FINAL REPORT

SERIOUS INCIDENT 2019/4685

State Commission on Aircraft Accidents Investigation (PKBWL)

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FINAL REPORT

SERIOUS INCIDENT

OCCURRENCE NO – 2019/4685

AIRCRAFT – Airplane, Embraer ERJ 190-200 LR., SP-LNO

DATE AND PLACE OF OCCURENCE – 11 October 2019, EPWA

The Report is a document presenting the position of the State Commission on Aircraft Accidents Investigation concerning circumstances of the air occurrence, its causes and safety recommendations. The Report was drawn up on the basis of information available on the date of its completion.

The investigation may be reopened if new information becomes available or new investigation techniques are applied, which may affect the wording related to the causes, circumstances and safety recommendations contained in the Report.

Investigation into air the occurrence was carried out in accordance with the applicable international, European Union and domestic legal provisions for prevention purposes only. The investigation was carried out without application of the legal evidential procedure, applicable for proceedings of other authorities required to take action in connection with an air occurrence.

The Commission does not apportion blame or liability.

In accordance with Article 5 paragraph 6 of the Regulation (EU) No 996/2010 of the European Parliament and of the Council on the investigation and prevention of accidents and incidents in civil aviation […] and Article 134 of the Act – Aviation Law, the wording used in this Report may not be considered as an indication of the guilty or responsible for the occurrence.

For the above reasons, any use of this Report for any purpose other than air accidents and incidents prevention can lead to wrong conclusions and interpretations.

This Report was drawn up in the Polish language. Other language versions may be drawn up for information purposes only.

WARSAW 2023

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Abbreviations

AGL	Above Ground Level
ASEL	Altitude Select
ATOW	Actual Take-off Weight
ATPL(A)	Airline Transport Pilot Licence
EASA	European Aviation Safety Agency
EPWA	Warsaw Chopin Airport
EU	European Union
FGCS	Flight Guidance Control System
FMA	Flight Mode Annunciator
FO	First Officer
Ft.	Foot
ICAO	International Civil Aviation Organisation
Kt	Knot
MACTOW	Mean aerodynamic chord take-off weight
MACZFW	Mean aerodynamic chord zero fuel weight
PF	Pilot Flying
PIC	Pilot-in-Command
SCAAI/PKBWL	State Commission on Aircraft Accidents Investigation [Poland]
RWY33	Runway 33
TLA	Thrust Lever Angle
TO/GA	Take-Off/Go-Around
V AC	V approach speed
V/S	Vertical speed
ZFW	Zero fuel weight

General Information

Occurrence reference number:	**2019/4685**			
Type of occurrence:	SERIOUS INCIDENT			
Date of occurrence:	11 October 2019			
Place of occurrence:	EPWA			
Type and model of aircraft:	Airplane, Embraer ERJ 190-200 LR.			
Aircraft registration marks:	SP-LNO			
Aircraft user/operator:	PLL LOT			
Aircraft Commander:	ATPL(A)			
Number of victims/injuries:	Fatal	Serious	Minor	None
	-	-	-	105
Domestic and international authorities informed about the occurrence:	ICAO, EASA, EU, Brazil			
Investigator-in-charge:	Jakub Cichocki			
Investigating authority:	State Commission of Aircraft Accidents Investigation (PKBWL)			
Accredited Representatives and their advisers:	ACCREP from Brazil			
Document containing results:	FINAL REPORT			
Safety recommendations:	YES			
Addressees of the recommendations:	OPERATOR – PLL LOT			
Date of completion of the investigation:	23.05.2023			

Synopsis

The flight took place on the route from Brussels to Warsaw. The FO was a PF. The approach and landing was performed on RWY33.

Crosswind of 10 up to 15 kt was recorded just prior to touch down. The aircraft slightly lost its direction and touched down with the vertical acceleration of 1.96 g. During touch down, the aircraft bounced off the runway and the PF initiated the go-around procedure. The auto-throttle was disengaged in accordance with the system's operating logic. The thrust lever was moved forward to 72° TLA without pushing the TO/GA button.

During the go-around, the maximum climb speed amounted to 4,384 ft/min, while the aircraft maximum nose up pitch angle reached 32.2°. At the altitude of 1,470 ft. (1,218 ft. AGL), the aircraft speed dropped to 95 kt. The crew started to correct the flight parameters, the so-called "Stick Shaker" was activated, and a while later the crew started an upset recovery manoeuvre.

At the altitude of 1,382 ft. (1,044 ft. AGL), the system terminated warnings on nearing critical angle of attack. The TO/GA was pushed, thereby activating the "Flight Guidance Control System" (FGCS).

From that moment on, the crew carried out the flight based on the FGCS indications. According to the air traffic control guidelines, the pilots turned right, carried out another approach and completed the landing on RWY33.

The investigation into the occurrence was conducted by:

Jakub Cichocki Investigator-in-Charge (PKBWL).

Causes of the serious incident:

1. **Incorrect execution of the "Bounced Landing Recovery" and "Go-Around" procedures.**
2. **Delayed reaction of the Pilot Monitoring to the errors made by the Pilot Flying during landing and go-around.**

After completion of the investigation, PKBWL issued four safety recommendations for the carrier.

1. FACTUAL INFORMATION

1.1. History of the flight

On 11 October 2019, the crew of Embraer ERJ 190-200 LR., SP-LNO registration, belonging to PLL LOT, was carrying out a flight on the route from Brussels to Warsaw. The FO was the Pilot Flying. There were three persons in the cockpit: the captain, the FO and a cabin crew member (stewardess).

The landing approach to the Warsaw Chopin Airport (EPWA) was carried out towards RWY33. The aircraft flap configuration for landing was set to position 5. The landing approach featured wind blowing in the 240° direction (on the left hand side) with gust up to 21 kt.

The landing approach parameters at the so-called “landing gates”[1], at altitudes of 1,000 ft. and 500 ft., met the stabilised approach criteria (determined by the operator). After clearance from the aerodrome ATC to land on RWY33, the PF disengaged the auto-pilot and performed the landing approach manually.

Crosswind average speed of 10 up to 15 kt was recorded during the final approach, just prior to touchdown. The aircraft slightly lost its direction and touched down with the vertical acceleration of 1.96 g. After touch down, the aircraft bounced off the RWY and the PF decided to abort the landing and initiated the go-around procedure. The autothrottle was automatically disengaged in accordance with the system operating logic. The thrust lever was moved forward to 72° TLA without pushing the TO/GA button.

During the go-around, the maximum climb speed reached 4,384 ft/min., which caused the air traffic control to react and ask the crew to confirm vertical speed. The pilots reacted to the decreasing speed and increased the engine thrust by moving the thrust levers to 75° TLA (the correct position to perform the go-around procedure). This caused an additional increase in the aircraft positive pitch angle, which reached 32.2° (the details are provided in the analysis).

At the altitude of 1,470 ft. (1,218 ft. AGL), the aircraft speed decreased to 95 kt. The warning system of critical angle of attack and the “Stick Shaker” were activated. This was accompanied by the yoke shaking. and a specific sound signal. At the time, the pilots had already commenced upset recovery manoeuvre. They pushed the yoke, thereby causing the aircraft to pitch down, descend temporarily, and increase its speed.

The aircraft was recovered at the altitude of 1,382 ft. (1,044 ft. AGL). The stick shaker activation was recorded during one second (from 10:14:21 hrs - to 10:14:22 hrs), in altitude range 1,461 -1,459 ft. (1,123 ft. – 1,121 ft. AGL). The system terminated

[1] Flight altitude during landing approach at which the flight stabilisation criteria determined by the carrier are verified.

generating warnings of critical angle of attack. The TO/GA[2] button was pushed, thereby activating the "Flight Guidance Control System" (FGCS).

From that moment on, the crew carried out the flight based on the FGCS indications. According to the air traffic control guidelines, the pilots turned right, carried out another approach and completed the landing on RWY33.

1.2. Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	**-**	**-**	**-**	**-**
Serious	**-**	**-**	**-**	**-**
Minor	**-**	**-**	**-**	**-**
None	**6**	**99**	**-**	**105**

1.3. Damage to aircraft

The aircraft was not damaged during the occurrence.

1.4. Other damage

None.

1.5. Personnel information (crew data)

PIC:

Male, aged 41, holder of:

- ATPL(A) with a valid rating for Embraer ERJ 190-200 LR as PIC;
- Total flight time: 4,450 hours;
- Flight time as PIC: 2,090 hours;
- Flight time on Embraer: 2,840 hours;
- Flight time over the last 24 hours: 4 hours and 35 minutes;
- Flight time over the last 7 days: 14 hours;
- Flight time over the last 90 days: 68 hours and 48 minutes;
- Experience at the occurrence's aerodrome: PIC`s Operating Base;
- Service and rest in the last 48 hours: the PIC had a day off (24 hours) prior to the occurrence.
- Last 10 flights: PIC operated from the EPWA aerodrome from 30 September and was in continuous training;
- Aero-medical assessment: Class 1, valid – no restrictions;

[2] "Take-Off/Go-Around". It is mandatory to engage the TO/GA button when performing the go-around procedure. Pressing the button changes the operating mode of the Flight Guidance Control System located on the Primary Flight Display (PFD) as well as the aircraft's drive assembly operation regime and available power.

- Role during the flight: Pilot Monitoring.

FO:

Male, aged 38, holder of:

- CPL(A) with a valid rating for Embraer ERJ 190-200 LR. as the FO;
- Total flight time: 726 hours;
- Flight time as PIC: 115 hours;
- Flight time with Embraer: 519 hours;
- Flight time over the last 24 hours: 4 hours and 35 minutes;
- Flight time over the last 7 days: 9 hours;
- Flight time over the last 90 days: 174 hours;
- Experience at the occurrence's aerodrome: FO`s Operating Base;
- Service and rest in the last 48 hours: the FO had a day off (24 hours) prior to the occurrence.
- Last 10 flights: FO operated from the EPWA aerodrome by carrying out the last 10 operations from 28 September and was in continuous training;
- Aero-medical assessment: Class 1, valid – no restrictions;
- Role during flight: Pilot Flying.

1.6. Aircraft information

Embraer ERJ 190-200 LR is a narrow-body, regional passenger aircraft manufactured by the Brazilian Embraer, carrying 114 passengers.

Aircraft data:

Length: 36.24 m

Height: 10.28 m

Wing span: 28.72 m

Maximum Take-off Weight: 50,790 kg

Number of seats: 114

Engines: 2 x turbofan GE CF34-10E, 82.3 kN thrust

Cruise speed: 0.82 Mach (890 km per hour)

Range: 4,262 km

Maximum Operating Altitude: 12,500 m

Year of manufacture	Manufacturer	Airframe serial number	Identification symbols:	Registration no.	Registration date
2007	Embraer ERJ 190-200 LR.	19000084	SP-LNO	5241	04/07/2019

Fuel & Lubricants pre-flight status:

fuel: Jet-A-1, 6,600 kg;

Aircraft load:

- empty weight: 29,179.6 kg
- fuel weight: 6,600 kg
- crew weight: 480 kg (3 in cockpit/3 in cabin)
- luggage weight: 1,021 kg

Total weight:

- permissible: 50,790 kg
- actual: 45,801 kg

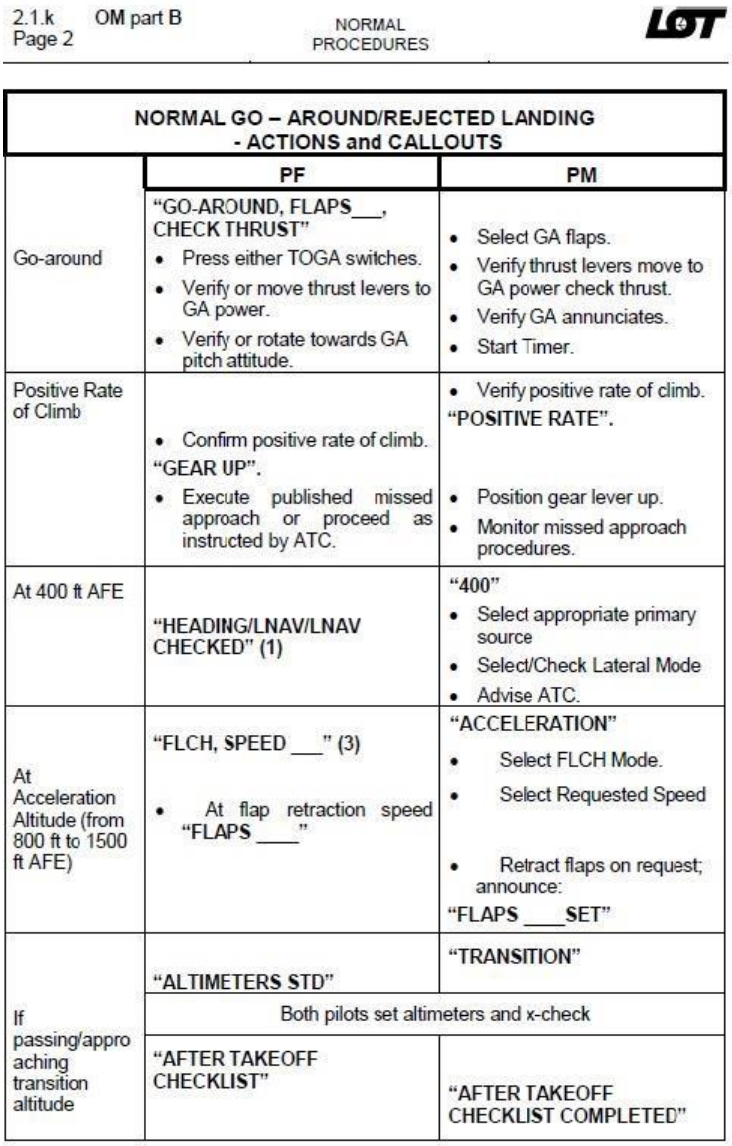
1.6.1. Aircraft balance

According to the loadsheet, MACTOW was 23.3%, MACZFW was 27.4%. The ATOW amounted to 45,801 kg, while the actual landing weight amounted to 42,401 kg, and the ZFW amounted to 39,201 kg.

The aircraft weight and location of its centre of gravity were within the prescribed limits and had no effect on the occurrence.

1.6.2. Go-Around Procedure

An extract from PLL LOT Operations Manual, part B, regarding the normal go-around/rejected landing procedure with the division of actions between the PF and the PM, including the standard phraseology, is presented below.



2.1.k OM part B
Page 2

NORMAL PROCEDURES

LOT

NORMAL GO – AROUND/REJECTED LANDING - ACTIONS and CALLOUTS		
	PF	**PM**
Go-around	"GO-AROUND, FLAPS___, CHECK THRUST" • Press either TOGA switches. • Verify or move thrust levers to GA power. • Verify or rotate towards GA pitch attitude.	• Select GA flaps. • Verify thrust levers move to GA power check thrust. • Verify GA annunciates. • Start Timer.
Positive Rate of Climb	• Confirm positive rate of climb. "GEAR UP". • Execute published missed approach or proceed as instructed by ATC.	• Verify positive rate of climb. "POSITIVE RATE". • Position gear lever up. • Monitor missed approach procedures.
At 400 ft AFE	"HEADING/LNAV/LNAV CHECKED" (1)	"400" • Select appropriate primary source • Select/Check Lateral Mode • Advise ATC.
At Acceleration Altitude (from 800 ft to 1500 ft AFE)	"FLCH, SPEED ___" (3) • At flap retraction speed "FLAPS ____"	"ACCELERATION" • Select FLCH Mode. • Select Requested Speed • Retract flaps on request; announce: "FLAPS ____SET"
If passing/approaching transition altitude	"ALTIMETERS STD"	"TRANSITION"
	Both pilots set altimeters and x-check	
	"AFTER TAKEOFF CHECKLIST"	"AFTER TAKEOFF CHECKLIST COMPLETED"

Fig. 1. Division of pilot actions during Go-Around/rejected landing procedure, including the standard phraseology.
Source: PLL LOT`s Operations Manual, part B, 2.1.k. page 2.

An extract from PLL LOT Operations Manual, part B, regarding the Go-Around procedure, including information on proceeding in case of missing Flight director indications, is presented below.

MISSED APPROACH

There have been many accidents in commercial aviation caused by the decision to land when all evidence signaled that the safest alternative was a missed approach. The approach must be planned with the missed approach in mind. In other words: the crew must always be ready for missed approach, not only for landing.
This mentality must be emphasized during training and during normal operation. The missed approach must be briefed in detail and both pilots must be totally aware of what will happen if a missed approach is performed.

Whenever the approach or safety of the landing is threatened, a go-around or rejected landing procedure shall be initiated.

WARNING: **EITHER THE PILOT FLYING OR THE PILOT MONITORING MAY MAKE A GO-AROUND CALLOUT, AND THE FLYING PILOT'S IMMEDIATE RESPONSE TO A GO-AROUND CALLOUT BY THE MONITORING PILOT IS THE EXECUTION OF A MISSED APPROACH.**

GO AROUND

Go Around button.....PRESS
Thrust Levers.....TO/GA

Rotate or verify that autopilot rotates the airplane following the flight director guidance.

NOTE: When flight director is inoperative, rotate the airplane to 8° nose up.

Select flaps according to the table below:

Landing Slat/Flap	Go Around Slat/Flap
FULL	4
5	3

With positive climb:

Landing Gear.....UP
Minimum Airspeed.....V_{REF} + 20

If an engine failure occurs during the Go Around:
Minimum Airspeed.....V_{AC}

At the acceleration altitude proceed as in a normal takeoff.

Fig. 2. Go-Around procedure.
Source: PLL LOT's Operations Manual, part B, 2.1.k. page 1.

1.6.3. *Bounced Landing Recovery* procedure

An extract from PLL LOT's Operations Manual, part B, on proceeding in case of bouncing off the runway during landing (Bounced Landing Recovery).

2.1.l **OM** part **B**
Page 4
NORMAL PROCEDURES

BOUNCED LANDING RECOVERY

The key factor for a successful landing is a stabilized approach and proper thrust/flare coordination. Do not extend the flare at idle thrust as it will significantly increase landing distance. Reducing to idle before the flare will also require an increase in pitch. Flaring high and quickly reducing thrust to idle can cause the plane to settle abruptly. Do not apply stabilizer trim during the flare.

When a light bounce occurs, maintain or re-establish a normal landing attitude. Increasing pitch can lead to a tail strike. Beware of the increased landing distance and use power as required to soften the second touchdown. When a more severe bounce occurs, initiate a go-around – do not attempt to land. Press the go-around button and advance thrust levers to TOGA. Hold the flare attitude until the engines spool up and reset stabilizer trim, then follow normal go-around procedures.

Fig. 3. Description of procedure in case of Bounced landing. Source: PLL LOT's Operations Manual, part B, 2.1.i. page 4.

1.6.4. Procedure: *Upset Recovery Manoeuvre*

An extract from PLL LOT Operations Manual, part B, defining Airplane upset conditions[3] and the division of actions between the PF and the PM during the Upset Recovery Manoeuvre, is presented below.

UPSET RECOVERY MANEUVER

DEFINITION:

An airplane upset condition is recognized when one or a combination of the following unintentional conditions occur:

- Pitch more than 25° nose up
- Pitch more than 10° nose down
- Bank angle more than 45° bank
- Flight within these parameters at airspeeds inappropriate for the condition

NOSE-UP RECOVERY

ACTIONS AND CALLOUTS		
	PF	**PM**
Upon recognizing the upset situation.	• Disengages the Autopilot and Autothrottle. • Reduces the airplane pitch angle.(1)	• Checks Auto Throttle and Auto Pilot disengaged. • Verify all required actions have been performed, monitors altitude and speed. Performs any necessary callout.
When the airplane pitch is back to normal.	• Levels the wings and resumes normal level flight.	• Reconfigures the airplane at PF command.

(1) If the airplane pitch is too high, consider:

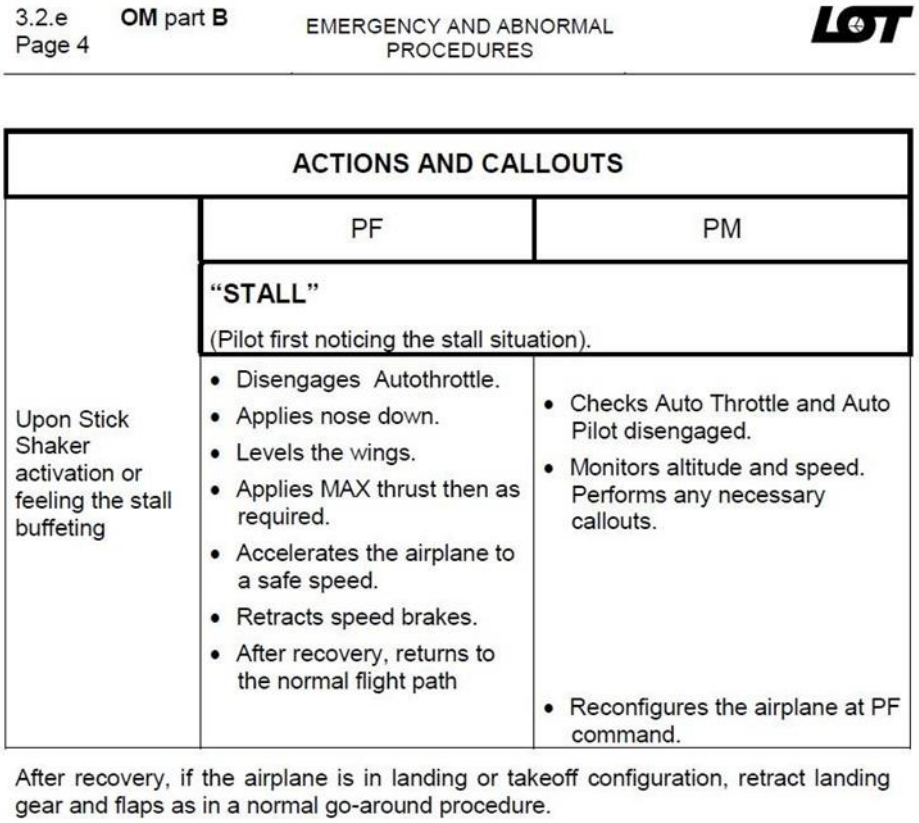
- Using pitch trim or reducing engine thrust to lower the nose;
- Banking the airplane 45° to 60°, or maintaining the bank angle if in a turn, until pitch angle is reduced, then level the wings.

Fig. 4. Description of Airplane upset conditions, and the division of actions between the PF and the PM during the Upset Recovery Manoeuvre. Source: PLL LOT's Operations Manual, part B, 3.2.i. page 5.

[3] An **airplane upset** is an undesired airplane state characterized by unintentional divergences from parameters normally experienced during operations. An airplane upset may involve pitch and/or bank angle divergences as well as inappropriate airspeeds for the conditions.
Deviations from the desired airplane state will become larger until action is taken to stop the divergence. Return to the desired airplane state can be achieved through natural airplane reaction to accelerations, auto-flight system response or pilot intervention.
Source: https://www.icao.int/safety/LOCI/AUPRTA/index.html [Accessed on: 22/10/2021].

1.6.5. Procedure: *Stall Recovery*

An extract from PLL LOT's Operations Manual, part B, regarding the division of actions and the standard phraseology in case of an aircraft stall is presented below.



3.2.e OM part B
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EMERGENCY AND ABNORMAL PROCEDURES

LOT

ACTIONS AND CALLOUTS		
	PF	PM
	"STALL" (Pilot first noticing the stall situation).	
Upon Stick Shaker activation or feeling the stall buffeting	• Disengages Autothrottle. • Applies nose down. • Levels the wings. • Applies MAX thrust then as required. • Accelerates the airplane to a safe speed. • Retracts speed brakes. • After recovery, returns to the normal flight path	• Checks Auto Throttle and Auto Pilot disengaged. • Monitors altitude and speed. Performs any necessary callouts. • Reconfigures the airplane at PF command.

After recovery, if the airplane is in landing or takeoff configuration, retract landing gear and flaps as in a normal go-around procedure.

Fig. 5. Division of actions between the PF and the PM during the Stall Recovery procedure.
Source: PLL LOT's Operations Manual, part B, 3.2.e. page 4.

1.7. Meteorological information

Based on the collected information about the weather conditions (www.ogimet.com) on the day of the occurrence on the Warsaw Chopin Airport (EPWA), which prevailed between 10:00 hrs UTC and 10:30 hrs UTC, the following was established:

METEO conditions at 10:00 hrs:

- Wind from the 230° direction, alternating from 190° to 270°, 10 kt speed.
- Visibility: above 10 km.
- Overcast: 1/8 - 2/8, cloud base: 2,700 ft.
- Temperature: +14° C.
- Dew point: +7° C.
- Pressure: 1,017 hPa.
- No significant changes expected.

METEO conditions at 10:30 hrs:

- Wind from the 240° direction, alternating from 190° to 280°, 11 kt speed, with gusts up to 21 kt.
- Visibility: above 10 km.

- Overcast: 1/8 - 2/8, cloud base: 3,200 ft.
- Temperature: +15° C.

- Dew point: +7° C.
- Pressure: 1,017 hPa.
- No significant changes expected.

METAR/SPECI from EPWA, Warsaw-Okęcie (Poland)		
SA	11/10/2019 10:30->	**METAR EPWA 111030Z 24011G21KT 190V280 9999 FEW032 15/07 Q1017 NOSIG=**
SA	11/10/2019 10:00->	**METAR EPWA 111000Z 23010KT 190V270 9999 FEW027 14/07 Q1017 NOSIG=**

1.8. Aids to navigation

Aid type, cat. ILS/MLS (declination for VOR/ILS/MLS)	ID	Frequency	Working hours	Transmitting antenna position coordinates (WGS-84)/	DME ELEV	Notes
DME	WA	CH40X	H24	52°09'24.4" N 020°58'22.7" E	120 m AMSL	Designated operational coverage: 25 NM (up to FL100)
DME	WAS	CH36X	H24	52°10'16.2" N 020°57'05.9" E	120 m AMSL	Designated operational coverage: 25 NM (up to FL100)
DVOR/DME (6°E/Nov 20)	OKC	113.450 MHz CH81Y	H24	52°10'11.1" N 020°57'36.2" E	120 m AMSL	Designated operational coverage: 80 NM (up to FL250)
DVOR/DME (5°E/Oct 05)	WAR	114.900 MHz CH96X	H24	52°15'33.3" N 020°39'25.8" E	90 m AMSL	Designated operational coverage: 150 NM (000°-090°), 80 NM (090°- 000°) - up to FL500
ILS GP	-	333,800 MHz	H24	52°10'16.2" N 020°57'05.9" E	…	Coverage acc. to Annex 10 ICAO volume I. RDH: 53 ft. GP 3.0°
ILS GP	-	335.000 MHz	H24	52°09'24.4" N 020°58'22.7" E	…	Coverage acc. to Annex 10 ICAO volume I. RDH: 54 ft. GP 3.0°
ILS LOC (6°E/Nov 20)	WAS		H24	52°09'38.2" N 020°59'07.5" E	…	Coverage acc. to Annex 10 ICAO volume I. CAT. II
ILS LOC (6°E/Nov 20)	WA	110.300 MHz	H24	52°10'50.0" N 020°57'15.0" E	…	Coverage acc. to Annex 10 ICAO volume I. CAT. III A

Tab. 1. EPWA aids to navigation aids
[source: https://www.ais.pansa.pl/aip/pliki/EP_AD_2_EPWA_en.pdf AIP Poland].

1.9. Communications

The crew maintained radio communication which did not affect the occurrence.

1.10. Aerodrome information

1.	**ARP - WGS-84 coordinates and aerodrome location** 52°09'57"N 020°58'02"E - Runway intersection.
2.	**Distance, direction from city** 10 km (5.4 NM) BRG 205° GEO
3.	**Aerodrome elevation/Reference temperature** 362 ft./27.8°C
4.	**Geoid undulation at the aerodrome elevation measurement point** 103 ft.
5.	**Magnetic declination and its annual correction** 6°E (2020)/ 9'E
6.	**Aerodrome administrator, address, telephone, fax, telex, AFS** Przedsiębiorstwo Państwowe "Porty Lotnicze" ul. Żwirki i Wigury 1 00-906 Warsaw +48-22-650-1555 (tel.) AFS: EPWAYDYX www.lotnisko-chopina.pl
7.	**Permitted air traffic (IFR/VFR)** IFR/VFR
8.	**Notes** Duty Officers Shift Manager: +48-22-650-1555 +48-22-846-1100 +48-22-650-1343 +48-22-650-1428 Customs Department: +48-22-650-3403 +48-22-650-2873 ATM Shift Manager: +48-22-574-5542, +48-81-452-5542 +48-22-574-5543, +48-81-452-5543 +48-22-574-7000, +48-81-452-7000 ACC: +48-22-574-7029, +48-81-452-7029 +48-22-574-5539, +48-81-452-5539 (fax) FMP: +48-22-574-5532, +48-81-452-5532 +48-22-574-7051, +48-81-452-7051 +48-22574-5539, +48-81-452-5539 (fax) APP: +48-22-574-5552, +48-81-452-5552 TWR Shift Manager: +48-22-574-5562, +48-81-452-5562 TWR: +48-22-574-5563, +48-81-452-5563 ARO: +48-22-574-7173, +48-81-452-7173 +48-22-574-7188, +48-81-452-7188 (fax) Brigade General Walerian Czuma Border Guard Outpost at Warsaw-Okęcie: +48-22- 650-2244 Aerodrome and Handling Fee Collection Booth: +48-22-650-3878 Medical Unit: +48-22-650-2444

Tab. 2. Aerodrome data
[source: https://www.ais.pansa.pl/aip/pliki/EP_AD_2_EPWA_en.pdf, AIP Poland].

1.11. Flight recorders

The Embraer ERJ-190-200LR aircraft was equipped with two Honeywell DVDRs (Digital Voice Data Recorders), featuring built-in cabin data and voice recorders (CVR). The CVR recordings were not secured.

The flight data were analysed with the use of adequate interpretation tools developed by Aerobytes (see paragraph 1.16). The flight course was established on this basis.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

The crew health raised no objections and did not affect the occurrence.

1.14. Fire

Fire did not occur.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

One of the investigation methods was an analysis of the recorded data. The data are acquired by the carrier from an external company named Aerobytes with registered seat in UK[4]. The carrier is using dedicated software to develop complete data (on the objective flight control) specifying flight parameters, instrument indications, positions of flight control surfaces, levers, switches and technical data of systems. The data can later be used to recreate the flight course and analyse specific settings of the auto-pilot's modes and the crew's actions.

1.17. Organizational and management information

Not investigated.

1.18. Additional information

None.

1.19. Useful or effective investigation techniques

Standard investigation techniques were applied.

2. ANALYSIS

The crew performed a standard, routine flight from EBBU to EPWA, which is a base aerodrome very well known to both pilots. The landing approach, completely stabilised at the altitudes of 1,000 ft. and 500 ft., gave the pilots a sense of comfort.

After receiving the landing clearance, the PF disengaged the auto-pilot and performed the further part of the approach manually. The low experience of the PF (519 FH on type) caused that the landing conditions were too difficult for him. When "countering" the crosswind and correcting the aircraft attitude, the pilot made an incorrect

[4] https://www.aerobytes.co.uk/ [Accessed: 22.10.2021].

assessment of the sink rate, which resulted in a hard landing. That error during landing and the PIC failure to properly monitor the PF response led to the aircraft bounce. The PM did not recognise a hazard and did not react timely to prevent the hard landing.

The plot based on the data recorded (Fig. 6) shows the moment of touchdown which took place with g-load of 1.96 g.

Following the aircraft bounce, the PF immediately made the Go-Around decision, but did not use the standard phraseology, thereby surprising the PIC, who needed some time to analyse the current situation.

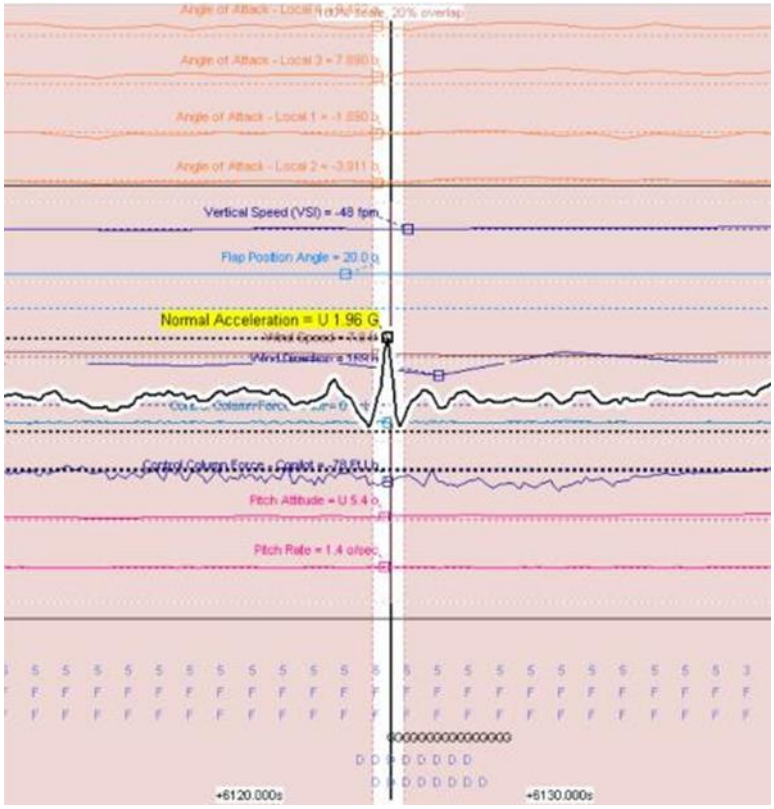


Fig. 6. Aerobytes screenshot.
Source: PLL LOT's Special Report of the EMB Fleet, page 2.

The procedure for the so-called "Bounced Landing" contained in the Operations Manual states that in such case it is necessary to push the TO/GA button, to increase engine thrust by moving the levers to the TO/GA position and set the trim accordingly.

BOUNCED LANDING RECOVERY

The key factor for a successful landing is a stabilized approach and proper thrust/flare coordination. Do not extend the flare at idle thrust as it will significantly increase landing distance. Reducing to idle before the flare will also require an increase in pitch. Flaring high and quickly reducing thrust to idle can cause the plane to settle abruptly. Do not apply stabilizer trim during the flare.

When a light bounce occurs, maintain or re-establish a normal landing attitude. Increasing pitch can lead to a tail strike. Beware of the increased landing distance and use power as required to soften the second touchdown. When a more severe bounce occurs, initiate a go-around – do not attempt to land. Press the go-around button and advance thrust levers to TOGA. Hold the flare attitude until the engines spool up and reset stabilizer trim, then follow normal go-around procedures.

Fig. 7. Procedure for Bounced landing recovery.

PLL LOT Operations Manual, part B, 2.1.i. page 4.

An analysis of the recorded data shows that the crew used the pitch trim only after initiating the Go-Around at the altitude of 3,000 ft. This is illustrated in the figure (Fig. 8). In the diagram bottom right corner, the green entry in red framing indicates the pitch trim activation.

Failure to change the pitch trim' setting in combination with the change in the aircraft configuration and increased engine thrust created conditions favourable for the increase in the aircraft positive pitch angle.

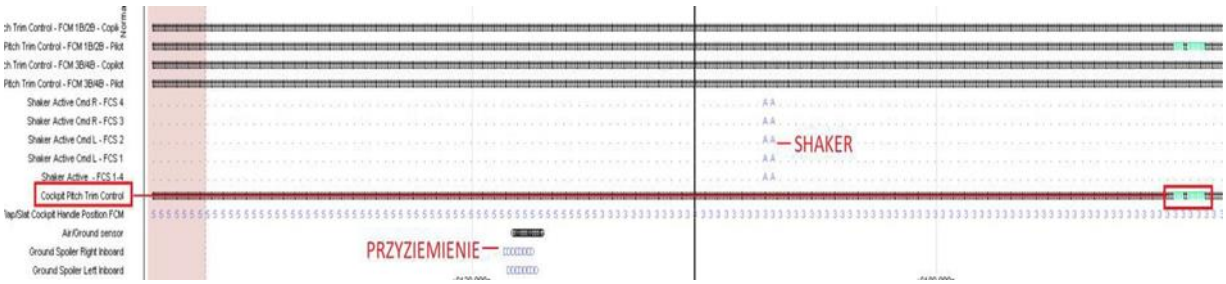


Fig. 8. Usage of pitch trim. Source: PLL LOT`s Special Report of the EMB Fleet, page 10.

The PF initiated execution the procedure contrary to the standards developed by the manufacturer and the airline. Failure to push the TO/GA button (excerpt from procedure below: item one: Go Around Button…PRESS) prevented the "Flight Guidance Control" system from generating standard "Flight Director" indications which would display the correct climb profile to the pilot. Additionally, the autothrottle disengaged automatically upon touchdown, in accordance with its logic.

GO-AROUND

Go Around button ..... PRESS

Thrust Levers ..... TOGA

Rotate or verify that autopilot rotates the airplane following the flight director guidance.

NOTE: In case of flight director is inoperative, rotate the airplane to 8° nose up.

Select flaps according to the table below:

Landing Slat/Flap	Go Around Slat/Flap
FULL	4
5	3

With positive climb:

Landing Gear ..... UP

Minimum Airspeed ..... V_{REF} + 20

At the acceleration altitude proceed as in a normal takeoff.

Fig. 9. Go-Around procedure.
Source: PLL LOT's Operations Manual, part B, 2.1.k. page 1.

Furthermore, the procedure applicable to the Go-Around manoeuvre without the "Flight Guidance Control" system indications was not executed. If the FGCS is inoperable, it is necessary to lift the aircraft nose to achieve the positive pitch angle of 8°. This information is specified in the Go-Around procedure - Fig. 9.

NOTE: In case of flight director is inoperative, rotate the airplane to 8° nose up.

The PF did not use standard callouts that are associated with the Go-Around procedure. In addition, the PM did not verify the correct position of the thrust lever. In Fig. 10 below, except from the operator documentation, specifying the division of duties as well as obligatory actions and callouts for the PF and PM. Actions not carried out correctly by the crew are shown in red frames.

NORMAL GO – AROUND/REJECTED LANDING - ACTIONS and CALLOUTS		
	PF	**PM**
Go-around	**"GO-AROUND, FLAPS___, CHECK THRUST"** • Press either TOGA switches. • Verify or move thrust levers to GA power. • Verify or rotate towards GA pitch attitude.	• Select GA flaps. • Verify thrust levers move to GA power check thrust. • Verify GA annunciates.
Positive Rate of Climb	• Confirm positive rate of climb. **"GEAR UP".** • Execute published missed approach or proceed as instructed by ATC.	• Verify positive rate of climb. **"POSITIVE RATE".** • Position gear lever up. • Monitor missed approach procedures.
At 400 ft AFE	**"HEADING/LNAV" (1)**	**"400"** • Select appropriate primary source • Select Lateral Mode • Advise ATC.

Fig. 10. Division of pilot's actions during the Go-Around procedure, including the standard callouts. Source: PLL LOT's Operations Manual, part B, 2.1.i. page 2.

Increased thrust resulted in increased positive pitch, which is characteristic to jet aircraft with engines positioned below the wings. In combination with the setting of the pitch trim (which remained at values set for landing) it caused the aircraft to commence a high rate of climb.

The crew's lack of reaction to the increasing positive pitch angle caused the aircraft to lose speed rapidly. The correct positive pitch angle during the initial Go-Around phase should be 8°. The quickly changing flight conditions made the PF, who had low experience, incapable of controlling the aircraft, which led to reaching the positive pitch angle of 32.2° and the vertical speed of 4,384 ft/min. This is illustrated in the plot below (Fig. 11), which is an excerpt from the objective flight control analysis in the Aerobytes system (value highlighted in yellow).

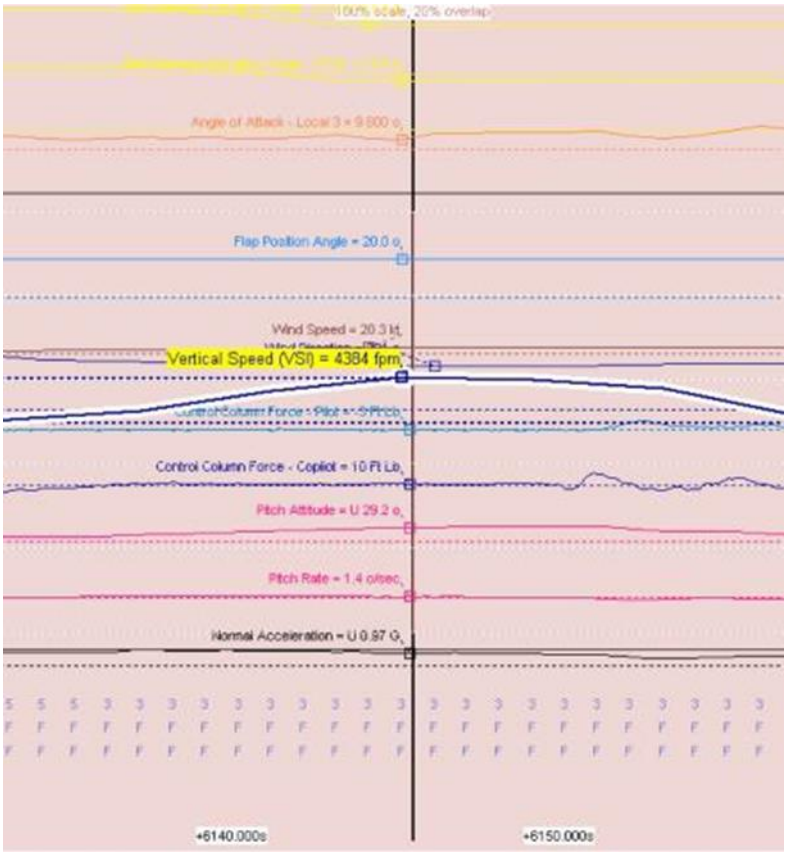


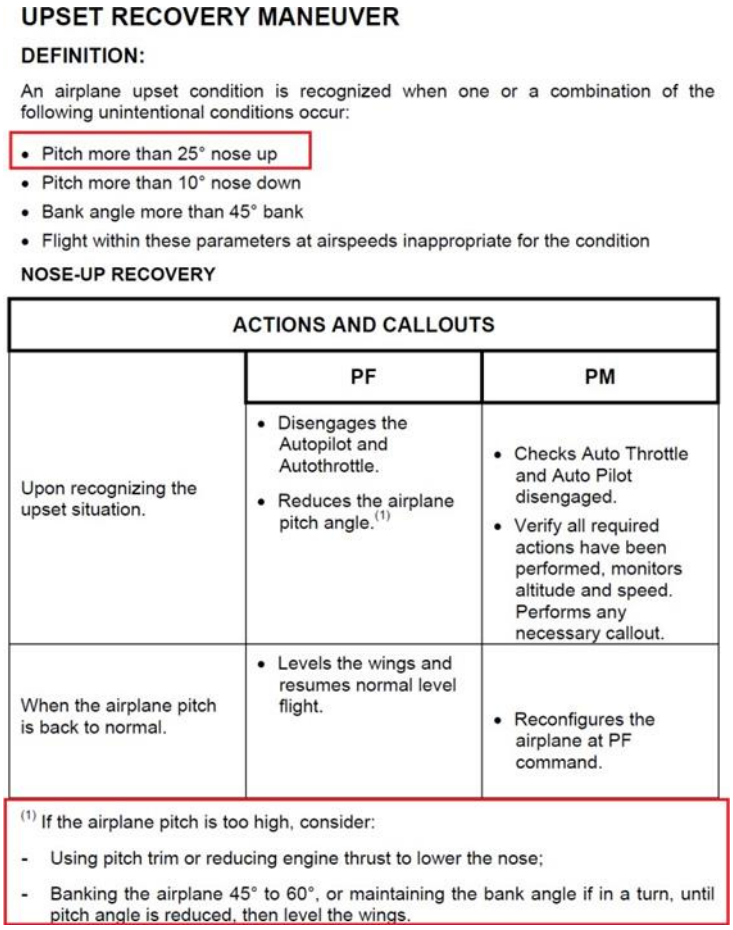
Fig. 11. Aerobytes screenshot. Source: PLL LOT`s Special Report of the EMB Fleet, page 3.

At that time, the Captain (PM) was changing the aircraft configuration (retracting the flaps and landing gear according to the Go-Around procedure) and responding to the air traffic controller who noticed the non-standard, rapid climb. By concentrating on his tasks as the PM, he did not notice timely the errors of the PF, which led to the substantial speed loss. The Captain reacted to the speed loss by increasing thrust. That action, in combination with the lack of reaction to the additional moment turning up the nose of the aircraft, led to an even greater positive pitch angle of the aircraft, which in turn caused an increase in the angle of attack[5], which resulted in a decrease in speed to 95 kt, - 42 kt lower than V Ref. At 1218 ft AGL, the "Low Speed Awareness" and "Stick shaker" were activated.

Within a short time, the crew found themselves in a more difficult situation, which directly endangered the flight safety. The Captain became directly involved in the aircraft control and in the “Upset Recovery” procedure. The manoeuvre was completed at the altitude of 1,044 ft. AGL (approx. 300 m). This procedure was not performed in accordance with typical standards specified in the carrier Operations manual. According to the entries presented in Fig. 12, if the flight is performed with a positive pitch angle of more than 25°, it is necessary to immediately apply the “Upset Recovery”

[5] Angle of attack – is the angle at which relative wind meets an aerofoil. It is the angle formed by the chord of the aerofoil and the direction of the relative wind or the vector representing the relative motion between the aircraft and the atmosphere.
[Accessed: 22.10.2021 https://skybrary.aero/articles/angle-attack-aoa].

procedure and use the pitch trim or thrust reduction to decrease the aircraft positive pitch angle. The crew reduced the thrust; however, the pitch angle was changing too slowly and too late to prevent speed loss and the “Stick shaker” activation.



UPSET RECOVERY MANEUVER

DEFINITION:

An airplane upset condition is recognized when one or a combination of the following unintentional conditions occur:

- Pitch more than 25° nose up
- Pitch more than 10° nose down
- Bank angle more than 45° bank
- Flight within these parameters at airspeeds inappropriate for the condition

NOSE-UP RECOVERY

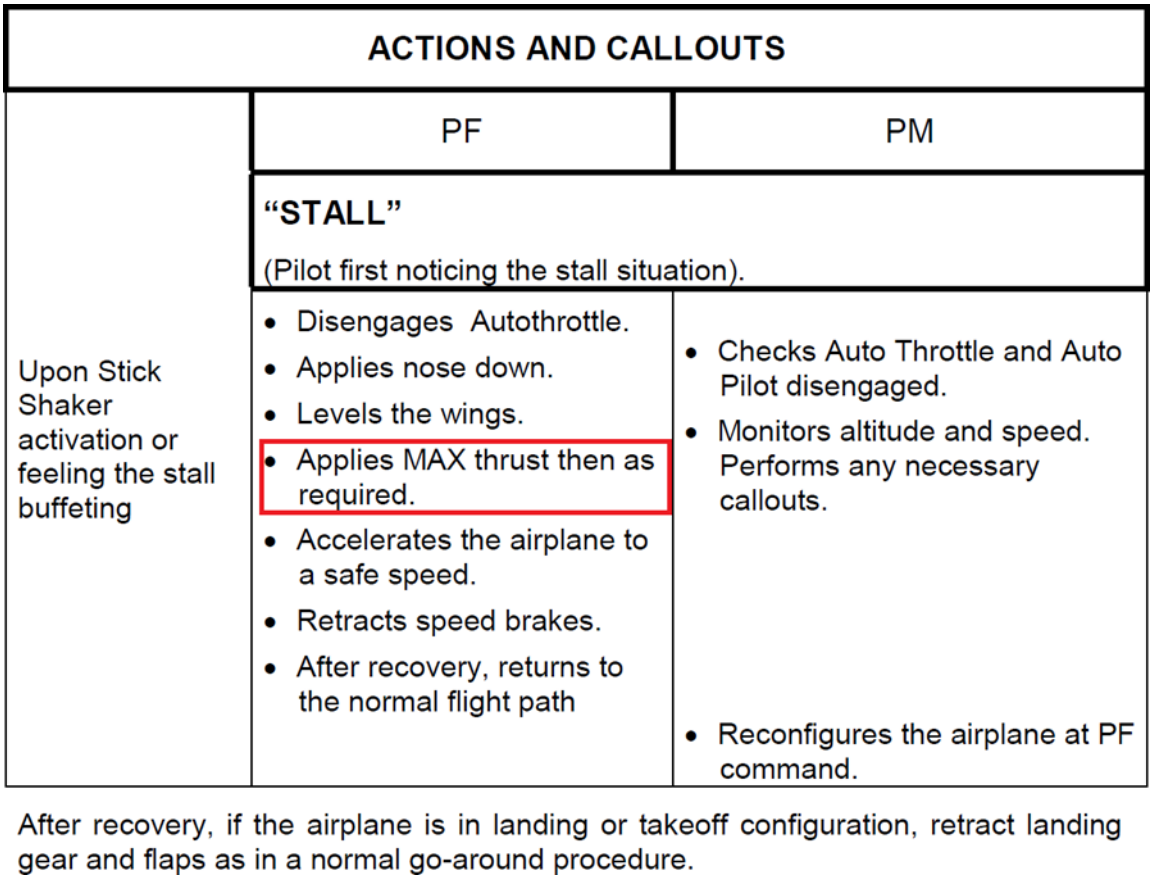
ACTIONS AND CALLOUTS		
	PF	**PM**
Upon recognizing the upset situation.	• Disengages the Autopilot and Autothrottle. • Reduces the airplane pitch angle.(1)	• Checks Auto Throttle and Auto Pilot disengaged. • Verify all required actions have been performed, monitors altitude and speed. Performs any necessary callout.
When the airplane pitch is back to normal.	• Levels the wings and resumes normal level flight.	• Reconfigures the airplane at PF command.

(1) If the airplane pitch is too high, consider:

- Using pitch trim or reducing engine thrust to lower the nose;
- Banking the airplane 45° to 60°, or maintaining the bank angle if in a turn, until pitch angle is reduced, then level the wings.

Fig. 12. Description of conditions favouring the occurrence of the so-called: Airplane upset conditions and the division of actions between the PF and the PM during the aircraft recovery (Upset Recovery Manoeuvre). Source: PLL LOT’s Operations Manual, part B, 3.2.i. page 5.

The crew could have reacted more firmly to prevent the “Stick shaker’s” activation. There is a “Stall recovery” procedure, which specifies that if the aforementioned conditions occur, it is necessary to decrease the pitch angle, maintain the wings in horizontal position (no bank), but most importantly use the engines full thrust (excerpt from the procedure in Fig. 13).



ACTIONS AND CALLOUTS		
	PF	PM
	"STALL" (Pilot first noticing the stall situation).	
Upon Stick Shaker activation or feeling the stall buffeting	• Disengages Autothrottle. • Applies nose down. • Levels the wings. • Applies MAX thrust then as required. • Accelerates the airplane to a safe speed. • Retracts speed brakes. • After recovery, returns to the normal flight path	• Checks Auto Throttle and Auto Pilot disengaged. • Monitors altitude and speed. Performs any necessary callouts. • Reconfigures the airplane at PF command.

After recovery, if the airplane is in landing or takeoff configuration, retract landing gear and flaps as in a normal go-around procedure.

Fig. 13. Division of actions between the PF and the PM during the Stall Recovery procedure. Source: PLL LOT's Operational Manual, part B, 3.2.i. page 4.

The analysis of the objective flight data monitoring showed that during the "Stall Recovery" procedure, the crew used the engine thrust necessary to carry out the "Go-Around" procedure. The crew set 75° TLA for engine #1 and 77° TLA for engine #2 accordingly, which correspond to N1: 87.1% for engine #1 and N1: 90.4% for engine #2 (diagram below in Fig. 10, which shows the thrust lever position in degrees, highlighted in yellow, and the cockpit screenshot: N1 in %). According to the aforementioned procedure, the pilots should use both engines' full thrust (MAX) during this manoeuvre (marked in red frame in Fig.13).

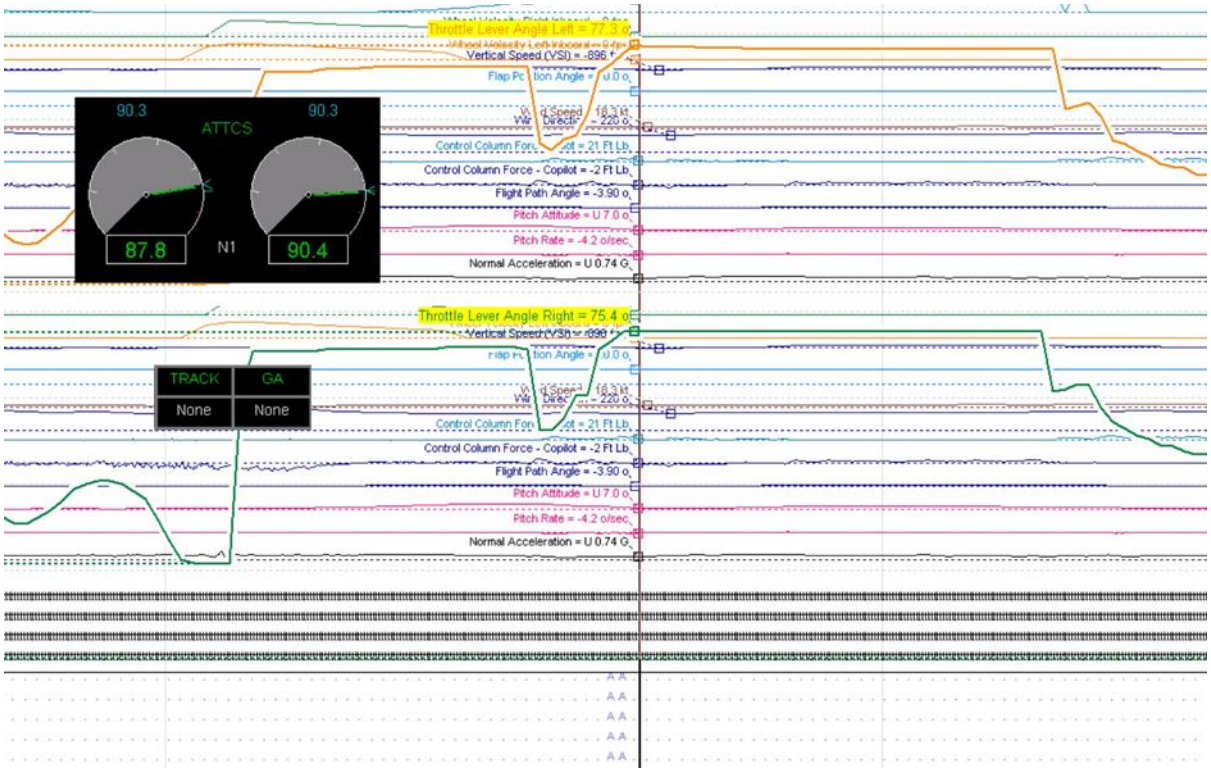


Fig. 14. Special Report of the EMB Fleet, page 12. Source: PLL LOT.

To illustrate this fully, Fig. 15 shows the thrust lever positions scaled up according to the setting angle.

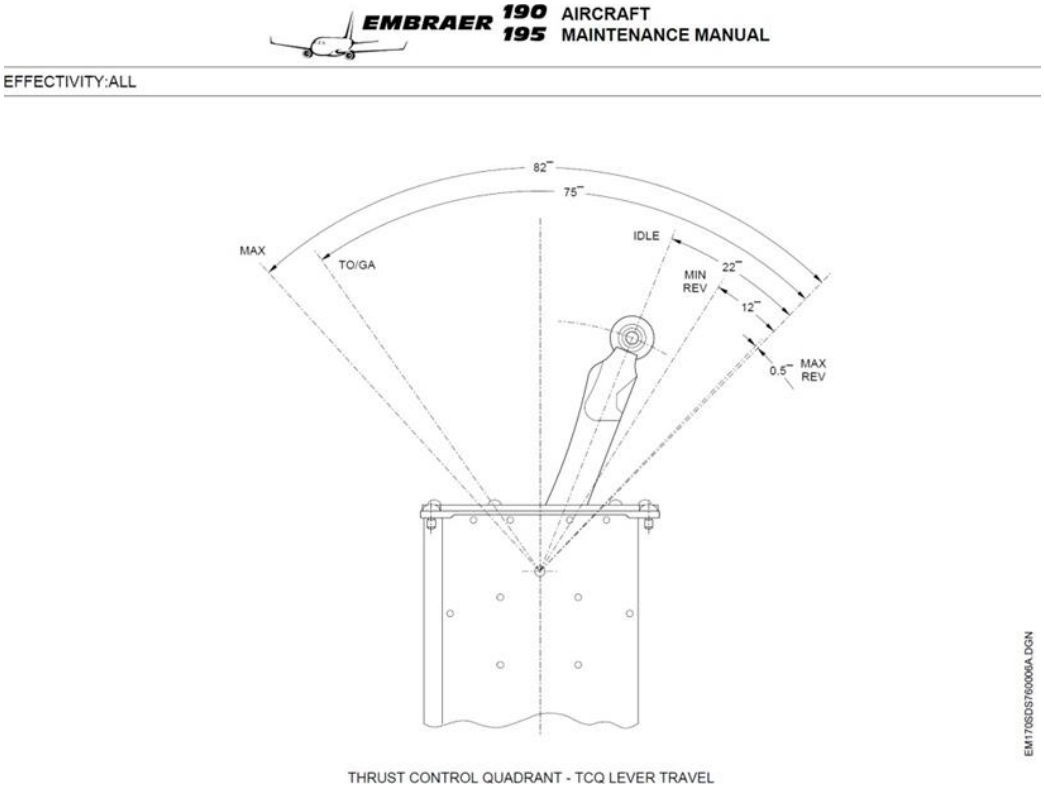


Fig. 15. Special Report of the EMB Fleet, page 13. Reprint from: Aircraft Maintenance Manual. Source: PLL LOT.

The crew was acting under time pressure and in dynamically changing conditions. The aircraft Captain, acting as the PM, took control over the aircraft, thereby preventing the standard division of tasks between the PF and PM.

An additional factor, which could potentially affect the pilot's performance, was the presence of a third crew member (stewardess) in the cockpit (during take-off and landing) according to the aircraft weight and balance document. Three other cabin crew members were present in the aircraft cabin, which is compliant with "ORO.CC.100, Number and composition of cabin crew"[6].

During the occurrence analysis, the operator provided information that the additional crew member was present in the cockpit due to the aircraft balancing aspects. At the Commission request, the LS AS company performed a balance simulation with data identical to the original version, i. e. 2 pilots in the cockpit and 4 cabin crew members in the cabin. One cabin crew member was assigned a seat in the last row. The simulation demonstrated that the balance parameters did not exceed the limit and it was possible to perform the flight in the 2/4 configuration.

When continuing the climb, pilots pushed the V/S mode ("vertical speed") on the auto-pilot panel several times. Due to the high climb rate, the V/S mode was automatically switching to the ASEL ("Altitude Select") operating mode. This mode is activated automatically, when the aircraft reaches the altitude pre-set on the autopilot panel. Information about this mode activation is displayed in green in the "FMA – Flight Mode Annunciator". The fact that the crew pushed the same mode several times indicates that their acquisition of information was impaired, which is typical for stressful situations. The second landing approach was uneventful.

3. CONCLUSIONS

3.1. Findings

1) Both pilots were performing their duties based on valid licenses, examinations and ratings obtained during trainings at PLL LOT.
2) Both pilots were current in training.
3) The FO acted as the Pilot Flying (PF).
4) PF had little experience with the Embraer aircraft.
5) The composition of the cockpit crew was non-standard.
6) The aircraft bounced off of the runway ("*Bounced landing*") during the landing.
7) The vertical acceleration during landing was 1.96 g.
8) The auto throttle was disengaged after touchdown in accordance with the system operating logic.
9) PF decided to perform the "*Go-Around*" procedure.
10) PF did not use the standard phraseology described in the Go-Around procedure: "*Go-Around, set flaps …, check thrust*".

[6] One cabin crew member per 50 passengers aboard the aircraft.

11) PF did not use the TO/GA button, which should initiate the Go-Around in accordance with the standard procedure described in the OM-B.
12) Failure to press the TO/GA button prevented the "*Flight Guidance Control System*" from displaying the correct indications.
13) PF increased the engine thrust to 72° TLA, while the engine thrust required for the "*Go-Around*" procedure was 75° TLA.
14) PF did not reset the pitch trim in accordance with the "*Bounced Landing Recovery*" procedure.
15) The Pilot Monitoring (Captain) (PM) reacted late to the non-compliances of the PF with the performed procedure and did not draw his attention to the matter.
16) PM incorrectly verified the thrust required for Go-Around procedure.
17) PM did not verify the auto-pilot modes that should be used during the Go-Around procedure.
18) During the climb as part of the "Go-Around" procedure (with no FGCS indications), the maximum pitch angle of +32.2° was recorded, while in the initial phase the angle should amount to +8°.
19) The lowest recorded speed during the go-around amounted to 95 kt, while it should amount to V Ref + 20kt, i.e. 137kt+20 kt = 157 kt.
20) The maximum climb rate recorded during the go-around manoeuvre was 4,384 ft/min.
21) The stall warning system was activated at the altitude of 1,440 ft. Then the thrust was increased to 75° TLA.
22) The stall warning system was deactivated at the altitude of 1,382 ft.
23) The engine thrust was not set to maximum ("wall" position) during the stall recovery manoeuvre.
24) The pressing on TO/GA button was recorded after the stall warning system was deactivated.
25) The further part of the flight was based on the "*Flight Guidance Control*" system indications.
26) In the second phase of climb, during the go-around, the V/S mode was activated by the crew several times, however it automatically switched to the ASE mode (in accordance with the system operating logic).
27) No personal or medical factors that could have affected the flight's course were identified.
28) The aircraft weight and centre of gravity were within the limits specified in the Flight.
29) FO did not inform the Captain about any aircraft control issues that exceeded the FO capabilities.
30) PIC did not identify timely the problems faced by FO.
31) PIC did not identify timely the potential hazard and the FO problems during touchdown and did not take over control of the aircraft.
32) PF did not carry out the actions specified in the "*Bounced landing recovery*" procedure.

33) PF did not carry out the "*Go-Around*" procedure in accordance with the standards.
34) PF did not react to the rapidly increasing positive pitch angle.
35) PF did not carry out the "*Stall Recovery*" procedure properly.
36) PF did not carry out the "*Upset Recover Manoeuvre*" properly.
37) PM did not recognise timely the irregularities in the procedures.
38) PM (PIC) became involved in the aircraft control too late.

3.2. Causes of the serious incident

1) **Incorrect execution of the "Bounced Landing Recovery" and "Go-Around" procedures.**
2) **Delayed reaction of the Pilot Monitoring to the errors made by the Pilot Flying during landing and Go-Around.**

3.3. Contributing factors

1) **Weather conditions (gusty crosswind).**
2) **Aircraft control error during landing.**
3) **Low experience of the FO.**
4) **Failure to follow standard procedures during the "*Bounced Landing Recovery*" and "*Go-Around*".**
5) **Lack of proper cooperation in the crew.**
6) **Incorrect application of the "*Stall Recovery*" procedure.**
7) **Incorrect execution of the "*Upset Recover Manoeuvre*".**

4. SAFETY RECOMMENDATIONS

After getting acquainted with the materials collected during the investigation, the State Commission on Aircraft Accidents Investigation proposed the following safety recommendations for the carrier:

Recommendation no. 2019/4685-1

Revise the simulator training program regarding procedure: "Bounced Landing Recovery".

Recommendation no. 2019/4685-2

Revise the simulator training program regarding stall recovery at low altitudes.

Recommendation no. 2019/4685-3

Introduce an obligation that FO experience in flying the given aircraft type must be communicated to a Captain – if the flight time is less than 500 hours FO should be treated as inexperienced.

Recommendation no. 2019/4685-4

Introduce a limit for inexperienced FO to land with a crosswind: 1/2 of the maximum crosswind component for a given aircraft type.

5. ANNEXES

None.

THE END

Investigator-in-Charge

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Signature on original