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Report
IN-020-2017

Incident involving an ATR 72-212A aircraft, registration EC-KKQ, operated by Swiftair, at flight level 170 in the vicinity of reporting point NARGO (Albacete-Spain) on 9 September 2017

GOBIERNO
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Notice

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1., 4. and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

Contents

Abbreviations

ºC	Degrees centigrade
ACC	Area control center
AESA	National Aviation Safety Agency
AEMET	National Weather Agency
AFM	Aircraft Flight Manual
APM	Aircraft performance monitoring
AUPRTA	Airplane Upset Prevention and Recovery Training Aid
ATC	Air traffic control
CLB	Climb
CRI	Course rating instructor
CRZ	Cruise
CVR	Cockpit voice recorder
EGPWS	Enhanced ground proximity warning system
FCOM	Flight crew operation manual
FI	Flight instructor rating
FL	Flight level
fpm	Feet per minute
ft	Feet
GS	Ground speed
h	Hours
IAS	Indicated airspeed
IEP	Ice evidence probe
IMC	Instrument meteorological conditions
IFR	Instrument flight rules
IR	Instrument rating
IRI	Instrument rating instructor
kg	Kilograms
kt	Knots
m	Meters
MAX PWR	Maximum power
MCT	Maximum continuous thrust
min	Minute
N	Newtons
NM	Nautical miles
ICAO	International Civil Aviation Organization
PRM	Pilot reference manual

PWR MGT	Power management
QRH	Quick Reference Handbook
s	Second
S/N	Serial number
SAT	Static air temperature
seg	Seconds
SP	Stick pusher
SW	Stall warning
TACC	Terminal area control center
TAT	Total air temperature
TLU	Travel limitation unit
TO	Take off
TRI	Type rating instructor
TWR	Control tower
VMC	Visual meteorological conditions
VS	Vertical speed

Synopsis

Owner and operator:	Swiftair
Aircraft:	ATR72-212A, registration EC-KKQ
Date and time of incident:	Saturday, 9 September 2017 at 20:26 local time[1]
Site of incident:	10 NM north of reporting point NARGO at FL170
Persons on board:	Crew: 4 (uninjured)
	Passengers: 22 (uninjured)
Type of flight:	Commercial air transport – scheduled - domestic - passenger
Flight rules:	IFR
Phase of flight:	En route – climb to cruise level
Date of approval:	27 November 2019

Summary of incident

On Saturday, 9 September 2017, aircraft EC-KKQ, with callsign AEA4050, after climbing for 16 minutes, 8 of which had been in icing conditions, suffered an uncommanded loss of altitude of 1661 ft for 33 seconds, along with a series of uncommanded pitches and banks.

The aircraft had taken off from the Alicante Airport at 20:08 with 26 persons on board (2 pilots, 2 cabin crew and 22 passengers) en route to the Madrid-Adolfo Suárez Airport. After the event, which lasted 33 seconds, the aircraft continued flying to the destination airport, where it landed, touching down lasting the first third of the runway after making an unstabilized, high-speed approach.

The investigation has determined that the probable cause of the loss of control in icing conditions was a deficient flight management by the crew and an inappropriate use of automation.

The report contains four safety recommendations issued to Swiftair, as the operator of aircraft EC-KKQ.

[1] All times in this report are local.

1. FACTUAL INFORMATION

1.1. History of the flight

On Saturday, 9 September 2017 at 20:08:41, an ATR-212A aircraft, registration EC-KKQ, took off from runway 10 at the Alicante Airport en route to the Madrid-Adolfo Suárez Airport with 26 persons on board (2 pilots, 2 cabin crew and 22 passengers). Its planned flight profile called for an initial climb segment to reporting point NARGO, and then a cruise phase at FL170.

The temperature at the departure airport was 28° C, with light winds and few clouds at 2000 ft. At the Madrid airport, the forecast was for 20° C and visibility in excess of 10 km. The forecast for the initial 80 NM of the flight called for light icing conditions at FL140, worsening to moderate icing conditions at reporting point NARGO (35 NM away from Alicante). The first officer was the pilot flying.

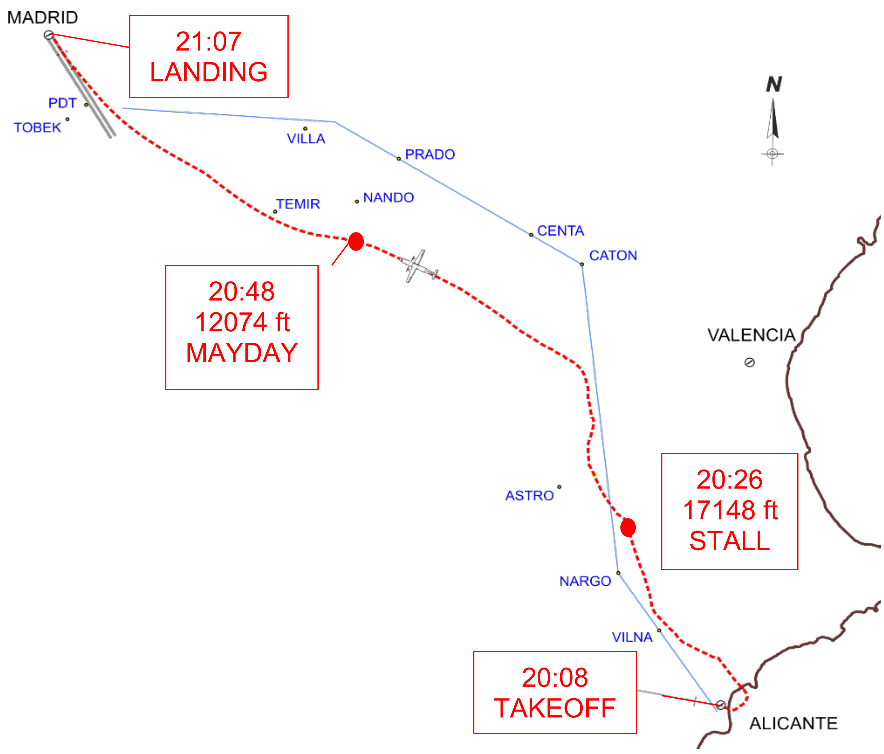

Figure 1. Full flight path of aircraft EC-KKQ

Eight minutes into the flight, with the aircraft passing FL100 (10023 ft) and climbing to FL170 (its authorized level), the temperature TAT reached a value 7° C[2]. Two minutes later, with the TAT at 2.7° C and climbing at a speed of 175 kt[3] at 12516 ft, the crew turned the anti-icing systems on (ANTI ICING ON). Within 28 s, the aircraft's ice build-up

[2] 7° C and visible moisture are the reference criteria for identifying icing conditions.

[3] The speed references used in this report are the indicated airspeeds (IAS).

caution was activated (icing illuminating amber on the central panel: ICING LIGHT ON), as a result of which, 5 s later the crew turned the de-icing systems on (DEICING ON). Two minutes after the de-icing systems were turned on, at 20:20:58, with the aircraft at 14883 ft and still climbing, the FDR recorded the ICING signal went off (ICING LIGHT OFF), only to turn on again 42 s later (ICING LIGHT ON).

The aircraft continued to climb and two minutes later, at 20:22:45, at 16067 ft and 169 kt, the DEGRADED PERF caution turned on. The vertical speed during this period had decreased from 1100 fpm to 500 fpm[4].

Reaching 16200 ft, the vertical speed was 0 fpm and the aircraft, unable to climb, maintained the altitude for a minute and a half. The captain selected the VS (vertical speed) mode with a rate of climb of 1100 fpm in order to climb up to the top of the clouds. At the same time, at 20:25:41 (16852 ft), the crew requested permission from the Valencia TACC to climb to FL190 to "*clear*" weather conditions.

By 20:26:03, as a consequence of the previous actions, the aircraft had lost speed and was stalling at 153 kt. For 33 s, the aircraft descended, from 17148 ft to 15487 ft. During this descent, a minimum speed of 151 kt, an angle of attack of up to 19.6°, a pitch angle of up to -11°, and left and right bank angles of 58° and 39°, respectively, were recorded.

Stall was recovered at 20:26:36, 15487 ft and 195 kt.

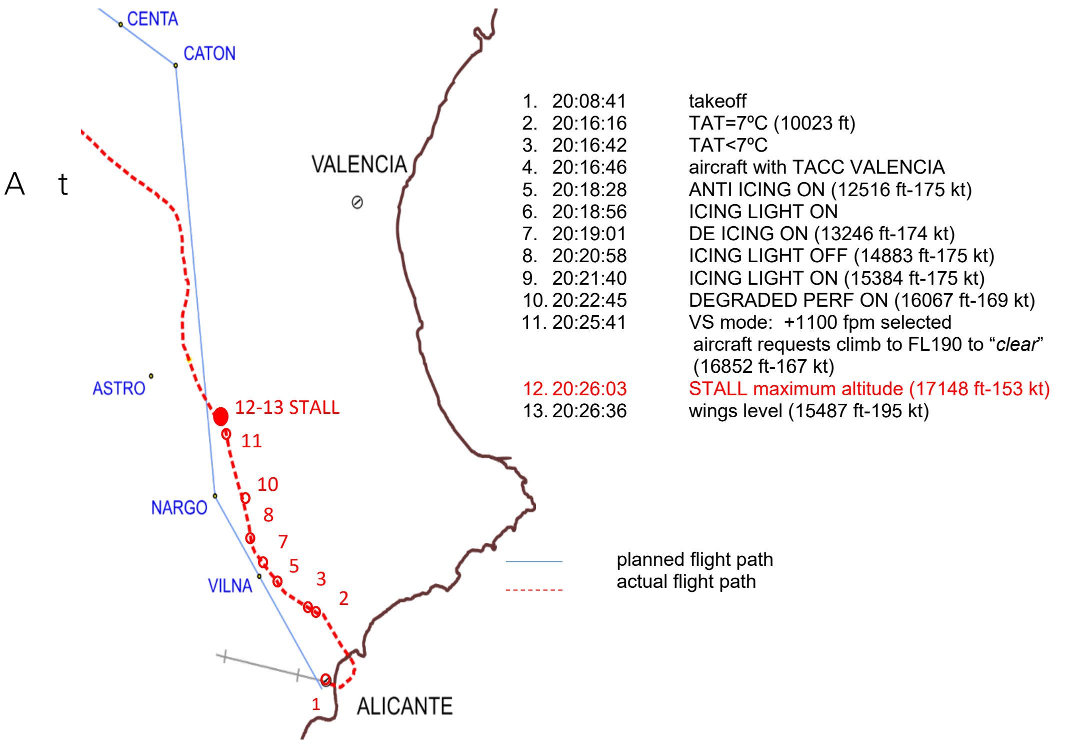

Figure 2. Flight path up to the event (18 min of flight time)

[4] Theoretical climb rate computation in the assumed flight conditions shall have been above 600 fpm.

At 20:26:26, still descending to 15980 ft, the crew asked the Valencia TACC for an "*immediate descent*". The controller cleared them to descend at their discretion, reporting that the minimum radar in the area was FL70. The aircraft continued descending and at 20:28:04, the crew informed Valencia TACC they were descending to FL70, holding on course and asked the controller if there were any significant weather phenomena, receiving a negative reply. At that point, ATC inquired about the reason for the descent, to which the crew replied; "*we stalled due to icing*". The aircraft was at 14932 ft and descending (20:28:38).

After this information, the controller asked about their intentions and informed them of the location of the Valencia Airport with respect to their position (20:28:58).

At 20:31:32, at 13826 ft, the crew informed the Valencia TACC they were clear of the clouds and were proceeding to CENTA. This report was interpreted by the controller as meaning they had solved their icing problem, which is how the controller relayed it to the adjacent controller in the Madrid ACC, to whom he would soon be transferring the aircraft.

At 20:31:47, the aircraft was at 13752 ft and was stopping the descent.

At 20:33:23, with the aircraft at 13778 ft, the first officer took photos of the cockpit windshield and the right wing, showing the presence of ice on the aircraft (section 1.7.4). One minute later, the crew asked the Valencia TACC to continue direct to PRADO to avoid clouds, and initiated a left turn. At 20:35:25, the DEGRADED PERF caution cleared. It had been activated for 12 min 50 s. Three minutes later, ATC asked them to climb to FL150 due to the minimum altitude of the Madrid ACC sector, a flight level the crew accepted. At 20:41:27, the aircraft was transferred to the Madrid ACC.

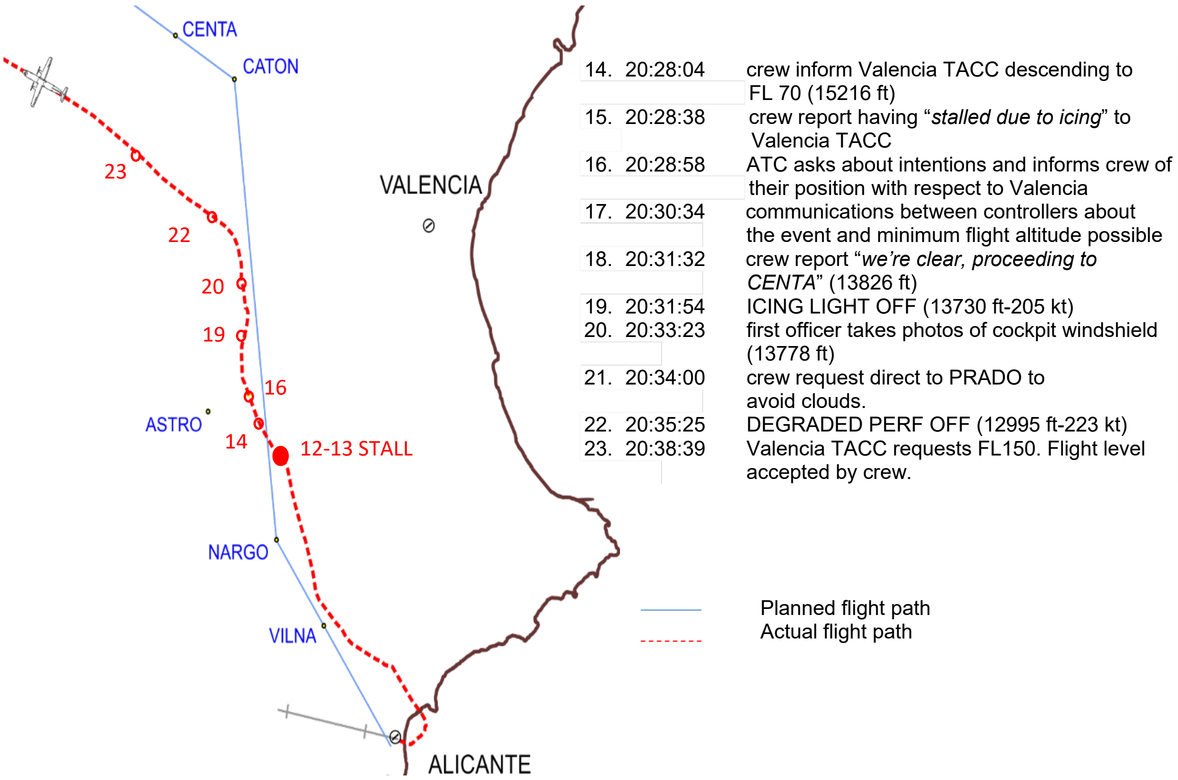

Figure 3. Flight path after the event (10 min of flight time)

At 20:42:26, after the controller asked if the icing situation was solved, the crew reported they had taken on a lot of ice, that something was wrong, the problem was still present but they were stable. Five minutes later, at 20:47:22, the crew reported they had not solved the problem yet and requested to descend. At 20:48:25, they reported a MAYDAY and requested direct to Madrid due to continuing "*problems with the controls*".

At 20:50:29, ATC asked if they needed help on the ground, to which the crew replied no. After several conversations on which runway to use in Madrid, and keeping in mind the crew's request to land on runway 32R, this runway was opened, even though the runway in use was 32L. At 20:57:31, once in contact with the approach controller, the crew asked if there had been any reports of turbulence in the area where they were flying, receiving a negative reply. The aircraft was cleared to make the 32R approach.

At 21:07:00 the aircraft touched down at a speed of 140 kt. The temperature was 22° C and the firefighters were on the scene. During the landing run, the captain, who had been the pilot flying since the event, was heard saying "*the left pedal is not working, the pedals are jammed*". This problem did not affect the landing run or the taxi, and the aircraft cleared the runway and taxied under its own power.

After leaving the runway, the purser requested an ambulance from the crew for one of the passengers who had been given oxygen during the flight. The request was relayed by the first officer to the tower, which initiated the medical protocol.

The aircraft stopped after taxiing for 7 min, at 21:14:04, at remote stand number 4, where the passengers disembarked. The passenger for whom the ambulance had been requested was treated for anxiety by airport medical personnel.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				
None	4	22	26	
TOTAL	4	22	26	

1.3. Damage to aircraft

None.

1.4. Other damage

None.

1.5. Personnel information

1.5.1. Captain

The captain was a 55-year-old Spanish national. He had an airline transport pilot license issued by the National Aviation Safety Agency (AESA). He had valid[5] ATR42/72 and instrument flight (IR) ratings. He also had valid[6] class rating instructor (CRI), type rating instructor (TRI), instrument rating instructor (IRI) and flight instructor (FI) ratings.

He had a total experience of 18294 h 46 min, of which 4497 h had been on the ATR72, of which 3267 as copilot. He had worked for Swiftair since September 2015.

1.5.2. First officer

The first officer was a 33-year-old Spanish national. He had a commercial pilot license issued by the National Aviation Safety Agency (AESA). He had valid[7] ATR42/72 and instrument flight (IR) ratings. He also had a valid[8] flight instructor (FI) rating, restricted to single engine.

He had a total experience of 1431 h 24 min, of which 421 h 28 min had been on the ATR72. He had worked for Swiftair since October 2016.

[5] Until 31/12/2017
[6] Respectively until 31/10/2018, 31/07/2018, 30/04/2019 and 30/04/2019..
[7] Until 30/09/2018.
[8] Until 31/05/2018.

1.5.3. Training

Swiftair's training was described in Part D of the *Operations Manual* approved by AESA. Part D of this OM, with a total of 984 pages, contained the instruction, training and verification program approved by Swiftair for all operations personnel (both on the ground and in the air). The material instructional resources used were also described. The ground training was conducted in the operator's facilities, and practical training relied on simulators contracted from third parties approved by the Authority.

All of Swiftair's training content complied with the requirements laid out in European Union regulation 965/2012, on commercial air transport operations with airplanes.

In keeping with the reference regulation, the OM described the initial training required for any flight crew member joining the operator, as well as the refresher periodic training. The training activities covered aspects involving each of the fleets and general aspects (applicable to several fleets). Of all the training received, of interest to the investigation are the training activities involving flying in icing conditions and stall recovery.

The general training included training on cold weather operations, which contained three modules, the first two of which are applicable to the incident:

- Training on de-icing and anti-icing: it had a duration of 50 min (initial) and 30 min (refresher). The content included knowing how ice impacts flight and using weather documentation. In addition to a written test, there was a simulator verification of this training as part of the operator's proficiency check during its winter operations campaign.
- Training on flying in icing conditions: it had a duration of 50 min (initial) and 30 min (refresher). The course content included training on meteorology and procedures to use in icing conditions (normal, emergency, main wing and tailplane stalls, degraded performance, etc.). There was a written test as well as a simulator verification as part of the operator's proficiency check.
- Training on contaminated runways.

As concerns the stall, the instructional program included initial and refresher classroom and simulator training focused on recovering from a stall, which also repeated the training for recovering from abnormal positions. The training on this subject included concepts related to the angle of attack, identifying a stall, recovery procedures, the stick pusher and stick shaker systems and the effects of icing.

A review of the complete training program for the captain and first officer since joining the company showed compliance with the periodicity and contents specified in Swiftair's *Operations Manual* Part D. Each of the training activities was successfully completed by both crew members. Of interest to the investigation was all of the training received by the crew on flying in icing conditions and recovering from a stall from the time each crew member joined the company until the incident.

As concerns the simulator training, the one used by Swiftair (class-D simulator, with GTA certification ES-1A-028) did not have the APM implemented (see section 1.6.5) until 4 August 2017. Therefore, all simulator training in icing conditions done by the captain and first officer did not include this system, though they had received the relevant theoretical training.

Captain's training:

- September 2015: instruction on cold weather operations: training on de-icing and anti-icing, training on flying in icing conditions and training on contaminated runways.
- October 2015: simulator training on stall recovery and preventing and recovering from abnormal positions.
- April 2016: simulator training on stall recovery, preventing and recovering from abnormal positions and operating in icing conditions.
- May 2016: instruction on cold weather operations.
- September 2016: instruction on preventing and recovering from abnormal positions.
- October 2016: simulator training on preventing and recovering from abnormal positions.
- May 2017: instruction on cold weather operations.
- April 2017: simulator training on operating in icing conditions.

First officer's training

- October 2016: instruction on cold weather operations, consisting of three courses: training on de-icing and anti-icing, training on cold weather operations and training on contaminated runways.
- October 2016: simulator training on stall recovery and preventing and recovering from abnormal positions.
- February and March 2017: instruction on cold weather operations.
- March 2017: simulator training on operating in icing conditions.
- August 2017: instruction on preventing and recovering from abnormal positions.

1.6. Aircraft information

The aircraft, an ATR-72-500 (212A), S/N 763 with registration EC-KKQ, had been manufactured in 2007. It was outfitted with two Pratt & Whitney PW127F engines, it had a maximum takeoff weight of 22800 kg and an operating empty weight of 14062 kg. It had 10590 h and 12940 cycles. It had a certificate of airworthiness at the time of the incident that was valid until 27 July 2018.

The aircraft's load and balance at takeoff were within the limits specified by the manufacturer. On the incident flight, the aircraft's takeoff weight was 18415 kg.

1.6.1. Certification for operations in icing conditions

The certification of all commercial aircraft certified as per CS/JAR 25 allows flying in icing conditions as per Appendix C[9]. The airplane is deemed to be flying in certified icing conditions but a series of actions must be carried out on the aircraft (such as activating anti-icing measures or flying at certain speeds) and a series of procedures must be carried out to ensure that the aircraft can be flown safely in this environment.

The monitoring of the performances enable the flight crew to stay within the certified envelope. In case of inadvertent encounter of conditions outside of the envelope (severe icing), the manufacturer has published operational procedures to detect and escape the severe icing conditions.

1.6.2. Identifying atmospheric icing conditions

The procedures specify criteria for identifying if icing conditions are present and when the icing is severe (meaning the flight must not continue in that area):

- Icing conditions:
  - TAT ≤7°C and
  - Visible moisture (clouds, fog, rain, reduced visibility, ice or snow on the glass).
- Severe icing conditions:
  - Ice covering all or part of unheated areas of the side windows, and/or
  - Decrease in speed and/or climb rate, and/or[10]
  - Other secondary visual indications (water on windshield, ice build-up on parts of the aircraft where ice does not normally accumulate, ice on the underside of the wings behind protected areas, or more ice than usual on the spinner).

9 This aircraft is certified as per FAR/JAR part 25.1419 (ice protection), Appendix C, and DGAC Special Condition (SCB6). These sections of the regulation require manufacturers to demonstrate that the aircraft can operate safely in the maximum continuous and maximum intermittent icing conditions defined. The icing conditions in which the aircraft is capable of flying safely are defined in Appendix C by way of three parameters: water droplet diameter, water content and temperature range.

10 As explained in paragraph 1.18.2, after the event new icing procedures came into force. The new procedures emphasize ATR performance base philosophy. Severe icing detection is based on aircraft performance: the crew must be aware of the total energy level of the aircraft, and inflight, energy should be done through rate of climb and speed. So, these parameters are included in the first level on the new procedures, prior to visual cues of ice accretion.

1.6.3. Anti-icing protection on the aircraft

In order to operate in icing conditions, the ATR-72 has electrical and pneumatic protective systems. This protection takes place on three levels:

1. Permanent anti-icing protection (ANTI ICING): activated after engine start. Involves a heating system, through the electrical system, for the windshield and probes.
2. Anti-icing protection (ANTI ICING): turned on by the crew when icing conditions appear. Involves a heating system, through the electrical system, for the side windows, the ends of the flight control surfaces and the inboard leading edge of the propeller blades[11].
3. De-icing protection (DE ICING): turned on by the crew when ice build-up begins. Consists of a boot inflation and deflation system, with air supplied by the pneumatic system. The boots are located on the leading edges of the wing, horizontal stabilizer and engine air intakes.

1.6.4. Detection of icing on the aircraft

There are two elements that detect the presence of ice on the aircraft:

- An ice detector probe located under the left wing that, when ice builds up on it, turns on an amber ICING light.
- An ice evidence probe (IEP) located near the left cockpit window that is visible to both pilots. The IEP is foil shaped and is conducive to ice accretion, and is thus the best indicator of the presence of ice on the aircraft. The IEP is the first place where ice builds up and the last place from which it will disappear[12].

1.6.5. Aircraft performance monitoring (APM system)

The aircraft has a system called APM (aircraft performance monitoring) that:

- monitors the aircraft's aerodynamic drag in icing conditions against the theoretical performance it should have based on parameters measured in flight, and
- alerts the pilot if the speed drops below the minimum speed when the system has detected abnormal drag increase.

[11] The outboard part deices from the effect of centrifugal forces.

[12] Information included in the manufacturer's and operator's documentation (FCOM ATR 72 – PROCEDURES AND TECHNIQUES – ADVERSE WEATHER). The rest of the content included in this section 1.6 is taken from various documents of the manufacturer and operator.

The APM turns on in icing conditions[13] and displays three visual indications in the cockpit, in order of severity:

- CRUISE SPEED LOW (blue): monitors the cruise speed and turns on if an abnormal increase in drag causes the speed to fall 10 kt more than expected. The actions to take in this case are:
  - Monitor icing conditions and speed.
- DEGRADED PERF (amber) – turns on in cruise on when climbing if there is an abnormal increase in aerodynamic drag but the speed is above the minimum severe icing speed[14]. This is the caution that turned on during the incident flight. The actions to take are:
  - Turn on de-icing systems.
  - Maintain speed above severe icing speed.
  - Disengage autopilot.
  - If the conditions are confirmed, apply the severe icing procedure.
- INCREASE SPEED (amber): turns on in cruise, climb or descent phase if there is an abnormal increase in aerodynamic drag and the indicated airspeed is below the minimum severe icing speed. The actions to take are:
  - Immediately use the stick to recover speed.
  - Apply the severe icing procedure.

In order for the APM system to generate these cautions, it needs information on the aircraft's weight, which must be entered by the crew using a 12-position rotary switch. This selector must be set before takeoff, after the engines are started, and must be moved even if its value is the same as from the previous flight. The weight value will condition the thresholds for activating each of the cautions. On the incident flight, the value entered into the APM system did not match the aircraft's actual weight; instead, it was 2 tons lower (see section 1.11.1).

1.6.6. IAS, PITCH and VS autopilot modes

There are several autopilot modes used in the description of the incident. These are:

- IAS mode: maintains the aircraft's speed at the value set and entered by the crew as the selected speed. The autopilot will take action to maintain this speed at all times; as a result, in turbulent environments, for example, it could induce pitching up/down. This is the preset flight mode for the climb phase and required in icing conditions.

[13] APM only works if ice is detected on the aircraft, when a de-icing system has been activated or when the anti-icing system has been activated.

[14] This speed is defined as the icing speed (red bug) + 10 kt. See section 1.6.8.

- PITCH mode: maintains the aircraft's pitch angle at the value set and entered by the crew as the selected pitch angle. PITCH mode is more "comfortable" for passengers but leaves the aircraft exposed in turbulent atmospheric conditions, for example. Its use in icing conditions is strictly prohibited[15].
- VS mode: maintains the climb rate at the value set and entered by the crew as the selected climb rate. This mode of operation must not be used in icing conditions[16].

1.6.7. Power management

To make it easier to understand the description of the incident in section 1.11, a very general description is provided of this aircraft's power management system. The power settings are selected by using the thrust and condition levers (located on the pedestal) and a power management (PWR MGT) selector, located on the pedestal, and which the crew use to adapt the power to each phase of flight. The fuel flow rate into the engines is conditioned by the position of the PWR MGT switch and by the power lever.

With the condition levers in AUTO and the power lever in NOTCH, the PWR MGT can be set to:

- Takeoff power (TO)
- Maximum continuous thrust (MCT)
- Climb power (CLB)
- Cruise power (CRZ)

The power lever has several positions:

- NOTCH position, where the engine rating is managed through the PWR MGT switch.
- Maximum power (MAX PWR) position, used only in emergencies.
- Others: reverse, ground idle, air idle, go-around and manual mode.

1.6.8. Minimum icing speed or red bug

As part of the flight preparation, the crew must identify a series of speeds, which are also marked on the airspeed indicator by way of bugs. These include the speed for icing

[15] The Swiftair *Pilot Reference Manual* (PRM, Rev. 08), point 3.9 on the final climb specifies that at around FL150 and/or when the autopilot starts to pitch up and down, the basic PITCH HOLD mode can be set for increased comfort. As a safety measure, the pitch mode is limited to 4°.

[16] *Flight Crew Operations Manual*, chapter on Procedures and Techniques, Adverse Weather, Icing Procedures.

conditions[17], which in the case of the incident flight was 149 kt[18] (weight 18 t[19] and flaps 0). This speed is marked using a red indicator, and is colloquially known as the red bug speed. One of the photos taken during the flight by the first officer shows that this speed was correctly marked on the air speed indicator.

1.6.9. Rudder travel limiter unit (TLU)

The purpose of the travel limiter unit (TLU) is to restrict the travel of rudder pedals so as to prevent the damage that may result from moving the rudder at high speeds. When the TLU is in automatic, which is its normal condition[20], when the air data computers detect 185 kt and accelerating or 180 kt and decelerating, the TLU is placed in HI SPD or LOW SPD mode, respectively. The HI SPD mode restricts the travel of the pedals, and the LO SPD mode expands their travel.

There is a visual indicator in the cockpit that allows checking before landing, for example, that the TLU has transitioned from the HI SPD mode it will have in flight to the LO SPD mode that will be necessary for control on the ground.

The BEFORE LANDING checklist includes verifying the position of the TLU (in LO SPD).

1.7. Meteorological information

1.7.1. Information provided by AEMET

The weather information issued by AEMET on the 20:00 significant low-level chart forecast that the flight would take place in an area with storms embedded in the clouds of the front and in the subsequent lines of instability. Moreover, the precipitation that was falling in the area could have been taking place in icing conditions, since the zero-degree isotherm (level at which the outside air temperature is 0° C) was close to FL100. This chart was not given to the crew since the operator did not have this information in its flight dispatch offices; rather, it gives its crews information for medium/high levels. In this case, the information displayed on both charts (low level and medium/high level) was similar.

1.7.2. Icing report from two hours earlier

Two hours before the incident, at 18:35:33, an aircraft (RAM969C) reported moderate icing at point ASTRO (marked in Figure 3) to the Valencia TACC. It was at 16500 ft, cleared to FL190 and it requested to stay at FL170 due to icing. This information was not known by the crew of EC-KKQ.

[17] This is the absolute minimum maneuvering speed, which provides the best climb gradient in a flaps 0 configuration and which provides a margin of 1.40 above the stall speed at 1g.
[18] The manufacturer recalculated this speed for the aircraft's weight at the time of the stall, considering the fuel consumed and ISA+10 conditions, yielding a result of 149.2 kt.
[19] Takeoff weight: 18415 kg. Weight at the time of the incident: 18195 kg.
[20] The option exists to operate the TLU in manual.

1.7.3. Weather information provided to the crew

The weather information involving icing provided to the crew before the flight was on a vertical cross-section map of significant phenomena and the medium/high level significant weather chart (FL100-FL450). On these two maps, the forecast was for:

- Moderate icing and turbulence at FL150 and above from takeoff until Castejón (medium/high level significant weather chart).
- Light icing at FL140 from Alicante until 22 NM before CATON (vertical cross-section map). Moderate icing at FL140 at NARGO (vertical cross-section map).

The 20:00 (18:00 UTC) METAR that the crew used to prepare the takeoff showed that at the Alicante Airport the temperature was 28° C, light and variable winds, visibility in excess of 10 km and few clouds at 2000 ft. Upon arriving in Madrid, the expected conditions were CAVOK and 20ºC.

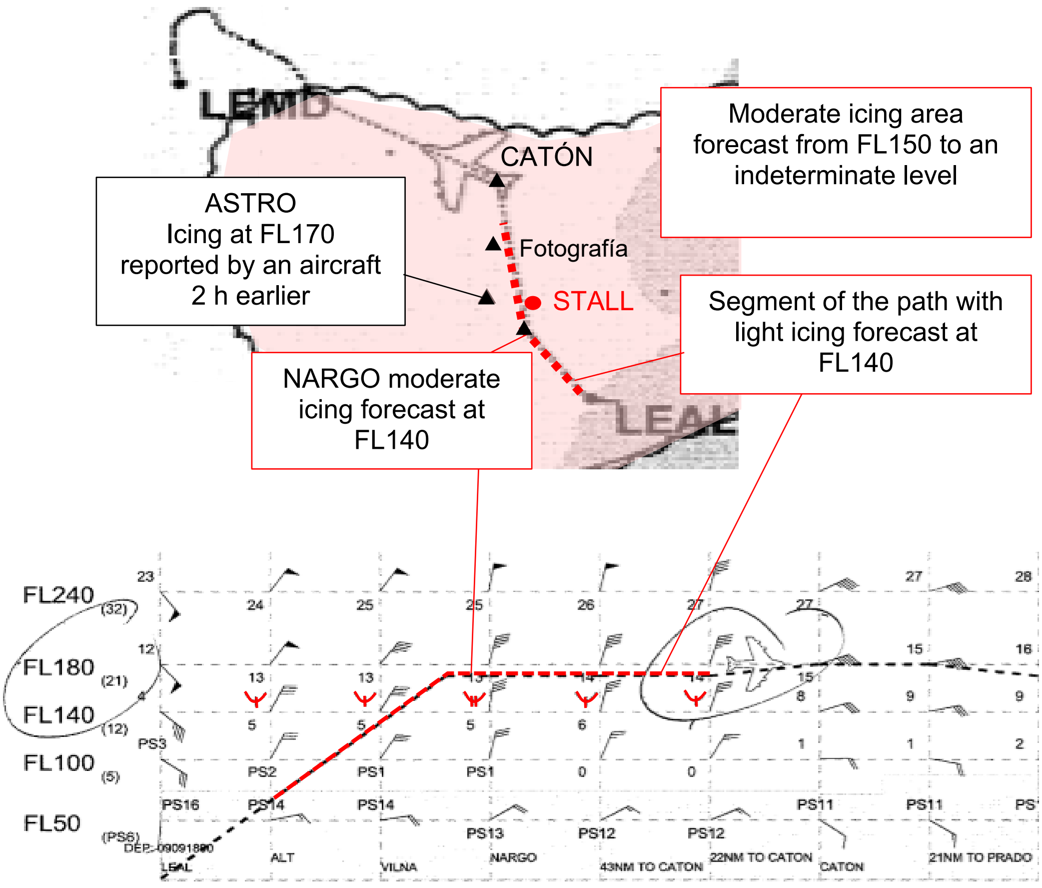

Figure 4. Information on icing forecast

1.7.4. Photographs taken by the crew 8 min after the incident

The crew took photographs from the cockpit 8 min (and 27 NM) after the event (point marked on Figure 4). These photos[21] show:

- Ice build-up on the windshield wipers, on the side windows of the cockpit, at the interface between the boots and the leading edge of the right wing and on the flap actuator fairings.
- A 5-cm block of ice on the IEP.

Figure 5. Photos taken by the first officer

1.7.5. AEMET's analysis of the incident

AEMET's analysis of the incident noted the presence of a front that moved toward the Balearic Islands during the afternoon, leaving in its wake several lines of instability over the mainland that first affected Catalonia and then Valencia, with strong, fast-moving local storms that eventually exited out to sea over the Balearic Islands. Initially, the remote sensing images (satellite, lightning strike and radar) did not show much convective activity in the area of the incident, though an analysis of the radar images (especially the radar in Murcia) did show significant precipitation in the area north of Alicante.

[21] Photographs taken below the event level.

AEMET was given temperature data (SAT and TAT) during the incident in order to assess and confirm the presence of severe icing. The information available was not sufficient to conduct this study. AEMET's findings involving this incident were as follows:

"The actual temperatures (recorded by the aircraft) could have been affected by highly localized processes (such as the evaporation of unstable droplets of liquid water due to the droplets fragmenting upon impacting the aircraft), or the water collected during the climb phase may have accumulated and frozen locally in certain areas of the aircraft's structure.

In conclusion, though moderate icing at most should have been expected in the situation analyzed, local phenomena could have been conducive to the formation of severe icing."

1.8. Aids to navigation

Not applicable.

1.9. Communications

The communications between the crew and the seven ATC stations involved (Alicante TWR, 1 Valencia TACC sector, 1 Madrid ACC sector, 3 Madrid TMA sectors and Madrid TWR) were available to investigation. During the takeoff and climb, up to one minute before the event, communications with ATC were handled by the captain. All subsequent communications were done by the first officer.

The communications between the pilots, obtained from the cockpit voice recorder (CVR), lasted 31 min and started at 20:49:41, when the aircraft was in contact with the Madrid ACC, at 11575 ft and one minute after declaring a MAYDAY. The communications from the event proper were therefore not available.

The most relevant communications (ATC and CVR) are provided with the recorder data (Section 1.11) in order to give a more complete picture of the flight.

1.10. Aerodrome information

The Madrid-Adolfo Suárez international airport is part of the national network of airports managed by AENA. It is at an elevation of 1998 feet (609 meters) and has four pairwise parallel runways (32L/14R, 32R/14L, 36L/18R and 36R/18L) for its operations. Runway 32R has a stated length of 3000 m.

After the MAYDAY call at 20:48, the local alarm was activated at the airport and a series of actions was carried out to place runway 32R in service (as had been requested by the crew), which had been closed due to maintenance work:

- 20:50: personnel working on runway 32R asked to vacate.
- 20:55: coordination to move a tractor.
- 20:55: coordination with the runway and apron service to check runway 32R.
- 21:00: work personnel clear runway.
- 21:05: runway check completed.
- 21:07: aircraft EC-KKQ lands.
- 21:08: aircraft vacates runway.
- 21:09: crew requests ambulance.
- 21:09: TWR requests assistance from T4 medical service. Since it was busy, the medical service from T123 responds.
- 21:28: medical service reports to aircraft.
- 21:33: emergency terminated.

1.11. Flight recorders

The aircraft had a flight data recorder and a cockpit voice recorder[22], which provided information on the flight. As indicated in section 1.9, the information on the ATC communications, CVR and FDR is provided in this section.

The flight is described based on the various phases:

- Climb in 5 segments to the maximum altitude
- The event: the stall
- Flight after the event
- Initial descent to 8500 ft
- Approach and landing

The flight description uses the pitch and bank angle parameters, as these are most indicative of the aircraft's attitude during the event. The convention for the signs is:

- bank angle: + right bank / - left bank
- pitch angle: + nose up / - nose down

The angle of attack parameter is only used when the stall protection systems - the stall warning[23] (SW) and stick pusher[24] (SP) – should have activated, since their activation depends on the value of the angle of attack.

[22] The CVR yielded information on the communications in the cockpit after the event.
[23] Pre-stall warning that causes the control stick to vibrate.
[24] Automatic input provided by the aircraft to the control stick, pushing it forward in order to lower the angle of attack and the pitch angle and thereby increase speed.

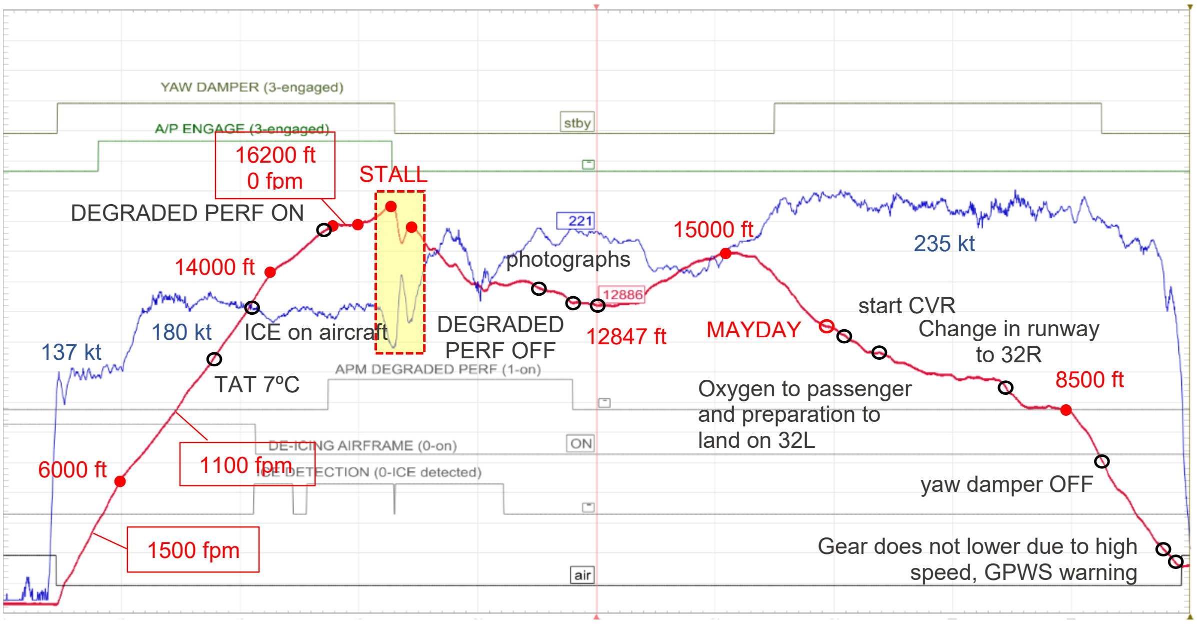

Figure 6. Complete flight profile

1.11.1. Takeoff and climb to 6000 ft (4 min)

At 20:08:41, the aircraft took off from Alicante with flaps 15. The aircraft's weight was 18 tons, but the value that was selected by the crew in the APM through the rotary dial was 16 tons.

This initial climb phase lasted 4 min (until 20:12:24) and was done at an average speed of 137 kt, at an average rate of climb of 1500 fpm and with the altitude set at 6000 ft, which was later increased to 14000 ft. After takeoff, the thrust was reduced and the LNAV and PITCH modes of the autopilot were engaged.

1.11.2. Climb from 6000 ft to 14000 ft (7 min)

For 7 minutes, the aircraft climbed at an average rate of climb of 1100 fpm and increased its speed to values of around 180 kt. During this time, the following events occurred:

- At 20:16:16, with the aircraft at 10023 ft and 180 kt, the TAT was 7° C (according to the crew's statement, there were clouds from approximately 6000 ft). One minute later it would be transferred to the Valencia TACC, which would clear it to FL170, which the crew set as the selected altitude.
- At 20:18:28, the crew turned the aircraft's anti-icing systems on (ANTI ICING ON). They remained on until landing.
- At 20:18:56, at 13111 ft, the ice detector turned on (ICING LIGHT ON). The TAT was 2° C, and 5 s later the crew turned the de-icing systems on (DE ICING ON).

The aircraft reached 14000 ft at 20:19:42 at 167 kt with the de-icing and anti-icing systems on. The autopilot modes were still set to LNAV and PITCH.

1.11.3. Climb from 14000 ft to 16200 ft (3.5 min)

For three and a half minutes the aircraft continued to climb, but at a slower rate than in the previous 7 minutes: rate of climb decreased from 1100 fpm to 500 fpm at the end of this climb. The speed remained at around 170 kt[25]. During these three minutes, the following three events took place:

- At 20:20:58, the ice detector turned off (ICING LIGHT OFF).
- At 20:21:40, the ice detector again turned on (ICING LIGHT ON) and remained on for 10 additional minutes (until 20:31:54).
- At 20:22:45, shortly before reaching 16200 ft, the DEGRADER PERF caution on the APM system turned on. The aircraft was at 16067 ft and 169 kt. 23 s later, the crew turned off the MASTER CAUTION, which had been turned on as part of the DEGRADED PERF caution.

At 20:23:01, the aircraft reached 16200 ft at 170 kt. The APM degraded performance caution DEGRADED PERF and the ICING LIGHT were both on.

1.11.4. Holding altitude at 16200 ft (1.5 min)

At 20:23:01, the aircraft reached 16200 ft, which it would hold for a minute and a half (until 20:24:29), unable to continue climbing. Rate of climb during this period was 0 fpm[26] and negative values and the average speed was 176 kt. During this time, the following actions were taken in the cockpit:

- At 20:23:14, the flight mode was changed from PITCH to IAS, with a speed of 176 set. LNAV mode was kept engaged.

1.11.5. Final climb from 16200 ft to 17148 ft (1.5 min) (t=-93 seg[27])

There was an initial segment (16200 ft to 16700 ft) lasting one minute (20:24:30 to 20:25:28) where the speed was kept at around 174-176 kt. In order to climb, the following actions were taken:

- At 20:24:30, the thrust was changed from CLIMB to MCT28.
- At 20:24:44, the flight mode was changed from IAS to VS, setting a climb rate of 500 fpm. The aircraft was at 16372 ft and 175 kt.

[25] 170 kt climb speed. The climb speed in icing conditions for the incident flight was 170 kt. This speed is calculated as the greater of 170 kt (climb speed) and 159 kt (icing speed + 10 kt).

[26] Theoretical climb rate for this flight conditions shall have been above 600 fpm.

[27] t= 0 s is the stall.

[28] Action confirmed by the crew: thrust lever in NOTCH and power management (PWR MGT) switch in MCT.

- By 20:25:19, the aircraft had climbed to 16598 ft, but the crew set a new climb rate, increasing it from 500 fpm to 1100 fpm[29]. This action coincided with the request to the Valencia TACC to go to FL190 to "clear" (the weather conditions) and a new altitude setting of 19000 ft. The pitch angle increased to 8°.
- At 20:25:26, the thrust was again changed, from MCT to CLIMB[30].

The final climb segment lasted half a minute. It began at 20:25:28 (t=-35s) and was characterized by:

- A reduction in the aircraft's speed from 174 kt to the 151 kt that was recorded during the stall.
- At 20:25:46 (t=-17 s), the speed dropped to 161 kt.
- An increase in pitch angle to 8°, in the angle of attack and fluctuations in the bank angle to the left ranging from 0° to 5°.
- Swings in vertical acceleration between 1 and 0.9 g.

The aircraft managed to reach its highest altitude of 17148 ft at 20:26:03, at a speed of 153 kt and pitch angle of 6°. Six seconds before reaching its highest point, the vertical speed was changed, first to 800 fpm and then to -200 fpm.

1.11.6. Stall (20:26:03 h, t=0 seg)

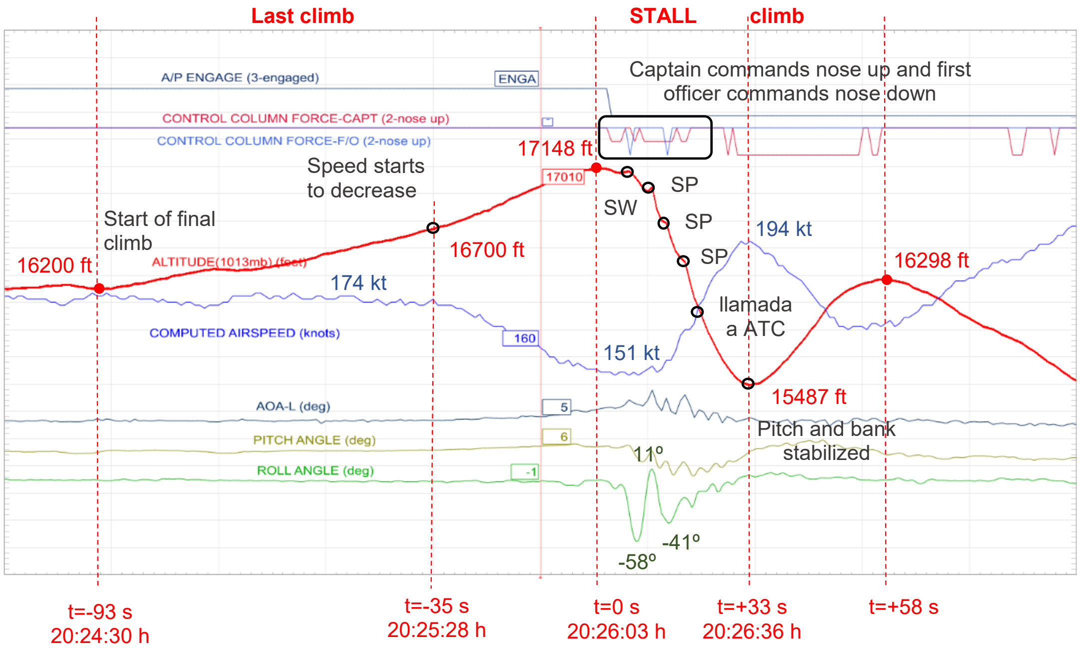

Figure 7. Detail of the stall

[29] The published vertical speed under normal conditions (clean aircraft) in similar altitude and temperature is around 800 fpm.

[30] Action confirmed by the crew: thrust lever in NOTCH and power management (PWR MGT) switch in CLB.

After reaching the highest point (t=0 s, 17148 ft, 20:26:03), the aircraft started a descent during which the following events were recorded:

t=0 s:	(20:26:03) Aircraft at highest point. 17148 ft, 153 kt, 6° pitch angle and 0° bank angle.
t=+1 s:	The vertical speed set was -200 fpm.
t=+3 s:	(20:26:06) First input (of four in total) to the captain's stick in the "nose up" direction (more than 10 daN). Autopilot disengaged. The aircraft was at 17137 ft and 152 kt, with a -6° pitch angle and 6° bank angle. The "nose up" input was held for 3 s.
t=+4 s:	Aircraft at 151 kt, 17119 ft, -8° bank and 5° pitch. Inputs were made to bank the aircraft right.
t=+7 s:	The angle of attack reached 14°, which should have activated the stall warning (SW)[31]. The first officer made a "nose down" input to his stick lasting 1 s. -42° bank angle, 6° pitch angle and 151 kt.
t=+8 s:	(20:26:11) 17095 ft, -58° bank angle, 0° pitch angle and 152 kt. Again, the captain commanded the nose up for 1 s. Inputs were made to bank the aircraft right.
t=+10 s:	Third "nose up" input (longest in duration) to the captain's stick, lasting 7s. Aircraft at 16997 ft, 152 kt, -39° bank angle and -3 pitch angle. Yaw damper disconnected.
t= +12 s:	17003 ft, 154 kt, 11° bank angle and 2° pitch angle. The angle of attack reached 19.6° and the stick pusher (SP)[32] was activated for the first time.
t= +15 s:	16611 ft, 156 kt, -41 bank angle and -11° pitch angle. Opposite inputs were made to the controls, with the captain commanding the "nose up" while the first officer, for 1 s, commanded the "nose down". The angle of attack exceeded 15° and the stick pusher was activated for the second time.
t= +19 s:	The angle of attack was 16.9° and the stick pusher was activated for the third time.
t= +20 s:	16293 ft, 166 kt, -26° bank angle and the maximum pitch angle reached during the event: -12°. Termination of "nose up" inputs by the captain.
t= +23 s:	-10° bank angle and -9° pitch angle. The first officer asked ATC to descend immediately.

[31] The activation threshold for the stall warning, based on information from the aircraft manufacturer, for the conditions at the time (no flaps, icing and cruise) is 11.2º.

[32] The activation threshold for the stick pusher, based on information from the aircraft manufacturer, for the flight conditions (no flaps, icing and cruise) is 15.3º. This value can drop by 3º if the change in the angle of attack reaches 4.87º/s.

t= +26 s: -11° bank angle, -7° pitch angle, 15753 ft and 185 kt. First "nose down" input made by the captain.

t=+33 s: (20:26:36) End of descend, wings level. They were at 15487 ft and 195 kt. 4° pitch angle and 5° bank angle.

The total loss of altitude during these 33 s was 1661 ft (3020 fpm). Vertical acceleration values of 1.5 g were recorded. The flap configuration remained at 0° during the event. The aircraft's heading changed from 330° to 298°.

From this moment (t=+33 s), the aircraft began a climb during which it again lost speed:

- During this climb segment, inputs were again recorded from the captain to pitch the nose down even though the aircraft's tendency was to gain altitude, since the trim was not changed and the engine thrust was increased. During this climb, the pitch angle will reach 10°.
- t=+58 s and +61 s (20:27:01): end of climb. The aircraft reached 16298 ft and its speed was 166 kt. The bank angle was 0°.

1.11.7. En route flight after event

The en route segment was done without the autopilot or yaw damper, both of which were disengaged during the stall. This segment included a descent, a level segment and a climb.

In the descent:

- The crew initially requested to descend to FL70, but it was stopped on the crew's initiative at around 13000 ft. The minimum altitude reached was 12847 ft.
- The speed was recovered.
- During this descent, the degraded performance caution remained on (DEGRADED PERF ON), as did the ice detector (ICING LIGHT ON).
- At 20:31:54, the ice detector turned off (ICING LIGHT OFF).
- At 20:33:23, the first officer took photos (section 1.7.4) of the airplane that showed ice build-up on the airplane.

The aircraft stabilized at around 13000 ft at an approximate speed of 220 kt. This coincided with the deactivation of the degraded performance caution (DEGRADED PERF OFF) at 20:35:25. After requested by ATC, the aircraft again climbed to FL150 and its speed decreased to 200 kt.

The aircraft reached FL150 at 20:43:34 under control of the Madrid ACC. The icing light and degraded performance cautions were off. They were not in the clouds but the anticing and de-icing systems were kept on.

1.11.8. Initial descent to 8500 ft

The descent from FL150 to 8500 ft was done without the autopilot but with the yaw damper turned on. The descent was characterized by an increase in the average speed to 235 kt, a value that was maintained practically until contact was made with the runway.

The following events occurred during this segment:

- At 20:44:51, within a minute of starting the descent, there was an increase in the vertical acceleration that persisted until landing. The maximum values were 0.21 g and 1.53 g at around 9700 ft. These accelerations did not have associated any movements of the elevator.
- Three minutes later, due to vibration, the crew informed ATC that they could not solve the problem.
- One minute later, at 20:48:26, they declared a MAYDAY due to control problems. The aircraft was descending, at 12074 ft and 244 kt.

The CVR recording starts at 20:49:43, with the aircraft at 11571 ft and 244 kt. There were three people in the cockpit: the captain, first officer and a third individual (an Air Europa captain who was traveling as a passenger and who had gone into the cockpit at the captain's request after the event). Due to his presence, the captain removed his headset, probably to make it easier to speak with him, since he took part in the cockpit conversations for the remainder of the flight. The cockpit communications from this moment until reaching 8500 ft showed:

- Conversations at various times during the descent about the aircraft's vibrations. In fact, the first officer even asked if the flaps were properly stowed. The vibrations were the reason why they asked ATC if any turbulence had been reported in the area.
- Concern about the performance when they had to lower the flaps for landing and the decision to land without flaps.
- At 20:51:26, with the aircraft descending to 10896 ft at 236 kt, the purser went into the cockpit to report that a passenger was going to be administered oxygen. This report did not include a request for an ambulance.

- By 20:55:43, the captain had decided they would land without flaps and the first officer is heard preparing the maneuver for runway 32L without flaps, confirming that the speed would be 130 kt, 5 kt less than the correct one[33].
- At 20:52:14, at 9191 ft, ATC informed them he had arranged for them to use 32R.
- At 20:58:46, ATC asked them to reduce their speed to 220 kt. The aircraft was at 8731 ft and 240 kt.

The captain was the pilot flying and the first officer was handling all communications with ATC.

1.11.9. Approach and landing

At 8544 ft (21:01:04), the first officer reported having the runway in sight. The aircraft was at 234 kt, 20 NM away from the runway, but still right of the localizer. One minute later, the first officer again asked the captain to confirm they were landing with flaps 0.

At 7282 ft (21:02:23), the aircraft's speed was 230 kt and the following conversations took place in the cockpit:

- The captain reported he would land above 130 kt and that "*if something strange happens, I'll give it power*".
- The first officer asked for confirmation of what to do with the flaps in case of a go-around, to which the captain replied, "*don't even think of going around, we have to land*".

The captain decided to land without the yaw damper[34], so at 6351 ft he asked the pilot to disengage the system.

At 6000 ft, the captain saw something on the runway but rejected the first officer's offer to ask ATC about it. There were two marshaller's vehicles that were checking the runway and that were in fact still on the runway. At the same time, the approach controller informed them that judging by the radar display, they would be landing ahead of the PAPI. The first officer replied they were a bit below the glide slope, and the captain reminded him about the gear: "*We have to lower the gear. Let's not forget, ok?*"

At 21:04:41, the aircraft was transferred to the TWR controller. They were 7 miles out, but still right of the localizer. The first officer, on his initial communication with this

[33] Landing speed without flap with 18 tons is 135 kt.

[34] Disconnecting the yaw damper on final approach is not found in the normal ATR procedures; however, it is a routine technique among ATR pilots, and is justified by the fact that the need to use the rudder pedals to compensate for the wind when landing could cause the yaw damper to disengage automatically, which could destabilize the maneuver.

station, reported they were in a MAYDAY situation and were unable to "*do a go-around*" and needed confirmation of their landing clearance, since the runway seemed to be occupied.

Six miles out, at a radioaltitude[35] of 1736 ft (21:05:00), the aircraft intercepted the localizer.

Eventually, the two runway and apron service vehicles vacated the runway and at 21:05:35, with the aircraft 4 miles out, at 1276 ft and 216 kt and descending at 1200 fpm, they were cleared to land on runway 32R.

The aircraft continued descending until the captain ordered that the gear be lowered at 840 ft, 3 NM out from the runway, at 21:06;00. As concerns the lowering of the gear:

- The first officer had previously warned the captain on three occasions that the speed was too high to lower the gear: "*careful, speed for lowering the gear*", "*speed*", "*it's 170, ok?*" The aircraft was at 213 kt.
- Despite the warnings, at 21:06:00, the captain called out "*gear down*", and it was recorded the movement of the gear lever. The aircraft was at 840 ft, but its speed was 204 kt, well above the recommended speed, which triggered a sequence of four aural warnings on cockpit for this reason. The first officer rebuked the captain, who then noticed the speed, "*right, the speed*", and quickly reduced the speed.
- At 21:06:22, at 539 ft, the captain again ordered the gear down. The speed was below the recommended speed (about 170 kt) and the gear extended, which the first officer confirmed, "*gear down, gear down, three green*".

At 340 ft (21:06:35), the first officer had just confirmed the gear was down and mentioned the word "*speed*" to the captain, since their speed was increasing again, to 183 kt. The descent rate was -1000 fpm.

At 21:06:41, 23 s before landing, at 216 ft, 177 kt and -1100 fpm, the purser made the landing announcement to the passengers, reminding them to fasten their seat belts. At the same time, a sequence of five "TOO LOW, TERRAIN"[36] warnings was issued by the EGPWS, which finished at 37 ft with the aircraft at 160 kt and descending at a rate of 700 fpm.

At 21:07:00, the aircraft contacted the runway at 140 kt, 750 m away from the threshold[37]. During the deceleration, the captain detected a problem with the pedals,

[35] From now on, radioaltitudes are used in the flight description.

[36] Warning related with mode 4B on the EGPWS, which indicates that the aircraft is too close to the ground. Specifically, this warning was issued because the aircraft descended below a radioaltitude of 245 ft at a speed in excess of 149 kt (the aircraft crossed this altitude at 178 kt) with the gear down but with the flaps not configured for landing.

[37] Runway 32R has a landing distance available of 3000 m.

"*the pedals aren't working, the left pedal, they're jammed*". The first officer asked if he could free it or if he should ask for help. By that point, they had decelerated to 17 kt and the captain replied no. Three seconds later they reported "*runway clear*" to the TWR (21:08:22) and the controller asked if they needed assistance, to which they replied no.

One minute later, at 21:09:24, while taxiing, the purser entered the cockpit and asked for an ambulance, a request that the first officer relayed to the TWR.

The aircraft stopped at 21:14:04. At 21:14:43, the purser instructed the passengers to sit down so that the passenger requiring medical assistance could exit first. At the same time, the captain instructed the cabin crew over the PA to open the doors. The flight attendant had to make a new announcement later asking the passengers to remain seated until the ambulance came.

1.11.10. APM system cautions

As noted in section 1.6.5, the APM system generates three alerts to the crew based on the aircraft's takeoff weight as a reference.

In this case, the weight selected in the APM was 16 tons, while the actual weight was 18 tons. The activation thresholds[38] for the INCREASE SPEED warning for these weights were:

- 150 kt for the weight entered into the APM on the incident flight. This speed was not reached at any point, which is why this caution was not activated.
- 161 kt for the weight the APM should have had. This speed was reached 17 s before the stall initiated.

The DEGRADED PERF caution was activated at 20:22:45, when the aerodynamic drag exceeded the theoretical value by 28%. From then on, it continued to increase, reaching values of 50% during the event.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

Not applicable.

[38] The system is activated when icing speed + 10 kt + 2 kt is reached, meaning it is 2 kt higher than the severe icing speed.

1.14. Fire

Not applicable.

1.15. Survival aspects

There are two survival aspects of interest in this incident:

- The medical assistance request, and
- The operation of the oxygen bottles.

Based on the information obtained from the communications during the event, oxygen was administered to a passenger at 20:51:26. The aircraft landed at 21:07:04 and the need for an ambulance was relayed by the purser to the crew at 21:09:24, after which the arrangements were made for the medical service to report to the aircraft. According to airport logs, the service arrived at 21:28. The passenger was treated and required no further medical assistance.

The information provided by the cabin crew showed there were problems with the use of the bottles: one did not provide sufficient oxygen flow and during the used of the other the mask could not be used, which required the oxygen to be administered by placing the tube under the nostrils.

Tests performed by the operator showed the bag lasted 1,5 - 2 min to inflate so, in its opinion, this period of time could be identified by the cabin crew as a malfunction of the system.

1.16. Tests and research

1.16.1. Captain's statement

In addition to the written statement, the captain was also interviewed, during which he provided the following information[39] on the takeoff and climb:

- It was the fourth and final flight of the day.
- The weather forecast called for moderate icing. The layer of clouds they encountered was stable and the radar did not show anything. He thought the radar equipment was working correctly, since the test done before the flight was satisfactory.
- They took off with some clouds.
- From approximately 6000 ft, they went into the clouds but with no turbulence.

[39] The interview is not transcribed in its entirety, only the information of interest to the investigation.

- They climbed in PITCH mode, which is not according to procedure, but this mode is used extensively. It offers the advantage of a constant attitude, unlike SPEED[40] mode, which varies the nose position and is less comfortable for passengers. The procedure is to climb in SPEED mode.
- There was no sunlight, but it was daylight.

Regarding the event:

- He stated they were climbing in the clouds but that they saw the end of the cloud layer, and that the reason for requesting FL190 was to clear the cloud layer. This was also the reason for selecting maximum power (MCT on the PWR MGT).
- Regarding the ice build-up, he never thought they would stall. They were mindful of the ice because they knew it was accumulating, but the amount they saw on the windows was not indicative of severe icing. He had had one previous icing experience in a small aircraft where the entire windshield was covered in ice, but that did not happen on this flight. He did not think the icing was severe.
- When the stall occurred, the stick shaker[41] activated and the entire plane vibrated. The first officer, who was then the pilot flying, turned over control to him.
- To regain control of the airplane, he advanced the throttle lever to RAMP[42], which provides additional torque (up to 115%).
- They did not carry out the specified stall recovery procedure[43] because the airplane recovered quickly. He did not lower the flaps to 15 because he did not deem it necessary. He noted that the procedure requires lowering flaps 15°, but does not note the overspeed limit of the flaps (186 kt).
- The seat belt sign was not on because the cloud layer was stable.

Regarding the DEGRADED PERF he stated that:

- He did not trust the cautions because they turned on easily on a lot of airplanes.
- The ICE DETECT caution would sometimes turn on due to moisture even if there was no ice build-up.

Regarding the flight after the incident:

- He flew the airplane to Barajas without the autopilot.
- He noticed it vibrated cyclically and gradually, so they asked ATC if any turbulence had been reported in the area.

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40 The term SPEED mode is not used in the manuals; it is referred to as IAS mode.

41 The term stick shaker is not used in the manuals, it is referred to as stall warning, which warns of an impending stall by shaking the control column.

42 This position is described in section 1.11.6 as MAX PWR, and must only be used in an emergency.

43 The stall recovery procedure requires selecting flaps 15.

- They flew at high speed until short final.
- Upon reaching the parking stand, he got out to look for evidence of icing or damage to the tail, wings or fuselage but found nothing.
- Maintenance told him that the TLU was broken.

A pilot who was traveling as a passenger went into the cockpit after the event and confirmed there was ice on the flap fairings. When asked about coordinating with the passenger cabin, he stated he spoke twice with the cabin crew after the event.

1.16.2. First officer's statement

The first officer was interviewed, during which he gave information matching that given by the captain and the following additional data:

- He was monitoring the ice build-up during the climb, but the amount that was accumulating did not particularly surprise him.
- They turned off the seat belt sign after FL110. The sign was off at the time of the event.
- The red bug was at 140[44], giving them about a 30-kt speed margin.
- They climbed in PITCH mode.
- As they were reaching FL170, the captain said they were very close to the cloud ceiling and that it was best to clear the clouds by going over them and to request FL190 to exit the clouds. The captain shifted to MCT.
- Over the next 20-25 s, the situation worsened and he saw the ice build-up had increased considerably. There was ice on the side windows and windshield wiper.
- The DEGRADED PERF caution turned on and the airplane started to vibrate.

About the event:

- He was sure the stick shaker activated. Once it did, he pushed the stick forward and transferred control to the captain.
- The speed never dropped below the red bug.
- The captain did not want to lower the flaps in case they were blocked by ice and made the situation worse.
- The controls continued to vibrate. He insisted on descending.

[44] Although in the interview he stated that the red bug was at 140 kt, the air speed indicator reference was correctly set at 149 kt, which is the icing speed for a weight of 18 tons.

On the flight after the event:

- For the landing, the captain did not want to lower the flaps, using the same reasoning of not wanting to risk worsening the situation by doing so. The pilot who was traveling as a passenger and who was in the cockpit agreed.
- The DEGRADED PERF caution was on the entire flight. They did not perform the procedure and the captain explained that this was a non-standard operation and they would focus on flying the airplane without using the QRH or calculating the landing distance.
- He trusted the captain’s experience but he did not feel comfortable because that is not how they train.
- The purser asked the captain to make an announcement to calm the passengers after the event.

1.16.3. Purser’s statement

The purser was interviewed, during which he provided the following information:

- She had been working at Swiftair since July 2017.
- She was seated at the rear of the airplane.
- The assistant was in the front.
- The captain did not inform them of any special weather conditions expected during the flight.
- The seat belt sign was turned off at FL100, when they began their service.
- The service consisted of a small cart and container they moved from front to rear.

Regarding the event:

- Upon starting the on board service, they felt vibrations in the rear. In the tail, they felt a “dry or harsh” vibration that was unlike any other.
- Next they heard a noise like something was hitting the propellers. It was a banging sound[45] and they only heard it on the left side. At that point, everyone looked at the engine.
- The airplane then swerved hard to the left and pitched down.
- They felt the acceleration at the rear more.
- They went to the rear and fastened their seat belts since the airplane was moving up and down suddenly. The flight attendant sat down in row 17 and the purser in the rear jumpseat.

[45] Describes the sound made when ice fragments that detach from the propellers, due to centrifugal force, impact reinforcing plates located on the fuselage on either side of the propellers.

After the event:

- A passenger in the third row called them from his seat to attend to his wife, who had a history of heart attacks. She was sweating, her hands were cold and her mouth open. They thought it might have been an anxiety attack.
- She asked over the PA if there was a doctor on board, but there was not.
- They tried to relax her but since they could not, they decided to administer oxygen.

Communication with cockpit and administration of oxygen:

- While treating the passenger, he received a call from the captain to inform him they had had ice build-up but that it was under control. During this call, she informed the captain that they had a medical emergency.
- While administering oxygen to the passenger, she noticed there was still ice on the wings, "*everything was shiny*" and she called the captain to tell him.
- The captain asked to check the boots and to ask the pilot who was flying as a passenger to check the wings and boots. He did so and saw large blocks of ice on the boots and that the left wing had more ice than the right.
- She called the captain a second time and informed him of what he had seen. She also requested that they call an ambulance. During this conversation, the captain asked that the pilot who was flying as a passenger go into the cockpit.
- In addition to the passenger who needed oxygen, two people were vomiting and a girl age 13 or 14 had an anxiety attack.
- She had problems with the oxygen bottle:
    - To administer the oxygen, she took the bottle from the flight attendant (located in the front), but the oxygen came out very slowly. She decided to take her bottle (located in the rear), and this one worked correctly.
    - The mask also did not work because it did not fill, so she decided to administer the oxygen like they do with babies, by placing the outlet of the tube near the nose, until they landed. The passenger improved somewhat.
    - They had checked the bottles before the flight and they were charged.

During the landing:

- There was no announcement from the pilots regarding where or when they would land.
- The passengers were also not told what had happened.
- At one point, the seat belt sign turned on.
- In fact, she was surprised when she heard the gear lower. They landed without the cabin being fully prepared since they had not been notified.

- They were not told they were descending or landing.
- When they landed, she was surprised that the ambulance was not standing by. It arrived later.
- The ambulance took the passenger away, who did not require any subsequent medical attention.
- When they exited the airplane, she was unable to find any ice on the airplane.
- In training they are not shown images of ice build-up scenarios[46].

1.16.4. Statement from flight attendant

The flight attendant was interviewed. He provided similar information to that of the purser, so only new information of interest is included here:

- He heard a sound "*like a grinder*" coming from the engines on both sides, though it was louder on the left. The noise was heard between row 16 and the tail.
- The airplane started to shake at the back and it leaned left and then right. It dropped like a stone. The passengers yelled when the airplane fell.
- He saw the wings and they were frozen, "*like when you open a freezer*". The boots and flaps were also frozen. The ice was white.
- The pilot who was flying as a passenger told him "*you have ice on the wings*".
- They were standing when it happened but they did not hit anything. Nothing fell down in the passenger cabin.
- The captain's only announcement to the passengers was when they landed, nothing during the emergency.
- They both attended to the passengers. He administered oxygen to one passenger and the purser looked after everyone else. One of the bottles did not work and he had to take the other one.
- The pilots did not ask about the medical emergency. He was surprised when he saw there was no ambulance waiting for them.
- In training, they are shown the types of ice, the procedure with the boots, told to inform the cockpit and shown photos.

1.16.5. Maintenance activities after the event

The pilots stated that the TLU range of travel was not complete. The post-flight report also recorded a TLU fault. As a consequence, operational tests of the system were done and parts of the TLU (one of the air data computers, the centering unit and the trim actuator) were sent to the shop to be checked. The inspection identified some defects

[46] According to the operator, cabin personal have visual information regarding ice accreation during training.

in the air data computer and the trim actuator, but with no apparent consequences on the stuck pedals reported by the pilots. According to information provided by the operator, airplane EC-KKQ had no further problems with the rudder jamming after the incident.

1.17. Organizational and management information

1.17.1. Procedure when entering icing conditions

E) PROCEDURES IN ATMOSPHERIC ICING CONDITIONS

During operations with AP ON during climb and descent, vertical speed mode should not be used unless the airspeed is carefully monitored.
The suggested procedure is to use IAS mode with a speed selected which is equal to or greater than the appropriate minimum speed (VmLB or VmHB in accordance with the BANK selection on the autopilot).

CAUTION : Close attention should be paid to the appearance of an AILERON MISTRIM message flashing on the ADU: if the message appears, apply the AILERON MISTRIM procedure.

Note : Permanent heating (Probes/windshield) is Always selected ON.

▷ **ENTERING ICING CONDITIONS**

- ANTI ICING (PROP – HORNS – SIDE WINDOWS) .... ON

R *Note : horns anti icing selection triggers the illumination of the "ICING AOA" green light, and lowers the AOA stall warning threshold.*

- MODE SEL .... Confirm AUTO

R
- MINIMUM Maneuver/Operating ICING SPEED .. BUGGED and OBSERVED

- ICE ACCRETION .... MONITOR

Note : 1. These procedures are applicable TO ALL FLIGHT PHASES including take off.

1.17.2. Procedure when visual indication of ice build-up exists

▷ **AT FIRST VISUAL INDICATION OF ICE ACCRETION, AND**

R **AS LONG AS ATMOSPHERIC ICING CONDITIONS EXIST**

R
- ANTI ICING (PROP – HORNS – SIDE WINDOWS) .... Confirm ON

R
- MODE SEL .... Confirm AUTO

R
- ENG DE ICING .... ON

- AIRFRAME DE ICING .... ON

R
- MINIMUM Maneuver/Operating ICING SPEED .. BUGGED and OBSERVED

- BE ALERT TO SEVERE ICING DETECTION.
  In case of severe icing, refer to 2.04.05.

1.17.3. Procedure when leaving icing conditions

▷ **WHEN LEAVING ICING CONDITIONS**

R DE ICING and ANTI ICING may be switched OFF.

Note : Leaving DE ICING in operation UNNECESSARILY is detrimental to boots life.

The DE ICING blue light on memo panel will blink if deicers are still ON more than 5 minutes after ice detector has stopped to signal ice accretion (ICING amber light OFF).

1.17.4. Procedure when aircraft is clear of ice

R ▷ **WHEN THE AIRCRAFT IS VISUALLY VERIFIED CLEAR OF ICE**

R ICING AOA caption may be cancelled and normal speeds may be used.

R *Note : Experience has shown that the last part to clear is the ice evidence probe. As*
R *long as this condition is not reached, the icing speeds must be observed and the*
R *ICING AOA caption must not be cancelled.*

1.17.5. Emergency procedure in case of severe icing

SEVERE ICING

MINIMUM ICING SPEED	INCREASE by 10 kt
PWR MGT	MCT
CL 1 + 2	100% OVRD
PL 1 +2	NOTCH
AP (if engaged)	FIRMLY HOLD CONTROL WHEEL and DISENGAGE
SEVERE ICING CONDITIONS	ESCAPE
ATC	NOTIFY

- **If an unusual roll response or uncommanded roll control movement is observed :**
  Push firmly on the control wheel
  FLAPS . . . . EXTEND 15
- **If the flaps are extended, do not retract them until the airframe is clear of ice.**
- **For approach, if the aircraft is not clear of ice :**
  GPWS . . . . FLAP OVRD
  STEEP SLOPE APPROACH (≥4.5°) . . . . PROHIBITED
  APP/LDG CONF . . . . MAINTAIN FLAPS 15
  APP SPEED . . . . "REDUCED FLAPS 15 LDG icing speeds" + 5 kt
  Multiply landing distance FLAPS 30 by 2.12

DETECTION

Visual cue identifying severe icing is characterized by ice covering all or a substantial part of the unheated portion of either side window

and / or

Unexpected decrease in speed or rate of climb

and / or

The following secondary indications :

. Water splashing and streaming on the windshield
. Unusually extensive ice accreted on the airframe in areas not normally observed to collect ice
. Accumulation of ice on the lower surface of the wing aft of the protected areas
. Accumulation of ice on propeller spinner farther aft than normally observed

The following weather conditions may be conducive to severe in-flight icing :

. Visible rain at temperatures close to 0°C ambient air temperature (SAT)
. Droplets that splash or splatter on impact at temperatures close to 0°C ambient air temperature (SAT)

COMMENTS

- Since the autopilot may mask tactile cues that indicate adverse changes in handling characteristics, use of the autopilot is prohibited when the severe icing defined above exists, or when unusual lateral trim requirements or autopilot trim warnings are encountered while the airplane is in icing conditions.
- Due to the limited volume of atmosphere where icing conditions usually exists, it is possible to exit those conditions either :
  . by climbing 2000 or 3000 ft, or
  . if terrain clearance allows, by descending into a layer of air temperature above freezing, or
  . by changing course based on information provided by ATC.

1.17.6. Abnormal procedure if performance is degraded

DEGRADED PERF

Mainly appears in level flight after CRUISE SPEED LOW or in climb, to inform the crew that an abnormal drag increase induces a speed decrease or a loss of rate of climb

The most probable reason is an abnormal ice accretion

AIRFRAME DE-ICING .... CHECK ON
IAS above ICING BUG + 10 KT .... MONITOR
AP (if engaged) .... HOLD FIRMLY CONTROL WHEEL and DISENGAGE

- **If SEVERE ICING conditions confirmed**

  – or –

- **If impossibility to maintain IAS above ICING BUG + 10 KT in level flight**

  – or –

- **If abnormal aircraft handling feeling**

  SEVERE ICING procedure (1.14) .... APPLY

- **If normal conditions**

  SCHEDULED FLIGHT .... CONTINUE
  ICING CONDITIONS and SPEED .... MONITOR

Note: In case of APM messages "DEGRADED-PERF" or "INCREASE-SPEED" Vmin OPS automatically increased by 10 kt.

1.17.7. Procedure for recovering after a stall

RECOVERY AFTER STALL or ABNORMAL ROLL CONTROL

CONTROL WHEEL .... PUSH FIRMLY

- **If flaps 0° configuration**

  FLAPS .... 15°
  PWR MGT .... MCT
  CL 1 + 2 .... 100% OVRD
  PL 1 + 2 .... NOTCH
  ATC .... NOTIFY

- **If flaps are extended**

  PWR MGT .... MCT
  CL 1 + 2 .... 100% OVRD
  PL 1 + 2 .... NOTCH
  ATC .... NOTIFY

Note: this procedure is applicable regardless the LDG GEAR position is (DOWN or UP)

1.17.8. Extracts from the SWIFTAIR Operations Manual

The Swiftair *Operations Manual* lays out the following guidelines for approaches.

- The regulatory callouts will be made on all approaches, whether the approach is made in VMC or IMC (O Part A, section 8/3).
- During the approach, the proper speed must be maintained as accurately as possible and the speed margins must not exceed the allowed margins (OM Part A, section 8/3).
- Stabilized approach: in order to ensure a safe final approach and landing, the approach must be stabilized by 1000 ft in IMC and 500 ft in VMC. An approach is stabilized if (OM Part A, section 8/3)[47]:
    - The speed is between Vref and Vref+20 kt.
    - The maximum descent rate is 1000 fpm.
    - All the checklists are complete.
- There is a series of callouts for indicating deviations from certain parameters:
    - "Speed" for deviations in IAS of >10 kt.
    - "Glide slope" for deviations of half a dot on the glide slope.
    - "Stabilized" for unstabilized approaches at 1000 ft (IMC) or 500 ft (VMC).

Regarding before takeoff, descent and ILS approach procedures:

- Before takeoff:
    - The current weight must be entered for the APM system.
- Descent:
    - The cabin crew must be notified of the start of the descent.
    - The descent checklist must be conducted.
    - At FL100, turn on seat belt sign.
- ILS approach. The actions to take include the following:
    - Begins 25 NM out. The speed at that point should be 220 kt.
    - At 17 NM, the speed must be reduced to 180 kt.
    - When the localizer is captured, the speed will be reduced to 160 kt.
    - Flaps 15° and gear down.
    - The pilot flying must request the "BEFORE LANDING" checklist, which includes a check of the three green gear down lights and verifies that the TLU position is in LO SPD.

[47] Not every condition for a stabilized approach is included, only those of interest for analyzing this incident.

  - At 1000 ft IMC (500 ft VMC) make landing determination.
- ILS approach at high speed: similar to above, but the speed is reduced later:
  - Begins 25 NM out at a speed of 220 kt at that point.
  - At 12 NM, the speed is 180 kt.
  - At 6 NM, the speed is 160 kt.

Regarding the task allocation in flight:

- The pilot flying is responsible for starting the procedures, while the pilot not flying will read the lists.
- During emergency or abnormal procedures, the pilot flying is responsible for communications.

Regarding the checks of the cabin crew:

- The checklist for the cabin crew on aircraft EC-KKQ included checking the pressure and expiration of the two O2 bottles and masks. There are two bottles on board, one at the front and another at the rear of the cabin, at the positions of the two cabin crew members, each of which is checked by the relevant crew member.

1.18. Additional information

1.18.1. Similar events

On 14 November 2016, aircraft OY-JZC[48], an ATR 72-212A, experienced a stall due to icing while climbing to FL170. At FL150, the aircraft was unable to continue climbing and the crew initiated a turn to head to an area free from icing. During the maneuver, the aircraft experienced uncontrolled banking and a significant loss of altitude. The crew regained control of the aircraft and completed the flight without further incident.

On 21 December 2016, aircraft G-COBO[49], an ATR 72-212A, experienced a stall due to icing while climbing to FL170. During the climb, ice accumulated on the aircraft structure and the DEGRADED PERF and INCREASED SPEED cautions on the APM were activated. The relevant procedures were not carried out and the crew did not maintain the proper climb speed, since they were focused on climbing to an area without clouds. The aircraft stalled, with left and right bank angles that reached 73°. The pitch angle reached -16°. The aircraft lost 1000 ft in altitude and its speed fell to 123 kt. The crew regained control of the aircraft and completed the flight without further incident.

[48] Investigation conducted by the Accident Investigation Board Norway (AIBN). The findings from this investigation have not been released as of the date of this report.

[49] Investigation conducted by the United Kingdom's Air Accidents Investigation Branch.

1.18.2. Actions taken by the manufacturer, ATR

Since 2014, along with the improvements in the frame of the new documentation format (called EDORA), ATR had been working in the improvement of the operational procedures. In particular, procedures associated to icing condition have been extensively reworked. Despite of the fact that the modifications and changes were included on the AFM procedures after the Swiftair event, previously were communicated to the operators[50]. The three events occurred in 2016 and 2017 were reviewed using the new procedures and confirmed appropriate.

With the contribution of different experts and based on in-service experience, ATR identified areas of improvement in terms of wording, formatting, and presentation to facilitate flight crew decision making and retrieval of essential information in flight. In-service experience has shown that the flight crew may have difficulty in identify the external conditions and manage the flight in accordance with the conditions. Indeed, ice accretion depends on several parameters and the severity of icing conditions on an aircraft is not directly accessible. Moreover, pilots experience and comfort level may also influence their perception of icing intensity.

To improve the situational awareness of the flight crew, ATR modified the procedures in line with ICAO AUPRTA[51] manual, to link the decision making with the objective performance figures. The main changes in approach are the following:

- Focus on providing most essential information in a clear and logical manner. This is done by improving sequence of actions in the "*entering icing conditions*" and "*when ice accretion observed or detected*" in the AFM and harmonize the FCOM and QRH with the AFM by merging the two distinct procedures into one single "*atmospheric icing conditions*" using the same logic.
- Use factual and verifiable information to aid decision making. The "icing conditions" procedure provides clear and factual triggers for identifying severe icing and calls for the emergency severe icing procedure:
  - unable to maintain red bug +10 kt , or
  - unable to maintain a rate of climb of 100 fpm, or
  - if abnormal vibrations occur.
- Enhance the situational awareness by guiding the attention of the flight crew to the most critical information while operating in icing condition.
- More emphasis has been made on simple figures (such as 300 fpm, the minimum residual rate of climb at the maximum operational ceiling) to enable early identification of abnormal situation.

[50] In the 2016 Flight safety conference, 2017 Operators conference, ICAO AUPRTA manual and videos on the topic.

[51] Airplane Upset Prevention and Recovery Training Aid. Last revision rec. 3 issued on February 2017.

In line with AUPRTA philosophy, there are key factors to manage efficiently the aircraft energy. Aircraft energy, as shown in figure 8, is split between potential energy (altitude), kinetic energy (indicated airspeed) and chemical energy (engine power). The pilot, in accordance with the flight conditions, is required to manage total aircraft energy.

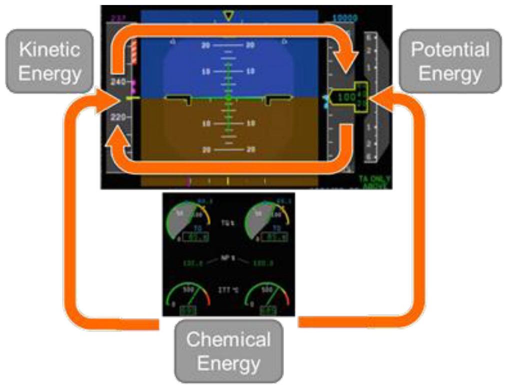

Figure 8. Key factors to manage aircraft energy

ATR in its new procedures emphasize the need to follow carefully the following steps to enhance the flight crew situation awareness:

- Flight preparation: anticipation is the first step to prevent the flight crew from being put in a difficult position on the first place.
- Flight management: the management of aircraft energy during the flight is the keystone of the prevention of upset situations.
- Escape: escape manoeuvers enable the aircraft energy to be kept within acceptable limits. ATR icing procedures removed the term “escape” and has been replaced with “descend”.

1.18.3. Previous recommendations issued to Swiftair

On 24 January 2012 and 24 June 2013, two events involving this operator took place, the first in Afghanistan and the second in Madrid. Both were investigated by the CIAIAC, references EXT A-001/2012 and IN-017/2013. In both cases, there was a failure to adhere to operating procedures. These two investigations resulted in three safety recommendations:

- REC 50/13. It is recommended that Swiftair, as the operator, generate a procedure that ensures that its crews do not perform unauthorized (and therefore prohibited) maneuvers.
- REC 51/13. It is recommended that Swiftair, as the operator, generate a procedure that ensures that its crews receive proper training on adherence to procedures.
- REC 45/15. Due to the crew’s identified failure to adhere to emergency procedures, it is recommended that the operator, Swiftair, prepare a specific training and monitoring plan that allows it to ensure that its crews carry out emergency procedures in strict compliance with said procedures.

For each of these three safety recommendations, the operator informed the CIAIAC of the plan of action that was put in place. Since these measures were deemed to be satisfactory, insofar as they complied with the objectives of the recommendations, all three were closed out as of the issue date of this report.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

On Saturday, 9 September 2017, aircraft EC-KKQ, 16 minutes after takeoff as it was climbing at 17148 ft with the wings level, experienced a loss of altitude of 1661 ft in 33 s, along with a succession of uncommanded pitch and bank angles. The aircraft's behavior during the event was consistent with a stall that began with the left wing. It was the third similar event within a period of one year (the previous ones had been in the United Kingdom and Norway).

Eight minutes before the stall, the aircraft had entered icing conditions[52], which worsened during the climb and turned into severe icing conditions. The crew were presented with a DEGRADED PERF warning but they did not action the checklist as they seemed to be focused on climbing out of the icing conditions. The speed was not maintained above the minimum severe icing speed (red bug + 10 kt) and a selection of a climb rate beyond the published aircraft performance.

2.1. Flight in severe icing conditions

The weather information provided to the crew, despite varying in the extent and severity of the icing forecast, anticipated that much of the flight would take place in icing conditions and that over NARGO, at FL140-FL150, moderate icing would be present. The reality of what happened in the flight showed that, in effect, icing occurred near that point, only it was worse than forecast.

Flying in icing environments requires crews to constantly monitor external conditions. The problem lies in detecting the severity of the icing, and specifically, in how to identify if severe icing is taking place. Due to design limitations, weather radar is unable to detect this phenomenon (as happened in this flight) and crews must rely on other detection methods. Two such methods are included in the procedure (SEVERE ICING):

- First, the visual observation of ice build-up in certain areas of the aircraft:

  The crew's evaluation of the ice that was building up during the climb led them to conclude that they were not flying in severe icing conditions. The photos taken, though 8 min later, in fact do not show extreme or remarkable conditions. From the point of view of the visual indications that are normally associated with severe icing, and which the procedures describe (ice covering much or all of the windshield, for example), these were not present in this incident or in the incident in the United Kingdom involving aircraft G-COBO.

- Second, the monitoring of the aircraft's performance, specifically, the drop in speed or climb rate.

[52] Visible moisture and a TAT of 7ºC.

> Three minutes before the event, the aircraft was unable to keep climbing, and 35 s before, the speed began to drop. These are clear indications, and are described as such in the procedure, that the aircraft's performance was degrading. Moreover, in the 4 min before the stall, the crew were given cautions that ice was building up on the aircraft (ICING LIGHT ON) and that the drag was increasing (DEGRADED PERF ON).

In other words, even if the visual indications may not have been as expected for severe icing, the remaining information (cockpit cautions and aircraft's behavior) provided a clear indication that the aircraft's performance was degrading and that the aircraft was flying in uncertified conditions. The crew only considered the visual indications and did not take into account the rest of the information, continuing to climb in severe icing conditions. Modifications included on the icing procedures after the event changed the priorities.

2.2. Management of the climb

The inability of obtaining the cockpit communications for the full flight limited the analysis of the crew's decision-making process before and during the emergency. Even so, the flight data recorder (section 1.11) did allow investigators to identify which actions were taken and which procedures were carried out.

The description provided below shows the actions taken by the crew (in response to the decision-making process used) and which procedures (in force at the time of the incident) were not complied with or what deviations were taken. The presentation follows the timeline of the flight until the time of the stall.

<u>Climb speed in icing conditions</u>:

Even though the specified climb speed in normal and icing conditions is 170 kt, this target speed was not used. Until 14000 ft, the aircraft climbed at 180 kt, and by the time IAS mode was selected, the speed was 176 kt, not 170 kt.

<u>Climb in PITCH autopilot mode</u>:

The flight mode recommended for the climb, both in normal and icing conditions, is the IAS autopilot mode. Aircraft EC-KKQ climbed in PITCH mode for reasons of passenger comfort, according to the crew's statement. The operator does in fact allow this, but only after FL150 or when the autopilot starts to pitch, and never in icing conditions. In other words, none of the conditions for using PITCH mode was present during the flight.

<u>Entering icing conditions</u>:

When the aircraft entered icing conditions (visible moisture and TAT equal to 7° C), the IAS mode should have been used, though, as noted earlier, it was not selected. The first item in the procedure was thus not performed.

Turning on the anti-icing systems (second item in the procedure) was done with a 2 min delay. They were turned on when the temperature was 2.7° C and the aircraft had climbed 2500 ft.

The remaining items in the procedure were satisfied, since the speed was kept above the icing, or red bug, speed (149 kt) at all times, and the crew's statement indicating that they were "*monitoring the ice*" is understood as complying with the final item in the procedure, which pertains to monitoring the ice accumulation.

<u>When the first indication of ice build-up appeared</u>:

When the icing light first turned on, it took the crew 5 s to turn on the de-icing systems, thus quickly complying with the procedure. The anti-icing systems were already on and the speed remained above 149 kt (icing speed). The final task in the procedure, which was to monitor for severe icing, is deemed to have been satisfied for the same reasons that are explained in the point above.

<u>When the degraded performance caution appeared</u>:

When the degraded performance caution turned on, the caution informing of ice build-up on the aircraft (ICING LIGHT ON) was already on. It took the crew 23 s to turn off the master caution that is triggered by any caution. Of the steps specified in the procedure:

- The first step was already done, since the de-icing systems had been on for 4 min.
- The second step was to maintain the speed above 159 kt, which was also satisfied since the speed was 169 kt.
- The third step was not done since the autopilot was not disengaged.
- The fourth step, which involves conducting the severe icing procedure, was not done. At that point, of the three applicable conditions, at least one was not checked:
  - the crew stated that there was no severe icing,
  - the speed could be maintained above the red bug + 10 kt (in fact, it was at red bug + 20 kt),
  - the abnormal feel of the flight controls could not be checked since the autopilot was not disengaged.

In other words, even though they had indications in the cockpit that the aircraft's performance was degraded, they did not carry out the associated procedure.

<u>When the aircraft was unable to climb</u>:

Sixteen seconds after the degraded performance caution turned on, the aircraft reached 16200 ft, and for 90 seconds it held that altitude, unable to climb further. During this time, the crew changed from PITCH mode (which is prohibited in icing conditions and which had been used to climb since takeoff) to IAS mode (the recommended mode) at 176 kt (not at 170 kt). In this new configuration, the aircraft was able to maintain the 176 kt set, but it was not able to climb.

This (the unexpected drop in climb rate) is one of the indications that is specified for determining that the aircraft is operating in severe icing conditions. Rate of climb this condition persisted for 1.5 minutes and was not taken into consideration by the crew. In this case, as noted in point 2.1, only the visual indications were considered, and the indications involving the aircraft's performance were ignored.

Neither the severe icing nor the degraded performance procedure was carried out.

<u>When the crew forced the climb</u>:

Not only was the SEVERE ICING procedure not conducted, even though the inability to climb indicated this condition, but the crew commanded a series of actions to force the aircraft to climb beyond its capabilities, which led to the stall. These actions were as follows:

- Changing the power management selector from CLIMB to MCT.
- Changing the autopilot flight mode from IAS to VS, which is prohibited during climb in icing conditions, selecting an initial climb rate of 500 fpm, and then, seeing that the aircraft did not react as expected, increasing the rate to 1100 fpm (above published 800 fpm).

By way of these actions, the crew attempted to climb through the cloud layer they were flying in. Their intention was clear, and was further confirmed by selecting a new flight level (FL190) and requesting a new clearance from ATC. According to the crew's statement, they were about to clear the cloud layer and thought that climbing (and not descending) was the best option to escape the icing, a decision that was also present in the G-COBO accident. These two actions show that the crew were completely focused on this objective and ignored the cautions that the aircraft was providing:

- The aircraft was unable to climb.
- Ice was accumulating (ICING LIGHT ON).

- The aircraft's performance was degrading (DEGRADED PERF ON).

The crew forced this situation for one minute, getting the aircraft to climb 500 ft. This was followed by the last 35 s before the event, during which the aircraft performed in a manner consistent with an approach to stall:

- Sudden drop in speed from 174 kt to 151 kt.
- Increase in the pitch, bank and attack angles.
- Vertical accelerations ranging from 1 g to 0.9 g.

The lowest speed reached was 151 kt, 2 kt above the icing (red bug) speed. This is mentioned because the crew, in their statements, said that the flight had been maintained above this value during the entire flight. It should be noted, however, that on the one hand, the minimum speed to maintain in severe icing conditions is this value plus 10 kt; and on the other, speed is not the only parameter to monitor in this environment to ensure that the aircraft is free from the effects of icing.

According to their statements, it was the captain who changed the power management switch from CLIMB to MCT, even though the first officer was the pilot flying, in violation of the specified task assignments. In this case, the vast difference in experience between them (18000 h versus 1400 h) affected, as he himself stated, the first officer's assertiveness to oppose or argue the actions or decisions made by the captain.

Use and operation of the APM system cautions:

The APM system is one of the protective devices the aircraft has to monitor how icing is affecting the aircraft. In this incident, as pertains to this system:

- The cautions that this system was providing in the cockpit were ignored.
- An incorrect weight value was entered by the crew and the APM cautions were generated late, and one not at all.

The calculations made by the APM assumed a weight that was 2000 kg below the aircraft's actual weight, which resulted in the INCREASE SPEED caution, for example, not being issued. Had the correct weight been entered, this caution would have been generated 17 s before the loss of altitude. It is impossible to analyze if the crew would have reacted differently with these two cautions (DEGRADED PERF and INCREASE SPEED), since in the incident, the DEGRADED PERF caution was on for almost 4 min before the stall, and the crew took no actions in response.

Conclusion:

During the climb, the crew took actions that were inconsistent with the procedures and recommendations specified by the manufacturer and operator. Though some were initially inconsequential (such as the use of PITCH mode and the 180-kt speed at the start of the flight), other did have consequences (like the failure to carry out the severe icing and degraded performance procedures, or the non-use of IAS mode in icing conditions). The crew did not consider the aircraft's behavior during the final part of the climb and forced the aircraft to its limits and then attempted to climb beyond said limits, all as a result of focusing on this objective.

Because of this focus on climbing, the crew selected autopilot modes that are prohibited in icing conditions, such as the use of vertical speed (VS) mode, which ultimately drove the aircraft to stall.

2.3. Management of the stall

At 20:26:03, after losing speed for 35 s, the aircraft began an uncommanded left bank that reached 58° in 8 s as it descended, also uncommanded, for 33 s. The aircraft had stalled. During this descent, the FDR recorded:

- Alternating right and left bank angles that in the initial phase of the descent changed very rapidly: over 7 s, the angle shifted from 58° left to 11° right and back again to 41° left.
- Sequential up and down pitch angles that reached maximums of 6° up and 11° down.
- A maximum angle of attack of 19.6°.
- A maximum vertical acceleration of 1.5 g.

Other stall incidents involving this aircraft model (ATR 72-212A) showed similar behavior to that of EC-KKQ: the left wing drops first, alternating bank angles of as much as 73°, pitching up to 16° and a loss of altitude of 1000 ft.

Within 33 s, the crew recovered from the stall since the aircraft was again level and its speed was 195 kt. The total loss of altitude was 1661 ft.

As with the climb leading up to it, the cockpit conversations during the event were not available to investigators, who only had the crew's statements and the data recorded in the FDR, which they used to draw the following conclusions involving the management of the stall:

- The captain did not seem to identify the stall, since for 21 s he made "nose up" inputs to his control stick. These inputs, four in all, were maintained over time (up to 7 s), were sufficiently strong to disengage the autopilot and, moreover, they countered the stick pusher. In fact, the last input to his control stick in the "nose up" direction, made at the same time as the throttle lever was placed in MAX PWR, suggest that he remained focused on making the aircraft climb.

- The first officer did seem to identify the stall, and the FDR recorded two "nose down" inputs he made to his control stick at the same time that inputs in the opposite direction were made by the captain. The first input coincided with the activation of the stall warning.

The stall warning should have activated once, and the stick pusher three times during the period when the captain was inputting contradictory nose-up commands. This alternation of nose-down commands from the stick pusher and nose-up commands from the captain would cause the angle of attack to lower due to the former, then rise due to the latter, which caused the stick pusher to be activated three times.

While managing the stall, specifically within 15 s, the throttle lever was moved, going from the NOTCH position to the MAX PWR position, and held there for 18 s. This input to the throttle lever does not correspond to any of the steps specified in the procedure that should have been applied: the stall recovery procedure. From this procedure:

- The first item, which involves pushing the stick forward firmly, was only done by the first officer. The captain made the opposite input.
- The second item, to lower the flaps to 15°, was not done.
- The power management (throttle lever to NOTCH and the power management switch to MCT) was also not done. The lever was placed in MAX PWR.
- The report to ATC involved a call by the first officer requesting an immediate descent.

This all indicates that the stall recovery procedure was not carried out. Since the cockpit communications were unavailable, it was not possible to identify what decision-making process led the crew not to carry out this procedure.

Although the crew recovered the aircraft from the stall in 33 s, they still were not in control of the aircraft. Even though the captain was operating the aircraft now, ordering the nose down using his control stick, the trim and power selected made the aircraft climb again at 33 s, which caused it to lose 29 kt of speed and increased its pitch angle to 10°.

In conclusion, the actions recorded suggest that the captain did not identify the stall until 21 s had elapsed, or that if he did identify it, he did not take the only essential action that is required, which is to push the stick forward to lower the angle of attack and recover speed, or any of the other actions in the stall recovery procedure.

2.4. Subsequent management of the flight

After the stall, the DEGRADED PERF caution stayed on for 9 minutes, without the crew carrying out the relevant procedure, as before. The decisions made by the crew in this regard were to stop the climb at 13000 ft, not to divert to any nearby airports and to accept the new climb requested by ATC, decisions that suggest that the crew thought the icing problem solved.

However, these decisions were not consistent with the crew's concern about the vibration exhibited by the aircraft, and which was confirmed on the CVR. This concern led them to ask ATC about turbulence phenomena in the area, to rule out using the flaps and finally to declare a MAYDAY. They kept the de-icing systems on until the end of the flight, but if there were doubts as to the presence of icing on the structure, they did not apply the recommendations specified in the procedures for this situation (such as, for example, making the approach with flaps 15º).

The last 25 minutes of the flight were clearly recorded on the CVR and allowed investigators to ascertain the specific dynamic at play in the cockpit, which yielded the following conclusions:

- The captain, as the pilot flying, instructed the first officer to prepare for the ILS approach and landing without flaps; however, he did not request the performance of any checklists, neither did the first officer request them or remind him, and as a result they were not performed.
- The localizer was intercepted late and the speed was not lowered practically until the landing, exceeding the speeds specified by the operator.
- The presence of two vehicles on the runway, identified by the captain, did not have the expected reaction (ask or inform ATC to clear the runway), even though the option of a go-around was not considered. This same reaction was identified in the problem with the rudder.
- The captain's comments that were recorded on the CVR ("if something happens, I'll give it power") do not reflect any standard phraseology for preparing (briefing) for landing or an emergency.
- The answer given by the captain to the first officer's question of what to do with the flaps in the event of a go-around ("don't even think of going around, we have to land") is deemed inappropriate for a public passenger transport flight, not only because he did not give the first officer any instructions on how to act in case of an emergency, but because it showed the captain's obsession with landing at all costs.
- In this regard, and as a consequence of not having done the procedures or checklists, the captain reminded the first officer not to forget to lower the gear, an inappropriate comment in the context of a transport flight made by an airline

that has developed checklists and procedures precisely so as not to have to resort to memory in emergency situations in a complex aircraft.

- This focus on landing was not accompanied by any action to avoid a go-around, since the approach that was made was unstabilized. None of the criteria were satisfied: the descent rate exceeded 1000 fpm, the speed exceeded the target speed by more than 20 kt and no checklists had been completed. A focus on landing is understandable in the sense of not wanting to prolong the flight, but it is precisely in order to achieve the landing that a stable and controlled approach should have been ensured.

For his part, the first officer handled all communications with ATC. He also monitored the aircraft's configuration, informing the captain of their position with respect to the glide slope and especially of their speed, using the "speed" callout on several occasions. He did not, however, use the callout for an unstabilized approach, undoubtedly because of the captain's prior comment.

The first officer's monitoring did not have any effect on the captain, since the speed was not lowered. In fact, the captain's instruction to lower the gear was given with the speed 43 kt higher than allowed. This situation had to be corrected by way of a sharp decrease in speed so that the gear was finally able to be lowered at an altitude above the runway of 539 ft, by which point the aircraft should have been fully configured for landing. The speed again increased and the first officer had to point this out to the captain. The speed was 86 kt above the reference speed used by the crew (130) 23 s before landing, and 30 kt higher 11 s before landing. GPWS warnings were generated that, in keeping with the desire to land at all costs, triggered no reaction. The airplane decelerated again and landed at a speed of 128 kt, one-third of the way down the runway. Despite this, the aircraft managed to stop without any problems and did not have to resort to using the braking zone.

In conclusion, the approach maneuver was executed at high speed, no procedure or checklist was performed to verify that the aircraft was correctly configured for landing and the stabilized approach criteria were not met. No action (such as a missed approach) was taken because the captain was completely focused on landing. He also ignored the first officer's observations regarding basic flight parameters, such as speed. The length of the runway in Barajas meant that even though the aircraft touched down ending the first third of the runway, this had no consequences.

2.5. Rudder problems

The investigation was unable to determine the cause of the problems the crew encountered with the rudder while decelerating on the runway. The results of the inspections of the TLU components replaced after landing do not seem to provide an answer as to the jamming reported by the crew. The aircraft has not exhibited similar problems since, meaning that if it actually was caused by a physical issue, it was solved by replacing those components.

Another possible explanation is that the TLU may have been in the HIGH SPEED position, meaning its travel was limited, which gave the crew the sense that it was jammed. Considering how, until 25 s before landing, the speed did not fall below 180 kt, the transition from HIGH to LOW SPEED would have started practically at that moment. This may have limited the system's response time, preventing it from transitioning to LOW SPEED in time.

The recorder data did not provide information on the position of the TLU switch at the time of landing, since this parameter is not recorded. The failure to do the BEFORE LANDING checklist also means that investigators could not confirm if the crew checked the position of the TLU switch in flight. This check, had it been completed, would have allowed confirming that it was in HIGH SPEED, since when this list is done, the speed was almost 40 kt above the transition speed, meaning it would not have transitioned to LOW SPEED yet.

None of the theories proposed involving the TLU failure could be confirmed.

2.6. Management of the medical emergency

The medical emergency posed several problems. One was the difficulties reported by the cabin crew when attempting to administer oxygen to the distressed passenger. According to their statements, they checked the pressure in both bottles before the flight, as specified in their procedures. However, they experienced problems with the discharge pressure in one of the bottles, and the mask. Despite of these problems the purser managed to find a way to administer oxygen to the passenger. This solution had positive results on the passenger.

Another problem encountered involved the request for an ambulance. According to the purser's statement, they requested an ambulance from the flight crew during the flight and were surprised when it was not standing by at the Madrid airport.

The CVR did, however, record a communication from the purser regarding the administration of oxygen to the passenger, in which the pilots were not asked for an ambulance at the destination. The only explanation is that a previous request was made that was not recorded on the CVR, but then the communication that was recorded would make no sense. Moreover, the crew had the chance to relay the request to ATC, since they were asked about needing assistance upon arriving several times and did not relay the request. Therefore, it is very likely that the first information the crew had involving an ambulance was when one was requested by the purser once they were already taxiing.

Regarding the medical emergency, the pilots did not speak with the cabin crew to inquire as to the status of the medical emergency that had been reported to them.

2.7. Coordination with passenger cabin

The coordination with the passenger cabin is another aspect to consider in this incident. The crew's statements and the recordings from the last 25 minutes of the flight confirm that there was no coordination of any kind with the cabin crew. After the emergency, the purser was not informed of the nature of the emergency, of the intentions for the remainder of the flight, of the expected flight time or of any special actions that were required[53]. Relaying this information does not require an inordinate amount of time, and in the case of this flight, with two pilots and sufficient flight time, should have been done in order to prevent the uncertainty that the cabin crew described in this regard.

There were also no communications with the purser to prepare for landing. In fact, the purser reported feeling surprised when he felt the landing gear being lowered. The CVR in fact confirmed that as the gear was being extended, the purser began the announcement to inform the passengers of the imminent landing. If the checklists had been performed, this point would have been covered, since notifying the cabin crew is part of the checklists done before landing.

2.8. Changes to procedures after the incident

The manufacturer modified some of the procedures applicable to this flight. The modifications have improved and clarified certain aspects of the procedures.

Removing the term "escape" with the requirement to "descend" in every case is deemed more suitable since, in two of the incidents, the insistence on climbing to escape the adverse conditions was one of the reasons that led to the stall.

The order of the criteria for defining severe icing was also changed to have the criteria involving degraded performance of the aircraft precede the visual observation of icing on the aircraft. In every case, the visual indications have proven to be either subjective or different in terms of their intensity and extent.

2.9. General conclusions

The above sections analyzing this incident revealed deficiencies not only in how the emergency was handled, but the flight as a whole, deficiencies involving:

- The failure to perform procedures.
- The failure to perform checklists.

[53] Other operators refer to this as NITS: nature of emergency, intentions, time and special instructions.

- A certain complacency in how the flight was handled in icing conditions.
- The failure to recognize the aircraft stall.
- The focus first on increasing the aircraft's altitude and then on landing.
- The first officer's lack of assertiveness.
- The lack of coordination with the cabin crew.
- The incomplete oversight of the medical emergency by the cabin crew, which delayed the arrival of the ambulance.

All of these behaviors are related to training, which is the process through which crews acquire and develop the skills needed to safely carry out both normal and emergency operations.

A review of the two pilots' training and instruction confirmed that:

- The training specified by the operator in Part D of its Operations Manual was adequate and satisfied the relevant regulation for the operation, for the flight and for potential emergency situations.
- The crew had properly received the training specified in terms of both its content and frequency.
- The crew satisfactorily completed the training.

Therefore, when the crew completed the training, it is assumed that they acquired the intended knowledge and behavior; however, what the deficiencies identified during this investigation show is that said knowledge, skills and abilities were not present at the time of the flight. Since these results are similar to those found in two previous investigations, and in order to ensure that refresher training is provided in the specific areas defined previously and that said training endures over time, two safety recommendations are issued.

3. CONCLUSIONS

3.1. Findings

General:

- The aircraft and crew were making the fourth and final flight of the day. The previous flights had been uneventful.
- The captain was highly experienced, with 18000 total hours and 3600 h on the type.
- The first officer had little experience, with 1400 total hours and 400 on the type.
- The training specified by the operator was suitable for the flight and operation in question and complied with regulations.
- The crew had received training on flying in icing conditions and recovering from stalls and abnormal positions.
- The crew had successfully completed the training received.
- The simulator used to train on icing conditions did not have the APM system implemented.
- Light and moderate icing was forecast for the flight, and the crew were aware of this information.

Flight prior to the stall:

- The flight prior to the stall lasted 18 minutes and corresponded to the climb phase. It was made in daylight conditions.
- IAS mode (speed) was not used during the climb, which is always recommended, and required in icing conditions.
- The climb was made in autopilot PITCH mode, even after the aircraft entered icing conditions.
- Once icing conditions appeared, there was a 2-minute delay before the anti-icing systems were activated.
- Once the icing light turned on, the de-icing systems were turned on immediately (5 s).
- The procedure was not applied when the degraded performance caution turned on.
- The severe icing conditions were not detected and the procedure was not applied.
- The autopilot was not disengaged.
- In order to climb above the cloud layer, VS (vertical speed) mode was selected on the autopilot. This is prohibited in icing conditions. Thrust was changed from

CLIMB to MCT.

- The thrust mode was changed from CLIMB to MCT by the captain even though the first officer was the pilot flying.
- The speed was maintained above the icing speed (red bug) at all times.
- In the final 35 s of the climb, the speed dropped from 174 kt to 153 kt. It was not kept above the severe icing speed (red bug + 10 kt).
- The correct weight was not entered into the APM system, which prevented one of the cautions (INCREASE SPEED) from being generated.
- The cabin crew reported that the wings were iced over, and they heard the ice break off from the propellers, due to the centrifugal force, and impact the fuselage.
- The pilot flying during the climb was the first officer.

The stall:

- 18 min after takeoff and 8 min after flying in icing conditions, the aircraft stalled.
- The stall began with the left wing, causing a descent of 1661 ft. The minimum speed reached was 151 kt.
- The maximum bank angles reached were 58° left and 41° right.
- The maximum pitch angles reached were 6° nose up and 11° nose down.
- The maximum angle of attack was 19.6°.
- During the stall, the autopilot and yaw damper disconnected.
- The stall warning was activated once, and the stick pusher three times.
- The captain provided a nose-up command to his stick on four occasions, countering the effect of the stick pusher.
- The first officer pushed down on his stick on two occasions.
- The stall recovery procedure was not used.
- The stall recovery lasted 33 s.
- The pilot flying during the stall was the captain.

Flight after the stall:

- The flight after the stall lasted 4 min.
- The crew continued flying to the destination airport.
- The aircraft was vibrating and the crew declared a MAYDAY 22 min after the stall due to “control problems”.
- No checklists were competed during the final 25 min of the flight.

- The flight after the stall was done at high speed until landing.
- The ILS approach maneuver was not done according to the operator's procedures: the ILS was intercepted later, the speed was higher than it should have been and they were below the glide slope.
- The excessive speed during landing gear actuation triggered warning on cockpit. They had to decelerate sharply and finally the gear extended at a radioaltitude of 539 ft.
- The aircraft flew an unstabilized approach.
- The aircraft landed without flaps lasting one-third of the way down runway 32R.
- The flight crew did not make any passenger announcements, did not inform the cabin crew about their intentions after the emergency and did not instruct the purser to prepare for landing.
- The cabin was not prepared for landing.
- The crew reported problems with the rudder, the cause of which could not be determined. Some parts were replaced in the TLU, after which the unit has not exhibited similar problems
- The aircraft vacated the runway under its own power and taxied to the parking stand.
- The pilot flying during the flight after the stall was the captain.

Medical emergency:

- During the flight, oxygen was administered to one of the passengers, which the purser reported to the flight crew.
- While administering oxygen, the cabin crew reported problems with the oxygen flow and with the mask.
- The ambulance request was relayed by the purser to the flight crew once the aircraft was already on the ground.

3.2. Causes/Contributing factors

The investigation has determined that the probable cause of the loss of control in icing conditions was a deficient flight management by the crew and an inappropriate use of automation.

4. SAFETY RECOMMENDATIONS

The investigation has revealed deficiencies in the way the flight and the emergency were managed, as a result of which the following safety recommendations are issued to the operator, Swiftair:

REC 12/19. It is recommended that Swiftair, as the operator, take the measures needed to ensure that its technical crews maintain over time the knowledge and skills related to the following areas:

- Flying in icing conditions.
- Aircraft assistance and protection systems in icing conditions.
- Stall and recovery procedures.

REC 13/19. It is recommended that Swiftair, as the operator, take the measures needed to ensure that its technical crews maintain over time the knowledge and skills related to the following areas:

- Non-technical skills (CRM): decision making, emergency management, focus and assertiveness.
- Adherence to operating procedures, task assignment in the cockpit and completion of checklists.
- Communication and coordination with the passenger cabin in emergency situations.

REC 14/19. It is recommended that Swiftair, as the operator, provide the measures needed to ensure that its passenger cabin crews acquire and maintain over time the knowledge and skills needed to manage, in a complete and adequate manner, medical emergencies on board.

REC 15/19. It is recommended that Swiftair, as the operator, take the necessary measures involving the quality control of the oxygen supply equipment on board to ensure to operability of the oxygen bottles and masks.