluation of secondary impacts of the airframe on the ground after the destruction of the landing gear is not required.

1.18.14. Lightning resistance and classification of special situations

AP-25, п. 25.581. Lightning protection

(a) The aircraft must be protected against emergency or catastrophic effects from lightning strike and static electricity impact.

AP-25, Definitions

9. Abnormal situation (effect). A situation arising in flight as a result of the effect of adverse circumstance or their combinations and resulting in reduction of the flight safety. Abnormal situations (effects) severity may be assessed according to the following criteria:

(a) Degradation of airplane performance, stability and controllability, structural integrity and systems functioning.

Note. A flight is considered from the airplane initial motion over runway at take-off up to the moment when airplane leaves the runway, or stops.

(b) Increase of flight crew workload (psycho-physiological load) above a normally allowed level.

(c) Discomfort, injuries to, or death of the occupants.

9.1. Abnormal situations (effects) as to their severity should be classified as following:

(a) Catastrophic situation (catastrophic effect). An abnormal situation for which it is excepted that fatality prevention is practically impossible in case of its occurrence.

(b) Hazardous situation (hazardous effect). An abnormal situation characterized by:

(i) A large degradation of airplane performance and/or reaching/exceeding ultimate limitations; or

(ii) Physical distress or excessive workload such that flight crew cannot be relied upon to perform their tasks accurately or completely.

(c) Major situation (major effect). An abnormal situation characterized by:

(i) A significant degradation of airplane performance and/or exceeding operating limitations for one or more parameters, but not exceeding ultimate limitations.

(ii) Reduction of the flight crew ability to cope with adverse operating conditions (the situation occurred) due to both workload increase and circumstances which impair flight crew efficiency.

(d) Complication of flight conditions (minor effect). An abnormal situation characterized by:

(i) A slight degradation of airplane performance; or

(ii) A slight increase in flight crew workload, such as routine flight plan changes.

1.18.15. FAR-121 Periodical Extended Envelope Crew Training

FAR-121.423 – Pilot: Extended Envelope Training

(a) Each certificate holder must include in its approved training program, the extended envelope training set forth in this section with respect to each airplane type for each pilot. The extended envelope training required by this section must be performed in a Level C or higher full flight simulator, approved by the Administrator in accordance with § 121.407 of this part.

(b) Extended envelope training must include the following maneuvers and procedures:

(1) Manually controlled slow flight;

(2) Manually controlled loss of reliable airspeed;

(3) Manually controlled instrument departure and arrival;

(4) Upset recovery maneuvers; and

(5) Recovery from bounced landing.

(c) Extended envelope training must include instructor-guided hands on experience of recovery from full stall and stick pusher activation, if equipped.

(d) Recurrent training: Within 24 calendar months preceding service as a pilot, each person must satisfactorily complete the extended envelope training described in paragraphs (b)(1) through (4) and (c) of this section. Within 36 calendar months preceding service as a pilot, each person must satisfactorily complete the extended envelope training described in paragraph (b)(5) of this section.