REPUBLIC OF SERBIA
CENTER FOR INVESTIGATION
OF ACCIDENTS IN TRANSPORT

FINAL REPORT ON ACCIDENT INVESTIGATION

Aircraft:	Embraer E190-200LR
Registration:	OY-GDC
Year of manufacture:	2008
Serial No.:	MSN 190000204
Owner:	Marathon Airlines S.A., Republic of Greece
User:	Air Serbia
Accident location:	“Nikola Tesla” Airport, Belgrade
Accident date:	February 18th, 2024
Accident time:	17.39 (LT)
Flight phase:	Take-off

August, 2025

This Report presents the results of the investigation on accident involving Embraer E190-200LR (EMB-195 LR), registration OY-GDC, which occurred on February 18th, 2024, at "Nikola Tesla" Airport, City of Belgrade.

The Working Group for investigation of this accident was formed by the Main investigator of the Center for Investigation of Accidents in Transport (hereinafter referred to as: the Center) by Decision No. 343-00-01/2024-01-01-9 dated February 20th, 2024, and by the amended Decision No. 343-00-01/2024-01-01-72 dated April 9th, 2025.

Investigation of this accident was performed in accordance with the provisions of the Law on Investigation of Accidents in Air, Railway and Waterborne Traffic ("Official Gazette of Republic of Serbia", No. 66/2015 and 83/2018) and the Rulebook on Investigation of Accidents and Serious Incidents in Air Traffic ("Official Gazette of Republic of Serbia", No. 113/2015 and 50/2019).

Investigation and detection of the accidents and serious incidents causes is not aimed at determining criminal, economic, misdemeanor, disciplinary, civil or any other liability. The professional activities related to accident investigations are independent of criminal investigations or other parallel investigations that establish responsibility or determine the degree of guilt. All accidents and serious incidents in air traffic must be investigated and analyzed in order to determine the facts under which they occurred, if possible to discover their causes and then take measures to prevent occurrence of the new accidents and serious incidents.

All times in this Report are shown as LT (Local Time).

Contents

ABBREVIATIONS

- **ICAO** – *International Civil Aviation Organization*
- **ARC** – *Airworthiness Review Certificate*
- **COA** – *Certificate of Airworthiness*
- **AOC** – *Air Operator Certificate*
- **ILS** – *Instrument Landing System*
- **LOC** – *Localizer*
- **RWY** – *Runway*
- **TORA** – *Take-Off Run Available*
- **TODA** – *Take-Off Distance Available*
- **TOGA** – *Takeoff/Go Around*
- **MTOW** – *Maximum Take-Off Weight*
- **ATOW -** *Actual TOW*
- **ATTCS** – *Automatic Takeoff Thrust Control System*
- **PIC** – *Pilot in Command*
- **FLEX** – *Flexible Take-Off / Temperature*
- **NOTAM** – *Notice to Air Missions*
- **ATTCS** – *Automatic Takeoff Thrust Control System*

1. FACTUAL INFORMATION

1.1. Flight history

On February 18th, 2024 at 17:39 local time, an accident occurred at Nikola Tesla Airport involving an Embraer E190-200LR aircraft, registration OY-GDC. The flight was being operated by Marathon Airlines on behalf of Air Serbia, under flight number JU324 from Belgrade to Düsseldorf, Federal Republic of Germany (IATA: BEG–DUS, ICAO: LYBE–EDDL).
The aircraft sustained damage which, in accordance with applicable aviation regulations, is classified as an accident. There were no injuries or fatalities reported. Onboard the aircraft were two flight crew members, three cabin crew members, and 106 passengers.

1.2. Injuries

Injuries	Crew	Other persons
Fatal	/	/
Serious	/	/
Minor	/	/

1.3. Damages to the airplane

The aircraft sustained physical damage to the left side of the fuselage, the wing-to-fuselage fairing on the left side, the leading edge of the left wing, the left air conditioning system, the left horizontal stabilizer, and the lower fuselage.

Figure 1. Zone 1 – Left side of the aircraft fuselage – initial contact between the fuselage and the airfield lighting in the area between fuselage frames 26 and 27 and along stringer 25L

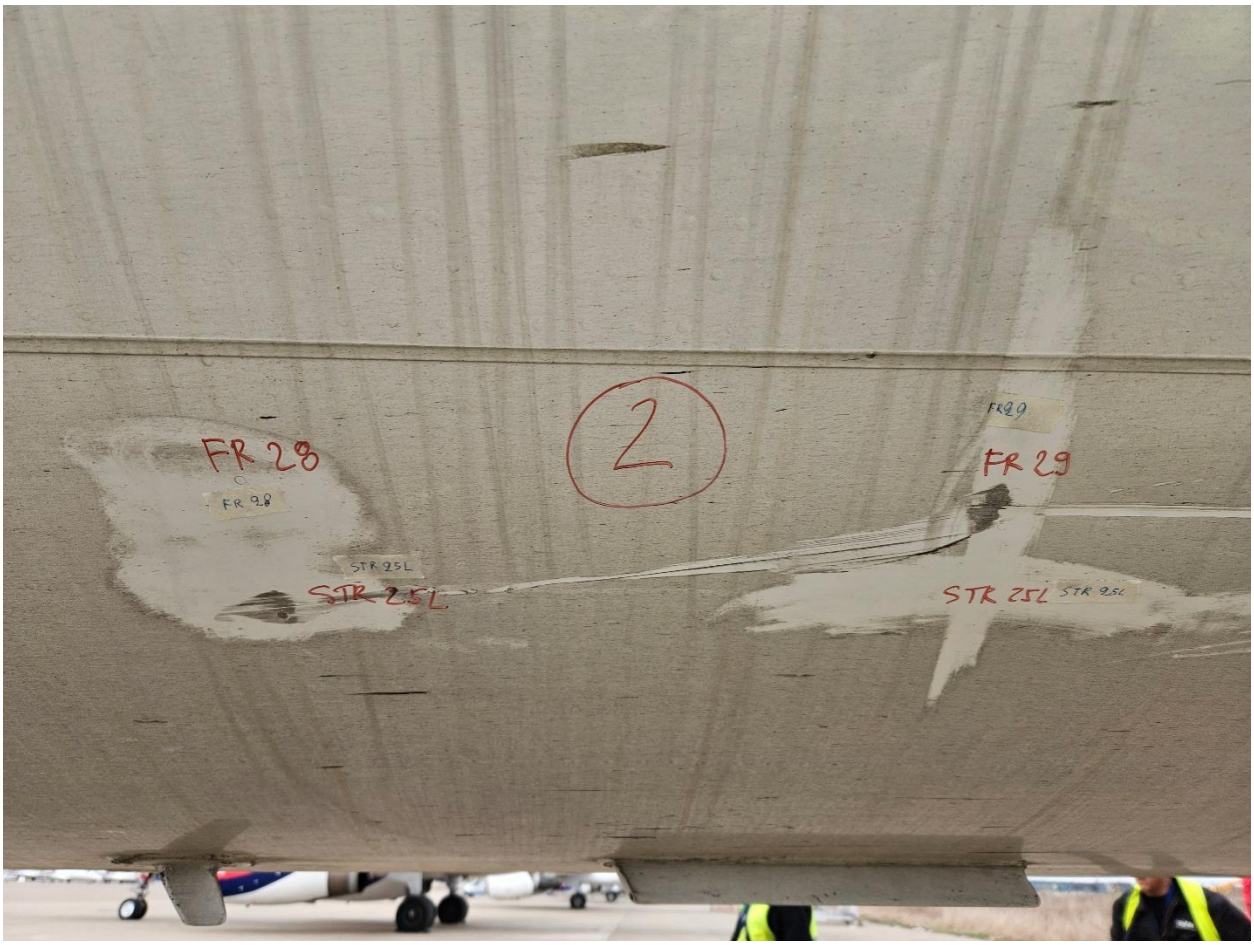


Figure 2. Zone 2 – Left side of the aircraft fuselage – second contact between the fuselage and the airfield lighting in the area between fuselage frames 28 and 29 and along stringer 25L

Figure 3. Zone 3 – Left side of the aircraft fuselage – continued contact between the fuselage and airfield equipment in the area between fuselage frames 28 and 31 and along stringer 22L

Figure 4. Zone 4 – Left side of the aircraft fuselage – continued contact between the fuselage and airfield equipment in the area between fuselage frames 32 and 40 and between stringers 17L and 22L

Figure 5. Damage to the composite panel in the lower wing-to-fuselage fairing area

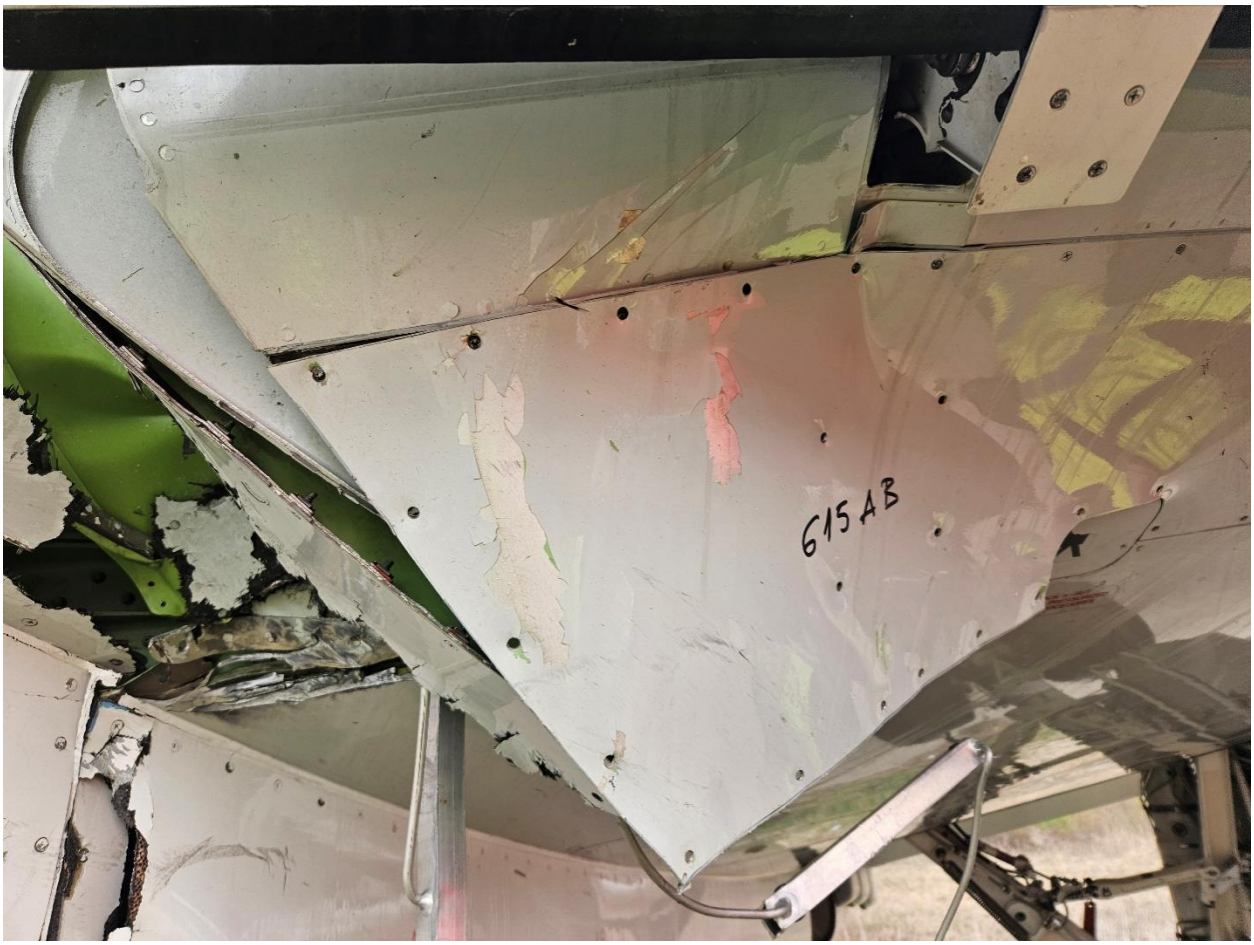


Figure 6. Damage to the lower skin of the left wing

Figure 7. Impact area of the airport antenna mast at the root of the left wing

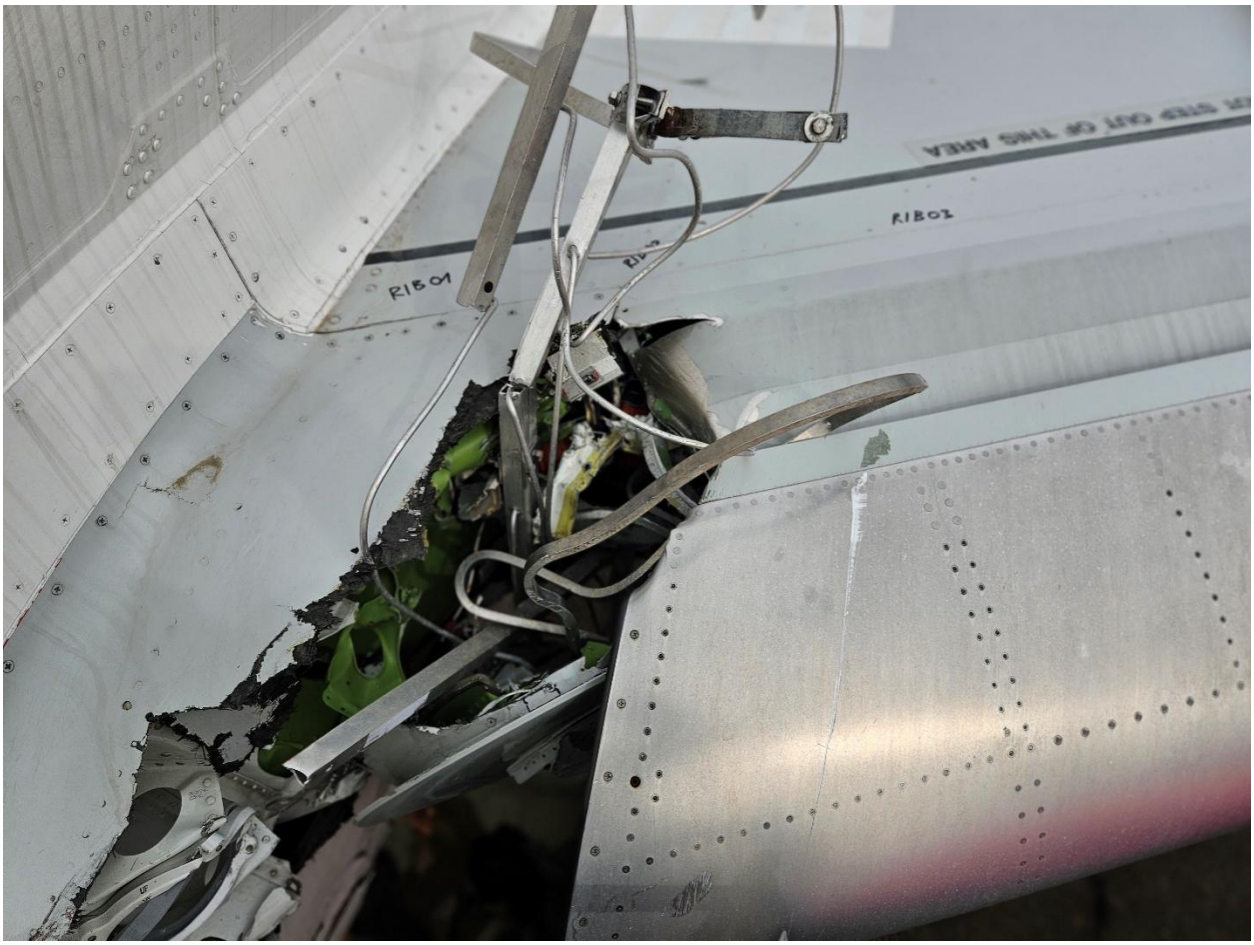


Figure 8. Parts of the airport antenna lodged in the wing root between ribs 1 and 3 of the left wing

Figure 9. Damage to the connection between the lower wing skin and the front spar of the left wing between ribs 1 and 2. The marked area indicates the damage through which fuel leakage from the left-wing tank occurred.

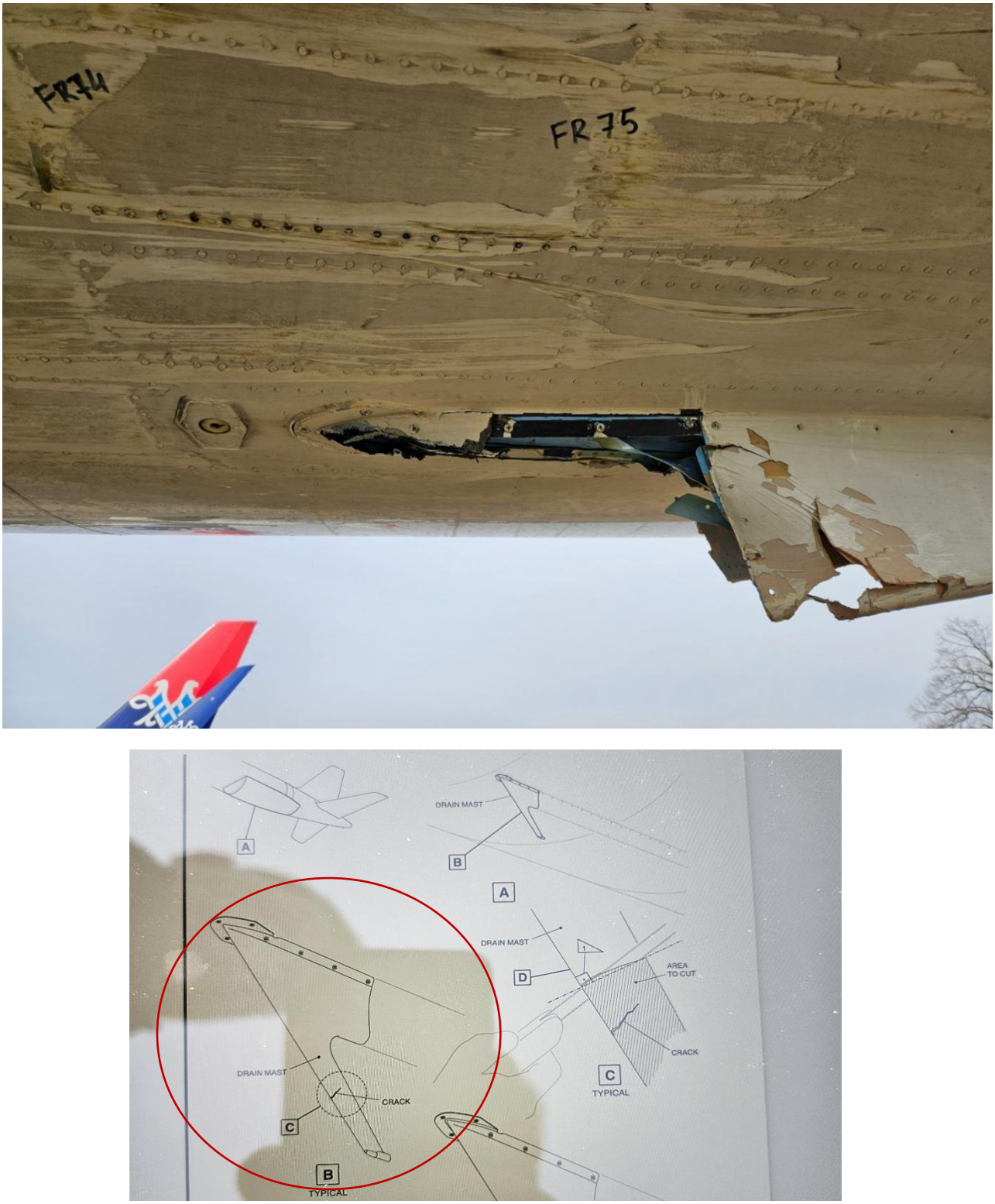


Figure 10. Damage to the lower fuselage skin in the area from fuselage frame 74 to frame 75 and a broken drain mast

Figure 11. Damage to the lower fuselage skin in the area from fuselage frame 75 to frame 76 between stringers 27L and 29R

Figure 12. Damage to the left air conditioning system

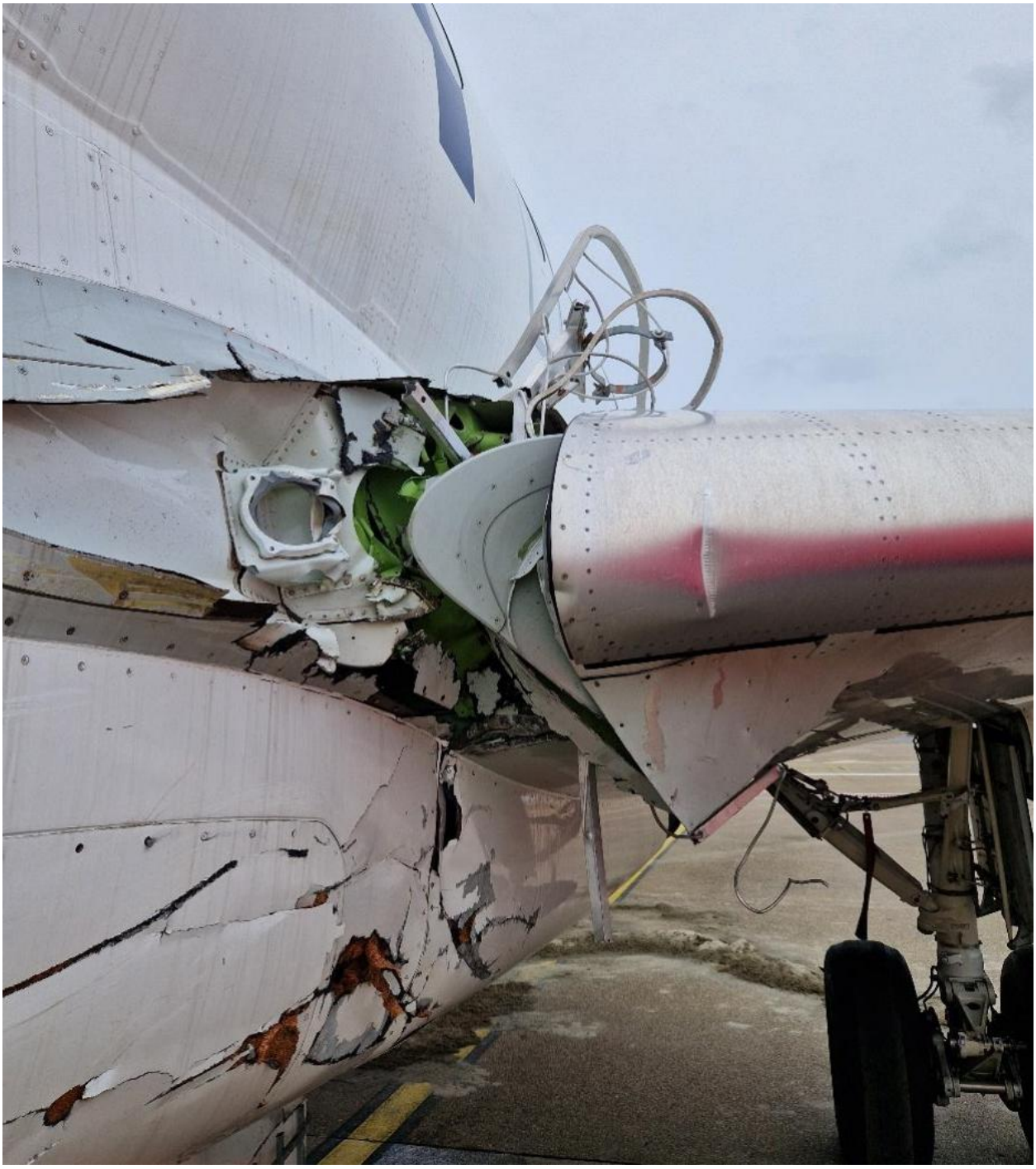


Figure 13. Damage to the leading edge of the left wing as well as the wing-to-fuselage joint on the left side

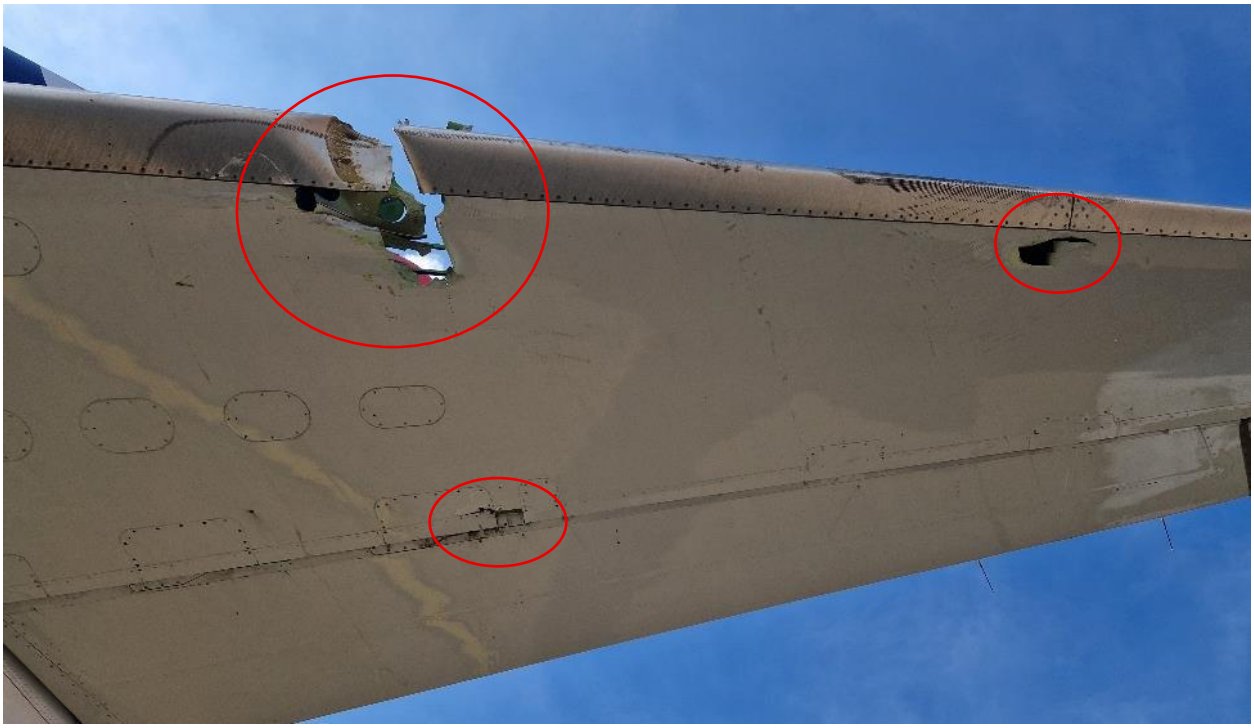


Figure 14. Damage to the leading edge between ribs 8 and 9 and to the lower skin of the left horizontal stabilizer

Figure 15. Left main landing gear wheels showing damage marks

1.4. Damage done to the third parties

Inspection of the aerodrome surfaces along the take-off direction from RWY 30L revealed damage to the approach lights for RWY 12R – specifically the outermost right lights in all three rows (i.e., the outermost left lights relative to the take-off direction of the aircraft involved), including broken control boxes located in the middle of the lights, where tire marks were observed.

Flashing lights situated in the grassy area outside the runway strip were broken, as well as individual approach threshold lights (see Figure 16). The antenna of the Far Field Monitor for RWY 12R was also broken. The mast of the Far Field Monitor antenna was found outside the perimeter fence, at a distance of 107.9 meters from its original location.

Figure 16. Damage to the lighting system – second row of lights from the end of the runway

Figure 17. Damage to the lighting system - first row of lights approximately 150 meters from the runway threshold

The support structure of the monitoring antenna, with its concrete foundation and severed cables remaining at the original site (Figure 18), was found at a distance of approximately 60 meters outside the airport's safety-restricted zone, on arable land. The total length of the support is 5 meters. It was located about 175 meters from the end of the asphalt surface in line with the runway extension. The support exhibited bending approximately 90 centimeters from its tip, along with traces of aircraft paint.

Figure 18. Foundation of the "Far Field Monitor" antenna support structure, located approximately 260 meters from the end of the runway threshold

Figure 19. View of the pole with the antenna / the pole on which the “Far Field Monitor” antenna for RWY 12R was mounted, before and after the accident

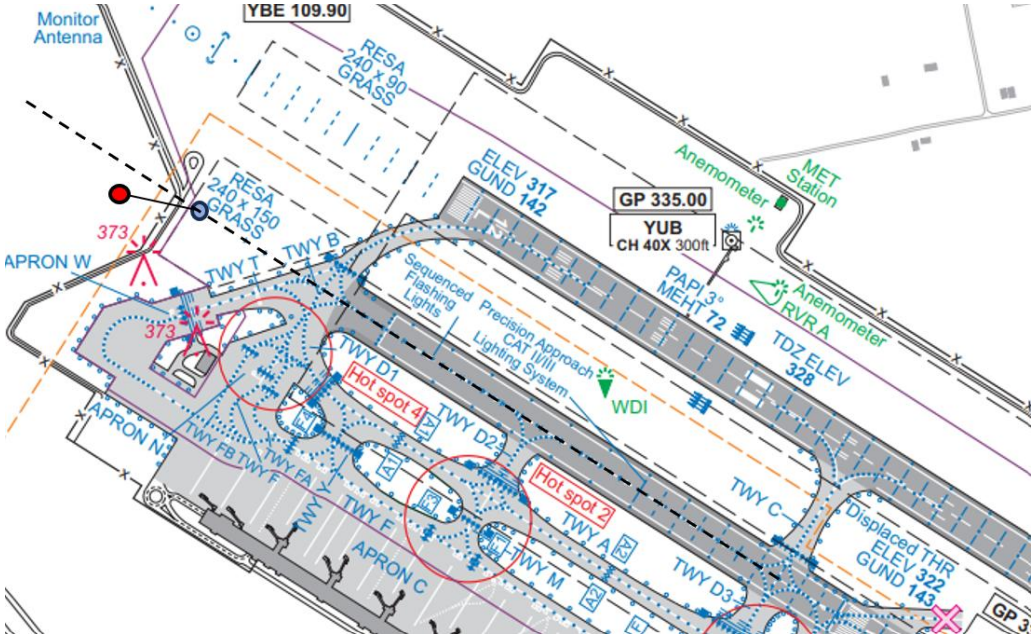


Figure 20. Location of the pole before and after the impact

The location of the pole before the impact is marked with a blue circle, and the location after the impact is marked with a red circle.

1.5. Aircraft pilot data

Age:	58 years old
Gender:	Male
License No.:	/
License type:	APL (A) from 2013, November 18th
Class:	A320, EMB170, IR ME MP
Medical certificate:	Valid until: 2024, May 5th

1.5.1. Aircraft co-pilot data

Age:	44 years old
Gender:	Male
License No.:	/
License type:	CPL (A) from 2016, October 4th
Class:	EMB170, IR, FI CPL
Medical certificate:	Valid until: 2025, April 4th

1.6. Aircraft data

Type:	ERJ 190-200 LR
Manufacturer:	Embraer S.A.
Registration Mark:	OY-GDC
Serial No:	MSN 19000204
Year of Manufacture:	2008
Maximum Takeoff Weight (MTOW):	50 790 kg
Certificate of Registration:	Document No: 19151, issued: 17. 05. 2023
Certificate of Airworthiness:	Document No: EA2968, issued: 05.12.2019
Airworthiness Review Certificate:	Document No: EA2968/0003, issued on 29.03.2023, valid until 29.03.2024.
Total Time Since New (TTSN):	22,297 hrs

1.7. Organization information

Nikola Tesla Airport (IATA: BEG, ICAO: LYBE) is registered with the Civil Aviation Directorate of the Republic of Serbia as a certified aerodrome under certificate number 1, issued on 2018, December 22nd, with unlimited validity. The airport is classified as CAT III b, and supports both IFR and VFR operations. It has two parallel runways: RWY 12L/30R and RWY 12R/30L, both measuring 3400 x 45 meters, with asphalt surfaces. The airport operator is the private company

VINCI Airports, which took over operational management of the aerodrome on 2018, December 22nd under a concession agreement.

The aircraft operator was the Greek airline Marathon Airlines S.A., acting as a lessor conducting operations on behalf of Air Serbia on flight JU324 (Belgrade – Düsseldorf).

The Certificate of Airworthiness (COA), document number E2968, was issued on 2019, December 5th and is valid indefinitely, subject to a valid Airworthiness Review Certificate (ARC). The ARC, issued by the Danish Civil Aviation and Railway Authority, document number E2968/0003, was issued on 2023, March 29th, with validity until 2024, March 29th.

Marathon Airlines S.A. holds an Air Operator Certificate (AOC), document number GR-062/OS-009, issued by the Hellenic Civil Aviation Authority (HCAA) on 2023, October 13th.

1.8. Accident site condition

After landing at the airport and vacating the runway, the flight crew, following instructions from air traffic control, parked the aircraft at position "C2" at Nikola Tesla Airport (Figure 21). The aircraft was continuously monitored by an airport fire service vehicle. Due to significant fuel leakage from the aircraft structure, and in coordination with airport services, a high-capacity container was placed to collect the fuel leaking from the left tank. Crew and passenger disembarkation was carried out via the passenger boarding bridge at the parking position.

Figure 21. Condition of the aircraft at parking stand "C2"

After the fire and rescue unit secured the fuel leakage area, a preliminary inspection was carried out. Following the inspection, airport services were instructed to relocate the aircraft from the terminal area to a safer location, as soon as possible. After the investigation conducted by the investigators from the Center for investigation of accidents in traffic, the aircraft was towed from parking position “C2” to parking position “B3”.

1.9. Meteorological data

Not relevant.

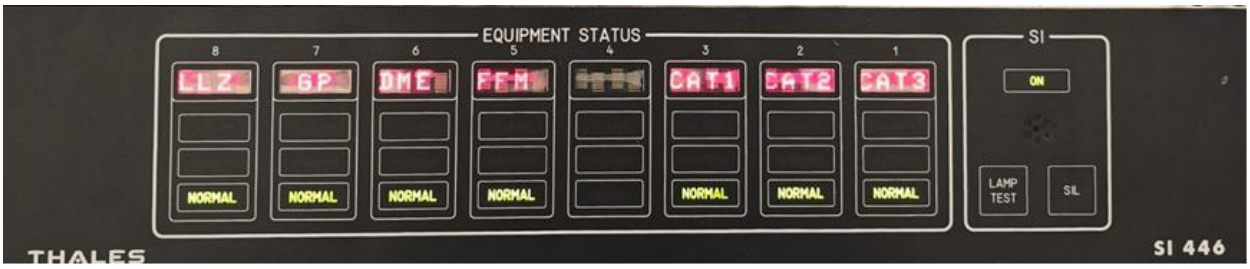
1.10. Navigational tools and equipment

On 2024, February 18th, at Nikola Tesla Airport, the aircraft *Embraer E190-200LR*, registration OY-GDC, struck and knocked down the Far Field Monitor (FFM) antenna of the LOC 12R system.

The FFM is a receiver that captures and verifies the signal transmitted by the Localizer (LOC), and it is an integral part of the ILS 12R system implemented for runway 12R/30L at Nikola Tesla Airport.

Indications of the ILS 12R system status (including the FFM and operational category) are available at the air traffic control workstations at the TWR (aerodrome control) and TMA B1 (approach control). Additionally, the ILS 12R operational status is accessible to the aeronautical technical personnel responsible for system maintenance via the Remote Control and Monitoring Unit (RCMU).

During the event on 2024, February 18th, the impact that caused the FFM antenna to collapse rendered the FFM inoperative, triggering fault indications for FFM 12R at all aforementioned workstations. As a result, the ILS 12R operational category was downgraded from ICAO CAT III to ICAO CAT I.



Display of the ILS 12R status indication as seen on air traffic controller workstations.

1.11. Communication with Air Traffic Control (ATC)

Taxi Procedures, Communication with the Crew, and Take-off Clearance

Taxi to Position: The flight crew established communication with the airport air traffic control unit and requested clearance for engine start and pushback. Upon completion of those procedures, the crew reported readiness to taxi. Air traffic control (ATC) issued proper instructions and

clearance for taxiing to intersection D6, via taxiways F, G, and A, in accordance with the flight plan. Since taxi clearance is granted only up to the runway holding position, ATC informed the crew to wait at the D6 intersection holding line. However, as the aircraft reached intersection D5 instead (a deviation from the planned taxi route), ATC promptly contacted the crew to clarify.

Recommendation to Return to D6: ATC informed the crew of the available take-off distance from intersection D5, in accordance with requirements for providing relevant information under such circumstances, and recommended the crew return to the planned intersection D6, as take-off conditions from D5 did not meet the prescribed safety requirements.

Take-off Clearance from D5: Despite the deviation from the planned runway entry point, ATC cannot forbid a take-off. In accordance with the Rules of the Air and Air Traffic Services Regulation (SERA.2015 – *Pilot-in-command authority*), the pilot-in-command, while on duty, holds the final authority over the operation of the aircraft. It was therefore up to the flight crew to decide whether to proceed with take-off despite ATC's recommendation. After a brief assessment of the available take-off distance and the departure direction, the crew determined that a take-off from intersection D5 was feasible and proceeded accordingly.

Take-off / Landing

In-Flight Issue Notification: Shortly after departure, upon leaving the runway, the crew identified certain technical issues on the aircraft. They immediately reported to ATC vibrations and an unusual noise coming from the fuselage area, along with issues related to the flap system. The crew decided to return to Nikola Tesla Airport and initiated preparations for an emergency landing. Air traffic control responded without delay, coordinating with airport emergency services and activating rescue and firefighting units to support the aircraft’s safe return.

1.12. Flight recorders

During the investigation process, the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) (Figure 22) were removed from the aircraft and sent for download and analysis in coordination with the aircraft manufacturer. The data retrieved from the FDR will be analyzed in Section 2 of this report.

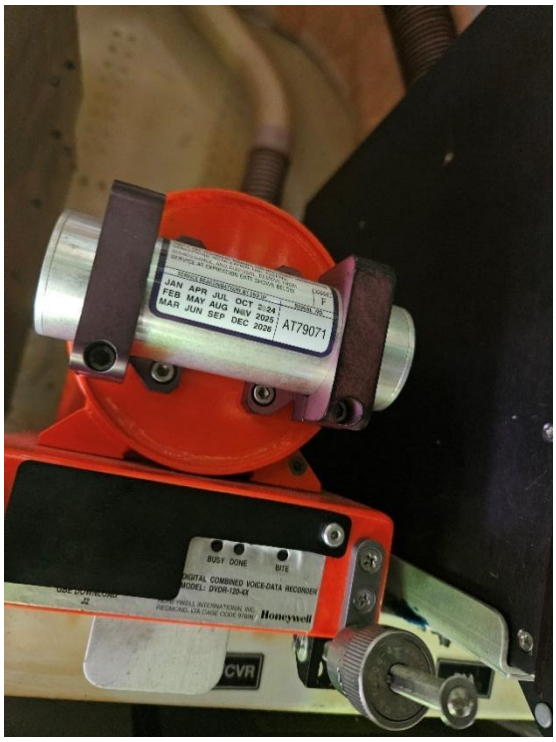


Figure 22. DVDR – Digital Voice Data Recorder

1.13. Medical and pathological data

An alcohol test was administered immediately after the accident by authorized personnel of the Ministry of Internal Affairs. The results confirmed that no traces of alcohol were present in the crew's system.

1.14. Fire

No fire occurred as a result of this accident. Immediately after landing, the airport fire service implemented precautionary fire protection measures. While the aircraft was positioned at parking position "C2", a fire vehicle was deployed to apply foam over the fuel leaking from the left wing.

Additionally, a cooling fan was positioned at the left rear side of the aircraft as a precaution in case of landing gear overheating.

Figure 23. Implementation of aircraft fire protection measures

1.15. Search and rescue

There was no action taken.

1.16. Survival aspects

There was no action taken.

1.17. Examination and investigation

All examinations and investigations were conducted based on the conditions observed on-site, as well as participant and witness statements and collected documentation and data related to the accident.

2. ACCIDENT ANALISYS

During flight preparation, the crew planned to take-off from the left runway in direction 300 (RWY 30L) at Nikola Tesla Airport, entering via intersection D6. According to the crew's statement, a double check of the take-off performance calculations was carried out for this configuration.

- **17:31 LT** – During pushback from the terminal building, the flight crew received taxi instructions from the air traffic control unit to taxi to holding position D6 via taxiways F, G, and A. The crew correctly acknowledged by repeating the received instructions.
- **17:35:10 LT** – The crew contacted air traffic control reporting they were approaching D6. ATC instructed the crew to prepare for take-off from that intersection with runway entry and alignment.
- **17:36:45 LT** – ATC sent an urgent message to the crew, asking if they were aware that they had entered the runway from intersection D5.
- **17:37:07 LT** – The crew acknowledged the advice, while ATC informed them that the Take-Off Run Available (TORA) from D5 was 1,273 meters and considered insufficient/unsafe for take-off. The crew requested one minute to perform checks (take-off performance calculations using the co-pilot's handheld tablet). ATC advised the crew that, if needed, they could taxi back to D6.

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DECLARED DISTANCES

RWY designator	TORA (M)	TODA (M)	ASDA (M)	LDA (M)	Remarks
1	2	3	4	5	6
12L	3400	3400	3400	3400	NIL
12L	2800	2800	2800	NU	Take-off from intersection with TWY C
30R	3400	3400	3400	3000	TORA, TODA and ASDA applicable for ACFT with wingspan up to 44.84 M, wheel base up to 18.60 M and main gear wheel span up to 10.93 M. Take-off from turn pad. Turn pad not to be used during night and in low visibility conditions.
30R	3045	3045	3045	NU	Take-off from intersection with TWY E
12R	3500	3500	3500	2814	Take-off from intersection with TWY D1
12R	3293	3293	3293	NU	Take-off from intersection with TWY D2
12R	2927	2927	2927	NU	Take-off from intersection with TWY D3
12R	2848	2848	2848	NU	Take-off from intersection with TWY D4
12R	2266	2266	2266	NU	Take-off from intersection with TWY D5
30L	3500	3500	3500	2983	Take-off from turn pad.
30L	1273	1273	1273	NU	Take-off from intersection with TWY D5
30L	2349	2349	2349	NU	Take-off from intersection with TWY D6
30L	3086	3086	3086	NU	Take-off from intersection with TWY D7

Figure 24. Take-Off Run Available (TORA) from intersection D5

The aircraft took-off from intersection D5 with Flaps 1 and thrust set to TO-3 with 33 deg of Flex Temperature. The take-off performance assessment determined that the minimum required take-off distance for the given ATOW (45.737 kg) is 1,440 meters with Flaps 4, TO-1 and No Flex Temp (see item 2.2 for more details).

- **17:37:34 LT** – The crew confirms they are able to take-off from intersection D5, and the aircraft begins its take-off roll.

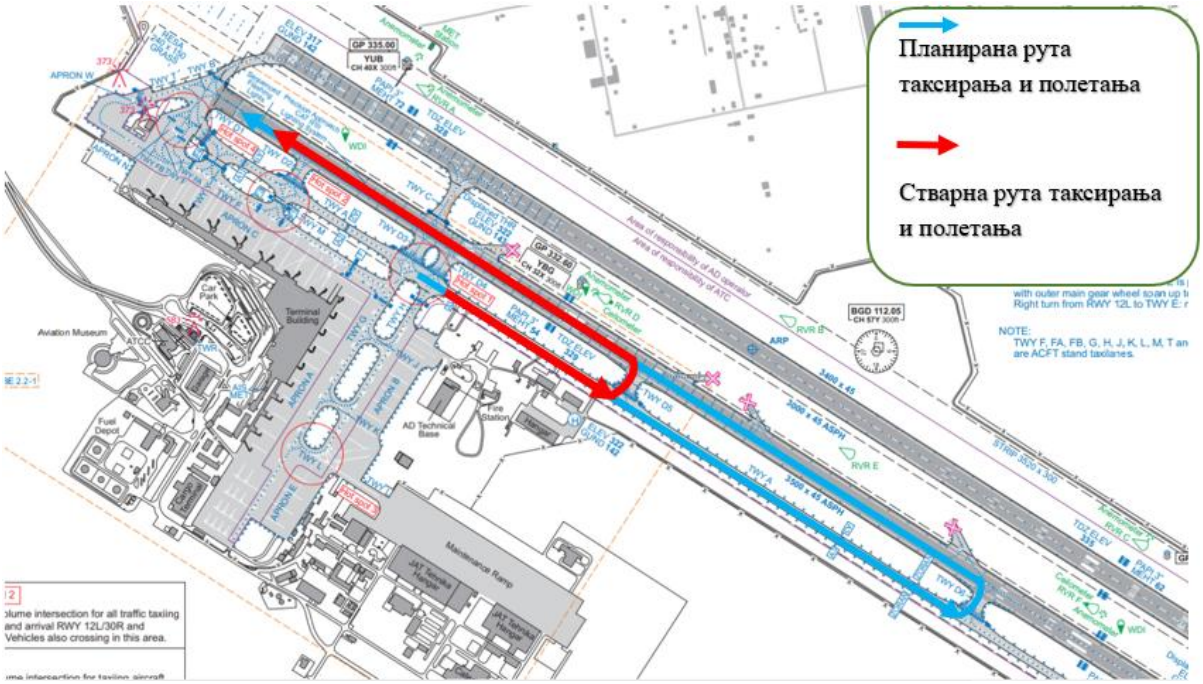

Figure 25. Planned and actual aircraft taxi route during take-off preparation

Upon receiving the report, air traffic control noted that the aircraft took off leaving a dust cloud behind and with low climbing gradient. The cabin crew reported standard acceleration during the take-off roll. The flight crew reported making thrust adjustments to achieve maximum speed. At 80 knots (kts), the crew stated that everything was fine; however, at 100 knots, they realized the remaining runway length was insufficient. Considering the available runway length and the aircraft's speed, the crew decided it was safer to continue the take-off, estimating that the aircraft would become airborne shortly. According to their statements, the crew set the engine thrust to maximum and decided to delay rotation (raising the aircraft's nose) as much as possible to utilize the entire available runway and the paved surface beyond. Shortly after leaving the runway and the paved area adjacent to it, the flight crew reported that the aircraft began to vibrate, followed by a sound indicating impact with an object. The cabin crew members stated that just before liftoff they felt vibrations similar to passing over uneven terrain, and immediately after becoming airborne, the aircraft struck an object.

- **17:39:43 LT** – Air Traffic Control (ATC) contacts the crew, inquiring if everything is in order, as the aircraft had deviated from the cleared departure vector during take-off. The crew responds that they are not sure and that they will likely need to return.
- **17:40–17:45** LT – The crew realizes that they have hit something on the ground and confirm that they must return. ATC suggests performing a visual inspection of the landing

gear via a low pass over the control tower, to which the crew responds requesting some time to conduct further internal checks.

Figure 26. Moment of impact with the “Far Field Monitor” antenna

According to crew statements, the flight crew conducted checks in accordance with the checklist to locate the issue with the aircraft. During this time, air traffic control prepared for a landing emergency, diverting other traffic and informing the airport’s emergency services, which in turn alerted the relevant authorities.

The aircraft then performed a low pass over the runway heading 300 with the landing gear extended. ATC verified that no issue was detected with the landing gear. During the descent and low pass, the crew reported a problem with the flaps, along with increased vibrations. After the low pass, the crew elected to proceed with landing. They executed a left turn into the airport traffic pattern and successfully landed on runway 30L at 18:36 LT.

Figure 27. Aircraft flight path: takeoff, low pass, holding pattern, landing.

After landing, the crew did not report any issues with the aircraft. Following communication with air traffic control, and as instructed, they proceeded to the C2 parking position at Nikola Tesla Airport.

2.1. Analysis of Crew Actions Before and During Take-off

According to crew statements, after completing two sectors: Belgrade–Vienna and Vienna–Belgrade, with a third crew member as a safety pilot present in the cabin, the crew was scheduled for the next two sectors as part of regular line duty. The first of these was flight JU324 from Belgrade to Düsseldorf, during which the accident occurred.

Flight preparation

During pre-flight preparations for take-off, significant discrepancies were observed in the parameters entered into the performance calculation application. Non-compliance with standard operating procedures led to the input of inconsistent data, and the absence of a standardized departure briefing resulted in incorrect data being entered into the aircraft's Flight Management and Guidance System (FMGS).

The table below presents the calculated data and flight configuration from both the pilot's and co-pilot's portable computers.

Captain - pilot	First officer – co-pilot
TAKEOFF FROM LYBE (18 Feb 2024, 14:35:07) +2h **16:35:07 LT** MM: 170-29723-267; ACDB: 191-05678-278; ENGDB: 191-05679-265 TAIL NUMBER: OY-GDC MODEL: EMBRAER 195 ENGINE: CF34-10E7 CERTIFICATION: EASA EPERF VERSION: 8.3.1 AIRLINE FILE NAME: airline.eperf CREATION DATE: 19 Dec 2023, 14:33:41 AIRPORT FILE NAME: EMB-ALL.eperf.xml CREATION DATE: 17 Feb 2024, 15:37:40 EFFECTIVE DATES: Effective from 18 Feb 2024 until 19 Feb 2024 ---------- DEPARTURE ---------- AIRPORT: BELGRADE NIKOLA TESLA CITY: BELGRADE NIKOLA TESLA ICAO: LYBE IATA: BEG RUNWAY: 30L D6 ELEVATION: 330 ft TORA: 2349 m TODA: 2349 m ASDA: 2349 m SLOPE: -0,11 % RWY COND: Dry WIND (°/kt): 320/09 OAT: 13 ºC QNH: 1030 hPa REMARKS: *T/O FROM "D6"**T/O SHIFT 1151M* ENGINE OUT PROCEDURE: STD. ---------- CONFIGURATION ---------- THRUST MODE: OPTIMUM ATTCS: ON REF ECS: ON REF A/I: OFF FLEX T/O: ON FLAPS: OPTIMUM AUTOBRAKE: RTO THRUST REVERSER: MAX CG ENVELOPE: STD ATOW: 43900 kg CG (%): 15 % ---------- RESULTS ----------	**TAKEOFF FROM LYBE (18 Feb 2024, 15:16:42) +2h** **17:16:42 LT** MM: 170-29723-267; ACDB: 191-05678-278; ENGDB: 191-05679-265 TAIL NUMBER: OY-GDC MODEL: EMBRAER 195 ENGINE: CF34-10E7 CERTIFICATION: EASA EPERF VERSION: 8.3.0 AIRLINE FILE NAME: airline.eperf CREATION DATE: 19 Dec 2023, 14:33:41 AIRPORT FILE NAME: EMB-ALL.eperf.xml CREATION DATE: 17 Feb 2024, 15:37:40 EFFECTIVE DATES: Effective from 18 Feb 2024 until 19 Feb 2024 ---------- DEPARTURE ---------- AIRPORT: BELGRADE NIKOLA TESLA CITY: BELGRADE NIKOLA TESLA ICAO: LYBE IATA: BEG RUNWAY: 30L D6 ELEVATION: 330 ft TORA: 2349 m TODA: 2349 m ASDA: 2349 m SLOPE: -0,11 % RWY COND: Dry WIND (°/kt): 320/05 OAT: 11 ºC QNH: 1030 hPa REMARKS: *T/O FROM "D6"**T/O SHIFT 1151M* ENGINE OUT PROCEDURE: STD. ---------- CONFIGURATION ---------- THRUST MODE: OPTIMUM ATTCS: ON REF ECS: ON REF A/I: OFF FLEX T/O: ON FLAPS: OPTIMUM AUTOBRAKE: RTO THRUST REVERSER: MAX CG ENVELOPE: STD ATOW: 46900 kg CG (%): 18 % ---------- RESULTS ----------

THRUST MODE: T/O-3
OAT: 13 ºC
ATTCS: ON
REF ECS: ON
REF A/I: OFF
FLEX TEMP: 33 ºC
N1 TARGET: 83,5 %
FLAPS: 1
STAB TRIM: 1,4 UP
MTOW: 49160 kg (Field Length OEI)
ACCELERATION: 1330 ft
V1: 138 kt
VR: 140 kt
V2: 144 kt
VFS: 195 kt
VREF: 126 kt
VAC: 126 kt

The captain's performance calculation, carried out at intersection D5 immediately prior to take-off.

TAKEOFF FROM LYBE (18 Feb 2024, 15:37:25)
+2h
17:35:25 LT
AIRPORT: BELGRADE NIKOLA TESLA
CITY: BELGRADE NIKOLA TESLA
ICAO: LYBE
IATA: BEG
RUNWAY: 12R D5
ELEVATION: 323 ft
TORA: 2266 m
TODA: 2266 m
ASDA: 2266 m
SLOPE: 0,11 %
RWY COND: Dry
WIND (º/kt): 320/09
OAT: 13 ºC
QNH: 1030 hPa
REMARKS: *T/O FROM "D5"**T/O SHIFT 1234M*
ENGINE OUT PROCEDURE: S.A. TO D4.0 "BGD" VORDME, RT(15BA) TRK297.

CONFIGURATION

THRUST MODE: OPTIMUM
ATTCS: ON
REF ECS: ON
REF A/I: OFF
FLEX T/O: ON
FLAPS: OPTIMUM
AUTOBRAKE: RTO
THRUST REVERSER: MAX
CG ENVELOPE: STD
ATOW: 43900 kg

THRUST MODE: T/O-3
OAT: 11 ºC
ATTCS: ON
REF ECS: ON
REF A/I: OFF
FLEX TEMP: 33 ºC
N1 TARGET: 83,2 %
FLAPS: 2
STAB TRIM: 0,7 UP
MTOW: 49328 kg (Climb 2 Seg.)
ACCELERATION: 1337 ft
V1: 141 kt
VR: 144 kt
V2: 145 kt
VFS: 202 kt
VREF: 130 kt
VAC: 130 kt

The co-pilot's performance calculation, carried out at the stand before taxi commenced.

TAKEOFF FROM LYBE (18 Feb 2024, 15:23:42)
+2h
17:23:42 LT
AIRPORT: BELGRADE NIKOLA TESLA
CITY: BELGRADE NIKOLA TESLA
ICAO: LYBE
IATA: BEG
RUNWAY: 30L D6
ELEVATION: 330 ft
TORA: 2349 m
TODA: 2349 m
ASDA: 2349 m
SLOPE: -0,11 %
RWY COND: Dry
WIND (º/kt): 320/05
OAT: 11 ºC
QNH: 1030 hPa
REMARKS: *T/O FROM "D6"**T/O SHIFT 1151M*
ENGINE OUT PROCEDURE: STD.

CONFIGURATION

THRUST MODE: OPTIMUM
ATTCS: ON
REF ECS: ON
REF A/I: OFF
FLEX T/O: ON
FLAPS: OPTIMUM
AUTOBRAKE: RTO
THRUST REVERSER: MAX
CG ENVELOPE: STD
ATOW: 46000 kg
CG (%): 19,6 %

CG (%): 15 % RESULTS ---------- ---------- THRUST MODE: T/O-3 OAT: 13 ºC ATTCS: ON REF ECS: ON REF A/I: OFF FLEX TEMP: NO FLEX N1 TARGET: 84,3 % FLAPS: 2 STAB TRIM: 0,9 UP MTOW: 44106 kg (Obstacle) ACCELERATION: 1339 ft V1: 137 kt VR: 138 kt V2: 141 kt VFS: 195 kt VREF: 126 kt VAC: 126 kt	RESULTS ---------- THRUST MODE: T/O-3 OAT: 11 ºC ATTCS: ON REF ECS: ON REF A/I: OFF FLEX TEMP: 33 ºC N1 TARGET: 83,2 % FLAPS: 1 STAB TRIM: 0,9 UP MTOW: 48880 kg (Field Length OEI) ACCELERATION: 1337 ft V1: 142 kt VR: 143 kt V2: 148 kt VFS: 200 kt VREF: 129 kt VAC: 129 kt

Differences in flight data entry and resulting configuration settings are highlighted in red in the table.

In the performance calculation done by the captain, it is evident that in both data entries, the ATOW (Actual Take-Off Weight) does not correspond to the weight provided in the Load Sheet received just prior to engine start.

Taxiing and take-off

Taxi commenced and was conducted via taxiways F, G, and A to the expected holding position at D6. During taxi, the crew engaged in informal communication, during which the captain displayed a dominant attitude toward the first officer.

While taxiing on taxiway “A” near intersection D5, the first officer misidentified their position as D6 and advised reporting ready for departure. ATC issued a clearance to line up on Runway 30L via intersection D6. However, the captain entered the runway via D5 without visually confirming the intersection. The available Take-Off Run (TORA) from intersection D5 on Runway 30L is 1,273 meters.

ATC identified the error and instructed the crew to vacate the runway via D4 and return to intersection D6. The captain declined and instead performed a new takeoff performance calculation, changing the departure runway in the performance calculation application from 30L/D6 to 12R/D5. The calculation was performed at 17:37:25, with the resulting performance data shown in the table.

The captain, convinced that the available runway length was sufficient, chose to proceed with take-off from intersection D5. He pressured the first officer by asserting that the available distance was more than adequate. The first officer, influenced by the captain's insistence, did not cross-check the performance data on his Electronic Flight Bag (EFB). As a result, the take-off was initiated without updating the take-off speeds, FLEX temperature, or aircraft configuration in the Flight Management System (FMS).

Without applying the static take-off technique, the First Officer initially advances the thrust levers, after which the system automatically sets thrust for FLEX 33°C. Upon reaching a speed of 80 knots, the Captain observes that the end of the runway is approaching and makes a remark. The First Officer comments that the runway is "really short," but does not adjust the thrust setting—continuing with the preselected FLEX 33°C thrust instead of advancing the thrust levers to the TOGA detent.
At V_1 and Vr, the First Officer initiates rotation with full aft control column input, resulting in the aircraft's nose pitching up to 10°.
This leads to:

- A tail strike, with contact on the grass surface beyond the end of the runway
- Impact with the localizer antenna

After realizing that the aircraft is not transitioning into a proper climb, and following additional pitch trim inputs, the First Officer increases thrust, and the aircraft finally establishes a stable climb.

2.2. Take-off performance assessment from the runway

Based on the following conditions established during the investigation:

- Available Take-off Distance (TODA for Runway 30L-D5): 1,273 meters
- Available Accelerate-Stop Distance (ASDA for Runway 30L-D5): 1,273 meters
- Runway elevation: 323 ft
- Outside air temperature: 15°C
- Runway slope: -0.11%
- Engine thrust setting: TO-3 of CF34-10E7
- ATTCS: ON
- Flap setting for take-off: Flaps 1

The maximum allowable take-off weight (MTOW) under the above conditions, assuming reduced thrust, is 34,390 kg.
Considering the actual aircraft take-off weight (ATOW) of 45,737 kg, the aircraft was not capable of performing a take-off from the available take-off distance (TODA for 30L-D5 = 1,273 meters).

Further, under the following adjusted conditions:

- Runway elevation: 323 ft

- Temperature: 15°C
- Runway slope: -0.11%

And with aircraft configurations set for optimal take-off performance, minimizing take-off distance or maximizing allowable take-off weight:

- Engine thrust setting: TO-1 of CF34-10E7
- ATTCS: ON
- No reduced thrust
- Flap setting: Flaps 4

The minimum required take-off distance for the given ATOW (45,737 kg) is 1,440 meters.

2.3. Analysis of Parking Stand Allocation and Airport Emergency Response Plan Procedures

Upon receiving information from the ATC shift supervisor that the aircraft had struck an object during take-off and announced its intention to return, the airport fire and rescue service activated standard emergency response procedures.

In accordance with instructions, units of the Airport Rescue and Firefighting Service (RFFS) were deployed along taxiway D6, while the airside inspection team conducted a runway surface check at the end of Runway 30L.

During a low pass, the captain requested a visual check of the landing gear to confirm its position and lock status, after which landing was planned.

Air Traffic Control requested information regarding the parking stand. The dispatcher confirmed the following:

- Stand C2 – if the aircraft was deemed airworthy;
- Apron B – if any technical irregularities were identified.

The fire service adjusted its deployment and directed one vehicle to D7 to follow the aircraft from the moment of runway contact. Upon confirmation from ATC, all emergency vehicles were granted clearance to enter the runway.

ATC instructed the follow-me vehicle to wait for the aircraft at SB F and guide it to stand C2.

Following the operation, airport security reported the discovery of unidentified damage and debris on the grass area beyond the end of Runway 30L, with a note that it was unclear whether the debris originated from the aircraft.

At the time of the occurrence, Edition No. 2 of the Nikola Tesla Airport Emergency Response Plan was in effect. Chapter 12 of this document defines the *isolated parking position* as an area designated for aircraft subject to unlawful interference or, due to other circumstances, requiring isolation from regular airport operations. For all other types of emergencies involving aircraft—such as fires, incidents involving dangerous goods, or public health threats—the isolated parking position is determined based on an assessment by the fire intervention commander or another competent operational authority, in accordance with criteria ensuring a safe distance from airport

infrastructure and installations. In line with Section 12.3, titled “Malfunction of Aircraft in Flight,” airport services acted in accordance with the established procedures. Completed checklists from the airport duty dispatcher and the duty airport manager confirm that all steps outlined in the Emergency Plan were fully implemented.

Upon receiving the initial information regarding a technical malfunction, the dispatcher notified the duty airport manager, who, in accordance with procedure, subsequently informed the Safety Management Manager, the Airport Surveillance and Security Service (SSO), the communications department, the information desk, and representatives of Air Serbia.

Given that the situation was classified as an aircraft malfunction, and considering that in the initial phase—both during flight and taxiing to the parking position—there were no indications of serious damage that would suggest the occurrence of an accident, the Airport Emergency Operations Center (AEOC) was not activated.

The Nikola Tesla Airport Emergency Response Plan, Edition No. 3, entered into force on 29 April 2024, following the implementation of initial measures by the Civil Aviation Directorate. In accordance with this edition, activation of the Airport Emergency Operations Center (AEOC) is mandated not only in cases listed under Section 4.2.1, but also in situations where an aircraft declares MAYDAY in flight—which was the case in this accident.

This edition of the Plan also defines the designated isolated parking positions available for receiving aircraft requiring isolation due to an emergency situation. The designated isolated positions include stands located on Aprons B, E, T, as well as position D6.

Figure 28. Emergency Response Positions at Nikola Tesla Airport

The latest Edition No. 6 of the Nikola Tesla Airport Emergency Response Plan entered into force on 29 May 2025. This edition further clarifies the conditions under which isolated parking positions for aircraft must be activated. The use of isolated positions is mandated in the following situations: the presence of fire risk on the aircraft, fuel leakage, public health threats, as well as any other factors indicating a potential hazard to the aircraft, its crew, or passengers. The purpose of this procedure is to prevent further compromise of airport operational safety and to enable timely response by the emergency services responsible for managing such situations.

Figure 29. Positions Used During Emergency Situations at Nikola Tesla Airport

The designated isolated parking positions, if available, include: the position on taxiway A between D6 and D7, positions W1 and W1A on apron W, as well as aprons B and E, as shown in Figure 30.

Through Editions 2, 3, and 6, the Nikola Tesla Airport Emergency Response Plan has evolved from a model in which the activation of the Airport Emergency Operations Center (AEOC) and the designation of an isolated parking position were based on operational assessment (Edition 2), toward a model involving mandatory activation in the event of a declared “MAYDAY” and more precise definition of isolated parking positions (Edition 3), culminating in the most recent approach, where clearly defined specific risks—such as fire hazard, fuel leakage, and public health threats—serve as criteria for isolating an aircraft (Edition 6).

The flight crew was unable to detect the damage during taxiing after landing, as confirmed during the investigation by simulating the crew's line of sight from the aircraft toward the damaged area (Figures 30 and 31).

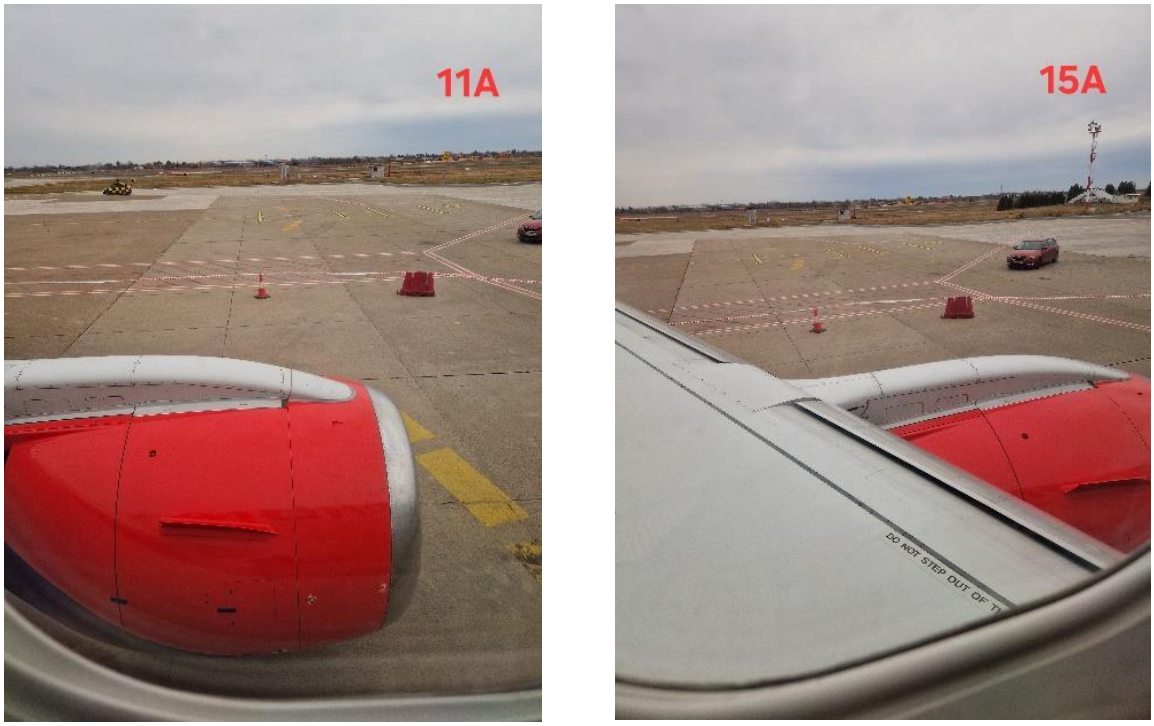

Figure 30. Line of sight from passenger seats 11A and 15A clearly shows that the cabin crew would not have been able to detect the extent of the damage.

Figure 31. Captain's line of sight toward the damaged area through the closed window and through the open window.

3. CONCLUSIONS

3.1. Findings

- It was determined that during two flights preceding the accident flight, a third crew member was present as a safety pilot, not as an instructor or examiner.
- The absence of a pre-flight briefing was established, along with inadequate verification of flight documentation and discrepancies in the take-off performance calculations.
- A lack of discipline during taxiing was observed, including unnecessary informal communication and failure to cross-check the aircraft's position using the taxi chart.
- An error was noted in entering runway 30L via intersection D5 instead of D6.
- A data entry error was identified in the performance application: the wrong runway was selected, and there is a possibility that the **Take Off Shift** length was mistaken for **TORA**, based on the incorrect runway.
- It was found that the flight management system (FMS) and aircraft configuration were not updated accordingly, with "FLEX 33" left unchanged instead of using "NO FLEX TAKE OFF." Additionally, the configuration **FLAPS 1** was selected instead of **FLAPS 4**, which later led to extended TODA, slow rotation, and inadequate climb performance after takeoff.
- Poor **Crew Resource Management (CRM)** was observed, especially by the captain, including inadequate crew response to errors and general lack of discipline in error correction.
- A lack of a "departure change" procedure in the **Marathon Airlines S.A.** Operations Manual was identified, along with poorly implemented runway and performance change procedures after taxiing had commenced.
- A lack of a proper "line-up" procedure was found in the **Marathon Airlines S.A.** Operations Manual.
- The crew failed to apply full engine thrust when they became aware of the mistake.
- After landing, neither the crew nor the airport services could assess the level of damage to the wing root or detect the fuel leak due to the location's specifics; at that point, the leak was minimal or not visible.
- The full extent of the aircraft damage became evident to airport services only after the aircraft was parked at stand C2, where a significant fuel leak was noticed at the junction between the front spar and the lower wing skin. At that moment, passengers were already in the process of disembarking.
- Due to a lack of information regarding the severity of the damage and the confirmation from the fire department that the aircraft was safe after landing, the dispatcher made the decision to assign the aircraft to parking stand **C2** instead of a remote (open) stand.

3.2. Accident causes

Direct Cause

Take-off from an intersection that did not provide sufficient runway length (TODA) for a safe departure.

Indirect Cause

- Lack of discipline in crew communication during taxiing.

- Incorrect data entry by the crew into the electronic flight bag (EFB) and performance application, including incorrect runway direction.

- Failure to update FMS and aircraft configuration data, and leaving "FLEX 33" instead of "TO-1 with NO FLEX TAKE OFF" and selecting "FLAPS 1" instead of "FLAPS 4," which led to an extended TODA, slow rotation, and poor climb performance. This ultimately resulted in the aircraft making ground contact and the left wing root striking the localizer antenna.

4. SAFETY RECOMMENDATIONS

To improve aviation safety and prevent future accidents or serious incidents caused by similar or related factors, the Center issues the following recommendations:

01/2024 – 1
It is recommended to the **Aviation Authorities of the Republic of Italy**, which issued the license to the pilot, and also to the **Hellenic Civil Aviation Authority** and the operator **Marathon Airlines S.A.** to:

- Conduct an extraordinary proficiency check for the pilot on the Embraer E190 type. Particular attention should be given to:
    - Crew Resource Management (CRM) weaknesses and behavior under stress.
    - Organize CRM workshops focusing on error management, interpersonal communication, and command responsibility, especially for PIC, to improve team coordination and effective deviation management from SOPs.
    - Ensure strict enforcement of mandatory pre-flight briefings with clearly defined crew responsibilities regarding performance checks, routing, and documentation to eliminate procedural omissions during flight planning and preparation.
    - Reaffirm discipline in taxiing procedures through additional CRM training, emphasizing the use of taxi charts and position confirmation to reduce the risk of entering the wrong runway.
    - Introduce mandatory **intersection verification** via the "challenge–response" method between crew members and use of real-time taxi maps to prevent errors when entering an incorrect runway or intersection.

- Add an “FMS verification” checklist before entering the runway, along with CRM procedures for double-checking FLEX/FLAPS values and other critical parameters to ensure accurate data entry and correct aircraft configuration.
- Include scenarios in CRM and simulator training that require immediate corrective action (e.g., switching from FLEX to TOGA thrust) to improve decision-making in critical moments.

01/2024 – 2

It is recommended to the **Aviation Authorities of the Republic of Italy**, which issued the license to the pilot, and also to the **Hellenic Civil Aviation Authority** and the operator **Marathon Airlines S.A.** to:

- Conduct an extraordinary proficiency check for the First Officer on the Embraer E190 type.
  Particular attention should be given to:
  - Crew Resource Management (CRM) weaknesses and behavior under stress.
  - Organize additional CRM workshops focusing on error management, interpersonal communication, and command responsibility, especially for PIC/first officers, to improve team coordination and effective deviation management from SOPs.
  - Ensure strict enforcement of mandatory pre-flight briefings with clearly defined crew responsibilities regarding performance checks, routing, and documentation to eliminate procedural omissions during flight planning and preparation.
  - Reaffirm discipline in taxiing procedures through additional CRM training, emphasizing the use of taxi charts and position confirmation to reduce the risk of entering the wrong runway.
  - Introduce mandatory **intersection verification** via the “challenge–response” method between crew members and use of real-time taxi maps to prevent errors when entering an incorrect runway or intersection.
  - Add an “FMS verification” checklist before entering the runway, along with CRM procedures for double-checking FLEX/FLAPS values and other critical parameters to ensure accurate data entry and correct aircraft configuration.
  - Include scenarios in CRM and simulator training that require immediate corrective action (e.g., switching from FLEX to TOGA thrust) to improve decision-making in critical moments.

01/2024 – 3
It is recommended to the **Hellenic Civil Aviation Authority** and the operator **Marathon Airlines S.A.** to:

- Revise the **Operations Manual (Part B EMB170/175/190/195 Issue 2, Rev. 3 Date 15 Jan 2024)** by implementing a clear **runway change procedure after taxi** begins, including a checklist and responsibility assignment for recalculating aircraft performance.
- Revise the same manual to incorporate a **line-up checklist** procedure that includes both visual and system confirmation of aircraft configuration.

  Note: The operator Marathon Airlines S.A. fulfilled safety recommendation during investigation.

01/2024 – 4
To **Belgrade Nikola Tesla Airport / VINCI Airports** (no further recommendations):

- Revise the Airport Emergency Plan of Belgrade Nikola Tesla Airport so that activation of the AOCES (Airport Operations Center for Emergency Situations) and designation of an isolated stand become mandatory in the event of a hazard, with clearly defined specific risks — such as fire hazards, fuel spills, and public-health threats — serving as the basis for aircraft isolation.

  Note: Belgrade Nikola Tesla Airport (VINCI Airports) fulfilled the safety recommendation during the investigation through the adoption of Revisions 3 and 6 of the documents.

5. APPENDIX