Federal Safety Investigation
Authority

Final report

Serious incident involving aircraft type EMB195,
on October 27, 2017 at approximately 15:35 UTC during the approach to
Salzburg Airport Ref no.: 2021-0.534.000

Vienna, 2021

Content

Preamble

The safety investigation took place in accordance with Regulation (EU) No. 996/2010 and the Accident Investigation Act (UUG), Federal Law Gazette I No. 123/2005, as amended.

The sole purpose of the safety investigation is to prevent future accidents and incidents. Investigation of the causes does not imply any determination of culpability or any administrative, civil, or criminal liability (Regulation (EU) No. 996/2010 Art. 2).

Unless stated otherwise, the safety recommendations are directed at bodies in a position to implement these recommendations in the form of suitable actions. Decisions to implement these safety recommendations will be at the discretion of such bodies.

The scope of the safety investigation and the methodology to be applied when performing the safety investigation will be set out by the Federal Safety Investigation Authority, taking into account the lessons it expects to learn from the investigation for the improvement of flight safety (Regulation (EU) No. 996/2010 Art. 5).

Unless stated otherwise, safety recommendations are directed at those bodies that can implement the safety recommendations in the form of suitable measures. The decision regarding implementation of safety recommendations lies with these bodies.

To preserve the anonymity of all persons involved in the incident, the report is subject to restrictions in terms of content.

All times stated in this report are UTC (local time = UTC + 2 hours).

This is a courtesy translation of the final report on the safety investigation. As accurate as the translation may be, the original text in German is the work of reference.

Note

The scope of the safety investigation and the methodology to be applied when performing the safety investigation will be set out by the Federal Safety Investigation Authority, taking into account the lessons it expects to learn from the investigation for the improvement of flight safety.
Regulation (EU) No. 996/2010 Art. 5

Investigation of the causes does not imply any determination of culpability or any administrative, civil, or criminal liability. Regulation (EU) No. 996/2010 Art. 2.

Note on persons in photographs:

The photographs of objects and locations included in this report may show persons that may be uninvolved or involved with investigations into the accident or with recovery and possibly anonymized. The colours of clothing worn by these persons (e.g. luminous reflective vests) were digitally retouched as needed (e.g. greyed) since colours may distract from the purpose of the illustrations.

Introduction

Aircraft operator:	Air carrier
Operation type:	Scheduled flight based on instrument flight rules (IFR)
Aircraft manufacturer:	Empresa Brasileira de Aeronáutica S.A., Brazil
Type designation:	E195
Aircraft type:	Fixed-wing airplane
Nationality:	Austrian
Location of incident:	On approach to runway 15 in Salzburg, approximately 2.3 NM from the runway.
Coordinates (WGS84):	N 47°50‘, E 12°59‘
Altitude:	Approximately 2140 ft
Date and time:	October 27, 2017, approximately 15:35 UTC

The Civil Aviation Section of the Federal Safety Investigation Authority was informed in writing on October 27, 2017 by the operator of the aircraft via a message in accordance with the notification ordinance that there was "*windshear at 1300 ft. Performed escape maneuver and missed approach. Entered holding overhead SBG VOR. Waited for weather improvement. Second approach was successful.*".

On January 17, 2018, the air carrier reported "*stick shaker activation for 1-3 seconds during windshear escape procedure.*" After this message had been compared with the notification received on October 30, 2017, it became clear that these two messages referred to the same flight, although their timing and content were different.

Following consultation with the air carrier, it became clear that their Safety department had already performed an internal investigation. This was carried out using data that had not been made available to the Safety Investigation Authority at this time. However, since this information is now available, the Safety Investigation Authority initiated a safety investigation pursuant to Art. 5 (1) of Regulation (EU) No. 996/2010.

Pursuant to Art. 9 (2) of Regulation (EU) No. 996/2010, the states involved were informed of the incident:

State of manufacture:	Brazil (aircraft) United States of America (engines)
State of operator:	Republic of Austria
State of air carrier:	Republic of Austria

Brief description

During the ILS approach to runway 15 at Salzburg Airport, a windshear caution was displayed by the onboard system approximately 2.3 NM from the runway threshold at approximately 15:35 UTC. As the pilot in control, the PF took the decision to pull up. However, since neither of the two TOGA-switches were pressed, the autothrottle system reduced the power again. Due to the high pitch angle and the continuous reduction in speed, a stall warning was issued by the onboard system. Since the autothrottle system remained in Speed mode, even following the stall warning, only a very flat climb was achieved in the first phase of the missed approach procedure. Not until around 73 seconds after the windshear caution was one of the two TOGA-switches pressed, causing the power of the two engines to increase again and thereby allowing a regular climb to be achieved.

Following the missed approach procedure, two holding patterns were flown, and the aircraft then landed safely in Salzburg on runway 15 at approximately 16:01 UTC.

1 Factual Information

1.1 Events and history of the flight

The flight trajectory and the course of events resulting in the incident were reconstructed as follows on the basis of the statements submitted by the two pilots, available recorded data from the aircraft, documentation of the air carrier (as well as its Safety department) in connection with the investigations of the Federal Safety Investigation Authority:

The scheduled flight with aircraft type EMB195 was a return flight from Frankfurt to Salzburg. It was the second flight of the day for the cockpit crew. The PF and PM flew together for the first time the previous day. The outbound flight from Salzburg to Frankfurt was completed without incident. Due to the weather conditions, the two pilots discussed the windshear procedure for the return flight in Frankfurt prior to taking off. During the flight from Frankfurt to Salzburg, the aircraft was routed toward Salzburg VOR via radar vectoring with heading instructions while in the Munich area. The aircraft was controlled via autopilot and the autothrottle system. Beside the PF and the PM, one trainee pilot from the air carrier was also in the cockpit. However, this trainee pilot was not on duty, but rather on board as a passenger.

The cockpit crew observed storm cells in the Salzburg area during the flight. As the tail-wind component was potentially too high for a landing on runway 15, the cockpit crew also discussed a circling approach with subsequent landing on runway 33, although this was ultimately not necessary.

During the ILS approach to runway 15, the aircraft passed through heavy rain showers, which caused a high noise level in the cockpit. The pilots had not been given any advance warning of the risk of windshear during the approach either via ATIS or via radio communication with air traffic control. The rain showers were extremely intensive, so the windshield wipers were set to MAX.

During the approach, the SPEED selector knob was set to MANUAL. The Vref reference speed was determined as 125 kts using EFRAS 3. Gusts increased this by 5 kts to 130 kts. The speedbug recorded 146 kts at approximately 2660 ft MSL. However, this was reduced back down to 130 kts some 12 seconds later.

During the approach, the aircraft was controlled using the HGS (Head-up Guidance System) and stabilized in accordance with the OM-B stipulations of the air carrier. At approximately 2400 ft MSL (approximately 1000 ft HAT), the aircraft suddenly experienced a tail-wind component of 24 kts. The autopilot was switched off at approximately 15:35 UTC.

One second later, at an altitude of approximately 2130 ft MSL and a distance from runway 15 of approximately 2.3 NM, a windshear caution with a duration of 8 seconds was triggered by the onboard system due to the tail-wind component suddenly falling to 4 kts.

The windshear caution came as a surprise to both pilots. Based on the windshear caution being displayed in the cockpit, the PM called out "windshear", which was then confirmed by the PF. Four seconds after the windshear, the lowest altitude during the approach was reached at approximately 2060 ft MSL (approximately 650 ft or approximately 198 m HAT). Six seconds after the windshear, the speedbug was raised to 133 kts.

The PF took the decision to pull up and initiated a missed approach procedure.

During the go-around, the PF moved the two power levers forward up to a throttle lever angle (TLA) of 74.9°/75.3° (left/right), then removed his right hand from the thrust levers, pulled back on the stick with both hands and initiated the climb. Runway 15 at Salzburg Airport (LOWS) was located in front of the aircraft and angled to the right at this point in time.

At this time, the two pilots believed that the power levers had been moved far enough forward and that TOGA-mode had been engaged.

However, since this was not actually the case, the Automatic Takeoff Thrust Control System (ATTCS) was also not activated. The autothrottle system therefore remained activated in Speed mode and moved back the two power levers that had previously been moved forward in order to maintain the set speed Vref of 130 respectively 133 KIAS.

Since the pitch angle was increased up to 14 degrees and the power was reduced again by the autothrottle system, the speed of the aircraft decreased to 113 KIAS. This configuration and the aircraft situation, in combination with the increased G-load, triggered a stall warning (stick shaker) for 2 seconds some 15 seconds after the windshear caution.

The flaps were moved back to position 4 some 42 seconds after the windshear caution at an altitude of approximately 1110 ft above the airport.

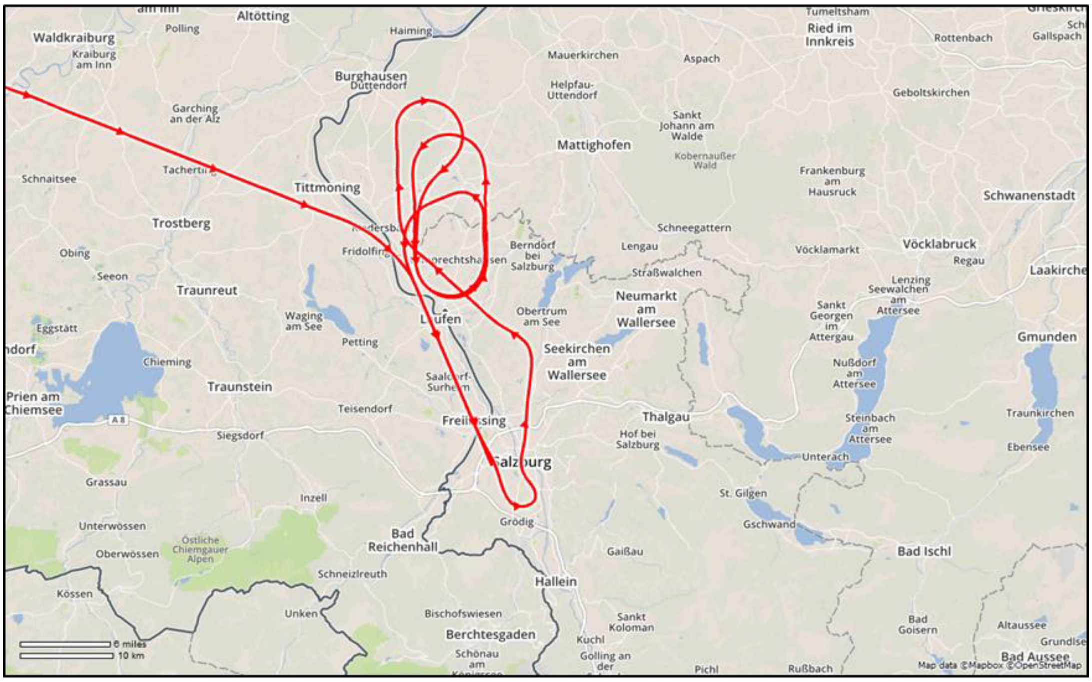
A further 10 seconds later, the landing gear was retracted at an altitude of approximately 2590 ft MSL (approximately 1180 ft HAT).

The TOGA-procedure was only initiated some 73 seconds after the windshear caution. TOGA-mode triggered increased thrust to the ATCCS value of 87.9% N1. Some 103 seconds after the windshear caution, navigation mode LNAV was selected at a DME display of approximately 2.1 NM. A further 6 seconds later, the left turn of the missed approach procedure was initiated/flown at an altitude of approximately 4100 ft MSL and DME display of approximately 2.3 NM (instead of 2.0 NM), so somewhat delayed.

As a consequence of this, the PF directed the aircraft to 10,000 ft MSL and flew two holding patterns above VOR Salzburg.

The second approach and the landing on runway 15 at Salzburg Airport (LOWS) took place at approximately 16:01 UTC without any further issues/incidents.

Figure 1: Flight path



Source: Safety Investigation Authority (SUB)

1.1.1 Flight preparation

The flight preparation required pursuant to EU Regulation 923/2012 Appendix SERA.2010/b, as amended, was performed and could be demonstrated.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Others
Fatal			
Severe			
None	2 cockpit + 3 cabin	97	

1.3 Damage to aircraft

The aircraft did not suffer any damage.

1.4 Other damage

No further damage occurred.

1.5 Personnel information

1.5.1 Pilot

Age:	44 years
Gender:	Male
Type of civil aviation license:	Pilot's license for scheduled flights
Authorizations:	Fixed-wing airplane piloting
Model/type rating:	EMB 170 *)
Instrument rating:	Yes
Instructor license:	F70/F100
Other authorizations:	TRE F70/F100
Validity:	Valid on the day of the serious incident

Checks:

Medical check:	Medical Class 1/2/LAPL issued on October 5, 2017
Refresher training (simulator):	June 1, 2017
Operator proficiency check:	June 2, 2017
CRM-Recurrent Ground Training:	March 20, 2017 (without surprise and startle effect module)
CRM-Recurrent Ground Training:	February 2, 2015 (with surprise and startle effect module)

Overall flight experience (including serious incident flight):	Approximately 15,000 hours
Of which in the last 90 days:	169:20 hours, of which 20 hours in the simulator
Of which in the last 30 days:	42:54 hours, of which 20 hours in the simulator
Of which in the last 24 hours:	05:24 hours

Flight experience on EMB170:	595:24 hours, of which 195 hours in the simulator
On-duty time:	
On-duty time up to the serious Incident flight:	4:00 hours (including 1 hour before 1st flight)
Rest period before the serious incident flight:	14:16 hours (including 30 minutes after the previous flight)

*) Remark:
The license entry is made with the designation "EMB170".

It covers the following types:	ERJ 170-100 (Embraer 170)
	ERJ 170-200 (Embraer 175)
	ERJ 190-100 (Embraer 190, Lineage)
	ERJ 190-200 (Embraer 195 / E95)

1.5.2 Co-pilot

Age:	24 years
Gender:	Male
Type of civil aviation license:	License for pilots with multi-member flight crews
Authorizations:	Fixed-wing airplane
Model/type rating:	EMB170*) (first flight on June 19, 2017)
Instrument rating:	Yes
Instructor license:	None
Other authorizations:	None
Validity:	Valid on the day of the serious incident
Checks:	
Medical check (Class 1):	August 9, 2017
Refresher training (simulator):	September 22, 2017
Operator Proficiency Check:	September 23, 2017
Competence Line Check:	September 10, 2017
CRM-Recurrent Ground Training:	January 5, 2017 (with surprise and startle effect module)

Overall flight experience (including serious incident flight)	34:51 hours in gliders 450:46 hours in powered aircraft
Of which in the last 90 days:	193:32 hours, of which 12 hours in the simulator
Of which in the last 30 days:	60:31 hours
Of which in the last 24 hours:	5:24 hours
Flight experience on EMB170:	359:53 hours, of which 77 hours in the simulator
On-duty time:	
On-duty time up to the serious incident:	4:00 hours (including 1 hour before 1st flight)
Rest period before the serious incident flight :	14:16 hours (including 30 minutes after the previous flight)

*) Remark:

The license entry is made with the designation "EMB170".

It covers the following types:	ERJ 170-100 (Embraer 170)
	ERJ 170-200 (Embraer 175)
	ERJ 190-100 (Embraer 190, Lineage)
	ERJ 190-200 (Embraer 195 / E95)

1.5.3 Practical training and checks

After acquiring the type rating, the cockpit crew completed the following training courses and check flights (if evident in the records, it was also noted whether the windshear procedures were completed):

Table 2: Training courses and checks - Pilot

Training courses and checks - Pilot					
Date	**Training / type of check**	**Type**	**Sim / aircraft**	**Result / excerpts**	**Remarks**
June 12, 2015	OPC	F100	Sim AAA	Pass;	No windshear
August 11, 2015	Recurrent Line Check	F70/100	OE-XXX	STD; Very smart appearance, good overall performance	
December 15, 2015	Refresher Training Autumn 2015	F100	Sim AAA		Windshear pilot response and crew coord.
January 22, 2016	OPC+RH	F100	Sim AAA	Pass; Excellent support of the PNF; Good performance	No windshear
June 21, 2016	LPC+OPC+RH	F100	Sim AAA	Pass; Calm cooperation, excellent performance; FORDEC+NITS applied;	No windshear
September 14, 2016	Recurrent Line Check	F70/100	OE-XXX	HS; Very professional CRM,	
December 8, 2016	FFS3	EMB195	Sim AAA	Safe flown Windshear escape maneuvers	Windshear reactions and procedures during T/O and approach phase
December 12, 2016	FFS5A	EMB195	Sim AAA	Good overview, quick perception, calm, good CRM	Go-around due to Windshear on short final
March 31, 2017	Competence Line Check	EMB195	OE-XXX	HS; Great airmanship, good leadership,	
June 1, 2017	Refresher Training Autom 2016	EMB195	Sim VIE	Passed	No windshear
June 2, 2017	OPC	EMB195	Sim VIE	Pass; Professional; Impeccable support of the PF; Good leadership; communicates goals;	No windshear
December 5, 2017	Refresher Training	EMB195	Sim VIE	Passed	No windshear, would have been PCK2/REF2 in 3Y Autumn

December 6, 2017	LPC+OPC1, Spring 2017	EMB195	Sim VIE	Good PM-work, Very nice CRM	No windshear

Source: Air carrier

Table 3: Training courses and checks - Copilot

Training courses and checks - Copilot				
Date	**Training / type of check**	**Sim/Aircraft, Flight**	**Result / excerpts**	**Remarks**
April 29, 2017	FFS4	Sim 4	Passed	Windshear take off No. 4, 200ft moderate
May 5, 2017	FFS7	Sim 7	Passed	Take off Windshear mod Criteria 200ft, before landing Windshear mod criteria 200ft, before landing Windshear criteria flaps full, <300ft
September 10, 2017	Competence Line Check	LOWW, LIBD, LIRN	HS; Good decision making; good application of all SOP; Helpful in adverse WX-condition	
September 22, 2017	Refresher Training Spring 2017	Sim, LFT VIE		
September 23, 2017	OPC/1 Spring 2017	Sim, LFT VIE	HS; Very good and calm, very good SA and decision making, Very good leadership, always calm,	No windshear
November 9, 2017	Competence Line Check	OE-LWN; LOWW, UDYZ	HS, Correct application of SOPs, good knowledge,	Would have been PCK2/REF2 in 3Y fall.
May 31, 2018	OPC	Sim	Passed	No windshear

Source: Air carrier

Both the PF and the PM have only flown the windshear procedure on EMB195 during type training (PF: at the end of 2016).

1.5.4 Theoretical training courses

The air carrier conducts courses for the cockpit and cabin crew via its crew resource management operations. The elements to be completed are divided into phases over 3 years.
In the current OM-D, special reference is made to the "surprise and startle effect". This also goes into detail regarding "management of abnormal and emergency situations" with "recognizing the loss and rebuilding situation awareness and control".

CRM-Training Pilot (pilot)

As per OM-D Part 1, 2.2.7.; AR-CRM, Annual Joint Recurrent Training/Classroom

Table 4: Crew Ressource Management Training - Pilot

Date, duration	Course location, host	CRM-elements Pilot (Pilot)
February 2, 2015 3:15 hours	Vienna International Airport, Schwechat XXX XXX	Threat and Error Management, Personality awareness, human error and reliability, attitudes and behaviors, self-assessment and self-critique, Assertiveness, situation awareness, information acquisition and processing, Automation and philosophy on the use of automation, Specific type related differences, Monitoring and intervention, Shared situation awareness, shared information acquisition and processing, Surprise and Startle Effect, Cultural Differences
March 16, 2016 3:15 hours	Vienna International Airport, Schwechat XXX XXX	Human Factors in aviation, Human performance and limitations, Fatigue and Vigilance, Automation and philosophy on the use of automation, Specific type related differences, Workload Management, Effective communication and coordination inside and outside the flight crew compartment, Resilience Development, Operator safety culture, standard operating procedures (SOPs)
March 20, 2017 3:15 hours	Vienna International Airport, Schwechat XXX XXX	General instructions on CRM principles and objectives, Stress and stress management, Leadership, cooperation, synergy, delegation, decision making, actions, Organisational factors, factors linked to the type of operations, Effective communication and coordination with other operational personnel and ground services

February 19, 2018 **3:15 hours**	Vienna International Airport, Schwechat XXX XXX	"Surprise and startle effect" gem. AMC1 ORO.FC.115.f.4. Human performance and limitations, Threat and Error Management, Stress and stress management, Workload Management, Resilience Development, Operators safety culture and company culture, SOP's, organizational factors, factors linked to the type of operations

Source: Air carrier

As per OM-D Part 1, 2.2.8. FC-PMT, Pilot's Modular Recurrent Training/Classroom

Table 5: Pilot's Modular Reccurrent Training - Pilot

Date Duration	Course location, Host	CRM-elements Pilot (Pilot)
February 19, 2015 **February 20, 2015** **2 days**	Hotel XXX XXX XXX	"Surprise and startle effect" gem.AMC1 ORO.FC.115.f.4. Why CRM? TEM, NOTECHS, Group Think, Case Studies, Feedback
February 1, 2018 **February 2, 2018** **2 days**	Hotel XXX XXX XXX	Case Study Lugano (SHELL Model), Resilience, Situational Awareness, Monitoring & Intervention, Automation, Health Management

Source: Air carrier

CRM Training Copilot

As per OM-D Part 1, 2.2.5. FC-OCO Operator Conversion Training when Changing Operator/Classroom.

Table 6: Crew Ressource Management Training - Copilot

Date Duration	Course location Host	CRM-elements Copilot
January 5, 2017 **7:00**	Vienna International Airport, Schwechat	"Surprise and startle effect" gem. AMC1 ORO.FC.115.f.4.

	XXX XXX	NOTECHS, Operational Debriefing, Threat and Error Management, Case Study, Complacency, Cultural Differences, Operators Safety Culture, Leadership - Followership.

Source: Air carrier

As per OM-D Part 1, 2.2.7.; AR-CRM, Annual Joint Recurrent Training/Classroom.

Table 7 Annual Joint Recurrent Training - Copilot

Date Duration	Course location, Host	CRM-elements Copilot
March 5, 2018 **3:15**	Vienna International Airport, Schwechat XXX XXX	"Surprise and startle effect" gem. AMC1 ORO.FC.115.f.4. Human performance and limitations, Threat and Error Management, Stress and stress management, Workload Management, Resilience Development, Operators safety culture and company culture, SOP's, organizational factors, factors linked to the type of operations.

Source: Air carrier

1.6 Aircraft information

Figure 2: Embraer 195

Source: https://www.embraercommercialaviation.com/commercial-jets/e195/

Aircraft type: Powered aircraft

Aircraft category: Large Aeroplane

Manufacturer: Empresa Brasileira de Aeronáutica S.A., Brazil

Manufacturer's designation:	Embraer 195
Approach category:	C
Year of manufacture:	2012
Aircraft operator:	Air carrier
Total operating hours:	13.335:13
Landings:	11683
Engine:	Twin-jet engine
Manufacturer:	General Electric Company
Manufacturer's designation:	CF34-10E5A1

1.6.1 Aircraft documents

Certificate of registration:	Issued by Austro Control GmbH on August 3, 2016
Airworthiness certificate:	Issued by Austro Control GmbH on August 31, 2016
Airworthiness review certificate (ARC):	Issued by Austro Control GmbH on February 23, 2017
Aircraft noise certificate:	Issued by Austro Control GmbH on October 20, 2016
Insurance:	Issued on October 23, 2018, valid on the day of the incident
Permit for an aircraft radio communication system:	Issued on July 20, 2016 by the Telecommunications Office for Vienna, Lower Austria and Burgenland

1.6.2 Aircraft maintenance and airworthiness

The last maintenance work on the aircraft was performed in the course of a daily check on October 25, 2017 at 13322 total operating hours and 11622 landings. The last A check (A01) was performed on September 27, 2017 at 13108 total operating hours and 11443 landings.

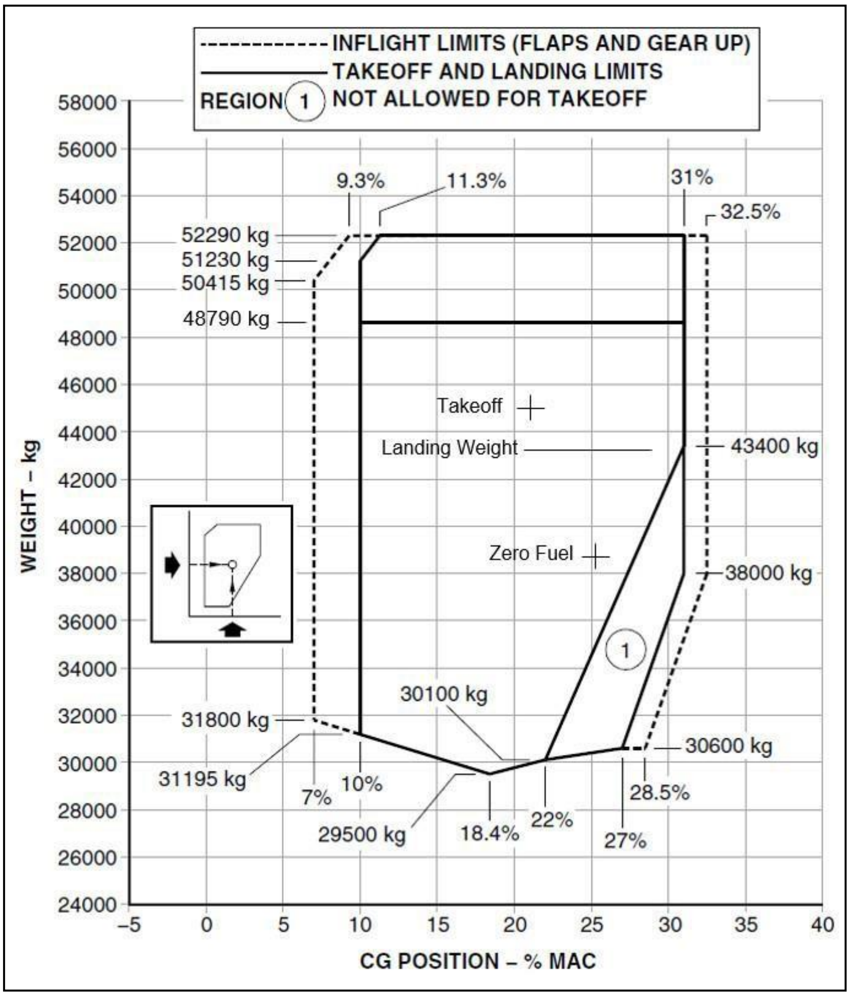
The last airworthiness check was performed on February 23, 2017. At the time of the serious incident, all stipulated maintenance work had been performed and there were no open points on the aircraft's hold item list.

1.6.3 Aircraft loading and centre of gravity

A calculation of the aircraft's cargo and centre of gravity was performed by the operator of the aircraft using the loading plan and was subsequently checked by the pilots. All values were within permitted operating limits throughout the entire flight. According to loading plan, the aircraft's cargo was as follows:

DOW	29.867	DOI	54,00
Load	8856	ULD	1.577
ZFW	38.723	Max	42.500
TOF	6280	TIF	1.520
TOW	45.003	Max	48.790
LDW	43.423	Max	45.000
LIZFW	64, 00	(FWD 38, 13 AFT 71, 31)	
LITOW	55, 00	(FWD 26, 83 AFT 75, 87)	
MACZFW	25, 10%	MACTOW 21, 40%	

Figure 3: Calculation of the centre of gravity



Source: Safety Investigation Authority (SUB)

According to the loading plan and AFM, both the mass and the centre of gravity were within permitted limits at all times throughout the flight.

1.7 Meteorological information

1.7.1 METAR, Austro Control GmbH aviation weather service

Weather at LOWS:

METAR

1420Z 22011KT 9999 VCSH FEW015 SCT040 BKN070 08/04 Q1024 TEMPO SHRA=

1450Z 22007KT 9999 FEW013 FEW030CB SCT038 BKN050 09/05 Q1024 TEMPO SHRA=

1520Z 25004KT 210V280 9999 FEW028 FEW030CB SCT050 BKN060 09/05 Q1024 TEMPO 4000 TSRA=

1550Z 31016G28KT 260V340 9999 SHRA FEW003 SCT026 FEW030CB BKN036 07/05 Q1025 RETS BECMG NSW=

1620Z 28011KT 250V310 8000 SHRA FEW010 SCT024 BKN032 06/05 Q1026 BECMG NSW=

TAF

1115 TAF LOWS XX1115Z 2712/2812 33008KT 9999 -SHRA SCT020 BKN040 TX10/2812Z TN07/2804Z
TEMPO 2712/2719 31015G25KT SHRA FEW020TCU BKN035 PROB40 TEMPO 2712/2717 30020G32KT 2500 TSRA SCT020CB BECMG 2800/2802 23006KT BECMG 2810/2812 NSW=

WOOS53 LOWS XX1515

LOWS AD WRNG 3 VALID 271530/271630

TS FCST=

Remark:
The windshear warning was displayed in the cockpit at approximately 15:35 UTC. The aircraft landed at approximately 16:01 UTC.

1.7.2 Flight crew weather briefing

The two pilots were given the requisite weather briefing for the flight before taking off from Frankfurt. During the flight to Salzburg, the ATIS was received via ACARS and printed out. The ACARS updates the weather every 30 minutes, as well as when a special report is available. The code letter "F" was recorded in the operational flight plan (OFP).

1.7.3 Natural light conditions

Daylight (ECET 16:30 UTC)

1.8 Aids to navigation

The flight from Frankfurt (EDDF) to Salzburg Airport (LOWS) was performed under instrument flight rules (IFR).

1.9 Communications

The aircraft was in contact with Salzburg air traffic control center. Due to the late start of the investigation, the recordings of the radio communication were no longer available. The tower controller on duty, who was questioned by the Safety Investigation Authority (SUB), was unable to remember the incident.

1.10 Aerodrome information

1.10.1 General information

Salzburg Airport (LOWS) is located approximately 3.2 km west southwest of the city of Salzburg and has runways 15/33 with the following instrument approach procedures:

- Runway 15: ILS Cat I, ILS Cat II/III*, NDB, RNAV
- Runway 33: RNAV*

*) only permitted with special authorization for the aircraft and the crew.
The aerodrome reference point with the coordinates 47° 47´40´´ N, 13° 00‘ 12‘‘ E, is located 1050 m to the south of the threshold of runway 15. The airport is located 430 m (1.411 ft) above mean sea level MSL.

1.11 Flight recorder

The stipulated and fitted flight data recorder (FDR) was functional and recorded the data. However, this data was not available to the Safety Investigation Authority (SUB) in full. Only data exported by the operator of the aircraft and used in its own internal report, as well as a video animation showing the cockpit, were made available to the Safety Investigation Authority (SUB). The video animation starts when the aircraft was on its first approach to runway 15 at approximately 2700 ft MSL and ends after 2:52 minutes, when the aircraft was at approximately 4650 ft MSL after the go-around.
The recording of the cockpit conversations on the CVR was not secured by the operator of the aircraft and was therefore also not available to the Safety Investigation Authority (SUB) for the investigation.

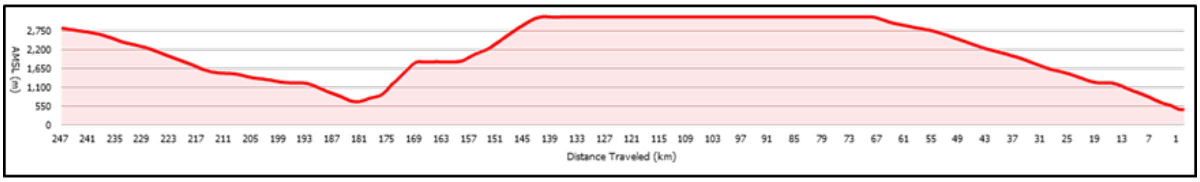
1.12 Radar data

The following radar data was made available to the Safety Investigation Authority (SUB) by Austro Control GmbH. It shows the last approximately 247 km of the flight track up to the landing in Salzburg.

Figure 4: Horizontal view of the flight track

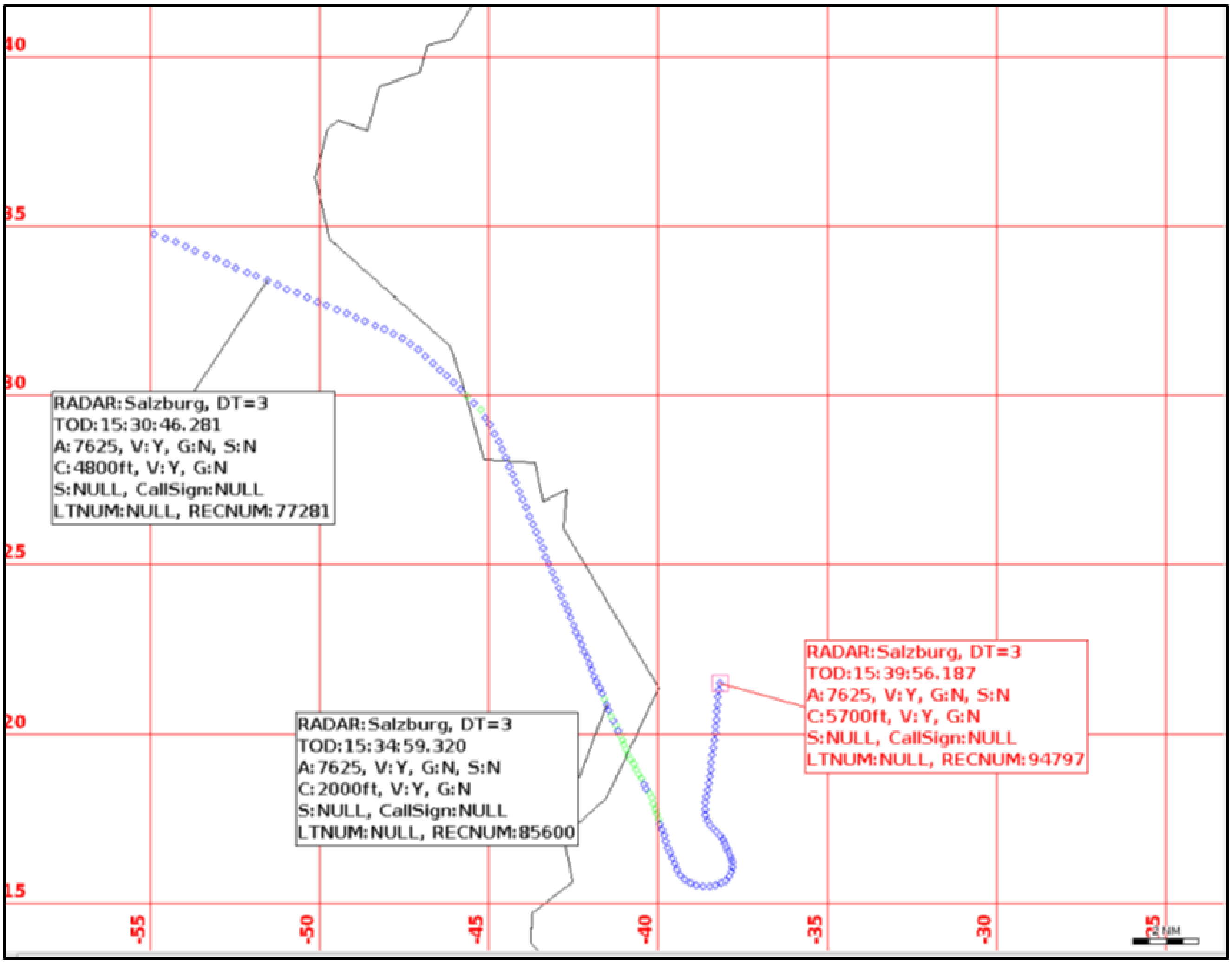
Source: Safety Investigation Authority (SUB)

Figure 5: Vertical depiction of the flight track



Source: Safety Investigation Authority (SUB)

Figure 6: Horizontal view of the flight track, detailed depiction

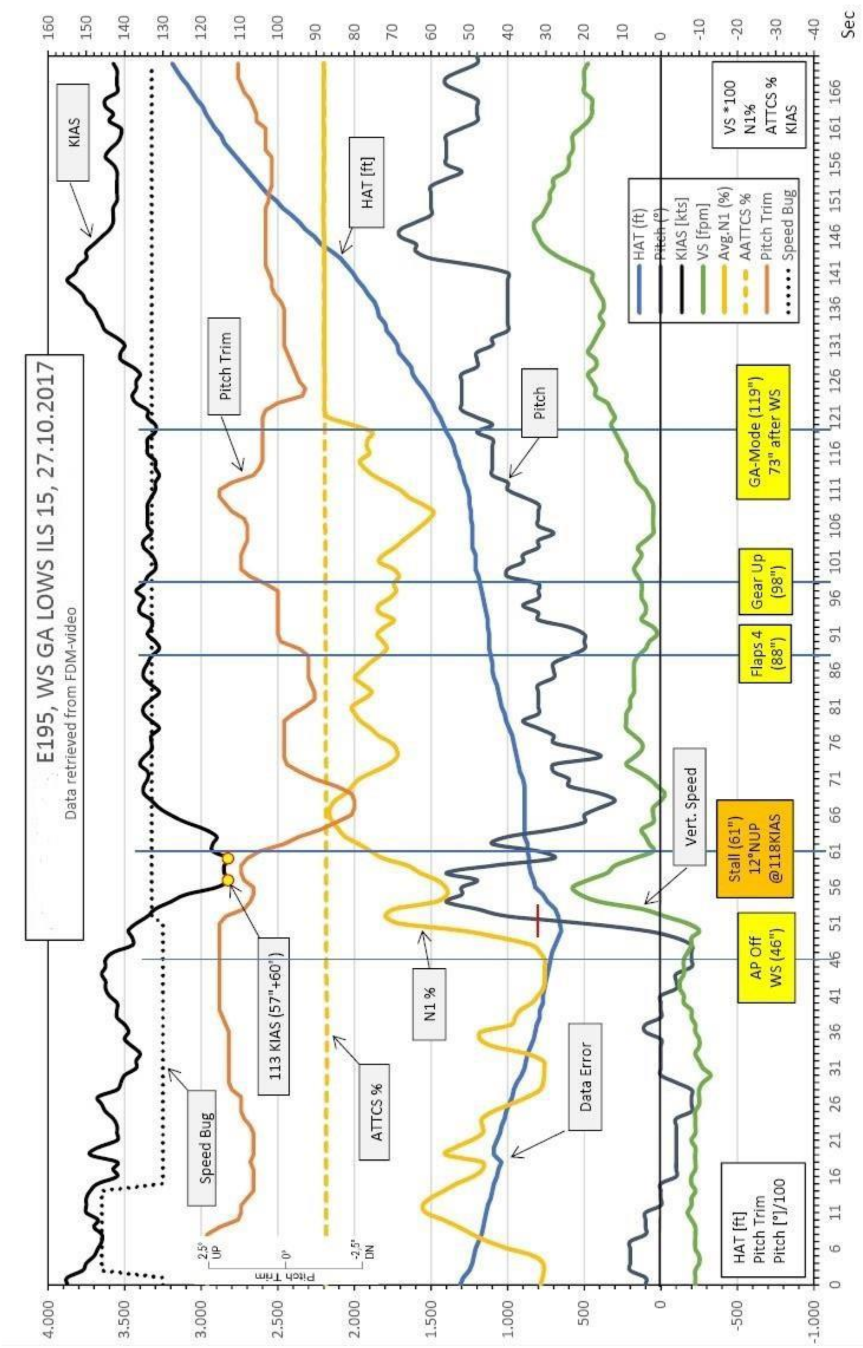


Source: Safety Investigation Authority (SUB)

1.13 Video analysis of the cockpit indications

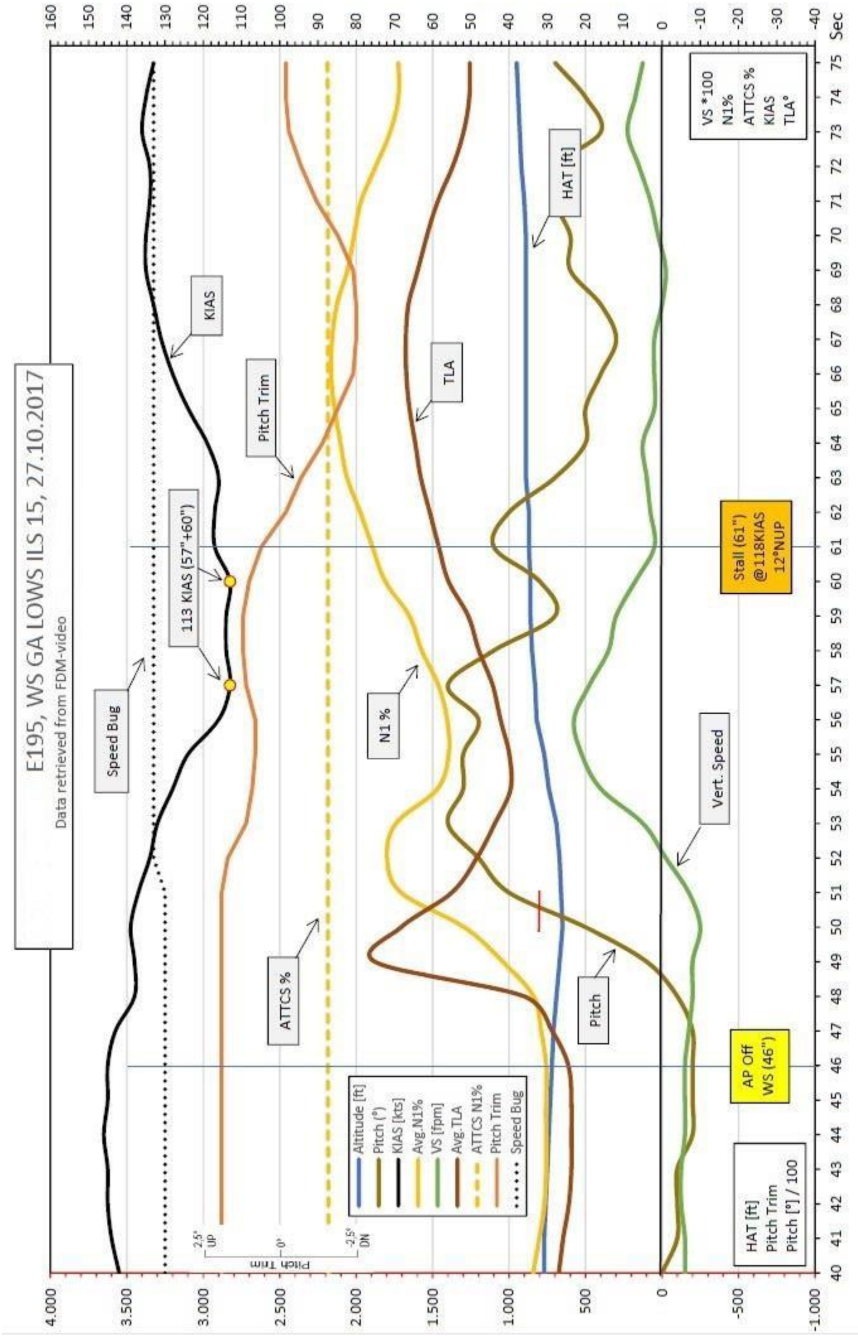
The video produced by the aircraft operator with the cockpit indications was analyzed and the data presented in two graphics as follows:

Figure 7: Flight data graphic #1, 170 seconds



Source: Safety Investigation Authority (SUB)

Figure 8: Flight data graphic #2, 75 seconds



Source: Safety Investigation Authority (SUB)

The graphics show the windshear caution at second 46 (remained active for 9 seconds). The autopilot was deactivated 1 second before. When the windshear caution was issued, the power levers were moved forward manually and reached a peak value some 3 seconds after the windshear caution was issued (left-hand TLA 74.9°, right-hand TLA 75.3°).

Remark:
For purposes of presentation, only the average TLA-value of the two power levers is shown in the graphic.

When the windshear caution occurred, the aircraft had a speed of 145 KIAS. By releasing the power levers and disengaging the active autothrottle system, the power levers were automatically moved back and reached a TLA minimum average value of 39.6° 12 seconds after the windshear caution. The performance of the two engines followed the TLA with a delay of approximately 2 seconds. The pitch angle was increased 1 second after the windshear caution. At 7 and 11 seconds after the windshear caution, the pitch angle reached a maximum value of 14 degrees positive.

The automatic reduction in engine power, in connection with the increase of the pitch angle, led to a loss of airspeed and the aircraft ultimately reached a minimum speed of 113 KIAS for a period of 3 seconds, 11 seconds after the windshear caution. Since the pitch angle was increased from 7 degrees to 11 degrees 13 seconds after the windshear caution was issued, a warning for an approximately stalled flight condition was then issued 15 seconds after the windshear caution at 113 KIAS. The pitch angle was then reduced to 3 degrees positive. Based on the speedbug setting of 133 KIAS, the engine power was increased again automatically until the target speed set by the speedbug of 133 KIAS was reached.

Since the engine power was too low, this resulted in a shallow climb with an average of approximately 500 fpm. Some 42 seconds after the windshear, the flaps were retracted from FULL to position 4. A further 10 seconds later, the landing gear was also retracted.

GA-mode was pressed some 73 seconds after the windshear warning. This led to the power levers being automatically moved forward to the ATTCS value of 87.8% N1 (TLA 74.8 degrees). The increase in power led to an climb rate of approximately 1800 fpm.
Key events after the windshear caution occurred:

Table 8: Key events after the windshear caution occurred

Seconds after windshear	Event	Altitude MSL	Altitude HAT	Speed KIAS	Pitch angle	TLA Avg.	N1 Avg.	VS
0 secs	Windshear, AP Off	2.130 ft	720 ft	145 kts	-2°	24.5°	30.3%	-600 fpm
3 secs	Maximum TLA	2.080 ft	670 ft	138 kts	1°	75.1°	41.7%	-800 fpm
4 secs	Minimum altitude	2.060 ft	650 ft	139 kts	5°	68.3	51.8%	-1.000 fpm
11 secs	1. speed minimum	2.240 ft	830 ft	113 kts	14°	44.3°	58.5%	1.900 fpm
15 secs	Stall	2.280 ft	870 ft	118 kts	11°	58.4°	75.8%	200 fpm
42 secs	Flaps 4	2.520 ft	1.110 ft	133 kts	5°	54.7°	73.6%	600 fpm
52 secs	Gear up	2.590 ft	1.180 ft	135 kts	10°	50.0°	69.8%	500 fpm
73 secs	GA-mode	2.810 ft	1.400 ft	147 kts	11°	61.8°	75.4%	1.200 fpm
103 secs	LNAV On	3.820 ft	2.410 ft	143 kts	15°	74.8°	88.1%	3.100 fpm

Source: Safety Investigation Authority (SUB)

1.14 Medical and pathological information

There are no indications of any pre-existing psychological or physical impairments among the cockpit crew.

1.15 Organisation and procedures

1.15.1 Documentation

Among other things, the organizational structures in place at the company and the procedures for flight operation are set out in the following manuals:

- Flight Operations, Operations Manual Part A, General Basic (OM-A)
- Flight Operations, Operations Manual Part B, Airplane EMB195 (OM-B)
- Flight Operations, Operations Manual Part D, Training (OM-D)
- Standard Operating Procedures Manual (SOPM)
- Safety Management System Manual (SMSM)

Based on the scope of services offered and the aircraft employed, the aircraft operator is a "Complex Operator" as per EU Directive 965/2012.

As such, it is obligated pursuant to ORO.GEN.200(a)(5) to operate a safety management system. The procedures to be observed here are described in the Safety Management System Manual (SMSM).

1.15.1.1 Operations Manual, Part A (OM-A)

At the time of the incident, Revision 49 from September 15, 2017 was valid. The following points of the OM-A are relevant to the serious incident:

„[…] *The OM has been prepared in accordance with the conditions contained in the Air Operator Certificate (AOC) including exemptions and waivers listed there and deviations from regulations approved by the Authority.*

The OM has been prepared in compliance with the relevant rules, regulations and provisions of ICAO Annex 6, EASA OPS and Air Crew Regulation and the applicable national rules and regulations.

It reflects the valid company policies, regulations and procedures as well as regulations imposed by other states. It has been prepared in the English language as prescribed by the relevant regulations. […]"

"[…] *The rules and regulations contained in the OM as well as the laws, regulations and* *procedures of those states, in which operations are conducted, shall be adhered to by the relevant personnel at all times.* […]“

Chapter 1 of the OM-A governs the duties and responsibilities of the crew members as follows:

„1.4 AUTHORITY, DUTIES AND RESPONSIBILITIES OF THE COMMANDER

“[…] *The Commander exercises the overall authority as to the operation of the aeroplane. He shall take all measures required by safety, whether on the ground, in flight, during takeoff, landing or taxiing.* […]”

1.4.2 IN-FLIGHT

“[…] *In flight, the Commander continues to coordinate the tasks / work of his flight deck team so as to obtain a maximum of good airman-ship for the conduct of the flight. He ensures:*

- *Observation of limitations, proper use and proper handling of the aeroplane's systems, including strict use of checklists;* […]”

1.5.2 DUTIES AND RESPONSIBILITIES OF THE CO-PILOT

“[…] *The Co-pilot is the Commander's deputy. When the Commander is absent or be-comes incapacitated the Co-pilot assumes the Commander's authority and the responsibility for the aeroplane and its crew, for its passengers and load. Therefore, it is his duty to responsibly participate in the preparation of the flight and to attentively monitor the progress of the flight in order to be able to assume this authority / responsibility at any given moment, either by the Commander's direction or when necessitated by the Commander's incapacitation.* […]”

1.5.2.2 In-flight

“[…] *In flight, the Co-pilot - as directed by the Commander - executes the tasks and functions of either the pilot flying or the pilot not flying. He assists the Commander in the management of the flight deck work by observing a well-balanced task distribution, by systematic cooperation and exchange of information, and by monitoring the flight progress and the aeroplane's systems, by observing the airspace and the performance of other Cockpit Crew Members.*

Notwithstanding the authority of the Commander it is of importance that the Co-pilot draws the attention of the Commander to facts, circumstances or unfavorable variables which may impair the safety of the flight and which may not yet have been noticed by the Commander. Such facts and circumstances may be: exceedance of limitations, abnormal indications, changes in meteorological conditions en-route or at alternates / destination, ambiguous ATS clearances, deficiencies in navigation or the aeroplane's handling, abnormal response of the aeroplane to controls input etc. […]“

Chapter 3 of the OM-A describes the management system as follows:

3.2.2 FLIGHT SAFETY PROGRAM

“[…] *Everybody dealing with safety aspects should follow the out-lined information. Main Aspects of the Flight Safety Program. The objective of any flight safety programme shall be prevention of accidents.*

In order to reach a high standard of flight safety adherence to standard flight operation regulations (OM-A, OM-B, etc.) and procedures (SOPs) is required. [...]“

Chapter 5 of the OM-A (Qualification and Requirements), point 5.2ff for flight crews refers to the importance of crew resource management (CRM):

„[…] *During flying training particular emphasis will be placed on the practice of Line Orientated Flying Training (LOFT) with emphasis on Crew Resource Management (CRM) and the use of correct crew coordinated procedures, including coping with Flight Crew Member incapacitation.* […]”

5.2.11.1 Recurrent Training

“[…] *CRM-Integration into all practical recurrent trainings Elements of CRM are integrated into all phases of the practical recurrent training (e.g. recurrent flight simulator training) by all involved personnel conducting this training.*

CRM Pilot’s Modular Recurrent Training

- *Conducted every three years;*

For details and scheduling rules refer to OM-D. […]“

1.15.1.2 Operations Manual, Part B (OM-B)

The OM-B is a document produced by the operator of the aircraft. It is based on the Aircraft Operations Manual Embraer AOM-1502-163 and is applicable to the operation of the type Embraer 195. At the time of the serious incident, Revision 5 from October 16, 2017 was valid.

The OM-B consists of 2 parts:
Volume 1: Operating procedures
Volume 2*:* Description of the aircraft systems

The following presenting the excerpts relevant to the serious incident:

Figure 9: Go-around (OM-B Chapter 3-25, Page 1)

GO-AROUND

►*Pre-mod MAU load 27.1*
TOGA button.. PRESSED
◄

Thrust Levers.. TO/GA
SLAT/FLAP... GA FLAPS SET

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.

Landing SLAT/FLAP	Go Around SLAT/FLAP
FULL	4
5	2

With positive climb:

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

At the acceleration altitude proceed as in a normal takeoff.

Source: OM-B of the air carrier

Figure 10: Missed Approach (OM-B Chapter 3-80, Page 9)

MISSED APPROACH

TO/GA.. PRESS

NOTE: The missed approach prompt is automatically activated and displayed on the MCDU MISSED APPROACH page after passing the initial approach fix (IAF) without pressing TO/GA button.
The missed approach prompt only activates the lateral part of the procedure, so the pilot is still responsible for selecting the vertical navigation mode.

►*Airplanes not equipped with Auto LNAV, Pre-mod MAU load 27.1*

LNAV.. SELECT

The pilot flying must immediately re-select LNAV after the TO/GA and follow the flight director's guidance to ensure airplane compliance with the procedure's track.

◄

►*190/195 models, Pre-Mod MAU load 25.1.0.1*

NOTE: When a go around is initiated (TO/GA button is pressed) far away and GA mode on FMA is not active prior to 2 NM from the FAF, the missed approach procedure will not be automatically activated. To activate the missed approach in the flight plan, the TO/GA button must be pressed again when within 2 NM of the FAF. After pressing TO/GA a second time, the NAV button must also be pressed again to re-engage LNAV, guaranteeing the missed approach path will be correctly followed.

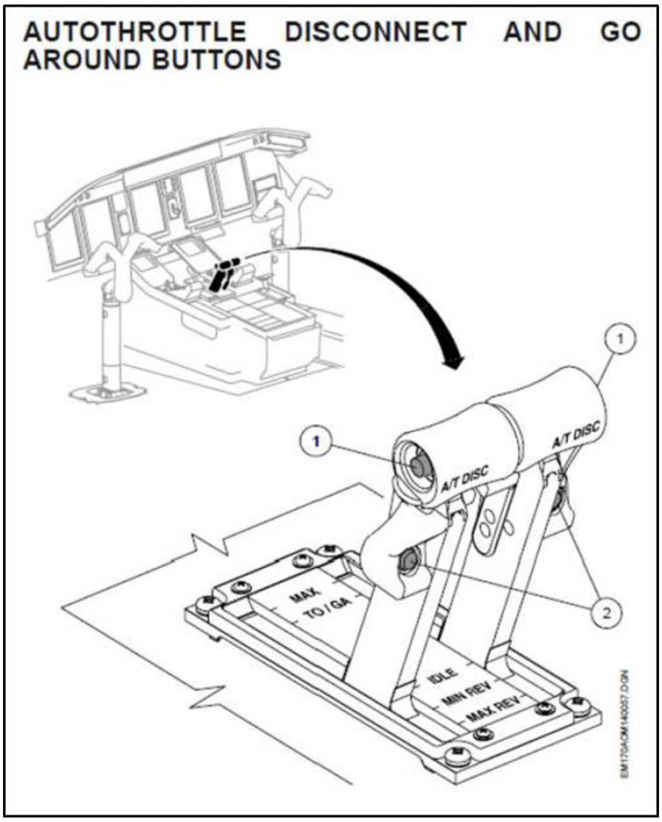
◄

Source: OM-B of the air carrier

Windshear Prevention / Recovery **(Chapter 3-98, Page 3)**

„[…] *When the EGPWS detects a windshear, the HGS will indicate a "WSHEAR" message to match the annunciation shown on the PFD. A voice message will be presented in case of a red "WSHEAR" indication on the PFD.*
The "WSHR" vertical mode is selected and a windshear guidance cue is provided. […]"

Figure 11: Autothrottle Disconnect and Go-Around Buttons (OM-B Chapter 14-03-05, Page 11)



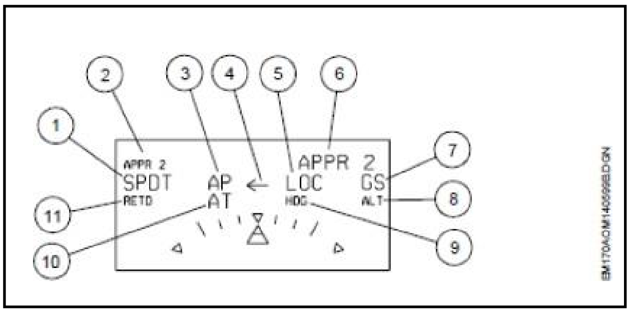
Source: OM-B of the air carrier

1 - AUTOTHROTTLE DISCONNECT BUTTON, Disengages the autothrottle

2 - TAKEOFF AND GO-AROUND BUTTON, Selects the TO, GA or Windshear Flight Director Modes

FMA Indications on HGS (OM-B Chapter 14-03-05, Page 17)

Figure 12: FMA Indications on HGS (OM-B Chapter 14-03-05 Page 17)



Source: OM-B of the air carrier

1 - AUTOTHROTTLE ACTIVE MODE, blinks for five seconds and then remains steady

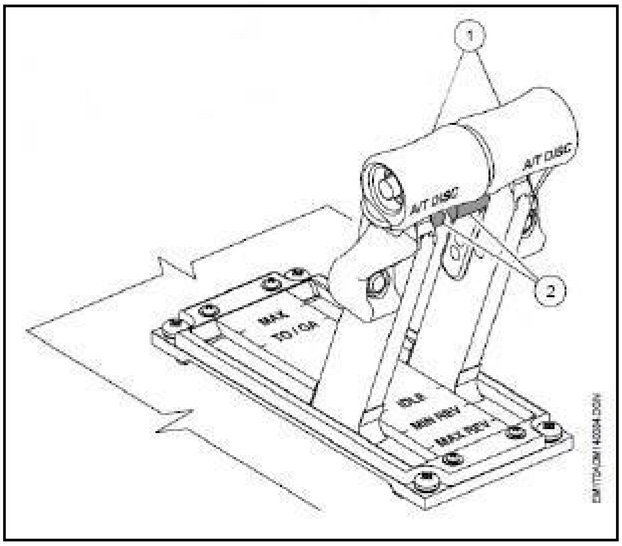
2 – APPROACH ARMED MODE, annunciates in small font the highest approach capability armed

3 – AUTOPILOT ENGAGED ANNUNCIATION, displays when AP is engaged; the annuncation blinks for 5 seconds and, then, remains steady

4 – FLIGHT DIRECTOR SOURCE ANNUNCIATOR, an arrow indicates the selected source 5 – FGCS LATEAL ACTIVE MODE

Thrust Lever Detents **(OM-B Chapter 14-06-05, Page 1)**

Figure 13: Thrust Lever Detents (OM-B Chapter 14-06-05, Page 1)



Source: OM-B of the air carrier

„[…] *1 – THRUST LEVER DETENTS*
MAX: provides the maximum thrust rating available for dual or single engine operation. TO/GA: selects takeoff, maximum continuous, and go.-around mode settings.
[…]“

A slight resistance in moving the thrust lever can be felt in TOGA-mode (TLA 70°). To engage the MAX setting, the thrust levers need to be moved all the way forward up to the mechanical stop.

The respective mode resulting from this is indicated to the two pilots both in the HGS and the FMA.

***AP Engagement / Disengagement* (OM-B Chapter 14-03-10, Page 3)**

„[…] ***DISENGAGEMENT***
NORMAL DISENGAGEMENT
The autopilot is normally disengaged by pressing the quick disconnect PB on either control wheel.

Pressing the button once:

- *Disengages the autopilot;*
- *Triggers the aural warning "AUTOPILOT";*
- *The FMA "AF'" annunciation blinks in red*

Pressing the button the second time cancels the aural warning and the FMA annunciation. The autopilot may be momentarily overridden by pressing the TCS button on the control wheel. Releasing the TCS, the autopilot resumes airplane control.

NON-NORMAL DISENGAGEMENT

The autopilot also disengages if one of the following conditions occurs:

- *AP button is pressed on the guidance panel;*
- *Either manual pitch trim switch is actuated;*
- *Either stick shaker is activated.*
- *Windshear escape guidance is activated.* […]”

Go-Around **(Chapter 14-03-10, Page 18)**

"[…] *The go-around mode automatically provides go-around guidance and thrust by pressing the TOGA-switch. The TRACK HOLD mode is engaged when TOGA is pressed. GA MODE ACTIVATION:*

- *Pressing TOGA-switch when inflight* […]"

„[…] *GA LOGIC:*

The GA mode first guidance sets pitch at 8°.
When IAS is greater than the speed target, the guidance will be the speed target according to the following:

– *All engines operating: VREF + 20 kt.*
– *One engine inoperative: VAC (approach climb).*

The VREF and VAC are inserted on the MCDU (PERF > LANDING page). If speed target is not valid, the airplane guides to pitch 8°.
In GA mode the pitch is limited to a minimum of 8° and a maximum of 18°. The maximum speed target is Vfe - 5 kt and minimum speed target
is Vshaker + 10 kt for all engines operating. For one engine inoperative the minimum speed target is Vshaker + 3 kt. […]"

Windshear **(Chapter 14-03-10, Page 19)**

„[…] *This mode provides FD escape guidance in case of Windshear detection below 1500 ft AGL. The system provides flight path guidance angle limited to stick shaker, commands wings level and provides aural alerts. The label "WSHR' is displayed when the Windshear Guidance mode is activated. The autopilot is disengaged when the Windshear Guidance mode becomes active.*
Windshear alerts are associated with vertical winds and rapidly changing horizontal winds and are divided as follows:

WINDSHEAR CAUTION:

– *Associated with increasing head wind and severe up drafts. A detection of a caution level Windshear is indicated by amber WSHEAR on the PFD and aural alert "CAUTION WINDSHEAR".*

WINDSHEAR WARNING:

– *Associated with decreasing head wind (or increasing tail wind) and severe vertical down drafts. A detection of a warning level Windshear is indicated by a red WSHEAR on the PFD and aural alert*

"WINDSHEAR, WINDSHEAR, WINDSHEAR".

WINDSHEAR GUIDANCE MODE ACTIVATION:

– *Windshear warning or caution condition is detected and TOGA-switch is pressed.*

– *Windshear Warning condition is detected and thrust lever is set to TO/GA position.*

– *Automatically when windshear warning condition is detected and the FD mode is in TO or GA.*

A green WSHR annunciation is displayed on the FMA when the Windshear guidance mode is activated. […]"

Autothrottle Normal Disengagement **(Chapter 14-03-20, Page 2)**

„[…] *Normal AT disengagement is accomplished by pressing any of the AT disconnect buttons on the thrust levers. Alternatively, the AT is normally disengaged by pressing the AT button on the guidance panel.*
The AT is also automatically disengaged when one of the following conditions occurs:

- *after airplane touchdown*
- *thrust levers beyond the TO/GA position*
- *reverse thrust operation during RTO. NORMAL DISENGAGEMENT ANNUNCIATION*

– *AURAL*
The aural alarm "THROTTLE" sounds when the AT is disengaged in flight. The aural alarm is cancelled by pressing the AT disconnect button on the thrust levers again.

– *FMA*

The AT annunciation on the FMA flashes in green for 5 s. […]“

Autothrottle Modes **(OM-B Chapter 14-03-20, Page 5)**

„GO-AROUND MODE (GA)

“[…] *The Go-Around thrust mode (GA) advances the thrust levers to the TO/GA position*.[…]”

ATTCS Activation Logic **("OM-B Chapter 14-06-30, Page 3)**

„[…] *The ATTCS automatically commands RSV whenever it is engaged, thrust levers are at TOGA-position, and one of following conditions occurs:*

- *Difference between both engine N1 values is greater than 15%;*
- *One engine failure during takeoff;*
- *One engine failure during go-around;*
- *Windshear detection.* […]”

GO-AROUND (GA) **(OM-B Chapter 14-06-30, Page 6)**

„[…] *The go-around mode is activated in flight whenever the landing gear and flaps are down. The GA mode can also be set from CRZ, CON or CLB by pressing the TOGA-switch. The go-around thrust can be achieved anytime in flight when the thrust rate mode is other than takeoff and the thrust levers are set to TO/GA. In this situation, the engine thrust mode label on EICAS is not modified.* […]”

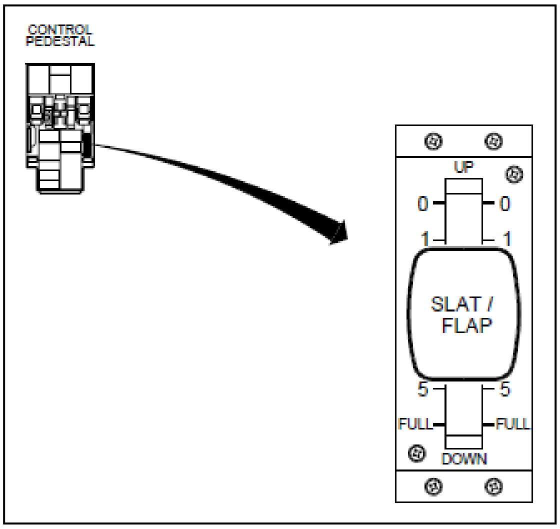
SLAT/FLAP SELECTOR LEVER **(Chapter 14-08-05, Page 2)**

"[…]

- *Selects slat/flap position by unlatching the lever and lifting a trigger below the head.*

- *Intermediate positions are not enabled. If lever is left at an intermediate position, flaps/slats remain in the last selected position. Position 4 is gated for normal Go-Around and Takeoff. Position 5 is used for landing.* […]"

Figure 14: Slat/Flap Selector Lever



Source: OM-B of the air carrier

Table 9: Slat/Flap Selector Lever position

Lever position	Slat position	Flap position	Detent/Gated
0	0°	0°	Detent/Stop
1	15°	7°	Detent
2	15°	10°	Detent
3	15°	20°	Detent
4	25°	20°	Gated/Stop
5	25°	20°	Detent
Full	25°	37°	Detent/Stop

Source: OM-B of the air carrier

Windshear Detection **(Chapter 14-15-35, Page 1)**

GENERAL

„[…] *The E-jets are equipped with the Windshear Detection and Escape Guidance System. This system provides Detection and Escape Guidance in case of a Windshear condition is encountered.*

WINDSHEAR DETECTION

Windshear detection is activated between 10 It and 1500 It radio altitude during the initial takeoff, go-around and final approach phases of flight.

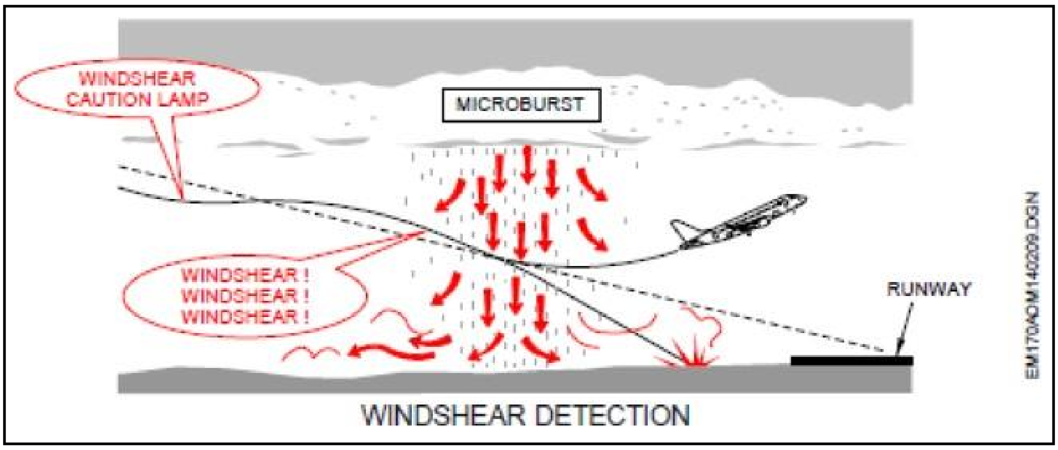
The label "WSHR" is displayed on the PFD when the Windshear Detection detects a windshear condition.

Windshear conditions will not be detected if either EGPWS or the Radar Altimeter is unavailable.

According to the windshear insensitivity it is divided in two levels. Each one has distinctive aural and visual indications

- *Windshear Caution*
- *Windshear Warning*

Figure 15: Windshear Detection



Source: OM-B of the air carrier

WINDSHEAR CAUTION

Increasing headwind and up drafts detection cause the annunciation of an amber WSHEAR on PFD and a CAUTION WINDSHEAR voice message.

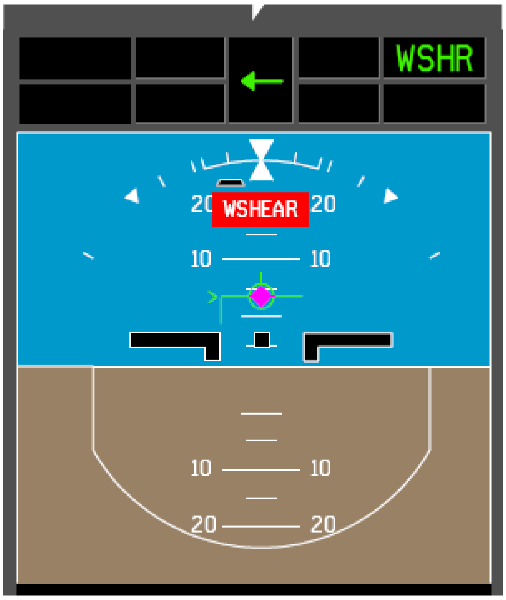
Figure 16: Windshear Caution am Primary Flight Display (PFD)

Source: OM-B of the air carrier

WINDSHEAR WARNING

Decreasing headwind (or increasing tailwind) and down drafts detection cause the annunciation of a warning windshear condition through a red WSHEAR on PFD and a "WINDSHEAR; WINDSHEAR; WINDSHEAR" voice message.

Figure 17: Windshear Warning auf Primary Flight Display (PFD)



Source: OM-B of the air carrier

WINDSHEAR ESCAPE GUIDANCE MODE

The Windshear Escape Guidance Mode provides through the Flight Director a pitch command limited to sticker shaker, and commands wings level to recover from a windshear, it minimizes altitude and airspeed loss during a windshear encounter.

It is indicated by a green "WSHR" annunciation on the FMA when activated.

The other flight director modes are canceled and the altitude pre-select, go-around and takeoff modes are inhibited while in a caution or warning windshear condition. No lateral mode is inhibited while in windshear mode.

WINDSHEAR ESCAPE GUIDANCE MODE ACTIVATION

The Windshear Escape Guidance Mode is activated in the following conditions:

- *Manually when windshear warning or caution condition is detected and TOGA-switch is pressed.*
- *Automatically when windshear warning condition is detected and thrust lever is set to TO/GA position.*

- *Automatically when windshear warning condition is detected and the FD mode is in TO or GA.*

AUTOPILOT OPERATION DURING WINDSHEAR ESCAPE GUIDANCE

The Autopilot automatically disconnects and is accompanied by appropriate visual and aural alerts when the Windshear Guidance is activated.

THRUST RATE SYSTEM (TRS)

When a windshear caution or warning condition is issued by the EGPWM, FADEC cancels any flex or derated thrust requirement. When following the Windshear Escape Guidance, moving the thrust levers to MAX position will set the engine thrust to GA-RSV regardless the label presented on EICAS.

AUTOTHROTTLE OPERATION DURING ESCAPE GUIDANCE

Autothrottle engaged:

- *The Autothrottle positions the Thrust levers to the TO/GA position.*

NOTE: *If the pilot manually advances the throttle lever beyond the TO/GA position, the Autothrottle will disconnect. The Autothrottle disconnection is accompanied by the appropriate visual and aural alerts.*

Autothrottle disengaged:

- *The pilot may engage the Autothrottle or manually position the thrust levers to TO/GA position.*[…]*"*

1.15.1.3 Standard Operating Procedures Manual (SOPM)

The STANDARD OPERATING PROCEDURES MANUAL (SOPM) is a document produced by the aircraft operator. It is based on the manufacturer SOPM EMBRAER SOPM–1755-001.

At the time of the serious incident, the edition from March 27, 2017 was valid.

The following presenting the excerpts relevant to the serious incident:

Figure 18: Go-Around (SOPM Chapter 2-42, Page 1)

GO-AROUND

CHALLENGE	ACTION / RESPONSE	PERFORMED BY
TOGA button	**PRESS**	**PF**

Post-Mod. LOAD 27.1

– VNAV is planned to engage according to the GO AROUND LIMIT page settings.

Thrust Levers	**TO/GA**	**PF**
SLAT/FLAP	**GA FLAPS SET**	**PM**

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.

With positive climb:

Landing Gear	**UP**	**PM**
Minimum Airspeed	**V_{REF}+20**	

At the acceleration altitude proceed as in a normal takeoff.

Source: SOPM of the air carrier

Figure 19: Windshear (SOPM Chapter 2-83, Page 1)

Windshear escape maneuver due to EGPWS announcement:

Thrust Levers	**MAX**	**PF**

When moving the thrust levers press either GA switch.

Flight Director Escape Guidance Cue	**FOLLOW**	**PF**

Maintain the actual configuration (landing gear and flaps) until 1500 ft AGL and with terrain clearance assured.

The windshear escape guidance mode does not automatically revert to any other flight guidance mode. The pilot must manually select another mode in order to exit windshear escape guidance.

Source: SOPM of the air carrier

PILOT MONITORING **(Chapter 3-05-01, Page 6):**

"[…] *It is the primary responsibility of each pilot to monitor the airplane and the other pilot.* […]"

WINDSHEAR **(SOPM Chapter 3-05-10, Page 7)**

"[…] *The most important policy is to avoid a windshear. Although windshear detection and annunciation system is installed, pilots may not perceive that an area of a potential windshear could be encountered ahead. Therefore some aids must be used by flight crews to develop an awareness of windshear causes and perceive danger signals to successfully avoid it. The following information can be used:*

- *Presence of thunderstorms, microburst, convective clouds or squall lines;*
- *Visual observation of strong winds near the ground;*
- *Onboard weather radar;*
- *Pilots or Air Traffic Services reports;*

Windshear escape guidance is provided by the FGCS Flight Director function, and is annunciated as WSHR in green in the vertical flight mode annunciator field when active. ROLL becomes the active lateral mode and the autopilot disconnects when windshear escape guidance is activated.

Windshear detection is enabled between 10 ft and 1500 ft AGL, and escape guidance may be initiated when the following conditions are met:

- *Manually when a windshear Caution or Warning is detected and the pilot presses the TOGA-pushbutton;*
- *When a windshear Warning is detected and Thrust Lever Angle > 70 degrees (70 degrees TLA is the TO-GA detent/flat);*
- *Automatically when the AFCS flight director mode is in Takeoff or Go-Around mode and a windshear Warning is detected.*

The windshear escape guidance mode does not automatically revert to any other flight guidance mode. The pilot must manually select another mode in order to exit windshear escape guidance, and the ability to successfully transition to another vertical guidance mode requires that the activation criteria described above be false.

When a windshear Caution or Warning is issued by the EGPWM, the FADEC cancels any flex or derated thrust requirements.

Regardless the label presented on EICAS, engines set to go-around reserve thrust when:

- *Windshear is detected during take-off phase, and*
- *TLA is set to MAX* […]"

STALL RECOVERY MANEUVER (Chapter 3-25, Page 33)

"[…] *The lift force generated on a surface is a result of its angle of attack (AOA), the dynamic pressure of the air moving around it, which depends on airspeed and air density, and the size and shape of the surface. As the AOA increases, lift increases proportionally. The lift increases until the wing reaches its maximum AOA, named critical AOA. Beyond the critical AOA, the air flown around the upper side of the wing separates, lift decreases, instead of increasing, and the airplane stall. To sustain a lifting force on the wing, the pilot must ensure that the wing is flown at an angle below the stall angle.* […]"

"[…] *The emphasis of the stall recovery maneuver is to reduce the AOA by putting the airplane in a nose down attitude. Upon recognizing a stall condition, stick shaker activation or feeling the stall buffeting, the crew must initiate the stall recovery procedure immediately.*

NOTE: Stick shaker activation causes the automatic disengagement of the autopilot. Beware that, in icing, the autopilot may mask heavy or asymmetric control forces due to airframe icing. The autopilot may even disconnect earlier because of excessive roll rates, roll angles, or excessive pitch.

The PF must disengage the autothrottle and simultaneously reduce the AOA. Push the control column to apply nose down, level the wings and adjust the thrust as required. The PM must confirm autopilot and auto-throttle are disengaged, and monitor altitude and speed of the airplane. […]"

"[…] *Due to the nose down attitude, during the recovery the airplane accelerates. The PM should monitor the speed to avoid the airplane flying above the VMO/MMO or other applicable speed limit. The PM should also monitor and inform any other airplane limitation exceedance.* […]"

“[…] *Additionally, when in the normal, setting the thrust levers to MAX position will automatically disengages the autothrottle and retracts the speed brakes, reducing the workload during the recover maneuver.*

Table 10: Actions and Callouts

ACTIONS AND CALLOUTS		
	PF	**PM**
	“STALL” (Pilot first noticing the stall situation).	
Upon Stick Shaker activation or feeling the stall buffeting.	• Disengages Autothrottle.	
		• Checks Auto Throttle and Auto Pilot disengaged.
	• Applies nose down and levels the wings until out of stall.	
		• Monitors altitude and speed. Performs any necessary callout.
	• Applies thrust as required.	
	• Accelerates the airplane to a safe speed.	
	• Retracts speed brakes.	
	• After recovery, return to the normal flight path.	
		• Reconfigures the airplane as necessary.

Source: SOPM of the air carrier

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

***Go-Around* (SOPM Chapter 3-35-10, Page 21)**

„[…]

- *To initiate the go-around press TO/GA switch, ensure go-around thrust is set (TO/GA position) or manually apply go-around thrust. Verify FMA annunciations (GA, TRACK, and GA). The TRACK mode is activated when TO/GA button is pressed and disengaged when another lateral mode becomes active. The selection of another vertical mode deactivates the GA mode. An automatic go-around cannot be initiated after touch* down.
- *The GA pitch mode initially commands a go-around attitude and then transitions to speed as the rate of climb increases. The GA roll mode maintains existing ground track.*

Rotate the airplane to the initial pitch of 8° nose up if flying manually or follow the FD guidance and monitor the AP. Select the flap according to the following table:

Table 11: Landing Slat/Flap and Go-around Slat/Flap position

Landing SLAT / FLAP	Go-Around SLAT / FLAP
FULL	4
5	2

Source: SOPM of the air carrier

XXX E195 are equipped with improved Go-Around Performance (IGAP)

The SLAT/FLAP setting for Go-around when landing with SLAT/FLAP 5 is 2.

- *With a positive rate of climb, retract the landing gear and maintain a minimum of VREF +20 kt.* […]”

Table 12: Normal Go-around actions and callouts

NORMAL GO-AROUND - ACTIONS AND CALLOUTS (callouts are shown in bold)		
	PF	**PM**
Go-around	**“GO-AROUND”.** • Press either TOGA - buttons. • Verify or move thrust levers to TO/GA detent. • With the airspeed greater than VREF. **“FLAPS_”.** • Verifies rotation or rotates towards GA initial pitch attitude (8°).	• Verify GA annunciations. • Verify engine at go-around thrust. • Selects GA flaps.
Positive Rate of Climb	• Confirm positive rate of climb. **“GEAR UP”.** **“TRACK”** **“GO-AROUND”**	• Verify positive rate of climb. **“POSITIVE RATE”.** • Position gear lever up. • Selects VFS. • Starts timing • Advises ATC **“CHECKED”**
400 ft AGL	**“SELECT FMS AND HEADING (NAV)”.** Note: If AUTO LNAV installed, verify LNAV and call **"LNAV”**	• Selects appropriate navigation primary source. • Selects Lateral Mode. **“CHECKED”**
At Acceleration Altitude	**“SELECT VNAV/FLCH”.** **“AUTOPILOT ON”.** (if not already on) **“VFLCH/FLCH”** At F Speed order **„CLIMB SEQUENCE“**	• Selects VNAV/FLCH and FMS speeds • Engages AP. **“CHECKED”** • Retracts flaps on schedule. • When flaps are zero calls: **“FLAP ZERO”.**

Source: SOPM of the air carrier

***WINDSHEAR* (SOPM Chapter 3-40, Page 13)**

"[…] *The most important way to cope with windshear is to avoid areas of known or potential windshear occurrence such as thunderstorms.*
Severe windshear may be defined as a rapid change in wind direction or velocity. The result is airspeed changes greater than 15 kt or vertical speed changes greater than 500 ft/min.

Whenever a windshear is suspected during landing take the following precautions:

- *During approach, maintain the V_{AP} with the applicable wind additive corrections*
- *Select Flaps 5 unless limited by other landing performance consideration*
- *If possible plan to land on the longest runway available, with the lowest possibility of a windshear encounter*
- *Adjust the radar using the Weather Radar Virtual Controller Panel to get the best information about weather formations on the airplane path*
- *Crew should monitor airspeed trend during approach. In the first evidence of Windshear, initiate a Go-around. If necessary, perform the windshear escape maneuver procedure*
- *Develop an awareness of normal airspeed, attitude, and vertical speed. The crew should closely monitor the vertical flight path instruments, such as, vertical speed and altimeters.*
  Callout any deviations.

WINDSHEAR RECOVERY TECHNIQUES

Perform the windshear escape maneuver whenever the following happens:

- *A warning windshear is annunciated during approach.*
  PFD: WSHEAR (red).
  Voice message: "WINDSHEAR, WINDSHEAR, WINDSHEAR"
- *A caution windshear is annunciated during approach and the pilot decides to perform the windshear recovery technique.*
  PFD: WSHEAR (amber).
  Voice message: "CAUTION WINDSHEAR".
- *Whenever the pilot decides to perform the recovery techniques due to the presence of windshear clues without EGPWS announcement.*

Windshear escape maneuver due to EGPWS announcement:

Pilot advances thrust levers to maximum thrust and follows Flight Director Escape Guidance Cue. When moving thrust levers press either GA switch. Maintain the actual configuration (landing gear and flaps) until 1500 AGL and with terrain clearance assured. The windshear escape guidance mode does not automatically revert to any other flight guidance mode. To exit windshear escape guidance, manually select another mode. […]"

Figure 20: Callouts for vertical FMA Changes (SOPM Chapter 4-01, Page 3)

FMA	Pilot Flying	Pilot Monitoring
GA	"GO AROUND"	"CHECKED"
WSHR	"WINDSHEAR"	"CHECKED"
OVSP	"OVERSPEED"	"CHECKED"

Source: SOPM of the air carrier

SOPM excerpt regarding Stabilized Approach:

„*STABILIZED APPROACH* (SOPM 3-05-01, Page 8)

"[…] *Criteria used to judge an approach according to the capability of the airplane to perform a safe landing after a determined point at the approach procedure (on the Approach Speed plus applicable additives, on the proper flight path, on the proper sink rate and with the thrust stabilized no lower than 1000 ft AFE. For exceptions refer to OM- A).*
[…]"

***APPROACHES* (SOPM 3-05-10, Page 15)**

"[…] *The airplane must be on a stabilized approach, that is, on the Approach Speed plus applicable additives, on the proper flight path, with the proper sink rate and with the thrust stabilized no lower than 1000 ft AFE. For exceptions refer to OM-A. A go-around is required anytime these criteria are not satisfied.* […]"

***STABILIZED APPROACH* (SOPM 3-35-01, Page 9)**

"[…] *The airplane shall be stabilized by 1000 ft AFE. For Exceptions refer to OM-A. An approach is considered stabilized when all of the following criteria are met:*

- *The airplane is on the correct flight path;*
- *Only small changes in heading and pitch are required to maintain the correct flight path;*
- *The airplane approach speed is VREF + Wind Correction, not exceeding VREF + 20 kt and not less than VREF;*
- *The airplane is in the correct landing configuration;*
- *Sink rate is no greater than 1000 ft/min; if an approach requires a sink rate greater than 1000 ft/min, conduct a special briefing;*
- *Power setting is appropriated for the airplane configuration;*
- *All briefings and checklists have been conducted;*
- *Fly ILS approaches within one dot of the glideslope and localizer.*

NOTE: *For EASA operators the following criteria are also applicable:*

- *Maximum Bank Angle 30º;*
- *Sink rate no greater than 1000 ft/min with a maximum deviation of +/- 300 ft/min.* […]"

STABILIZED APPROACH **(SOPM 3-35-01, Page 18)**

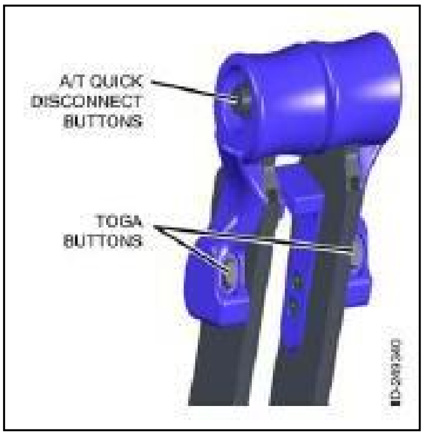
[…] *If the airplane cannot meet the stabilized approach criteria, execute a missed approach*. […]"

1.15.1.4 Honeywell Primus Epic Pilots Guide

„*Autothrottle Controls* (Primus Epic, Page 10-20)

"[…] *A/T switches are used to manually control the A/T system.*

Figure 21: A/T quick disconnect button and TOGA-buttons



Source: Honeywell

Quick Disconnect

Pushing the Quick Disconnect button on the throttle handle disconnects the A/T.

Go-Around Button

When the go-around button on the throttle handle is pushed, the go-around mode engages and the A/T moves the throttles to the TOGA-position.

The go--around buttons are active at radar altitudes less than 2,500 feet or BARO altitudes above 2,500 feet up to 17,000 feet.

Manual Movement of the Thrust Lever

*The pilot can override the autothrottle system by manually moving the throttles to any position between idle and TOGA without disconnecting the AP provided the A/T T/O mode is inactive. An **OVRD** message is annunciated on the PFD.*

Figure 22: Autothrottle Override Annunciator on PFD

Source: Honeywell

If the manual override reaches any of the following conditions the A/T disconnects:

- *The pilot overrides the thrust levers to the MAX power position (TLA > 78 degrees). (The system lets the A/T re--engage after the pilot moves the thrust levers below the MAX position.)*
- *The asymmetric thrust monitor detects an unacceptable amount of split between the thrust lever positions.*
- *The pilot positions or overrides the thrust levers below idle (TLA <40 degrees).*

WINDSHEAR CAUTIONS **(Primus Epic, Page 19-47)**

*This alert normally occurs because of increasing performance windshear conditions (that is, increasing headwind, decreasing tailwind, and/or updraft). This alert is considered advisory, and the crew must be alert to the possibility of subsequent significant airspeed loss and downdraft conditions. Coupled with other weather factors, the windshear **GND PROX** must be considered in determining the advisability of performing a go--around.*

WINDSHEAR WARNINGS

Wind and gust allowances must be added to the approach speed, increasing thrust when necessary. Disengage autopilot or autothrottle can be necessary. Avoid getting low on the approach glidepath or reducing the throttles to idle. When a windshear warning occurs, the following procedure must be followed:

1. *Immediately initiate the windshear escape maneuver in accordance with established windshear procedures.*
2. *Aggressively apply maximum--rated thrust, and disengage autopilot and/or autothrottle when necessary.*
3. *Rotate smoothly to the go--around/take--off pitch attitude, permitting airspeed to decrease when necessary. Maintain wings level. Do not retract flaps or landing gear.*
4. *When the aircraft continues to descend, increase pitch attitude smoothly and in small increments, bleeding airspeed as necessary to stop descent. Use stall warning onset (stick shaker) as the upper limit of pitch attitude.*
5. *Maintain escape attitude and thrust, and delay retracting flaps or landing gear until safe climb--out is assured.* […]”

Remark:
According to the SOPM, flaps and landing gear may only be retracted once the aircraft has reached an above-ground altitude of 1500 ft.

1.15.1.5 Quick Reference Handbook (QRH)

The Embraer 195 QRH, Rev. 5 from October 16, 2017 contains tables that specify the approach speed.

In Chapter PD30-3, the "Approach and Landing Speeds with or without Ice Accretion" table specifies the following values for the weight of 43,423 kg (landing weight in Salzburg according to OFP):

Vref Flap 5:	142 KIAS
VAC Flap 2:	142 KIAS
Vref Flap Full:	**125 KIAS**
VAC Flap 4:	125 KIAS
VFS:	195 KIAS

Pursuant to Chapter PD30-2, the Vref should be increased using the following formula based on the headwind component and gusts:

Headwind correction (HWcorr): ½ of headwind component + full gusts.

Remark:
The increase in Vref is not comprehensible, since there is

- no precise weather details from the time of the incident are available,
- the Salzburg METAR is too far away from the time of the serious incident (15 minutes before/after incident), and
- the wind situation was constantly changing

1.15.1.6 Operations Manual, Part D (OM-D)

Part D of the Operations Manual contains provisions on training and checks for the cockpit and cabin crew.

Part I regulates the general and type-independent provisions. At the time of the incident, version 23 from September 15, 2017 was valid.

With regard to CRM, the content that is conveyed both theoretically and practically (in the flight simulator) includes the following:

- *Communication*
- *Leadership and Teamwork*
- *Workload Management*
- *Information acquisitions and processing*
- *Threat and Error Management (TEM)*
- *Situation Awareness and Decision Making*

Relevant excerpts from OM-D, Part I Chapter 2:

„2.2 Crew Resource Management Training (CRM)

2.2.1.1 Training Elements

"[…] *The CRM training elements to be covered are specified in the Tables of OM-D Part I, chapter 2.2.17.*
The following aspects are addressed:

a) Automation and philosophy on the use of automation (Flight Crew)

- *The CRM training shall include training in the use and knowledge of automation, and in the recognition of systems and human limitations associated with the use of automation. Flight crew member receives training on:*
  - *The application of the operations policy concerning the use of automation as stated in the operations manual; and*
  - *System and human limitations associated with the use of automation, giving special attention to issues of mode awareness, automation surprises and over-reliance including false sense of security and complacency.*
- *The objective of this training shall be to provide appropriate knowledge, skills and attitudes for managing and operating automated systems. Special attention shall be given to how automation increases the need for crews to have a common understanding of the way in which the system performs, and any features of automation that make this understanding difficult.*
- *If conducted in an FSTD, the training shall include automation surprises of different origin (system- and pilot-induced).*

b) Monitoring and intervention (Flight Crew)

Flight crew shall be trained in CRM-related aspects of operation monitoring before, during and after flight, together with any associated priorities. This CRM training shall include guidance to the pilot monitoring on when it would be appropriate to intervene, if felt necessary, and how this shall be done in a timely manner. Reference shall be made to the relevant procedures for structured intervention as specified in the operations manual.

c) Resilience development

CRM training shall address the main aspects of resilience development. The training shall cover:

- *Mental flexibility*

Flight/Cabin crew shall be trained to:

  - *Understand that mental flexibility is necessary to recognise critical changes;*
  - *Reflect on their judgement and adjust it to the unique situation;*
  - *Avoid fixed prejudices and over-reliance on standard solutions; and*
  - *Remain open to changing assumptions and perceptions.*

- *Performance adaptation*

Flight/Cabin crew shall be trained to:

  - *Mitigate frozen behaviours, overreactions and inappropriate hesitation; and*
  - *Adjust actions to current conditions.*

The main aspects of resilience development can be described as the ability to:

- *learn ('knowing what has happened');*
- *monitor ('knowing what to look for');*
- *anticipate ('finding out and knowing what to expect'); and*
- *respond ('knowing what to do and being capable of doing it').*

Operational safety is a continuous process of evaluation of and adjustment to existing and future conditions. In this context, and following the description in above, resilience development involves an ongoing and adaptable process including situation assessment, self-review, decision and action. Training in resilience development enables crew members to draw the right conclusions from both positive and negative experiences. Based on those experiences, crew members are better prepared to maintain or create safety margins by adapting to dynamic complex situations.

Mental flexibility

- *The phrase 'understand that mental flexibility is necessary to recognise critical changes' means that crew members are prepared to respond to situations for which there is no set procedure.*
- *The phrase 'reflect on their judgement and adjust it to the unique situation' means that crew members learn to review their judgement based on the unique characteristics of the given circumstances.*
- *The phrase 'avoid fixed prejudices and over-reliance on standard solutions' means that crew members learn to update solutions and standard response sets, which have been formed on prior knowledge.*
- *The phrase 'remain open to changing assumptions and perceptions' means that crew members constantly monitor the situation, and are prepared to adjust their understanding of the evolving conditions.*

Performance adaptation

- *The phrase 'mitigate frozen behaviours, overreactions and inappropriate hesitation' means that crew members correct improper actions with a balanced response.*
- *The phrase 'adjust actions to current conditions' means that crew members' responses are in accordance with the actual situation.*

d) Surprise and startle effect (Flight Crew)

CRM training shall address unexpected, unusual and stressful situations. The training shall cover:

- *Surprises and startle effects; and*
- *Management of abnormal and emergency situations, including:*
  - *The development and maintenance of the capacity to manage crew resources;*
  - *The acquisition and maintenance of adequate automatic behavioral responses; and*
  -

2.2 Crew Resource Management Training (CRM)

2.2.5 CRM Operator Conversion Training when Changing Operator (FC-OCO)

Objectives

"[…] *The purpose of the CRM operator conversion course when changing operator is the integration of specific operator CRM elements into the operator conversion course.*

Prerequisites

The candidate has been assigned to an operator's conversion course by XXX.

Method of instruction

This course is performed in classroom environment.

Instructor qualification

CRM instructor

Duration

4 hrs. integrated into the operator's conversion course.

Content

Refer to table of CRM training elements.

Test requirements

Not applicable […]"

2.2.7 CRM Annual Joint Recurrent Training (AR-CRM)

"[…] ***Objectives***

The purpose of the CRM joint recurrent training is to update the CRM Skills of pilots and cabin crew members. This course serves also as ***Annual Recurrent CRM Training for cabin crew*** *and as* ***CRM Recurrent Training for flight crew****.*

Prerequisites

Shall be an active crew member of XXX.

Method of instruction

This course is performed in classroom / training device environment.

Instructor qualification

CRM instructor

Duration

4 hrs. every year

Content

Refer to table of CRM training elements.

A 3-year cycle shall cover all CRM Elements.

Test requirements

Not applicable

2.2.8 CRM Pilot's Modular Recurrent Training (FC-PMT) Objectives

The continuous enhancement of CRM Skills to improve flight safety.

Prerequisites

Shall be an active flight crew member of XXX.

Method of instruction

This course is performed in classroom environment.

Instructor qualification

CRM instructor

Duration

2 days every three years

Preferably to be conducted outside company premises, so that the opportunity is provided for flight crew members to interact and communicate away from the influence of their usual working environment.

To achieve an average 3-year-recurrent training cycle, following scheduling rule applies:

The first training event triggers an "initial period of validity", lasting 3 years from training event plus the remainder of the month of training.

Each next training event has to be scheduled between 0,5 years before and 0,5 years after this end of validity to keep original 3-year cycle. Scheduling beyond 0,5 years after expiration is not approved. Scheduling before 0,5 years before expiration triggers a new calculation of period of validity. This rule enables better mixing of different flight crew members, but must not be applied to extend the 3-year-recurrency on a long-term-focus.

Content

Overview

- *Human error and reliability, error chain, error prevention and detection*
- *Company safety culture, SOP's, organizational factors*
- *Stress, stress management, fatigue & vigilance*
- *Information acquisition and processing, situation awareness, workload management*
- *Decision making*
- *Threat and error management*
- *Communication and coordination inside and outside the cockpit*
- *Leadership and team behaviour synergy*

As required

- *Automation, philosophy of the use of automation*
- *Specific type-related differences*

As appropriate

- *Case based studies*

Test requirements

Not applicable […]"

Relevant excerpts from OM-D, Part V

Part V contains the provisions for type E95. At the time of the serious incident, Revision 3 from September 15, 2017 was valid. With regard to windshear and stall, the following training was stipulated (excerpts):

Theoretical Training

„[…] *CBT Block 7*

Warnings Chapter, duration of training 3 hours

- *Stall Warning and Protection System*
- *Enhanced Proximity Warning System*
- *Windshear Detection and Escape Guidance*
- *TCAS […]"*

Practical training in the full flight simulator:

"[…] *Session 4:*

- *Windshear*
- *Approach to stall recovery* […]"

Session 7 also stipulates the following:

"[…]

- *Safe reaction and correct procedure during windshear […]"*

CQT - CONTINUOUS QUALIFICATION TRAINING (OM-D, Part V, Page 5.1-1)

PRACTICAL TRAINING ON SIMULATOR – FFS

"[…] ***Lesson Summary***

This lesson during LIFUS is intended to provide the pilot lately typerated the opportunity to repeat some of the contents of the FFS during the rating and to ensure the transfer of competence from Simulator training to line operations. Correct handling of abnormal and emergency situations, abilities in basic aircraft control and own navigation as well as knowledge and application of SOPs will be proven by the crew and prepare them for oncoming recurrent check events. Manual flying abilities will be reinforced by not using the Autopilot in some phases of flight. As the Recurrent Refresher Training Simulator there will be no grading for this event, nevertheless the instructor will address strong/weak fields in a detailed debriefing.

The designated Instructor is responsible for not overloading the mission with malfunctions. He will watch that all mandatory items are done and react on the trainees demands. If the Trainees do not have any specific training Topics, the Instructor will choose scenarios to maintain Training efficiency

CRM items:

Workload Management and Distribution

- *Prioritize operation tasks*
- *Distribute tasks appropriate*
- *Complete tasks in good time*
- *Use external and internal ressources*

Leadership and Teamwork

- *Address and Manage conflict*
- *Achieve rational climate*
- *Avoid intimidation*
- *Adopt assertive behavior if appropriate and persist until attention of others is gained or corrected action is taken*
- *Accept and appropriate criticism*
- *Avoid competition between crew members*

Situation Awareness and Decision Making

- *Apply FORTEC for complex decision*
- *Involve others in the process*
- *Discuss discrepancies*

Lesson Objectives

Correct application of SOPs also in abnormal conditions after a while of normal line operation. Handling of engine failures, to gain optimum aircraft performance with only half thrust left. NPA and ILS approaches with due regard to systematic OEI flying, controlled pitch/thrust flying enhancing situation awareness during all flight operations. Correct all engine operating go-around procedure with low altitude level off. […]”

Remark:

- Beside the compulsory exercises, the candidate can also select additional, optional exercises from the following list (OM-D, Part V – Chapter 5, 5.1-2):

- *Windshear*
- *EGPWS*
- *RTO / Emergency Evacuation*
- *HGS HUD A3 Ops with approach warning*
- *Double Hydraulic Fail*
- *Flap / Slat Fail*
- *Stabilizer Trim Runaway*
- *Unreliable Airspeed scenario until landing*
- *Engine separation*
- *Multiple DU failure – IESS only operation*

1.16 Other disclosures

1.16.1 Incident reporting

The two incident reports were drawn up by the PF. An internal software provided by the operator automatically forwards the reports to the central reporting office at Austro Control GmbH.

Due to unknown reason, two different incident reports were produced for the same flight.

Content of the two incident reports:

Table 13: Incident reports of the air carrier

Report #	#33453	#33509
Header	**Windshear**	**Flight Envelope Exceedance**
Date	27.10.2017	27.10.2017
Time of Event	07:20z	14:33
Speed	145 KIAS	113 KIAS
Height	1.300 ft	1.000 ft
Weather	230/13 (gusty), 8km, BKN 030, mod turb 9°C	230/13 (gusty), 8km, BKN 030, mod turb 9°C
Description of Occurrence	Windshear at 1300 ft. Performed escape maneuver and missed approach. Entered holding overhead SBG VOR. Waited for weather improvement. Second approach was successful.	Stick shaker activation for 1-3 seconds during windshear escape procedure.
Risk analysis ESC		
Type of Evaluation	ERC without Bow Tie analysis	ERC without Bow Tie analysis
Likelihood of occurrence	E5	E6
Severity of consequences	A2	A5
Risk level	e-f (**green**)	c (**amber**)
Internal Comment		ESC Re-evaluation pfd
Risk analysis by	XXX	XXX
Risk evaluated	2017-10-30, 10:49:16	2018-01-17 14:23:02
Corrective Actions	XXXX Administrator Reporting Module 2017-11-02 08:24 DANKE für den Report Flight Safety XXX	**** EDITED by XXX on 2018-01-17 13:21:35 ** Risk Evaluation removed ** Report status changed to: Re-Evaluation ** Edit Comment: ESC Reevaluation
ADREP	Go-Around Windshear Encounter	Stall Warning Windshear Encounter

Source: Air carrier

1.16.2 Assessment of the event by the air carrier

In assessing the incident, the following matrix was used by the air carrier:

Figure 23: Event Severity Classification Matrix

Event Severity Classification Matrix **Question 1**: If this event had escalated into an accident outcome, what would have been the most credible accident scenario An/A0 to A5? (answer below)	**Question 2**: What was the effectiveness of the remaining barriers between this event and the most credible accident scenario E0 to E12? (answer below)												
	None		Not effect-tive 90%		Minimal 99%		Limited 99,9%		Effective 99,99%		Very effect-tive 99,999		Normal 99,9999%
	E0	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**	**E12**
	***Alternative* Question 2**: What is the likelihood that this event leads to the most credible accident scenario?												
	1 out of 1	1 out of 3	1 out of 10	1 out of 30	1 out of 100	1 out of 300	1 out of 1.000	1 out of 3.000	1 out of 10.000	1 out of 30.000	1 out of 100.000	1 out of 300.000	1 out of 1 mio.
Loss of aircraft or multiple fatalities (3 or more) *Catastrophic Accident (S5)* – **A5**	a	a	a	a-b	b	b-c	c	c-d	d	d-e	e	e-f	f
Several fatalities, multiple serious injuries, serious damage to the aircraft (almost lost) *Serious Accident (S4 – S5)* – **A4**	a	a-b	b	b-c	c	c-d	d	d-e	e	e-f	f	f-g	g
1 or 2 fatalities, multiple serious injuries, major damage to the aircraft *Major Accident (S4)* – **A3**	b	b-c	c	c-d	d	d-e	e	e-f	f	f-g	g	g-h	h
Serious incident with injuries and/or substantial damage to aircraft *Serious Incident (S3)* – **A2**	c	c-d	d	d-e	e	e-f	f	f-g	g	g-h	h	h-i	i
Incident with injuries and/or damage to aircraft *Incident (S2 – S3)* **A1**	d	d-e	e	e-f	f	f-g	g	g-h	h	h-i	i		
Minor injuries, minor damage to aircraft *Minor Injuries or damage (S2)* – **A0**	e	e-f	f	f-g	g	g-h	h	h-i	i				
Incident with discomfort and/or less than minor system damage or less *Incident or none (S1 or S0)* – **An**	f	f-g	g	g-h	h	h-i	i						

Source: Air carrier

Remark:
This matrix is used by the parent group of the air carrier and was not part of the air carrier SMSM at the time of the serious incident. It was incorporated as a fixed component of the air carrier's SMSM during the investigation of this serious incident.

1.16.3 EASA Safety Information Bulletin (SIB)

SIB No. 2010-33 was published by the EASA on October 18, 2010.

This SIB addresses the topic of "*Flight Deck Automation Policy - Mode Awareness and Energy State Management*".

Due to various incidents, reference is made to the importance of "*automation mode awareness*", and a list of recommendations for aircraft operators is published.

EASA SIB No.: 2010-33
"[...] *This Safety Information Bulletin (SIB) is issued to remind air operators of the importance of air crews continuing to be aware of the automation mode under which the aircraft is operating and to recommend implementation of an Automation Policy. This SIB is based on significant amount of safety data collected through pilots' reporting programmes and accident investigation information.*
This SIB on Automation Policy is prepared in a context in which air operators are requested to provide an Operations Manual which should contain Flight Procedures, one of them being related to the policy on the use of autopilot and auto throttle in accordance with Commission Regulation (EC) No 859/2008 of 20 August 2008 Subpart P 8.3.18.

Automation has contributed substantially to the sustained improvement of flight safety. Automation increases the timeliness and precision of routine procedures reducing the opportunity for errors and the associated risks to the safety of the flight.

Nevertheless, automation has its limits. Critically, in complex and highly automated aircraft, flight crews can lose situational awareness of the automation mode under which the aircraft is operating or may not understand the interaction between a mode of automation and a particular phase of flight or pilot input. Such confusion can lead to the mismanagement of the energy state of the aircraft or to the aircraft deviating from the intended flight path.

Air operators are recommended to:

- *Prepare, in cooperation with airplane manufacturers, an Automation Policy which should in particular address the seven following topics:*
    - *Philosophy*
    - *Levels of automation*
    - *Situational awareness*
    - *Communication and coordination*
    - *Verification*
    - *System and Crew Monitoring*
    - *Workload and System Use*

A core philosophy of "FLY THE AIRPLANE" should permeate the automation policy prepared by air operators.

- *If an Automation Policy already exists, assess the policy against the above topics and* *identify any needed changes.*

- *Ensure that each topic is regularly reinforced in operating procedures and training programs.*
- *Regularly train staff on the Automation Policy and related operating procedures, including flight manual emergency procedures.*
- *Regularly review the Automation Policy and related operating procedures for continuous safety improvement.* […]*"*

1.16.4 Startle Effect

When unforeseen events occur suddenly, this produces a so-called "startle effect". Among others, information on the startle effect has been published in the following policies/guidelines and by the following authorities:

- in FAA Advisory Circular 120-111 from April 14, 2015, entitled "Upset Prevention and Recovery Training".
- in the thesis by Wayne Martin, Patrick Murray, and Paul Bates - entitled: "The Effects of Startle on Pilots During Critical Events: A Case Study Analysis" and published by the Griffith University Aerospace Strategic Study Centre in Brisbane, Australia in 2012.
- on the homepage www.skybrary.aero (a source of data/information established by EUROCONTROL, the ICAO, and the Flight Safety Foundation)

1.16.4.1 Basics of the startle effect (SKYbrary)

„[…] ***Definition***

The startle response, which in professional circles is also referred to as amygdala (or limbic) hijack, is the physical and mental response to a sudden intense and unexpected stimulus. This physiological reaction, which is most commonly known as the "fight or flight" reflex, will occur in response to what may be perceived as a harmful event: an attack, a threat to survival, or more simply, to fear itself. The fight or flight response enables us to react with appropriate action: to run away, to fight, or sometimes, to freeze to be a less visible target. In some circumstances, it can also lead to actions inappropriate for the situation.

In aviation, startle effect can be defined as an uncontrollable, automatic reflex that is elicited by exposure to a sudden, intense event that violates a pilot's expectations.

Description

The startle effect includes both the physical and mental responses to a sudden unexpected stimulus. While the physical responses are automatic and virtually instantaneous, the mental responses - the conscious processing and evaluation of the sensory information - can be much slower. In fact, the ability to process the sensory information - to evaluate the situation and take appropriate action - can be seriously impaired or even overwhelmed by the intense physiological responses. These changes in physiological activity include:

- *Cardiovascular System: Heart rate increases, blood pressure rises and coronary arteries dilate to increase the blood supply to brain, limbs and muscles*
- *Respiratory System: Depth and rate of breathing increases providing more oxygen to the body*
- *Endocrine System: Liver releases additional sugar for energy. Adrenal glands release adrenalin*
- *Muscular System: Muscles tense in readiness for immediate action*
- *Excretory System: Sweat production increases*
- *Nervous System: Brain activity changes, reactions become less reasoned and more instinctive*

Effects

In addition to the previously listed temporary physiological changes which follow a high intensity stimulus, studies have determined that, following a startling stimulus such as a loud noise, basic motor response performance can be disrupted for as much as 3 seconds and performance of more complex motor tasks may impacted for up to 10 seconds.

The time that it takes to recover in a cognitive sense, after a startle event, must also be considered. Startle has been found to impair information processing performance on mundane tasks, such as the continuous solving of basic arithmetic problems, for 30 to 60 seconds after the event occurrence. The duration of the performance degradation increases as the task becomes more complex. Thus, the startle effect disrupts cognitive processing and can negatively influence an individual's decision making and problem solving abilities.

Consequences

As concluded by Martin, Murray and Bates in their paper The Effects of Startle on Pilots During Critical Events, the reliability of modern aircraft is part of the context in which inappropriate actions are sometimes taken after an unexpected event:

"… one of the common themes as aircraft become more reliable is that pilots are surprised or startled by some event and as a result have either taken no action or alternatively taken the wrong action, which has created an undesired aircraft state, or in some cases, an accident. This surprise or startle is largely due to the enduring reliability of the aircraft and the aviation system, which has unwittingly created a conditioned expectation of normalcy among today's pilots…The problem then is the level of expectation of novel or critical events is so low that the level of surprise or startle which pilots encounter during such events is higher than they would perhaps have had some decades ago when things went routinely wrong."

On the flight deck, pilots may be exposed to a variety of stimuli that have the potential to elicit the startle reflex and response. Bird strike, aircraft upset, simultaneous failure of multiple engines and visual stimuli, such as sudden illumination by lasers, have all resulted in incidents where pilots have been startled or even disoriented. In aviation, the immediate impact of the startle reflex may induce a brief period of disorientation as well as short term psychomotor impairment which may well lead to task interruptions and/or a brief period of confusion. Should this happen, a period of time will be required for reorientation and task resumption. While performance after a startle event can be affected to the detriment of safety of flight, the greater concern stems from what the crew did, or did not do, during the conditioned startle response itself. It is here that decision making can be most significantly impaired, especially higher-order functions necessary for making judgments about complex flight tasks.

Strategies for Improving Startle Performance

Researchers have identified a number of strategies that can reduce the negative effects of startle and help improve pilot performance during and immediately following a startle event. These include:

- *Know your aircraft: Develop a sound technical knowledge of your aircraft type and maintain it with regular revision*
- *Maintain handling skills: Be competent and comfortable flying the aircraft "without the automation"*

- *Train appropriately: Simulator exercises should be conducted in a constructive manner with a focus on evidence based (most likely) events. However, there should also be constructive use of unexpected critical events*
- *Be cognisant of your surroundings: Develop and maintain effective situational awareness skill-sets. The Pilot Monitoring (PM) should actively monitor the Pilot Flying (PF) and both should actively monitor the aircraft automation*
- *Avoid complacency: Have a healthy expectation and suspicion for things going wrong*
- *Anticipate threats: Utilise effective threat and error management (TEM) strategies*
- *Have a plan: Mentally rehearse or foster crew discussion of a "plan of action" for both common non-normal events, and for the rare, "out of the ordinary" events such as ditching, upset or uncontrollable fire. Adopt a "what would I do if.." mindset.* […]"

Measures for handling a startle effect more effectively

Both theoretical and practical training, as well as mental training reduce the impact of a startle effect.

Scientific trials have identified the following points for improvement:

Individual strategy:

- Sound knowledge of the systems used in the respective aircraft type, focusing in particular on automation
- Pronounced situational awareness and attentiveness
- A healthy expectation that things can go wrong
- Effective "threat and error management" strategies
- Mental preparation of an action plan for both regular and irregular events, as well as for unpredictable, rare events (so-called "black swan events")

Crew strategy:

- Effective cooperation, communication, and mutual monitoring
- Constructive discussion of scenarios during low workload flight phases

Organizational strategies:

- Pilot selection
- Professional corporate culture

- Exercises in the simulator
- Promoting discussion of incidents
- Focus on incident-oriented training
- Constructive use of unanticipated incidents during training
- Special training on how to avoid, recognize, and deal with undesired aircraft states

1.16.5 Air Carrier internal notifications and measures

Due to some similar incidents, the document "*FDM INVESTIGATION, WINDSHEAR ESCAPE MANEUVER E-195*" was prepared internally by the operator on October 30, 2017 and made available to the cockpit crew.

The summary includes the following:

„[…] *FLIGHT SUMMARY*

- *WEATHER CONDITIONS*
  - *TS and/or moderate showers caused WS system activation*

- *OPERATIONAL FACTORS*
  - *Delaying of approach could have avoided WS warning*
  - *Choice of runway (i.e. head-versus tailwind considerations) could have avoided WS warning*

- *ERRORS OBSERVED*
  - *Go-around maneuver instead of WSHR escape maneuver*
  - *Crews reported that they started with the go-around maneuver while the WSHR warning was triggered. They reported troubles to switch between maneuvers.*
  - *Thrust not MAX*
  - *Set throttle lever to MAX position in order to provide enough thrust in case of inadvertent autothrottle operation in SPD mode(or AT disconnection)*
  - *Late or improper cancellation of WSHR guidance*
  - *Reduce throttle levers slightly below TOGA-detent*
  - *Select FLCH*
  - *Select AT and AP ON*
  - *Select lateral mode(e.g. LNAV)*

- *DISCONTINUE APPROACH IN DUE TIME EVEN IF NO WSHR WARNING ACTIVE*
  - *A delayed response to a windshear may lead to an accident.*

- *MAIN RISKS*
  - *Loss of control in flight (e.g. STALL)*
  - *CFIT (due to improper lateral guidance) […]"*

In the fall of 2017, the following document was issued to the pilots of the Embraer 195 by the air carrier:

"[…] *The days with strong winds at the end of October presented a challenge to flight operations and led to numerous windshear escape maneuvers, as well as several diversions.*

The investigations have not yet been completed. However, analysis of the data has delivered quite serious results for our fleet. Together with Flight Safety, Flight Operations and the Fleet, we are in the process of analyzing any weaknesses and implementing measures as quickly and expediently as possible as a way of improving our performance.

Results in abbreviated form:

- *Windshear during departure*

The airports most affected were SZG, INN, and VIE.
Deviations from the procedures were registered due to delayed introduction of the windshear escape maneuver. Otherwise, good adherence to set procedures was generally observed during these events.

- *Windshear during approach*

In this category, the Embraer fleet recorded the greatest proportion of registered events (29%). The airports most commonly affected were VIE and INN.
Unfortunately, deviations from the procedures and incorrect reactions on the part of the crews were repeatedly recorded here. The most commonly encountered deviations are:
Improper thrust setting
Configuration change during escape maneuver, incorrect exit from windshear mode
These are then compounded by further downstream events, such as unstabilized approach or stick shakers.

Summary and interpretation of the results:

Approximately 0.15 out of every thousand flights in the time period from January 2016 to October 2017 had a reactive windshear warning. The distribution between departure and approach is about the same.
Weather conditions play an important role in triggering windshear events. However, a meteorological windshear warning was not issued in all cases.
SOP deviations primarily occurred during the approach phase.
Frequent reasons for the deviations include the surprise effect, confusion between go-around and windshear escape maneuvers, and incorrect application of the procedures.

Safety recommendations:

- *Preparation*

Choosing the right approach runway can help avoid potential windshear warnings. On several occasions, a later runway change has let to a successful completion.
Thunderstorms and rain showers or meteorological windshear warnings may indicate possible reactive windshear events. Looking out for these meteorological phenomena can help to avoid potential reactive WS events.
A detailed briefing of the potential procedures (windshear caution, windshear warning, windshear escape maneuver, exit of windshear escape maneuver) helps to execute them correctly later on and reduce the surprise effect.

- *Execution*

The procedure should be introduced as quickly as possible (criteria pursuant to OM-A 8.3.8.4.2). Beside incorrect application of the SOPs, long waiting periods with a loss of speed very often lead to further events such as an unstabilized approach or stick shakers.
The procedures need to be applied correctly and without delay.

Measures:

- *REF/PCK*

The current REF/PCK round includes, according to the 3 year cycle, windshear training. This takes on even greater importance, in light of the findings on our fleet, and the instructors will specifically address it.

- *Type rating*

We also analyze our type rating syllabus in order to eliminate any weaknesses in the training offered.

- *Information und Situational Awareness* […]“

1.16.5.1 Provisions of the “EU-Ops” EU Regulation 965/2012

„[…] Annex I, Definitions
‘Startle’ means the initial short-term, involuntary physiological and cognitive reactions to an unexpected event that commence the normal human stress response. […]”

AMC1 ORO.FC.115(f)(4) Crew resource management (CRM) training, Training elements

Surprise and startle effect

“[…] *CRM training should address unexpected, unusual and stressful situations.*
The training should cover:

- *surprises and startle effects; and*
- *management of abnormal and emergency situations, including:*
  - *the development and maintenance of the capacity to manage crew resources;*
  - *the acquisition and maintenance of adequate automatic behavioral responses; and*
  - *recognizing the loss and re-building situation awareness and control. […]”*

GM2 ORO.FC.220&230 Operator conversion training and checking & recurrent training and checking

“[…] *UPSET PREVENTION TRAINING FOR COMPLEX MOTOR-POWERED AEROPLANES*

GO-AROUNDS FROM VARIOUS STAGES DURING THE APPROACH

Operators should conduct the go-around exercises from various altitudes during the approach with all engines operating, taking into account the following considerations:

- *Un-planned go-arounds expose the crew to the surprise and startle effect;*
- *Go-arounds with various aeroplane configurations and different weights; and*
- *Balked landings (between Decision Altitude and touchdown or after touchdown unless thrust reversers have been activated). […]”*

GM3 ORO.FC.220&230 Operator conversion training and checking & Recurrent training and checking

Table 14: Stall Event Recovery Template

<table>
<tr><th colspan="3">Stall Event Recovery Template</th></tr>
<tr><td colspan="3">Pilot Flying - Immediately do the following at first indication of a stall (aerodynamic buffeting, reduced roll stability and aileron effectiveness, visual or aural cues and warnings, reduced elevator (pitch) authority, inability to maintain altitude or arrest rate of descent, stick shaker activation (if installed).) – during any flight phases except at lift-off.</td></tr>
<tr><td colspan="2">Pilot Flying (PF)</td><td>Pilot Monitoring (PM)</td></tr>
<tr><td>1</td><td>AUTOPILOT – DISCONNECT
(A large out-of-trim condition could be encountered when the autopilot is disconnected.)</td><td rowspan="7">MONITOR
airspeed and attitude throughout the recovery and ANNOUNCE any continued divergence</td></tr>
<tr><td>2</td><td>AUTOTHRUST/AUTOTHROTTLE – OFF</td></tr>
<tr><td>3</td><td>a) NOSE DOWN PITCH CONTROL apply until stall warning is eliminated
b) NOSE DOWN PITCH TRIM (as needed)
(Reduce the angle of attack (AOA) whilst accepting the resulting altitude loss.)</td></tr>
<tr><td>4</td><td>BANK – WINGS LEVEL</td></tr>
<tr><td>5</td><td>THRUST – ADJUST (as needed)
(Thrust reduction for aeroplanes with underwing mounted engines may be needed)</td></tr>
<tr><td>6</td><td>SPEEDBRAKES/SPOILERS - RETRACT</td></tr>
<tr><td>7</td><td>When airspeed is sufficiently increasing - RECOVER to level flight (Avoid the secondary stall due premature recovery or excessive g- loading.)</td></tr>
</table>

Source: EU Regulation 965/2012

2 Evaluation

2.1 Flight operations

The air carrier's flight operation and safety management have the legally stipulated documents and procedures to ensure safe operation of the aircraft type Embraer 195. The company maintains a dedicated Safety department pursuant to EU Regulation 965/2012.

The incident was investigated internally by the air carrier's Safety department in cooperation with the cockpit crew. The cockpit crew received feedback on the evaluation from the Safety department. The incident was anonymized and published internally with the findings. The pilots agreed to the "safety promotion". Among other things, the incident is discussed with other pilots from the air carrier during training courses.

The air carrier was unable to conclusively explain why it sent two very different incident reports for this one incident. The process for submitting incident reports by the air carrier was already addressed by the Swiss Safety Investigation Authority (SUST) back in 2015 in its final report no. 2316.

2.1.1 History of flight

The flight was reconstructed as follows on the basis of the analysis taken from the flight recorder and the radar recordings in conjunction with the statements of the two pilots:

The scheduled flight in question was the return flight from Frankfurt to Salzburg. It was the second flight of the day for the cockpit crew. The PF and PM flew together for the first time the previous day.

During the flight from Frankfurt to Salzburg, the aircraft was routed toward Salzburg VOR via radar vectoring with heading instructions while in the Munich area. The aircraft was controlled via autopilot and the autothrottle system. Beside the PF and the PM, one student pilot from the air carrier was also in the cockpit. However, he was not on duty, but rather on board as a passenger.

The cockpit crew observed Thunderstorm cells in the vicinity of Salzburg. Due to a tailwind component that might be too high for landing on Runway 15, the cockpit crew also discussed a circling approach with subsequent landing on runway 33, although this was ultimately not necessary. A diversion to an alternate airport was not considered.

During the ILS approach to runway 15, the aircraft passed through heavy rain showers, which caused a high noise level in the cockpit. The pilots did not receive any advance warning of windshear during the approach, either via ATIS or via radio communication with air traffic control.

During the approach, the SPEED selector knob was set to MANUAL. The Vref was determined as 125 kts using EFRAS 3. Due to gusts, it was increased by 5 kts to 130 kts.

During the approach, the aircraft was flown using the HGS (Head-up Guidance System) and stabilized in accordance with the OM-B stipulations. The speedbug was set to 146 kts at approximately 2660 ft MSL (43 seconds before the windshear). 12 seconds later, it was reduced again to 130 kts. At approximately 2400 ft MSL (approximately 1000 ft HAT), the aircraft suddenly experienced a tailwind component of approximately 24 kts.

Remark:
The cockpit crew considered the monochromatic HGS displays and the associated lower information content a disadvantage.

The cockpit crew was not distracted during the approach and the go-around procedure. At 15:35 UTC (video animation time 45 seconds), the autopilot was deactivated.

One second later (video animation time 46 seconds), at an altitude of approximately 2130 ft MSL and a distance from the runway threshold of approximately 2.3 NM, a windshear caution with a duration of 8 seconds was triggered by the onboard system due to the tailwind component rapidly decreasing to 4 kts.

The windshear caution came as a surprise for the two pilots, which potentially led to increased stress.

Based on the windshear caution being displayed in the cockpit, the PM called out "windshear". The PF then took the decision to go-around and initiated a missed approach procedure.

Remark:
The PF stated that he first noticed a windshear warning (negative windshear) and then a windshear caution. However, it was not possible to confirm this statement with the data available or the video animation.

The obligation to undertake a go-around is only stipulated in case of a windshear warning. If a go-around is executed during a windshear caution, the windshear escape maneuver is to be applied.

During the go-around, the PF moved the two power levers forward up to a TLA of 74.9°/75.3° (left/right), then moved his right hand from the thrust levers to the control yoke and initiated the climb. Four seconds after the windshear caution, the lowest altitude during the approach was reached at approximately 2060 ft MSL (approximately 650 ft or approximately 198 m HAT).

The two pilots were of the opinion that the power levers had been pushed far enough forward and that TOGA-mode had been pressed. However, neither of these was the case.

The Automatic Takeoff Thrust Control System (ATTCS) was therefore also not activated. As such, the autothrottle system remained activated in Speed-Mode and moved back the two power levers in order to maintain the set Vref of 130 respectively 133 KIAS.

To deactivate the autothrottle system, the power levers would have had moved forward to a TLA of 78.0°. The ATTCS (Automatic Takeoff Thrust Control System) was functional, although remained unused on standby. Engaging TOGA-mode would have triggered an engine power of 87.4% N1.

Since a windshear caution was indicated, pressing the TOGA-switch would have activated windshear escape mode and GA-RSV mode. GA-RSV mode would also have been activated if the power levers had been moved to MAX (mechanical stop).

Remark:
In case of a windshear warning, it is sufficient to push the power levers past the TOGA - detent (TLA 70°) or to press TOGA. Since TOGA was not pressed during the go-around, the pitch angle indication of the FD was also missing in addition to the required engine power.

When performing a go-around without FD, the nose of the aircraft needs to be pulled up 8 degrees (pitch angle). This 8 degree position should also be achieved as the "initial pitch" when performing a go-around.

6 seconds after the windshear, the speedbug was set to 133 kts and remained at this value until the end of the video recording. The cockpit crew was unable to explain why this 3 kt increase was set.

As the pitch angle was increased up to 14 degrees and the power was reduced again by the active autothrottle system (or the power required for a go-around was not available), the speed of the aircraft decreased to 113 KIAS. This configuration or aircraft attitude combined with the increased G-load triggered the stall warning (stick shaker) approximately 15 seconds after the windshear caution for a duration of approximately 2 seconds. The aircraft passed through an airstream during this flight phase, which hit the aircraft from the right rear at a force of approximately 29 kts.

Remark:
The PM stated that, based on his training in the simulator, he was aware that the aircraft could not be in a stall at that moment. The approach here is to "*simply allow the pitch to readjust and then fly the aircraft out of this situation*".

The two pilots likely encountered increased stress as a result of the startle and surprise effect.

This led to a situation in which the PF chose not to deactivate the autothrottle system, neither for the windshear nor the stall and also forgot to press the TOGA-switch.

The PM also did not check when performing the go-around or the windshear escape maneuver whether:

- TOGA-mode had been activated (switch pressed).
- The correct engine power had been set or was given
- The autothrottle system had been switched off or deactivated

In addition to this, the PM failed to check during the subsequent impending stall whether the autothrottle system had been switched off and also did not issue the necessary callouts (for example for the mode-switching that had not been performed and the low speed).

The flaps were retracted into position 4, 42 seconds after the windshear at an altitude of approximately 1110 ft above the airport.

A further 10 seconds later, or 52 seconds after the windshear, the landing gear was retracted at an altitude of approximately 2590 ft MSL (approximately 1180 ft HAT).

Remark:
According to the SOPM, the landing gear and flaps are to be retracted at an altitude of 1500 ft AGL at the earliest when performing the windshear escape procedure.
Pursuant to the Honeywell Primus Epic Pilots Guide, this is to be retracted once a secure climb has been achieved.

In the initial phase of the missed approach procedure, the aircraft flew at a speed of approximately 133 KIAS and an climb rate of approximately 500 fpm. The autothrottle system moved the power levers to an average of 75% N1 during this phase.

TOGA was not pressed until 73 seconds after the windshear caution. TOGA-mode triggered an increase in engine power to the ATCCS value of 87.9% N1.

103 seconds after the windshear caution, navigation mode LNAV was selected at a DME indication of approximately 2.1 NM. Another 6 seconds later, at an altitude of approximately 4,100 ft MSL and DME indication of approximately 2.3 NM (instead of 2.0 NM), the left turn of the missed approach procedure was initiated or flown slightly late.

The video recording ends 124 seconds after the windshear caution was issued. At this time, the aircraft was at an altitude of approximately 4600 ft MSL and moving at a speed of 143 KIAS. The climb rate was approximately 2000 fpm. The speedbug was set to 133 kts. The flaps were in position 4. The autopilot was deactivated.

The PF did not see any need to reactivate the autopilot directly after the go-around. As a consequence of this, the aircraft climbed to 10,000 ft MSL and flew two holding patterns above VOR Salzburg. The second approach was made to runway 15 via "Special ILS". The aircraft landed at 16:01 UTC with the flaps in position 5.

After landing, a de-briefing was held by the PF with the PM and the cabin crew.

2.1.2 Cockpit crew

The pilot has been piloting the type EMB195 since January 11, 2017, the copilot since June 19, 2017. Both pilots were licensed to fly this aircraft type on the day of the incident.

Both pilots practiced windshear procedures in the course of their type training. See Chapter 1.5.3.

The two pilots had received general training on the "surprise and startle effect" according to AMC1 ORO.FC.115.f.4. See Chapter 1.5.4.

2.1.2.1 Conduct of the cockpit crew

Due to unexpected windshear indication, both pilots were probably subject to the so-called "surprise and startle effect".

The “startle effect” causes short-term, involuntary physiological and cognitive reactions due to an unexpected (threatening) event. These in turn trigger standard human stress reactions.

The windshear indication represented the first threat and likely led to a limited capacity to act.

At this time, the cockpit crew therefore primarily reacted instinctively (windshear callout, increase engine power, pitch up) and was probably limited in terms of their sensory perception processing (not paying attention to FMA, TOGA-mode, pitch limit, etc.).

This constraint resulted in the temporary omission of the problem-solving procedures and maneuvered the aircraft into the near stalled flight condition (stall). This represented the second and far greater threat for the cockpit crew.

A stalled flight condition, in combination with a low altitude, is a threatening or dangerous situation.

This threat likely reduced the ability of the cockpit crew to take the necessary action even further and led to a mental block in terms of information processing and implementing the requisite procedures.

After the first threat (windshear caution), the cockpit crew flew the aircraft at very low speed and too low rate of climb for 73 seconds and were not capable of correcting this by activating TOGA-mode.

The aircraft flew in this condition toward the mountains in the area surrounding the airport, which represented another threat (at least for the PM). This inability to act for 73 seconds (and also after 58 seconds for the 2nd threat of the potential stall) is within the range that has also been found in scientific investigations.

For example, experiments with test persons have demonstrated that the ability to solve arithmetic problems was impaired for 30 to 60 seconds following a startle event.

2.2 Aircraft

The aircraft was in perfect technical condition on the day of the incident. Not only were all of the aircraft's warning systems functional, they also provided the cockpit crew with active support.

According to the loading plan and OM-B, both the mass and the centre of gravity were within permitted limits at all times throughout the flight.

2.3 Flying weather conditions

The cockpit crew identified multiple thunderstorm cells in the vicinity of Salzburg during the flight.

The PF informed the Safety Investigation Authority (SUB) that the ATIS via ACARS is retrieved every 30 minutes or when a special report is available. However, there was no special report relating to the flight in question.

There was also no advance warning via radio from air traffic control with regard to windshear during the approach to runway 15 in Salzburg (LOWS). During the ILS approach, the aircraft flew through heavy rain showers.

The prevalent weather conditions, with strong gusts of wind from variable directions, had an influence on the incident in question.

3 Conclusions

3.1 Findings

- The aircraft was properly registered, and a valid airworthiness certificate had been issued.
- The cockpit crew held the permission required to carry out the flight. Those were valid on the day of the incident.
- There were no signs of fatigue or any medical issues among the cockpit crew that could have contributed to the incident.
- The company had the stipulated documents and procedures in place in terms of training, flight operations, and safety management.
- The aircraft was operated within the operational limits in terms of mass and centre of gravity at every phase of the flight.
- The prevalent weather conditions was characterized by thunderstorm and rain showers in the vicinity of Salzburg Airport (LOWS).
- Diverting to an alternative airport was not considered.
- The approach was stabilized at 1000 ft HAT for ILS runway 15.
- At approximately 720 ft HAT, a windshear caution was indicated by the onboard system due to a decreasing tail-wind component.
- The PF decided to perform a go-around / windshear escape maneuver. Pursuant to flight operation procedures, this would have been mandatory only following a windshear warning.
- During the go-around, the power levers were not moved far enough forward.
- During the go-around, neither of the two TOGA-switches was pressed.
- The autothrottle system remained in Speed-mode.
- When initiating the go-around procedure, a high pitch angle was chosen.
- Due to the procedural deviations and the increasing tail-wind component, the aircraft almost stalled (stick shaker).
- During both the windshear and the near stalled flight condition, the autothrottle system should have been deactivated.
- The cockpit crew probably had a limited capacity to act as a result of the startle effect and therefore did not initiate the stipulated procedure.

- The lowest altitude above Salzburg Airport (LOWS) during the go-around was approximately 650 ft or about 198 m.
- Due to the lack of engine power, the rate of climb was too low in the initial phase of the missed approach procedure.
- The weather situation with alternating downwind and increasing tailwind components was the trigger for the event.
- The PF completed practical windshear training on December 15, 2015. However, this was not performed with the EMB195 aircraft type, but rather with the Fokker 100 aircraft type.
- Both pilots had completed the required theoretical and practical windshear training.
- Between SOPM of the air carrier and Honeywell Primus Epic Pilots Guide, there are different specifications regarding minimum altitude for retracting flaps and landing gear. However, apart from this, the air carrier documentation used is undoubtedly suitable to ensure safe flight operations.
- The air carrier was unable to conclusively explain why it sent two very different incident reports for this one incident.

3.2 Probable causes

- Procedural deviations of the cockpit crew due to “surprise and startle effect”
- Delayed reaction and activation of TOGA-mode

3.2.1 Probable factors

Crew:

- Impairment due to “surprise and startle effect”
- Delayed pressing of the G/A-buttons
- Procedural deviations

Weather:

- Windshear
- Alternating tailwind components
- Thunderstorm activity in the vicinity of the destination airport

4 Safety recommendations

The Federal Safety Investigation Agency did not identify any circumstances that would justify the issuance of a safety recommendation and concluded that this serious incident could have been avoided by following the relevant aircraft manufacturers, air carriers and statutory respectively regulatory procedures already in place.

5 Consultation procedure / comments procedure

Pursuant to Art. 16 (4) Regulation (EU) No. 996/2010, the Federal Safety Investigation Authority shall solicit comments from the authorities concerned, including EASA, the type certificate holder, the manufacturer and the operator concerned prior to publishing the final report.

In soliciting such response, the Federal Safety Investigation Authority followed the international guidelines and recommendations regarding investigations of aviation accidents and incidents as approved under Article 37 of the Chicago Convention on International Civil Aviation.

Pursuant to section 14 para. 1 of the UUG [Accident Investigation Act] 2005 as amended, the Federal Safety Investigation Authority asked the owner of the aircraft and any survivors or victims for their written comment on the facts and conclusions pertinent to the occurrence under investigation before finalization of the report on the investigation ("Stellungnahmeverfahren").

The responses obtained were taken into consideration and incorporated in the investigation report as applicable.

List of tables

List of figures

List of regulations/guidelines

Federal Act on independent safety investigation of accidents and incidents (**Accident Investigation Act (UUG 2005**), Federal Gazette I No. 123/2005, last amendment by Federal Gazette I No. 143/2020.

Regulation (EU) No. 996/2010 of the European Parliament and the Council from October 20, 2010 on the investigation and prevention of accidents and incidents in civil aviation and the repeal of Directive 94/56/EC .

Regulation (EU) No. 376/2014 of the European Parliament and the Council from April 3, 2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, amending Regulation (EU) No. 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No. 1321/2007 and (EC) No.
1330/2007, as amended.

Regulation (EU) No. 1178/2011 of the EU Commission from November 3, 2011, laying down technical requirements and administrative procedures related to civil aviation aircrew pursuant to Regulation (EC) No. 216/2008 of the European Parliament and of the Council.

Implementing Regulation (EU) No. 923/2012 of the Commission of 26 September 2012 laying down common air traffic rules and operating rules for air traffic control services and procedures and amending Implementing Regulation (EC) No. 1035/2011 and Regulations (EC) No. 1265/2007, (EC) No. 1794/2006, (EC) No. 730/2006, (EC) No. 1033/2006 and (EU) No. 255/2010. (**SERA**)

EASA Research Project: Startle Effect Management

EASA Safety Information Bulletin 2010-33 Flight Deck Automation Policy – Mode Awareness and Energy State Management

Griffith University Aerospace Strategic Study Center: Martin/Murray/Bates "The Effects of Startle on Pilots during Critical Events: A Case Study Analysis"

Abbreviations

AGL	Above Ground Level
AIP	Aeronautical Information Publication
ALT	Altitude
AMC	Acceptable Means of Compliance
AMSL	Above Mean Sea Level
AOA	Angle of Attack
ARC	Airworthiness Review Certificate
AR-CRM	Annual Recurrent Crew Ressource Manual
AT	Autothrottle
ATC	Air Traffic Control
ATTCS	Automatic Takeoff Thrust Control System
ATS	Air Traffic Service
AUW	All Up Weight
BCMT	Beginning of Civil Morning Twilight
BGBl.	Federal Gazette
BKN	Broken (5/8 - 7/8)
CBO	Cycles Between Overhaul
COM	Communications
CPL	Commercial Pilot Licence
CRI	Class Rating Instructor
CSN	Cycles Since New (manufacture)
CSO	Cycles Since Overhaul
CU	Cumulus
EASA	European Aviation Safety Agency
EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine Indication and Crew Alerting System
ECET	End of Civil Evening Twilight
ELEV	Elevation

ELT	Emergency Locator Transmitter
FC-OCO	Flight Crew Operator Conversion Training
FC-PMT	Flight Crew Pilot Modular Recurrent Training
FEW	Few (1/8-2/8)
FI	Flight Instructor
FMA	Flight Mode Annunciator
fpm	feet per minute
Ft	Feet
GA	Go-Around
GA mode	Go-Around-mode
GND	Ground
GS	Ground Speed
HAT	Height Above Threshold
HGS	Head Up Guidance System
ILS	Instrument Landing System
JAR-FCL	Joint Aviation Requirement – Flight Crew Licensing
KIAS	Knots Indicated Airspeed
Kts	Knots
LAPL	Light Aircraft Pilot License
LAT	Latitude
LIBN	Bari Airport
LIRN	Naples Airport
LNAV	Lateral Navigation
LONG	Longitude
LOWS	Salzburg Airport
LOWW	Vienna International Airport
LPC	Line Procedure Check
METAR	Aviation Routine Weather Report (Code Form)
Mmo	Maximum Operating Procedures Manual
MSL	Mean Sea Level

NCD	No Clouds Detected
NIT	Night Qualification
NOSIG	No Significant change
OM-A	Operations Manual Part A
OM-B	Operations Manual Part B
OM-D	Operations Manual Part D
OPC	Operational Procedure Check
OPS	Operational Safety Section
OVC	Overcast (8/8)
PF	Pilot Flying
PFD	Primary Flight Display
PIC	Pilot in Command
PM	Pilot Monitoring
P/N	Part Number
PPL	Private Pilot License
Q	Indicator for QNH in Hectopascal
QFE	Air pressure at airport altitude (or at the runway threshold)
QNH	Altimeter scale adjustment to maintain airfield altitude during landing
RA	Rain
RA	Radio Altimeter
RCC	Rescue Organisation Centre
RMK	Remark
RNAV	Area Navigation
RPM	Revolutions Per Minute
RTO	Reverse Thrust Operations
SC	Stratocumulus
SCT	Scattered (3/8-4/8)
SERA	Standardized European Rules of the Air
Sim LFT VIE	Simulator Lufthansa Flight Training Vienna

SMSM	Safety Management System Manual
S/N	Serial Number
SOPM	Standard Operating Procedures Manual
SSR	Secondary Surveillance Radar
TAF	Terminal Aerodrome Forecast
TLA	Thrust Lever Angle
TRE	Type Rating Examiner
TRS	Thrust Rate System
TAF	Aerodrome Forecast
TBO	Time Between Overhaul
TMG	Touring Motor Glider
TOT	Take-Off Thrust
TR	Track
TSN	Time Since New (manufacture)
TSO	Time Since Overhaul
UTC	Coordinated Universal Time
ASL	Above the Sea
REG/EU	Regulation of the European Union
VRB	Variable
Vref	Referential Speed
VS	Vertical Speed
Vmo	Maximum Operating Speed
WGS84	World Geodetic System 1984
WSHR	Windshear
WSHEAR	Windshear
Z	zulu – see UTC

Imprint

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Final report
This final report pursuant to Article 16 of Regulation (EU) No. 996/2010 has been approved by the Head of the Federal Safety Investigation Authority after finalisation of the consultation procedure in accordance with Article 16 of Regulation (EU) 996/2010 in conjunction with § 14 (1) UUG [Accident Investigation Act] 2005.

The sole purpose of the safety investigation is prevention of future accidents or incidents, without apportioning blame or liability. This investigation report is based on information provided by the involved parties. In the case of an extension of the information basis, the Federal Safety Investigation Authority reserves the right to supplement the present investigation report.

All information relating to data protection can be found via the following link
bmk.gv.at/impressum/daten.html

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