Civil Aviation Accident
Investigation Board (JIAAC)

# Technical
# Report 096/2011

**Accident that occurred on 18 May 2011**

**Aircraft Saab 340 A, LV-CEJ. Location: Caltrauna, between Los Menucos and Prahuaniyeu, province of Río Negro**

**Civil Aviation Accident Investigation Board (JIAAC)**

BUENOS AIRES, 11 MAR 2015

HAVING SEEN the proceedings related to Inquiry No. 096/11, initiated as a result of the aviation accident, involving a Saab 370 A aircraft, with registration number LV-CEJ, and

CONSIDERING:

That in accordance with what is established in Article 1 of Decree 1.193 of 24 August 2010, the Civil Aviation Accident Investigation Board's (JIAAC) obligations include carrying out a technical investigation of all civil aviation accidents and incidents which occur within Argentinian territory.

That on 18 May 2011, at approximately 23:48 (UTC) a Saab 340 A aircraft, with registration number LV-CEJ, was involved in an accident in the locality of Caltrauna, between Los Menucos and Prahuaniyeu, in the province of Río Negro.

That because of this, the following technical investigation was carried out in accordance with the Argentine Regulations of Civil Aviation (RAAC 13), and Regulation of Investigations of Civil Aviation Accidents (RIAAC), and in compliance with Annex 13 to the Convention on International Civil Aviation (Chicago/44), ratified by Law 13.891 as well as

of Civil Aviation Accident Investigation (MAPRIAAC), in accordance with International Civil Aviation Organisation's (ICAO) Manual of Aircraft Accident and Incident Investigation.

That, the content of the inquiry indicates that the investigation procedure is in compliance with national and international legislation regarding accident/incidents in civil aviation.

That the Final Report of the investigation includes: relevant aspects of the technical investigation, records and analyses of the events, conclusions and safety recommendations.

That it is advisable to publish and distribute the Final Report, which summarises the investigation of the incident, and which has been carried out to help prevent similar accidents/incidents from reoccurring.

That knowing what causes accidents/incidents and using this information will benefit future aviation activities, and operational safety in particular.

That the NATIONAL DIRECTORATE FOR ACCIDENT INVESTIGATION of the CIVIL AVIATION ACCIDENT INVESTIGATION BOARD has acted within its jurisdiction.

That the organisation's LEGAL DEPARTMENT has acted within its competence

That this measure is enacted pursuant to powers conferred by the National Aviation Code (Law 17.285), as well as Decree No. 935 of 10 March 1970 and Decree No. 1.193 of 24 August 2010.

Thus,

THE PRESIDENT OF THE CIVIL AVIATION ACCIDENT INVESTIGATION BOARD HAS DECIDED THE FOLLOWING:

ARTICLE NO. 1 - The Final Report, which was realized within the scope of the technical investigation, Inquiry No. 096/11, and carried out as a result of the aviation accident which involved a Saab 370 A aircraft, with the registration number LV-CEJ, and took place in the locality of Caltrauna, between Los Menucos and Prahuaniyeu, in the province of Río Negro, on 18 May 2011, at approximately 23:48 UTC must be accepted, as this Annex forms an integral part of the Resolution.

ARTICLE NO. 2 - A copy of this Resolution must be sent, along with its Annex, to the following for their information and consideration: -International Civil Aviation Organisation (ICAO) - Division AIG. -Aviation Authorities. -Aircraft manufacturers.

-Instruction Centres/ Flight simulator training.

-Air operators.

-National Meteorological Services.

The Argentine Air Force - the main authority of Air Traffic Control. -Swedish Accident Investigation Authority - SHK - (Sweden). -Operator - Operational Area/ Operational Safety. -National Directorate of Operational Safety - Directorate of Airworthiness - Directorate of Personnel Licensing of the National Civil Aviation Agency (ANAC). ARTICLE NO. 3 - A newsletter must be published on the website of the CIVIL AVIATION ACCIDENT INVESTIGATION BOARD, summarising the Final Report which is hereby approved. ARTICLE NO. 4 - A complete copy of this investigation must be sent to the National Library of Aeronautics.

ARTICLE NO. 5 - It must be communicated, published and filed.

RESOLUTION NO. 42__/15

# Index

CE. N° 096/11

WARNING

This Report is a technical document that reflects the opinion of the JIAAC regarding the circumstances under which the incident - the object of the investigation - occurred, as well as its causes and its consequences.

In compliance with Annex 13 to the Convention on International Civil Aviation (Chicago/44), ratified by Law 13.891, as well as with Article 185 of the National Aviation Code (Law 17.285), this investigation is strictly technical, and does not draw conclusions, make a presumptions of guilt , nor apportion administrative, civil nor criminal liability in relation to the investigated events.

The investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents.

The results of this investigation do not influence or prejudice any other proceedings of administrative or judicial nature that could be initiated in accordance with existing laws.

FINAL REPORT

ACCIDENT TOOK PLACE IN: The locality of Caltrauna, between Los Menucos and Prahuaniyeu, province of Río Negro.

DATE: 18 May 2011 TIME: 23:48 UTC (approx.)

AIRCRAFT: Aeroplane MAKE: Saab

MODEL: 340 A REGISTRATION NUMBER LV-CEJ

PILOT: Airline Transport Pilots Licence CO-PILOT: Commercial Pilots

Licence (1st class) OWNER: Air transport undertaking

Note: All times are expressed in Coordinated Universal Time (UTC), and the location of the accident is in time zone -3.

# 1 FACTUAL INFORMATION

## 1.1 Review of the flight

1.1.1 On 18 May 2011, the pilot in command (PIC) and the crew - composed of the co-pilot (COP) and cabin crew members (CCM) - initiated the flight OSL 5428 from Rosario International Airport (ROS) in the province of Santa Fe at 20:35, the final destination being the Comodoro Rivadavia International Airport (CRD), in the province of Chubut.

1.1.2 The flight had scheduled intermediate stopovers at Cordoba International Airport (COR), Medoza (MDZ), and Neuquén (NQN), according to the company's plans. The company designated aircraft Saab 340A, with registration number LV-CEJ, for the flight.

1.1.3 After having made the intermediate stopovers in Cordoba (COR) and Mendoza (MDZ), the pilot landed the aircraft at the airport in Neuquén at 22:20. After refuelling and carrying out the planned dispatch, the crew and 19 passengers (18 adults and one minor) on board, prepared to make the last leg of the flight OSL 5428, from Neuquén Airport (NQN) to the final destination: Comodoro Rivadavia International Airport (CRD). The flight took off at 23:05.

1.1.4 After the take-off, the aircraft started to climb AWY T 105, to reach FL 190, in accordance with the flight plan. After flying for 24 minutes, the pilot levelled the aircraft at 17800 ft, and remained at this level for approximately 9 minutes. Due to the fact that the meteorological conditions at this level caused icing, the technical crew descended to FL (flight level) 140. Shifting to FL 140 took five minutes. During this stage of the flight the icing conditions steadily worsened.

1.1.5 By the time the aircraft had reached FL 140, the icing conditions were severe. The aircraft flew for approximately two minutes with a straight and level flight attitude, increasing the accumulation of ice.

1.1.6 Then the aircraft completely lost lift, which resulted in a loss of control, and the subsequent entry into abnormal flight attitude. The aircraft plunged towards the earth and impacted the ground, which resulted in a fire. Everyone on board perished and the aircraft was destroyed.

1.1.7 The accident happened at night under IMC conditions.

## 1.2 Injuries to persons

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Deaths | 3 | 18 /X/1 | |
| Serious | – | -- | – |
| Minor | -- | – | – |
| Neither | – | -- | |

## 1.3 Damages to aircraft

The aircraft was destroyed as a result of the violent impact with the ground and subsequent fire.

1.4 Other damages

There were none.

1.5 Personnel

1.5.1 Pilot

1.5.1.1 The 45 year old pilot held an Airline Transport Pilots Licence (ATPL), had an instrument rating, and a night rating, and was authorised to fly both single-engine and multi-engine land-based aircraft of up to 5,700 kg. Furthermore, the pilot had type ratings for Casa 212, De Havilland DHC8, and Saab 340A aircraft.

1.5.1.2 According to the Directorate of Personnel Licensing of the National Civil Aviation Agency's (ANAC) records, the pilot is not reported as being involved in any previous accidents or aerial infringements. The document was last updated on 25 August 2010. The pilot was authorised to carry out the flight.

1.5.1.3 The pilot's certificate of medical fitness, Class I for the ATPL license, was valid until 30 June 2011. The certificate was not subject to limitations or observations.

1.5.1.4 According to the obtained documentation and the operators reports, the pilot's experience in terms of the number of flight hours at the time of the accident as follows:

| | |
|---|---|
| Total number of flight hours: | 6.902,1 |
| In the last 78 days: | 166.9 |
| In the last 30 days: | 62.2 |
| The day of the accident: | 6.1 |
| Of the type of aircraft involved in the accident: | 2.181,5 |

1.5.1.5 According to the documentationwhich exists on file, the pilot had taken out a total of 90 vacation days in the last 36 months.

1.5.2 Co-pilot

1.5.2.1 The 37 year old co-pilot held the Commercial Pilots Licence, Class 1 (CPL 1), had an instrument rating, and a night rating, and was authorised to fly both single-engine and multi-engine land-based aircraft of up to 5,700 kg. In addition he had a type rating for Saab 340A.

1.5.2.2 According to the Directorate of Personnel Licensing of the National Civil Aviation Agency's (ANAC) records, the First Mate had not previously been involved in any accidents. The document was last updated on 25 August 2010. The pilot was authorised to carry out the flight.

1.5.2.3 The pilot's certificate of medical fitness, Class I for the CPL 1 license, was valid until 31 August 2011, and was not subject to any limitations or observations.

1.5.2.4 According to the obtained documentation and the operators reports, the pilot's experience in terms of the number of flight hours at the time of the accident was the following:

| | |
|---|---|
| Total number of flight hours: | 1340.3 |
| In the last 78 days: | 151.8 |
| In the last 30 days: | 75.4 |
| The day of the accident: | 6.1 |
| Of the type of aircraft involved in the accident: | 285.7 |

1.5.2.5 The co-pilot had not had a vacation since commencing piloting duties with the company (approximately six months).

1.5.3 Cabin Crew Members

1.5.3.1 The 25 year old flight attendant was a licensed cabin crew member (CCM) with a SF34 type rating.

1.5.3.2 According to the Directorate of Personnel Licensing of the National Civil Aviation Agency's (ANAC) records, previous accidents or aerial infringements are reported, and the flight attendant was authorised to carry out the flight. There was no copy of the latest updated file.

1.5.3.3 The flight attendant's certificate of medical fitness, Class II for the CCM license, was valid until 31 January 2012. The certificate was not subject to limitations or observations.

1.5.3.4 According to the obtained documentation and the operators reports, the attendant's experience in terms of the number of flight hours at the time of the accident was as follows:

| | |
|---|---|
| Total number of flight hours: | 1.034,6 |
| In the last 78 days: | 63.8 |
| In the last 30 days: | 38.9 |
| The day of the accident: | 6.1 |
| Of the type of aircraft involved in the accident: | 1.034,6 |

1.5.3.5 According to the documentation which exists on file, the flight attendant had taken out a total of 90 vacation days in the last 36 months.

1.5.4 Aircraft dispatcher

1.5.4.1 The 47 year old aircraft dispatcher was a licensed aircraft dispatcher and had a SF34 type rating, granted in 2008 by the operating company.

1.5.4.2 The aircraft dispatcher's certificate of medical fitness, Class III, was valid until 6 April 2014. The certificate was not subject to limitations or observations.

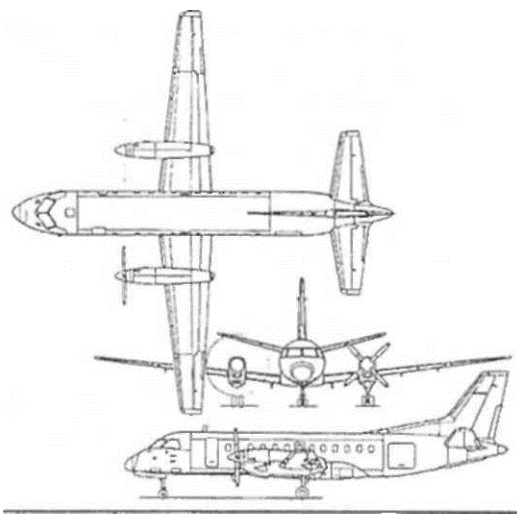
1.5.4.3 The aircraft dispatcher was employed by a private company which outsourced operative dispatch and traffic services to the airline company in question.

1.6 Information about the aircraft 5

1.6.1 General information

Transport aircraft made in 1985 by Saab Scania Sweden, model 340A, serial number 025. It was a bi-turboprop aircraft, of a semi-monocoque construction. It was 19.73 m long, with a wingspan of 21.44 m and a wing surface area of 41.81 m2 (aerodynamic profile MS (1) 0113). The structure is mostly made out of metal, with a pressurized cabin, and equipped with a retractable tricycle landing gear. The Saab 340A S/N 025 was certified to transport passengers, in accordance with the Federal Aviation Regulations (FAR) Part 25 (Type Certificate Number A52EU).

The aircraft has a cabin configuration of 37 passengers. The maximum operating speed (MOS )is 250 kts; the upper speed limit(Vne) is 282 kts.



*Graphic sketches of the Saab 340 A that was involved in the*

*accident.* 1.6.2 1.6.2 Cell

1.6.2.1 At the time of the accident it had a grand total (GT) of 41,422.6
hours and 44 477 cycles. Maintenance was carried out according to the plan established by the manufacturer and approved by the aviation authorities (progressive and periodic plan). The last inspection: (type: Phase 2) which the operating company carried out, was done on 22 April 2011, when the aircraft had a GT of 41,234,4 hours.

1.6.2.2 It had a Standard Airworthiness Certificate in the category of Transport, issued by the Directorate of Airworthiness on 25 July 2010, which at the time recorded a GT of 39443.7 hours
and 42,697 cycles. The registration certificate was issued on 22 July 2010 in the name of the air operator.

1.6.3 Engines

1.6.3.1 Turboprop propulsive system, manufactured by General Electric Aircraft Engines, USA. Both engines were of the model CT7-5A2 with a 1600 SHP rating. The certificates were in accordance with Type Certificate (FAA) E8NE. The engines were identified as: position 1 S/N° GE-E-367185KUD, position 2, S/N° GE-E-367165DKU. Both engines required jet A-1 fuel. The have take-off power of 1735 SHP, with a 5 min. limit.

1.6.3.2 Engine no. 1 had a GT of 38,592.1 hours and 41,779 cycles. The last inspection (cleaning the stage compressors) carried out by the Operator was on 5 May 2011, at which point the motor had a GT of 38,527.6 hours. Engine no. 2 had a GT of 34.408,9 hours and 41,779 cycles. The last inspection (cleaning the stage compressors) carried out by the Operator was on 5 May 2011, at which point the motor had a GT of 34.344,5 hours.

1.6.4 Propellers

1.6.4.1 The propellers were manufactured by Dowty Rotol, UK (the United Kingdom and Northern Ireland). Both were four-blade, variable-pitch propellers, made from composite materials. Both were of the model R389/4-123-F/25; position 1 had serial no. DRG/8770/84, and position 2 had serial no. DRG/1728/84.

1.6.4.2 At the time of the accident, propeller no. 1 had a GT of 37,104.9 hours, while no. 2 had a GT of 35,289.0 hours.

1.6.5 Weight and balance of the aircraft

1.6.5.1 The weight of the aircraft that was calculated during the operative dispatch, can be found in the Operator's weight and balance manual for the flight NEU-CRV (OLS 5428) on 18 May 2011. At the moment of take-off the weight was as follows:

| | |
|---|---|
| Operational: | 8,780 kg |
| Passengers (18/X/1) | 1.386 kg |
| Load: | 257 kg |
| Fuel: | 2.100 kg |

| | |
|---|---|
| Total at take-off: | 12,523 kg |
| Maximum take-off weight (MTOW): | 12.930 kg |
| Difference: | 407 kg less than the MTOW |

1.6.5.2 The estimated weight of the aircraft at take-off on 18 May 2011, as revealed by the investigation regarding flight NEU-CRV (OLS 5428), was as follows:

| | |
|---|---|
| Operational: | 8.780 kg |
| Passengers (18/X/1) | 1.386 kg |
| Load: | 257 kg |
| Fuel: | 2.450 kg |
| Total at take-off: | 12.873 kg |
| Maximum take-off weight (MTOW): | 12.930 kg |
| Difference: | 57 kg less than the MTOW |

1.6.5.3 The weight of the aircraft at the moment of take-off was 57 kg less than the MTOW and the centre of gravity was within the certified limits.

1.6.5.4 The weight and balance manual which was used for flight dispatch contains a value of maximum take-off weight (PMD - MTOW) of 12,930 kg (according to Saab service bulletin). However, the operational specifications approved by the aviation authorities in December 2009, with approval No. 0000204, state that the MTOW for the aircraft LV-CEJ was 12,700 kg.

1.6.5.5 The Operator's Operation Manual - OOM VOL 2 "Dispatch Manual", at the time of the accident there were no runway analysis tables for the airports of Neuquén and Comodoro Rivadavia.

## 1.7 Meteorological information

1.7.1 The National Meteorological Service's (NMS) report was developed using data which was obtained from the hourly records of Neuquén, San Carlos de Bariloche, Maquinchao, and San Antonio Oeste meteorological stations and interpolated with the site of the accident. GOES 12 images and the ETA NMS model number were incorporated. The surface map was also reviewed, at 00:00 UTC on 19 May. The weather conditions were: wind 320 °/ 05 kts, visibility 8 km; significant features: light rain, clouds: 5/8 ST 600 m, 8/8 NS 1.500 m, temperature: 11,5° C, dew point temperature: 4,7° C, pressure at station level: 1.010,5 hPa and relative humidity: 63 %.

1.7.2 Meteorological information used for the operative dispatch:

a) METAR from 22:00 (only the one from 22:00 is transcribed)

18 - 22:00 BARILOCHE 320/10 KT 7KM FBL RA CONS 4SÍ1000FT 4Sc2000FT 8Ns5900FT 08/05 Q1010.1 18 - 22:00 COMODORO RIVADAVIA 320/06KT 30 KM 2Ac9900FT 8Sc19800FT 10/M04 Q1008.0
18 - 22:00 ESQUEL 290/15KT 30KM 2Ac9900FT 7Cs19800 07/M06 Q1007.1 18 -22:00 NEUQUEN 050/01 KT 20 KM 1Sc6900FT 4Ac9900FT 15/04 Q1010.7 18 - 22:00 RIO GALLEGOS 320/06KT 30KM 3Sc3500FT 5As6900FT 04/M01 Q997.3
18 - 22:00 TRELEW 270/02KT 30KM 2Cu4500FT 3Cs19800FT 11/02 Q1009.2

b) TAF

18 - 16:00 - TAF SAZN 181600Z 1818/1918 29003KT CAVOK TX15/1918Z TN08/1910Z BECMG 1822/1823 34015KT BECMG 1904/1906 36005KT BECMG 1916/1918 25015KT
18 - 16:00 - TAF SAZC 181600Z 1818/1918 29020KT 4000RADZ BKN018 BKN 050 TX10/1818Z TN 08/1910Z BECMG 1905/1908 30005KT 2000 RASN 6Sc1000FT5Sc2000FT
18 - 16:00 - TAF SAVC 181600Z 1818/1918 25025KT CAVOK TX15/1819Z TN07/1911Z BECMG 1823/1901 30015KT

c) Aviation Area Forecast (ARFOR)

18-15:00 - ARFOR FIR EZE VALIDITY 1604 ON MAP 1200 UTC *SIGNIFICANT WEATHER PHENOMENA: COLD FRONT COMING FROM THE SW OF THE FIR INCREASING THE STRATIFORM CLOUDINESS WITH PRECIPITATION . JET STREAM: NIL*
*TURBULENCE: FBL/MOD al S/SW de la FIR BTN FL050/FL200 Y MOD VER/EZE BTN FL200/250.*
*ICING: FBL SW FROM THE FIR BNT FL080/FL150.*
*ZERO DEGREE ISOTHERM: VER/EZE FL078 VER/OSA fl105 VER/NEU (ESTIMATED) FL100.*
*TROPOPAUSA: VER/EZE FL362M56 VER/OSA FL415M063 VER/NEU (ESTIMATED) FL390M63.*
*WIND/T: DAY CDU ROS SVO PAR GUA AER EZE FDO MOR ENO PAL NIN OSA GPI PEH LYE BCA DIL MDP NEC FL030/32015P09 FL065/33015P05 FL100/30015P00 FL165/24030M12 FL230/24030M26 FL300/24065M42 FL360/24070M55 NEU BAR CHP FL030/30020P10 FL065/29030P03 FL100/29050M12 FL230/27060M25 FL300/27065M41 FL360/27070M56 FSCT: DAY CDU SVO PAR GUA ROS AER EZE MOR PAL ENO NIN DIL 1604 02005KT CAVOK LYE PEH GPI OSA 1604 36010KT CAVOK NEC MDP 1604 36015KT 9999 3SC1800FT 2CU2000FT BCA 1604 36020G30KT 9999 3SC3000FT 5AC10000FT NEU 1604 29003KT CAVOK BECMG 2223 34015KT BAR CHP 1604 29015KT 4000 RADZ 6SC1800FT 6NS5000FT"*

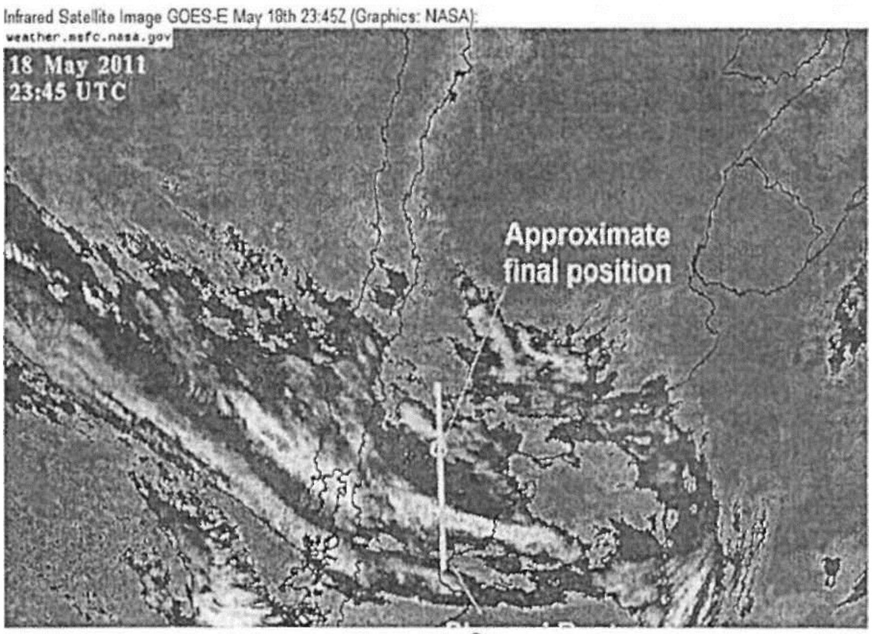
18 - 09:00 - ACTUALISATION FIR CRV VALIDITY 1016 UTC OVER MAP 0900 UTC NO SIG.

1.7.2.1 At the time of take-off, the crew did not have printed satellite images of the cold front.

1.7.3 Arfor obtained from the NNS, during the process of the investigation

18- 1500 - ARFOR FIR CRV VALIDITY 1604 OVER MAP 1200 UTC SIGNIFICANT WEATHER PHENOMENA: COLD FRONT 53S-65W-ADO-IND-ESQ MOVING NE WITHOUT ACTIVITY, ONLY PARTLY CLOUDY WITH LOW AND MEDIUM BROKEN AND ISOLATED RAINFALL.
JET STREAM: VTO MAX VER/CRV: FL350/29097KT VER/GRA FL290/33095KT.
TURBULENCE: MOD CLOSE TO MAXIMUM VTO AND IN THE FRONTAL AREA
*ICING: FLB IN FOOTHILLS N BTN FL030/150*
ZERO DEGREE ISOTHERM: VER/CRV FL055 VER/GAL: FL025 TROPOPAUSA VER/CRV: FL350M60 VER/GAL: FL285M49
WIND/T: VIE SAN AMQ ESQ IND TRE DRY FL030/27020P12 FL065/27020P05 FL100/28030M03 FL165/29050M18 FL230/29075M27 FL300/29085M42 FL360/29085M52 GRE SJU SCZ ECA GAL GRAN USU FLO3O/3OO30M00 FL065/28030M06 FL100/28035M15 FL165/29045M31 FL230/29050M48 FL300/30060M54 FL360/31060M51 CRV PTM ADO FL030/29020P03 FL065/27025M03 FL100/27030M12 FL165/29050M24 FL230/290085M40 FL300/30120M48 FL360/3011051M51
FCST: VIE SAN 1604 34015KT CAVOK BECMG 2201 20715KT 9999 2SC4500FT 6AC9000FT MAQ IND DRY TRE 1604 25015KT 9999 2SC4000FT 4AC10000FT ESQ 1604 27025G35KT 9999 1604 25025KT CAVOK GAL GRAN 1604 27020G60KT 99993 CU4000FT USU 1604 29015KT 9999 4SC500FT BECMG 1922 34015KT MLV 1604 30025KT 9999 5SC1800FT 6AS9000FT BECMG 2022 250KT 9999 - RA 6SC 2000 FT 5 AS8000FT."

1.7.4 Satellite image from 23:45 UTC - GOES E



1.8 Aids to navigation

1.8.1 At the time of the accident, the NQN Airport used the following navigation aids (according to the AIP Argentina NQN AD 21.5):

- NDB 332 kHz
- VOR/DME 116.7 MHz
- ILS/LOC 110.3 MHz
- GP/DME 335.0 MHz

1.8.2 The aircraft took the route AWY T 105 Area navigation route (RNAV), Lower airspace; its characteristics are described in the document AIP Argentina ENR. 3.0.1 General ATS routes

1.9 Communications

1.9.1 At 23:15, after the take-off and during the climb, the technical crew of the flight OSL 5428 contacted the control tower staff at Neuquén Airport, over the frequency 123.7 MHz, to report the waypoint ILTOS (the point of departure from TMA Neuquén). They were transferred to the frequency of the ACC (Area Control Center) of South Ezeiza (125.2 Mhz) and reported said waypoint.

1.9.2 At 23:33 the crew reported the waypoint EKOPA (change in Flight Information Area from FIR EZE to FIR CRV) over the frequency of the ACC of South Ezeiza. At this point, the crew could not establish a link with the ACC of Comodoro Rivadavia over the frequency 125.5 MHz.

1.9.3 At 23:37 the aircraft was flying within the airspace of FIR CRV. The crew was unable to establish contact with the ACC of CRV over the frequency 125.5 Mhz, and thus had to contact EZE SUR again to request descent. According to the communication transcripts between the crew on board flight OSL 5428 and the staff of ACC EZE south sector, the frequency 125.2 MHz was used, and the following stands out:

23:37:19 OSL 5428: *"THE OSL 5428 ARE NOT IN CONTACT WITH COMODORO AND WE ARE REQUESTING DESCENT TO 140 DUE TO ICING CONDITIONS.*
23:37:28 EZE: *"RECIEVED. DESCENT TO 140. WE WILL INFORM COMODORO"*
23:37:31 EZE: *"YES, THAT IS RIGHT. THEY HAD TOLD ME THAT WE MIGHT NOT BE IN CONTACT* 23:37:43 OSL 5428: *"YES, IN GENERAL WE NEVER ARE"* 23:37:45 EZE: *"AH, OK'.*

1.9.4 According to the CVR transcript from 23:46, the co-pilot tried to report the emergency over frequency 125.5, while the aircraft started to spiral out of control. The emergency warning was heard by another aircraft that was flying in FIR CRV, covering the route

Airfield - Comodoro Rivadavia, with FL350.

## 1.10 Information about the accident site

1.10.1 The accident took place in a dry rural area, in the locality of Caltrauna, between Los Menucos and Prahuaniyeu, in the province of Río Negro.

1.10.2 The aircraft impacted the ground in a desolate area with a hard terrain (rock and sandstone), which was located between hills that were 2,741 ft. above sea level.

1.10.3 The geographical coordinates of the site were: 41° 05' 16" S - 067° 56' 53" W.

## 1.11 Flight recorders

1.11.1 In accordance with Chapter 5, Section 5.18 of Annex 13 of the International Civil Aviation Organisation (ICAO), the US National Transportation Safety Board (NTSB) has acted through an accredited representative and the appropriate advisors, due to the fact that the aircraft's propulsive system was designed and manufactured in the States. As the Rep. of Argentina did not have the necessary equipment to carry out the entire task alone, nor the experience needed to work with destroyed and burned vehicles, the organisation offered JIAAC the use of its facilities within the framework of the Memorandum of Understanding that exists between the NTSB and the JIAAC.

1.11.2 In conjunction with the court hearing, both recorders were moved to the NTSB Engineering and Development Department and preserved all safety and security measures relevant to the case. The sending and returning of the material was uneventful; all the material remained in its original condition of discovery, along with its attached documentation.

1.11.3 Equipment

1.11.3.1 Cockpit Voice Recorders (CVR):

Manufacturer: Fairchild Model: A-100A, S/N° 60238, Recording medium: magnetic tape, Recording time: 26 min., Recording channel: 4, Channels with information recorded 3.
State of the equipment: severely damaged due to the impact and the fire.
State of the internal protection: partially damaged by impact and
fire.
Survival requirements: TSO C-51a.

1.11.3.2 Flight Data Recorders (FDR):

Manufacturer: Lockheed Aeronautical Systems (LAS), Model: 209, S/N° 2575, Recording medium: magnetic tape, Recording time: 25 h, Recording mode: binary coded digital format storage in six analogue signal tracks. Each register block occupies approximately % inch/es of the tape, which is bidirectional and endless (registered in accordance with specification ARINC 573)
State of the equipment: severely damaged due to the impact and the fire.
State of the protective measures: Partially damaged due to the impact.

Opening and evaluation

1.11.4.1 Cockpit Voice Recorders (CVR):

1.11.4.1.1 The CVR showed signs of severe impact shock and impact penetration, with the destruction of the external structure (impact and penetration) and the internal protection (resistant structure and thermal protection). There was evidence that the equipment had been on fire for a considerable period of time. The Underwater Locator Beacon (ULB) was found to be damaged; however, it withstood the impact and was still attached to the equipment.

1.11.4.1.2 The protective structure, along with the recording medium, were extracted with the use of manual tools, while the rest of the equipment was removed and preserved. Upon removing the subset and opening it up, the internal thermal protection was found to be damaged. When the last layer of mechanical protection was extracted, the recording medium was found to be fractured and damaged, as were the recording heads and other internal components.

*The state of the CVR equipment at the time of the retrieval.*

1.11.4.1.3 Upon the removal of the magnetic tape, it was found to be torn; one part was detached from the rest, but recovered. The damages to the tape ( "Mylar®" polymer tape coated with ferromagnetic material) were found close to the recording heads, and the impact had left the tape entangled.

1.11.4.1.4 Despite the damages and the tear, the tape was cleaned and reconstructed. In addition, special taping equipment was used to transcribe and digitise the tape.

1.11.4.1.5 This type of CVR technology is designed to record 30 minutes of (rewritable) audio, and (according to the assessment made by specialized NTSB staff and stated in the DCA 11RA059 report Attachment I) approximately 26 minutes of "poor" quality audio was retrieved from the three channels: *HOT-1:* Channel connected to the Commander microphone *HOT-2* Channel connected to the Co-pilot *CAM:* cockpit area microphone or environment microphones. The fourth recording channel, which in this case was not recording, is the passenger address, which is used for warning and communicating with passengers.

1.11.4.1.6 Given the quality of the audio, the contents that could be interpreted were transcribed verbatim. Noise filters and equalizers were used to improve the original quality and interpret the audio.

1.11.5.1 Flight Data Recorders (FDR)

1.11.5.1.1 The FDR equipment was damaged by the impact and the fire; however, it was in better condition than the CVR. During the impact, the protective internal module - in which the tape was located - became detached. Despite becoming detached, the recording medium was protected.

1.11.5.1.2 When opening up the equipment, it was revealed that the tape around the recording heads was damaged and torn. This occurred due to the violence of the impact. It resulted in the
tape tearing and stopping in the final recording position.

.

*The state of the FDR equipment at the time of the*

1.11.5.1.3 Both reels, which held the endless band, were removed and thoroughly cleaned before the damaged sections were reconstructed. Manual splicing techniques were carried out, using specific adhesives and "top" reinforcement tape.

1.11.5.1.4 When the tape had been reconstructed, it was wound again and processed by specific equipment for interpretation and decoding of the binary logs. This device had the ability to interpret blocks of 64 units (12 bits long) of information per second that was recorded by the FDR LAS 209. Each one of these 64 units consists of an internal "subframe" of one second, which is arranged in blocks of 4 "subframes". Each of these elementary data recording units, possesses a unique code which identifies the value that corresponds with each one of the parameters.

1.11.5.1.5 This type of recorder has two ways of storing flight information. First, numerical values (e.g., the air speed, the altitude pressure, the angle of roll, etc.) are stored as engineering units; second, dimensionless binary values that correspond to operations (taking off, activating, operating) of equipment or devices on board (e.g. the landing gear, the engine fire alarm, the operating mode of the autopilot, etc.) are stored in "discrete parameters".

1.11.5.1.6 The equipment LAS 209 S/Nº 2575, had a total of 115 recorded parameters, of which 74 corresponded to discrete values, with 66 of these belonging to the operating mode of the autopilot system (according to Appendix "A" Report NTSB DCA 11RA059 ). The remaining parameters with numeric values were: five regarding day and time, while the remaining 36 represented the variables of flight mechanics, atmospheric values (outdoor temperatures and pressure altitudes), aerodynamic performance commands and values regarding the propulsive operating system.

1.11.6 Obtaining the information from the FDR

1.11.6.1 Through the use of a specific decoding equipment, approximately 2 hours and 29 minutes of logged data was obtained. During the process of transcribing and digitalising the tape, there were many "drop-outs" of missing information, due to the damages that the tape had endured. In order for the decoded data to flow, manual editing was carried out using the "wave-form editing" technique.

1.11.6.2 The wave-form editing technique is a method of predicting values by interpreting the shape of the sine wave in which the binary values are represented, as these are downloaded and digitized. As such, if there are "gaps" in the sinusoidal, the fault is noted and assigning a value (zero or one) according to its position (peak, trough, positive trend, negative trend, etc.). Thereby, the parameters are able to flow, while taking the originally recorded values into account.

1.11.6.3 The units were converted in accordance with the manufacturer's technical manuals regarding the equipment. In accordance with the usual proceedings of the laboratory in which the task was carried out, climbing, as well as swerving and angling to the right, were assigned positive values in the graphic presentation of the parameters. This means that the following is understood as graphically positive: climb ascent angle, clockwise roll, yaw to the right and the positive deflection of the aerodynamic command surfaces.

1.11.6.4 In turn, the discrete parameter values were expressed as "true" or "false", corresponding to "yes" or "no"; to "engaged" or "disengaged".

1.11.6.5 With the information that was extracted from FDR, the flight which took place prior to the accident can be represented in its entirety, as well as approximately 43 minutes of the flight which terminated in the accident. Due to the damage to the tape, it was not possible to obtain all the data regarding the last 18 seconds of flight. The lab continued the process of wave-form editing in an attempt to reconstruct those last seconds; however, only two of those seconds were recovered.

1.11.6.6 With the information obtained, 16 graphs were produced that plotted values of significance to the investigation. In accordance with international and Argentinian law, both the audio and the transcription are classified as "Confidential" (Section 5.12 of Annex 13 of the ICAO, Section 13.35 of the RAAC, part 13, and Section 5.12 of the RIACC), "...unless the competent authorities of the Administration of Justice of said State determines that disclosure of such information is more important than the adverse consequences, nationally and internationally, that such a decision could have for that or any future investigations." (Annex 13).

1.11.6.7 With the data that was obtained, an aerodynamic study was conducted regarding the conditions of the flight mechanics, which evaluated and represented: the aircraft's angle of attack during the trajectory of the flight, the lift coefficient during flight, the drag coefficient during the operation (both with their corresponding variations) and the lift coefficient in function to the angle of attack.

1.11.7 Improving the audio quality of the CVR

1.11.7.1 The court which presided over the matter granted access to the Argentine Federal Police's scopometry laboratory, where independent filtrations of the CVR channels were performed. The different frequencies were equalised and filtered in order to better understand the conversations and sounds that were of interest to the investigation.

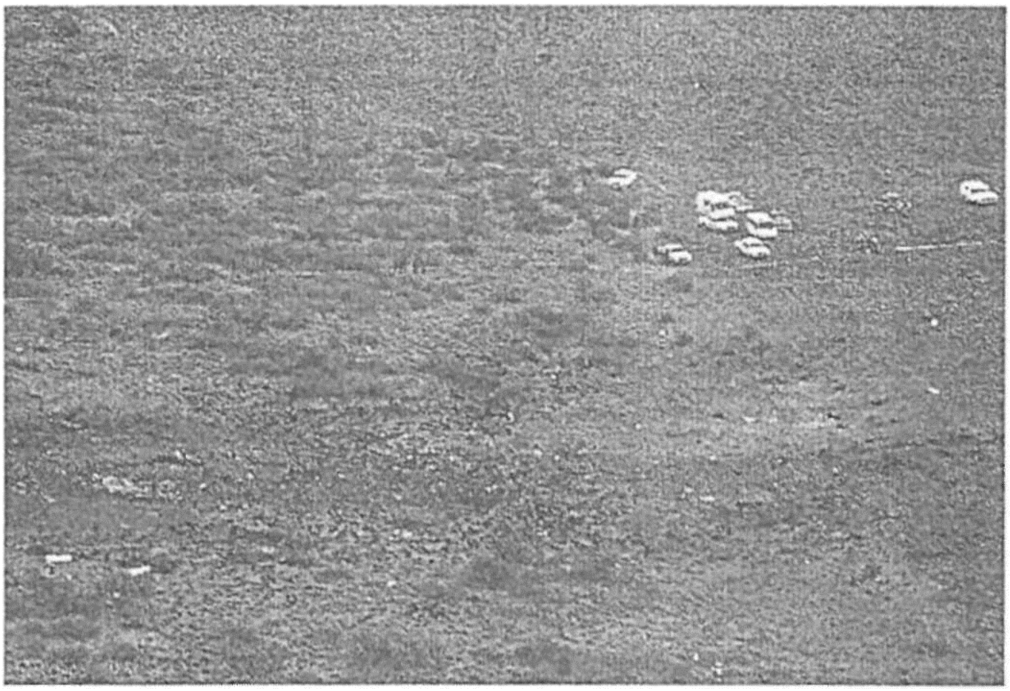
1.11.7.2 Due to the fact that the quality of the source recording was too poor for further analysis, the results that were obtained were not optimal. However, most conversations regarding the operation of the aircraft could be understood. The data was of good enough quality to carry out the investigation in full.

1.12 Information about the aircraft wreckage and the impact

1.12.1 The aircraft impacted the ground at an angle of approximately 20° with its nose down, a left lateral tilt of approximately 40° and a course approximately NNW in direction. After the impact, the main part of the airframe travelled four meters along the ground, stopped and caught fire.

1.12.2 Most of the wreckage was spread out, starting at the site of the first impact, with a heading that formed a scattering angle, ranging from 300° to 350° with a minor amount of wreckage spread out in a radius of about 200 m around the main point of impact. There was no evidence of the aircraft components detaching before impact.

1.12.3 The components of the right engine and the propeller blades were scattered about 130 m from the main impact point with the same heading. The components of the left engine and propeller blades were 90 m from the impact and with a recovery degree (Rº) of 350. The remaining propeller blades were found 70 m from the main impact and with Rº350.



*Aerial view of the impacted area.*

1.13 Medical and pathological information 17

1.13.1 There is no previous medical/pathological history of the crew that could have caused the accident.

1.13.2 The identification of the bodies was conducted by experts of the forensic team of the Supreme Court of Justice, at the request of the federal court. DNA samples were collected and used for identification. It was not possible to carry out complete autopsies of the crew.

1.14 Fire

1.14.1 The fire occurred after the impact with the ground. The fire was most intense in the area with the greatest concentration of wreckage (airframe, stabilator, wings).

1.14.2 The fire spread on the ground at an angle ranging from 300° to 350° from the point of primary impact.

1.15 Survival

1.15.1 Due to the violent impact and the subsequent fire, it was not possible to verify the conditions of the security features on board, such as seatbelts, seat attachment, etc. As a result of the impact, there were no survivors.

1.15.2 The Search and Rescue Report issued by south regional office of ANAC stated succinctly that:

182355 UTC The ACC of CRV told the southern office's Search and Rescue Centre that the commercial aircraft, OLS 5428, SF34 - which was flying from Neuquén to Comodoro Rivadavia - was not in communication with the ACC of CRV and that it had been informed by the pilot of a C550, who had heard "MAY DAY" three times on the frequency 125.5.

190004 UTC Contact was established with the regional unit of the Chubut Province Police, in order to establish a network of extended communication with the police stations and police forces that were close to the aircraft's navigation route.

The supplementary FPL (flight plan) was processed.

The 9th Air Brigade, Comodoro Rivadavia was informed

The on-duty staff of the Argentina Mission Control (ARMCC) - which is located in the 1st Air Brigade, Palomar - were asked to activate the aircraft's Emergency Locater Transmitter (ELT).

The on-duty staff of the JIAAC (central headquarters) were informed.

At 190035 UTC Approval was given to alert the established Directorates of the danger.

Flight Plan information, weight and balance manual, SPL and FPL messages were received.

The Weather Forecast Office in Comodoro Rivadavia were asked about the meteorological status of the flight route.

190150 UTC The Civil Defence staff in the town of Los Menucos, in the province of Rio Negro, were contacted. They reported that a crash and a "ball of fire" had been spotted close by, and that the necessary means had been sent.

190230 UTC The Civil Defence Staff from Los Menucos reported that their personnel had arrived and were recommended not to interfere with the accident site.

190435 UTC The same staff reported that there were no survivors at the site of the accident.

190522 UTC The provinces of Río Negro's Civil Defence staff reconfirmed that there were no survivors at the site of the accident, which was situated 40 km from Prahuaniyeu. In addition, the on-duty staff of the JIAAC were informed.

1.15.3 The airline has an Emergency Response Manual which was certified by the Aviation Authorities (2008). Once they entered the distress phase, the emergency response plan (ERP) was launched.

## 1.16 Testing and Investigations

1.16.1 At the accident site, the components were identified as they were found, and the general conditions were analysed. To carry out this task, the accredited representatives of States (NTSB of the USA, as the State which designed and manufactured the engines; and SHK of Sweden, as the State which designed and manufactured the aircraft) offered their collaboration, along with their advisers, in accordance with the provisions of ICAO Annex 13. JIAAC's investigators and specialists surveyed the wreckage, and isolated the components that were necessary in order to continue to investigate each specific area.

1.16.2 In turn, the AAIB (Air Accident Investigation Branch, United Kingdom of Great Britain and Northern Ireland) appointed an accredited representative who, despite not visiting the accident site, has provided technical assistance in relation to the propellers technical investigation.

### 1.16.3 Traceability and Maintenance

1.16.3.1 Documentation regarding technology and airworthiness was obtained through the operator of the aircraft and the aviation authority (the Directorate of Airworthiness - ANAC). In analysing the said document, the following can be deduced:

- The aircraft had a Certificate of Airworthiness, in accordance with applicable regulations. Furthermore, this certificate was incorporated into the company's Operational Specifications, in accordance with FAA Order 8300.10.

- Immediately after the incident, the Directorate of Airworthiness appointed an inspector to be sent to the operator's maintenance base (Rosario - Province of Santa Fe), in order to gather all maintenance documentation on the aircraft which was involved in the accident.

- From the information that was obtained, it was determined that two Airworthiness Directives (AD) were not completed at the time of the accident, those two being the following:

Propeller installed in left position: P / N ° R389/4-123-F/25 - S / N ° DRG8770/84 (Hub P / No. 660 714 259 - S / No. CW1255)

AD 2008-0033 (Service Bulletin SF340-61-A106), applies to the propeller
Required task: Visual inspection of the clamping sleeve area at the base of the propeller blade.
Compliance period: 1,600 h
Last compliance: 02/11/2009 at 35,121.9 h (TG propeller) Next compliance: 36,721.9 h (TG propeller) TG propeller at the time of the accident: 37,104.9 h AD expired at: 383 h

AD 2009-0005 (Service Bulletin SF340-61-95), applies to the hub
Required task: Ultra sound inspection of the propeller hub (detecting cracks)
Compliance period: 1.200 h
Last compliance: 02/11/2009 at 16,425.6 h (TG hub), 35,121.9 h (TG propeller)
Next compliance: 36.321,9 h (TG propeller) TG propeller at the time of the accident: 37,104.9 h AD expired at: 783 h

Propeller installed in left position: P/N° R389/4-123-F/25 - S/N° DRG1728/84

AD 2008-0033 (Service Bulletin SF340-61-A106), applies to the propeller
Required task: Visual inspection of the clamping sleeve area at the base of the propeller blade.
Compliance period: 1,600 h
Last compliance: 02/11/2009 at 33,310.8 h (TG propeller) Next compliance: 34.910 h (TG propeller) TG propeller at the time of the accident: 35.289 h AD expired at: 379 h

AD 2009-0005 (Service Bulletin SF340-61-95), does not apply to the installed hub (P/N° 660714289).

- As the company reported to the aviation authority, the failure to comply with these documents was due to an error in how tasks were loaded in the Airworthiness Directives (AD) control system, due to the operator's organisation of maintenance.

- No peculiarities were observed in the Flight Technical Log's (FTL Folio # 00011516) last entry, in the operating company's copies from 16 May 2011, in relation to the flight OLS 5427 from COR to ROS. The last entries in all the technical records were also analysed, starting from 13 January 2011 (FTL Folio # 00010576), and nothing significant was discovered in relation to the accident.

1.16.3.2 Through the Directorate of Airworthiness, information concerning the following service documentation was also obtained:

- Copies of the Certificate of Airworthiness, Registration, Ownership Registry and legal status in the National Aircraft Register.
- Registry of completed maintenance tasks

- Continuous Airworthiness Maintenance Programme
- General Maintenance Manual
- Mechanical Reliability Report.
  Mechanical Disruption Report.
  Report summarising the monthly fleet activities.
- Report regarding inspections and surveillance and the operator's scheduled maintenance times.

1.16.3.3 By analysing the documentation, the following can be observed:

- The aircraft's maintenance programme had been revised eight times; the last time being on 5 July 2010. According to the documentation, the required standards were met. The programme for aircraft LV-CEJ was valid, suitable, and eligible at the time of the accident.

- In the programme it is stated that the aircraft N/S° 025 (i.e. LV-CEJ) did not have a HF communication system, *-Section II Systems and Powerplant, with reference to the Job Card: 231201-* in accordance with the Air Traffic Directorate.

- The company's General Maintenance Manual, Document A-275 of the Maintenance Department, was developed and revised on 31 August 2010 by the company's authorities. The document was presented and reviewed by the Directorate of Airworthiness on 7 January 2011. It contains the development of the general inspection and maintenance procedures with regard to operator's aeronautical products, as required by the aviation authorities.

- The records of the Monthly Report on Inspection and Maintenance Work's, do not indicate any developments that may have influenced the airworthiness or the reliability of the service with regard to the aircraft that was involved in the accident.

- Copies were obtained of acts and auditory protocols carried out by AD in respect of the operator's maintenance procedures both at their base and during stop-overs. After reviewing and analysing the records, we can deduce that there were no significant developments which could have influenced or caused the accident.

1.16.4 Other Technical Aspects

1.16.4.1 Field Research

1.16.4.1.1 The researchers from JIAAC, along with the accredited representatives from the NTSB and SHK, verified the wreckage of the aircraft LV-CEJ at the accident site, and isolated all the components for further analysis.

1.16.4.1.2 The analysis of the wreckage and its components demonstrated that the aircraft had not lost any of its parts prior to the impact with the ground. Based on the damage to the engines, it was determined that they were operating and generating power at the time of the impact. Given the level of damage, the pitch angle of the propeller blades could not be reliably verified.

1.16.4.2 Review of the Propulsion System

1.16.4.2.1 The engine, model CT7-5A2, was composed of four main modules: the accessory box, the cold section (compressor), the warm section, and the power turbine.

1.16.4.2.2 During the field research - and with the support of the accredited advisers of the states that designed the engine - both engines' cold sections, i.e. the axial compressor stages (five axial rotor stages), a set of guide vanes, and the components of the compressor stator, were recovered in different places. Although the components were scattered and damaged, it was possible to observe a pattern of marks, chipping and damage that was consistent with the engine's rotation direction.

1.16.4.2.3 Once the scattered parts from the warm section of the right engine had been recovered, as well as the parts from the left engine (such as the main power axes), it was concluded that - despite the damage to the components - there was no evidence of any failure or fire, prior to the accident. The axes had the same pattern of marks and damages, indicating that the direction of the rotation was normal.

1.16.4.2.4 Both engines' accessory boxes were only partially recovered, due to the level of damage. Some severely damaged gear trains, which lacked signs of prior damage, were also identified.

1.16.4.2.5 With regard to the propellers, 18 main fragments, corresponding to both sets, were found at the site. Despite the level of damage, it was possible to determine the origin, by comparing the manufacturing numbers. No discrepancies were found regarding their eligibility or traceability, when compared with the information that was in the maintenance documentation. The level of damage and the dispersion of the fragments indicated that the blades made contact with the ground while operating.

1.16.4.3 Isolating components for testing

Once the field research had been finalised, the following components that were of interest for continued research were selected:

- Flight recorders (CVR and FDR).
- Pneumatic Valve Control System for de-icing the wings.
- Instruments recovered from the cockpit.
- Fuse panels from the cockpit.

- Alarm panel from the cockpit (*).
- The safety catch of the engine's fire extinguishers.
- Landing gear lever.

*(*) Due to the level of destruction and the inertia of the impact, the panel came apart once it became dislodged, and lost many of its indicator lights. Later, the staff of the Association of Airline Pilots recovered two of these indicators at the scene. They then delivered these indicators to the court, who in turn promptly forwarded them to the JIAAC so that further research could be carried out. The indicators that were found corresponded with "Avionics" (indicating avionic discrepancies) and "Doors" (indicating unlocked or locked doors). The Association also recovered identification plates and other parts, that were later forwarded to the JIAAC in the same way.*

Upon completing the task of isolating and preserving the various parts that were of interest to the investigation, the parts were returned to the court.

1.16.4.4 Testing carried out in the country that designed and manufactured the aircraft.

Both the de-icing control valve system and the central alarm panel were sent to the SHK, to be analysed and reviewed in detail under their supervision.

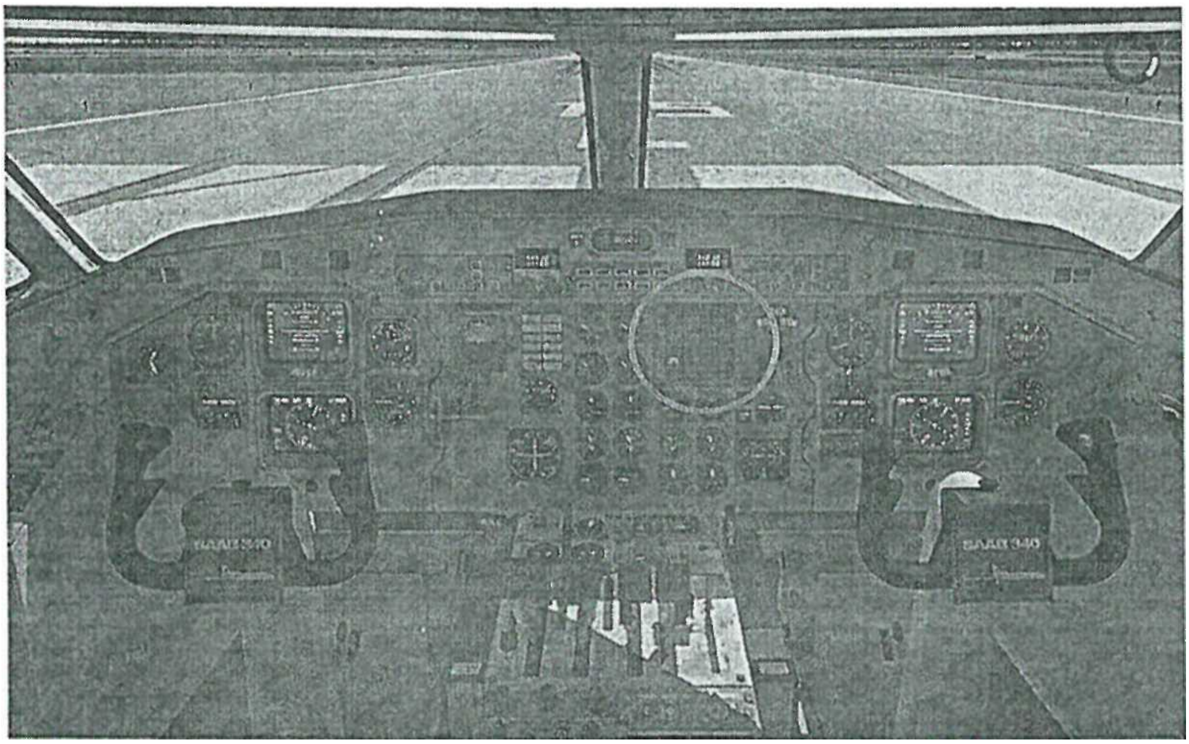
1.16.4.4.1 Wing de-icing valves

- Under the SHK's supervision, these parts, which were installed in the aircraft, were sent to the Saab Support Services (MRO Malmslätt division), where the remains were dismantled and inspected. In accordance with the damage, assessed by the specialists, the only function that could be checked was that of the pressure switches. It should be noted that the de-icing system's function, as well as the function of the valves, is linked to the display and function of these switches.

- After analysing these remains, the manufacturer (Report OFUOME/12:046), with support from the SHK, stated that: based on the assessed damage and the tests that were independently performed, it can be concluded that both of the de-icing system's pressure switches were displaying accurate values, and that the cockpit was being provided with this information, as was the system as a whole. The discrepancies that were indicated during the testing of the electric system, were due to the high level of destruction, damage and exposure to high temperatures (fire).

1.16.4.4.2 Central Warning Panel - CWP

The Central Warning Panel (CWP) is composed of a total of forty (40) light indicators. Each of these indicators has two micro-incandescent lamps that light up simultaneously to give an announcement. In order to determine whether an alarm was activated at the time of the accident, the remains that could be retrieved were sent to the manufacturer's facilities for referral (under the supervision of SHK Sweden).



*Blueprint of the cockpit, which details the location of the central alarm panel.*

1.16.4.4.3 Results of CWP Analysis

Using an optical microscope, the state of all of the recovered item's lamp filaments were analysed. As such, it was determined that only two indicators were lit at the time of the impact.

a) Indicator light "AVIONICS",

This indicator alerts abnormal: pitch and roll movements, headings, glide-slope angles, localizer signals (associated with the ILS system) and radio altimeters. The "AVIONICS" alarm is activated when there is a delay between the duplicate equipment in the cockpit, in relation to the following conditions and movements of the flight:

Comparing pitch rates:
Valid pitch rates taken from both the left and the right Attitude Heading Reference System (AHRS), and which are greater than 4º (3º when the autopilot is activated).

Comparing roll rates:

Valid pitch rates taken from both the left and the right AHRS systems, and which are greater than 4º (3º when the autopilot is activated).

Comparing the heading:
Valid heading data from the left and the right AHRS system, and an angle of roll which is greater than 20° and a difference in heading which is greater than 6°.

Comparing the localizer and the glide-slope angle:
In order to compare the glide-slope angle, it is necessary that the glide-slope angle is captured between a 90 and 1000 feet altitude.

Comparing radio altimeter:
In order to compare the radio altimeter, there must be two radio altimeters installed, and one of these most indicate valid data below 1000 feet.

The Saab report No. 031469 from 10 May 2012 determined that the AVIONICS indicator light was lit at the time of the accident, due to the fact that the duplicate equipment in the cockpit (left and right) indicated different values, as a result of the aircraft's loss of control prior to the final impact. The report No. 031469 concludes that:

*"The data registered by the flight data recorder demonstrates that the aircraft displayed excessive pitch, roll and yaw movements.*

*When an Attitude Heading Reference System (AHRS) - that uses both internal inertial sensors as well as external flow sensors - is installed, the AVIONICS general warning light will most likely be activated when the aircraft makes excessive pitch, roll and yaw movements, due to the comparative function described above."*

a) Indicator light "ICE PROT"

This indicator is connected to ten systems which the aircraft has in order to protect itself from, as well as control, the accumulation of ice. The systems are: the propeller blade heater, the windscreen heater, the engine air intake heater, the valve of the pneumatic de-icing system, the pitot heater, the alternate pitot tube heater, the heater for the angle of attack (AOA) indicator flap, the heater for the outside air temperature (OAT) sensor, the timer connected to the pneumatic de-icing surface, and the electrical power system of the various heaters.

According to Saab report No. 031484 from 31 May 2012, the "ICE PROT" light indicator was lit at the time of the accident. In accordance with the detailed analysis, carried out by the manufacturer and supervised by the

Swedish authorities, it was concluded that:

*"The information provided by the flight data recorder suggests that the ICE PROT's indication may have been caused by the timer. The reason for this is as follows:*

*A timer/individual control unit is used to defrost the aerofoil, as well as valves that distribute air to automatically control and monitor the distribution of air.*

*The timer's amber warning light and the ICE PROT general warning light will illuminate at the following times:*

- *when pressure is not detected at the valve output, with an opening sequence of under four seconds*
- *when the activated timer does not show signs of inflation*
- *when the defrosters are not operating*
- *when the timer controller loses its power supply*
- *when there is still pressure in the defrosters after the inflation cycle has ended.*

*The timer's warning is delayed by 4.5 seconds.*

*In addition to losing control of the aircraft, the recording shows that, prior to the general warning lamp/audible warning triggering, there was a decrease in power. This may have been caused by: pressure at the valve output, with an opening sequence of under four seconds, not being detected.*

*In accordance with the Aircraft Operations Manual (AOM), it is possible to adjust the power of the engine in order to obtain sufficient pressure for the aerofoil's de-icing system.*

*This investigation found no evidence that another de-icing system would have failed.*

*Based on the information that was obtained through the flight data recorder, the ICE PROT's general warning light was most probably lit due to the aerofoil's de-icing system.*

*In accordance with the Aircraft Operations Manual (AOM), it is possible to adjust the power of the engine in order to obtain sufficient pressure for the aerofoil's de-icing system.*

*The flight data recorder demonstrate that the actual engine power decreased over time. This may have been the result of an unfavourable setting, which might have triggered the ICE PROT general warning light. It is probable that the required pressure of the valve output, with an opening sequence of under four seconds, was not attained."*

1.16.5 Aircraft certification (flight into icing conditions).

1.16.5.1 The Saab 340A aircraft is certified in accordance with the FAR 25 requirements for transport aircraft. It has an A52EU type Certificate issued by the Federal Aviation Administration (FAA). This certifies that the aircraft meets all requirements, including those laid down in Appendix C, with respect to icing protection systems and flying in those types of conditions. The manufacturer of the aircraft met all requirements, according to the documentation found in the certification report *"Test Report 72FTS9301".* The on-board systems that protect against the formation and accumulation of ice, met the requirements of regulation FAR 25.1419.

1.16.5.2 Icing conditions with supercooled water droplets that are smaller than 50 microns (um) are covered by the certification standard. Both the regulation and the aircraft's operational documentation, distinguish between two types of critical conditions of icing: intermittent maximum and continuous maximum. The first is a variable atmospheric condition, with cumuliform clouds, while the second - the continuous maximum conditions - is also characterised by a variable atmospheric condition, but with stratiform clouds. Critical conditions are determined by combining the content of liquid water (expressed in $g/m^3$), and comparing this with the size of the supercooled water droplets (expressed in $\mu m$).

The aircraft's ice protection systems work, provided that the conditions expressed in the previous paragraph are met. If the icing conditions exceed the certification limits, the aircraft can enter into an unsafe flight condition.

1.16.6 Organising the operator's maintenance

At the time of the incident, the operator's organisation of maintenance met the aviation authority's requirements in terms of authorisation, provisions and performed tasks.

During the course of the investigation of this incident, a visit was made to the maintenance facilities at the operator's base. The investigation found that, after the accident, the organisation's internal structure had been changed, in order to mitigate pre-existing latent failures regarding the management of technical documentation and compliance with mandatory maintenance documentation.

1.16.7 Emergency locator systems

The aircraft was equipped with an Emergency Locator Transmitter (ELT) radio beacon. To determine whether there was activation upon impact, the local Cospas Sarsat office was consulted concerning whether the satellite detected the ELT signal. The organisation reported that no signal was received.

Due to the state of general damage of the wreckage, detailed analysis of the ELT system could not be performed. However, it is likely that the device was unable to transmit continuously after the impact due to the damage caused by the impact.

1.16.8 Complementary systems

A request was made through the operator's maintenance organisation regarding the instalment of satellite navigation equipment associated with the flight management system (FMS) in the aircraft S/N° 025. The company responded that the aircraft had the equipment Universal UNS-1L P/N° 2116-40-1116 S/N° 765 installed, which met the requirements of the Technical Standard Orders (TSO) C129. As reported, the system met the operational requirements of the AIC 09/ 09 , paragraph 8.4 ( e) 1) ( a).

1.16.9 The effect of weight

According to the operative dispatch, the weight at take-off was 12,523 kg and the centre of gravity (CG) was 26% MAC (mean aerodynamic chord). Taking this value into consideration, the data obtained from the FDR was compared to the mathematical model of the manufacturer (Digital Model DM340), the preliminary results indicated –

for those values established in regard to the compensators, and at three different climb altitudes (9,730 ft, 15,000 ft y 16,945 ft), as well as before ice contamination – that,

- in accordance with the AOA: +123 a +204 kg (average +159 kg)
- In accordance with the elevator deflection +203 a +601 kg (average 405 kg)
- Ratio between both: +282 kg

According to these values, it is estimated that the weight was approximately 280 kg above the dispatch weight and that the CG was between 1-2 % greater.

1.16.10 Air drag

With the data that was extracted from the flight data recorders, an analysis was carried out of the drag conditions that the flight developed prior to the crash. According to the analysis of the flight prior to the accident, the verified drag during the flight, before activating on the engine's anti-icing system (ENG A/I ON) ref.:20:58:34 UTC (OAT: -11° C) was approximately + 70 *drag counts* (*) relative to the Aerodynamic Design Data Book ( ADDB ).

*(*) Note: A drag count is the same as Cd/10,000 (one ten thousandth of the drag coefficient). In general, an aircraft in cruise has a Cd between 0.02 and 0.04.*

*For example, if you add five drag counts to a Cd of 0.02, the result will be: Cd = 0.0205 or 205 drag counts.*

The manufacturer's analysis of the preliminary performance, in accordance with the Swedish Aviation Authority, demonstrates the effect a of +500 kg increase in weight, or a -6% decrease in propeller thrust. The study was carried out using a polynomial of approximately six degrees, of varying Cd values (Delta Cd) over time (ref. FDR: 6,600 to 7,800). The aircraft that was involved in the accident is compared to the Delta Cd.

In accordance with the ADDB, a similar analysis was also performed of the Delta Cd, starting with the activation of the engine's anti-icing system, until stalling ( ref. time 20:58:34 to 21:18 UTC) with 0.5 inches of ice accumulation and a -6 % loss of propeller thrust due to contamination .

In conclusion, the analysis of the air drag, including the effects of ice contamination and of the thrust, has resulted in the following:

Prior to the increase in ice and the activation of the ENG A/I, there is indication of a slight increase in the level of drag (or an increase in the aircraft's weight, and/or a decrease in the thrust, due to surface erosion or repairs of the propeller blades).

- According to the certification data – in icing conditions – a 6% loss in thrust due to ice residue on the blades is feasible.
- When the aircraft entered into icing conditions (from 21:02 to 21:10 UTC) - taking into considering its dispatch weight - the extra drag was approximately + 40 drag counts (above certification for icing conditions). This value is about 30 counts below the extra resistance that was encountered before the activation of the ENG A/I.
- A correction would reduce +40 drag counts to almost zero, due to +280 kg in extra weight, and the thrust, which was caused by the state of the blades.
- After 21:10 UTC, the drag increased continuously until it reached approximately +300 drag counts.

The icing conditions that took place at 21:10 UTC, resulting in an increase of ice/drag that were clearly above the requirements determined by the certification (FAR 25, Appendix "C").

Based on what has been stated in the paragraphs above, it is important to note that the only explanation for the aircraft's drag coefficient, was severe (or extreme) ice formation and accumulation.

1.16.11 Training

1.16.11.1 A copy of the documentation, related to the crew's and the dispatcher's files, were obtained through the federal court; The National Civil Aviation Administration (ANAC) were requested to provide copies of their Operator's Operation Manual (OOM) and of their Staff Training Manual; the operator was requested to provide documentation regarding the training of its staff.

1.16.11.2 According to the obtained documentation regarding the airline's training centre and the pilot in charge, developments to the latest theoretical course - taught periodically - and conducted in April 2011, were found. These were:

a) There is no record in the thematic development plans of the pilot receiving training on the ice and rain protection system, or on the anti-ice system, despite this being a standard operating procedure and topic, found in the "Aircraft System's" course curriculum.

b) The meteorology course was not offered as it was not planned within the curriculum of periodical courses. The Aviation Regulations (RAAC) do not list this material as mandatory for recurrent or periodic courses. In addition, the pilot is not registered as having taken any meteorology course since his first technical course in 2007.

1.16.11.3 According to documentation regarding the operator's training centre, provided by the company, with reference to the initial technical course, which the co-pilot took in September 2010, the following was noted:

a) In the part "Basic Training", the courses that were provided, for example "Meteorology", were indistinguishable from one other. Furthermore, various plans for developing incomplete subjects were found. In "Aircraft Systems" the same omission of normal procedures, abnormal procedures, and emergencies were found.

b) All of the "Basic Training" courses, including the meteorology course, were taught by a pilot.

1.16.11.4 According to the documentation on file, the aircraft dispatcher completed the initial course on the SF34 aircraft in 2008 , but there is no documentation demonstrating that the dispatcher carried out the relevant periodic theoretical courses ( required to remain certified) in 2009 or 2010.

1.16.11.5 The Aviation Authority (ANAC) were requested to send copies of their records, regarding which basic and periodic theoretical courses that the aircraft's dispatcher had taken. The ANAC replied, on 29 May 2012, that it could not provide the requested information, as it was not on file.

1.16.12 Simulator training

1.16.12.1 At the time of the incident, the company was carrying out simulator training sessions, with airport scenarios that corresponded with the central (ROS, COR, AEP) region of Argentina. In accordance with the flight profiles specified in the Training Manual (MOE VOL 3 - Cap 3) there was no planned simulated operational training in cold or warm weather.

1.16.12.2 According to the instructor's reports, the simulator equipment that equated to the affected aircraft, and which was used to train the pilots during their initial and recurrent courses, could not simulate flight training in icing conditions; the pilots were only offered instructions on how to operate the anti-icing systems. The aircraft's manufacturer, as well as the aviation certification authority, confirmed this information.

1.16.12.3 According to documents obtained, the training plans which were made during the pilot’s beginners course (initial simulator training course) - held from 12/08/07 to 19/08/07 - the following features are noted:

a) The pilot would not, during any session, have received instructions on how to carry out an upset recovery, despite this being scheduled for session four.

b) In the licensing inspection form (FOR 23/03 – inspection order 832/07), carried out in a simulator that corresponded to the affected aircraft, and which had undergone the aviation authorities suitability control, it can be observed that the items listed in Section IV, Flight Manoeuvres; in No. 26, Upset Recovery; and in 27a-b-c, Approach and stall recovery(flying straight and when turning) had not been evaluated.

c) During the aircraft's enabling inspection, which took place 15 September 2007, the same form was used, and it was found that the item 27a-b-c, Approach and loss recovery, had been evaluated.

1.16.12.4 There is no record of manoeuvres for upset recovery being practiced during any of the simulator training sessions (periodic/recurrent courses), attended by the pilot from 2008 to April 2011, despite these manoeuvres being addressed in the simulator's training profile.

1.16.12.5 It is possible to verify that the pilot did not receive instructions on LOS (Line Operation Simulations), despite this being planned in the MOE VOL. 3 Instruction Manual, and being required by the aviation authority, in accordance with RAAC 121.407, Appendix G.

1.16.12.6 In the licensing inspection form (FOR 23/03 – inspection order 832/ 07) regarding the co-pilot, which was carried out in a simulator that corresponded to the affected aircraft, and which had undergone the aviation authorities suitability control, the items listed in Section IV, Flight Manoeuvres; in No. 26, Upset Recovery; and in 27a-b-c, Approach and stall recovery(flying straight and when turning) had been evaluated.

1.16.13 Operative Dispatch

1.16.13.1 The dispatcher carried out the flight dispatch, having the following meteorological information:

*METAR, TAF, ARFOR EZE at 15:00 UTC, ARFOR CRV at 09:00 UTC.*

1.16.13.2 The operative dispatcher was consulted about the Arfor of FIR CRV at 15.00, who responded that this information was not in the National Meteorological Service's (SMN) system.

1.16.13.3 The dispatcher explained that, during his briefing with the pilots of flight OSL 5428, he assessed that the route's meteorological conditions would be as normal. Furthermore, he stated that he did not print the sequence of satellite images of the weather front, as the crew had not requested him to do so.

1.16.13.4 According to the aircraft commander, who carried out the flight CRD-NQN OSL 5427, he had bumped into the pilot of flight OSL 5428, at Neuquén Airport, who *told him that the route was good.*

1.16.13.5 According to the dispatcher, the briefing for the NQN-CRD flight was carried out with the technical crew (Pilot/Co-pilot) on the aircraft's flight deck, during which he provided the obtained meteorological information, the dispatch release, and the weight and balance manual form. The meteorological information was obtained through the Internet, through the NMS's official website. The crew did not visit the meteorological office, as it is open between 0900 and 1600 UTC.

1.16.13.6 The dispatcher also stated that until the moment of the accident, he had not received any instructions or news from the company concerning ice on the ground or on the flight.

1.16.13.7 The following was recorded in the interview with the airline’s mechanic who serviced the aircraft during the flight’s stopover at Neuquén Airport:
Question:
How much fuel did the dispatcher request for the aircraft LV-CEJ, and upon closing the flight, how much fuel was on board the aircraft? Answer:
"The requested amount was 2,100 Kg. And there was 2,500 kg on board."
Question:
Can you confirm the previous testimony, that the aircraft commander told you to refuel 2,500 kg. and if so how, how do you control the load from the ground ?. Answer:
Yes, the aircraft commander requested 400 kg more as he only had a few passengers."

1.16.13.8 The following was extracted from the CVR transcripts:
20:53:53 (CVR timestamp) "We had a thousand, you refuelled 1500 litres, you went to 2200 kilos, 2500 kilos, do you understand .. "

1.16.13.9 According to the Take-off table in the AOM Manual - 28/3 page 2
TAKEOFF WEIGHT FLAP 0º vs FIELD LENGHT and CLIMB REQUIREMENT
Airport elevation: 961 ft
Temperature: 15°
Wind: Quiet
Pressure: 1010 hPa
Maximum take-off weight 29,000 lb./13.154 kg

1.16.13.10 The NMS staff that serve at the office at Neuquén Airport were interviewed, and they stated that the weather report service system "SAVIMA" [Automatic Weather Information Display System] was not working at the time of the accident.

1.16.14 Take-off and climb

1 As stated in the SOP Manual (Standard Operating Procedures), Second revision from 15 May 2009 (submitted electronically by the company) on page 7.51, point 4.1, the take-off procedure is as follows:

| | |
|---|---|
| "FLAP UP, CLIMB POWER" | Verify the speed that is indicated in the Vflap, or a higher speed, and place the flap lever in position 0. Turn the CTOT knob down to zero and then turn the keys to the OFF position. Adjust the take-off power to less than 10% (max. ITT of 820°). |

This procedure relates to the power adjustment - the ITT's (interturbine temperature) constant Power Setting.

1.16.14.2 The following procedure is stated in the AOM, in point 26.1, on

page 2:

Constant ITT Method

- valid except during high and low temperature, in accordance with the limits found in the table in the AOM - Be sure to set the TRQ (torque) in accordance with the table. Check/Control the ITT. When the ITT is constant, Climb Power is to be maintained. Check the torque again if there is a significant change in the outside air temperature (OAT). At 15,000 ft the torque values increase. At this altitude the TQR should be adjusted.

1.16.14.3 After take-off, the torque was adjusted for the climb phase in accordance with the table: Max Climb Power ECS ON and ENG A/I OFF interpolated 1,250 rpm and outside air temperature. The torque remained at this level until the aircraft reached FL 150. At this altitude the TRQ should be readjusted, according to the AOM, 26.1, page 2 (Constant ITT method). Once FL 150 had been, the torque was not adjusted correctly.

1.16.14.4 Upon reaching and altitude of 17,140 ft., the system ENG A/I was activated, according to the FDR, at 20:58:34, when the outside air temperature was minus 11°C. The activation of this system can also be linked to the increase in the engines' ITT and a decrease in the torque. This system prevents the formation of ice at the inlet of the engines, and should be used when the temperature is +10°C (FAA) /+5 °C (EASA) or less, and when there are icing conditions.

1.16.14.5 The infra-red satellite image of the cold front GOES - E from 23:45 UTC was superimposed on the route which the aircraft took. This helped determine the distinctive phases of the flight (climb, flight at 17,800 ft, descent, flight at FL140), and it was observed that the aircraft may have entered the cold front cloudiness at the same time as the ENG A/I system was activated, at 17,140 ft, and with an outside air temperature (AOT) of -11 °C.

1.16.14.6 It took the aircraft 24 minutes longer, between taking of and reaching 17,800 ft, than stated in the table in the Climb Performance AOM 32/2, page 3 for 28,000 Ib - Max Climb Power 1250-1330 RPM. However, the time it took for the aircraft to climb was not unusual for the conditions.

1.16.14.7 According to the Aircraft Flight Manual (AFM), (page 2-15) - Limitations of the aircraft - residual ice will remain when climbing in icing conditions. In "route climb speed" the minimum speed, above the MSA (minimum safe altitude), is 160kts with flp 0.

In the AFM Limitations - Minimum airspeeds (5-5) for icing conditions states:

The aircraft's minimum climb speed, above the minimum safe altitude (MSA), and when all the engines are operating, regarding cruise, descent, holding pattern, and approach:

Flaps 0 ......160 KIAS

If a lower rate must be used to exit icing conditions , "Enroute climb speed - with residual ice on the aircraft and propellers " (Vclean +15) can also be used when climbing with flaps 0.

1.16.14.8 During the climb the pilot was automatically was in Climb Low Mode, remaining at a speed of 140 kts until FL50, and subsequently maintaining a speed of 136 kts. The aircraft remained in this mode until reaching17,800 ft.

When the aircraft was cruising at 17,140 ft the ENG A/I system was activated. For these conditions, the optimal climb speed, according to the table, was 144/146 kts for an aircraft that weighs 28,000 Ib (12,700 kg). During this stretch of the flight, the aircraft's speed was 136 kts.

1.16.14.9 The AOM in the chapter on General Flight Procedures 25/1 (page 2) states the following:
During the climb, vertical mode should be used, in accordance with the following recommendations and restrictions:

Use the IAS mode only, if the aircraft accumulates ice, or if it cannot be determined whether the aircraft has accumulated ice. According to the AFM - The Limitations of Autopilot (page 2-16):

Under icing conditions, the autopilot/flight director, should select the IAS mode when climbing.

During this part of the climb, prior to the activation of the ENG A/I system, the autopilot remained in Climb low mode.

1.16.14.10 When the aircraft reached 17,800 ft, the engines had a torque margin of 7 % in relation to the MAX CLIMB POWER and 9% in relation to the MAX CRUISE POWER.

1.16.14.11 The FDR recordings from the previous flight between MDZ-NQN (Mendoza-Neuquén), show that during the climb of that flight, the autopilot was used the CLIMB mode in LOW, MEDIUM and HIGH.

1.16.15 Flight levelled at 17,800 ft

1.16.15.1 The ceiling service is defined as the level which is reached when the remaining rate of climb (ROC) is 100 ft. Thus, the aircraft LV-CEJ reached its ceiling service at 17,800 ft due to the conditions that it was in at that moment: Torque 54/55%, Engine Anti Ice ON, ECS ON, OAT minus 14° C (ISA + 8,3) and a weight close to 28,000 Ib (12,700 kg). At this moment, the engines were 9% away from reaching TRQ MAX CRUISE POWER.

1.16.15.2 The 17,800 ft altitude was reached at 21:02 (time from FDR), and a level flight altitude was maintained until 21:11:21, when descent to FL 140 commenced.

1.16.15.3 During this phase of level flight, the autopilot went into VS (vertical speed) mode, selecting 100 ft/min to make the aircraft accelerate.
At 21:08:20 the autopilot was turned off, only to be re-engaged at 21:10:50.

1.16.15.4 The average speed was 140 kts, reaching a minimum of just below 130 kts at approximately 21:03. At 21:08:45 (time from FDR) it can be observed that the power setting was adjusted to approximately a torque of 58 % and an ITT of 840°C. During the level flight at 17,800ft, the aircraft flew with an average pitch angle of 6/7 ° with the nose up.

1.16.15.5 At this stage of the flight, the aircraft started to accumulate ice; as such, the crew decided to change the flight level. According to an aerodynamic study in section1.16.9: "The icing conditions that took place at 21:10 UTC, resulting in an increase of ice/drag that were clearly above the requirements determined by the certification (FAR 25, Appendix "C")."

1.16.16 Descent

1.16.16.1 The descent was initiated at 21:11:21 (time from FDR), and flew for 5 minutes until levelling at FL 140 at 21:16:15. During this stage of the flight, the autopilot was in VS (vertical speed) mode, with a descent rate of 750 ft./min (with a pitch range of -4 °), reaching a maximum speed of 178 kts and ending at a speed of 168 kts upon reaching FL140. During the descent the aircraft maintained an average pitch (nose-up) attitude of 2/3°. The manoeuvre was carried out without adjusting the power that was used prior to initiating the descent.

1.16.16.2 According to the CVR transcripts, the crew noticed that there was an increase in the formation of ice on the aircraft at the last stage of the descent, and the *Ice Protection* systems were presumed to be connected and working. The FDR did not register the activation of the *Ice Protection* systems, such as the de-icing boots and the propeller heaters.

1.16.17 Flight levelled at FL 140

1.16.17.1 The aircraft arrived at this level at a speed of 168 kts and with a 62% torque (-8°C OAT). The autopilot achieved the selected altitude of FL 140, whereby it subsequently activated the depth stabilizer in order to maintain the selected flight level (FL).

1.16.17.2 To maintain the desired flight level of FL 140, the nose angle was increased from 5 ° to 9°. The aircraft therefore lost speed, reducing from 168 kts to 138 kts at an average of 1 kts per second (activation speed for STALL WARNING). The recommended speed for flying in icing conditions is 160 kts.

According to the communication that was extracted from the CVR, the crew noted the decrease in speed.
21:17:18 "Look, the speed is going down again..."

1.16.17.3 At 21:17:18 (time from FDR) the aircraft entered "natural buffeting" (aeroelastic trepidation prior to the stall) at a speed of 145 kts, (14 seconds before the roll off was initiated).

According to the CVR's communication, the crew noticed this situation five seconds later.

21:17:23 "Look at how the propeller is vibrating . . Maximize the propeller speed"

1.16.17.4 At 21:17:23, when the aircraft had an indicated airspeed of 142 kts, the crew increased the torque to 62%, which at the time of the "level off" was at 64/66% (cruise torque value 66%, according to tables for those conditions).

1.16.17.5 The RPM of the propellers was increased at 21:17:28, from 1,260 rpm to 1,380 rpm, i.e. 10 sec. after the buffeting started and 5 sec. after the power was increased.

1.16.17.6 According to the AFM's (6-2.17) "STALL SPEEDS" table, the stall speed, without the ice contamination and at a weight of 12,450 kg, corresponded to a stall speed of 102 kts.

1.16.17.7 The certification requirements (DNAR/FAR 25) regarding transport aircraft losing lift establish the following:
"An aeroplane is recognized as having stalled when one of the following conditions or a combination these occur:

> A movement which the pilot does not control and which cannot be immediately stopped, and which involves the nose dropping, and my be accompanied by a stall. Lateral inclination many not exceed 20$^{o}$ in the time between the stall and the recovery.

In accordance with the description above, let us imagine that the aircraft started to stall at 21:17:32 (time from FDR), with the speed of approximately 134 kts, when the nose rapidly dropped and the inclination to the left exceeded 20°.

1.16.18 Stalling and losing control of the aircraft

1.16.18.1 The artificial *Stall Warning* system was activated at 21:17:28 (time from FDR) when the AOA (LH vane) was less than 12,5° and the speed was 138 kts. As a result of this, the autopilot was de-activated at 21:17:28.8, while cruising at a speed of 137 kts

1.16.18.2 After the autopilot was deactivated, it took three seconds for the aircraft to stall. At this time (21:17:32 time from FDR), the aircraft's longitudinal and transverse axes experienced a change in flight attitude, which caused the aircraft's nose to rapidly drop and a 20° slope to the left. The inclination was increasing, meaning that uncontrolled rolls to the left and to the right were about to ensue.

- First roll: to the left, maximum roll angle of approximately 82°, roll amplitude of 82° in 12 sec. with a rate of 6,83° per sec., maximum pitch angle with nose down of 22°, change in heading of 50°, angular velocity

of 4.16 ° per sec. On command, the aircraft began turning to the right.
- Second roll: to the right, maximum roll angle of approximately 50°, roll amplitude of 132° in 6 sec. with a rate of 22° per sec., maximum pitch angle with nose down of 26°, change in heading of 35°, angular velocity of 3.8° per sec. On command, the aircraft began turning to the left.
- Third roll: to the left maximum roll angle of approximately 45°, roll amplitude of 95° in 4 sec. with a rate of 23.7° per sec., maximum pitch angle with nose down of 12°, change in heading of 25°, angular velocity of 6.2° per sec. On command, the aircraft began turning to the right.
- Fourth roll: to the right, maximum roll angle of approximately 126°, roll amplitude of 176° in 6 sec. with a rate of 29.3° per sec., maximum pitch angle with nose down of 42°, change in heading of 60°, angular velocity of 10° per sec.

Note: During instrument flights, turns should not exceed an inclination of 30° and for a standard turn, carried out during an instrument approach procedure, the angular turn velocity is $3^o$ per sec.

1.16.18.3 The crew reduced the engine power at 21:17:37 (time from FDR) to a torque of approximately 30% , when the second roll to the right began. At 21:17:47 the torque power was increased to the maximum; however, it is not possible to determine how long this level of power was maintained, as the FDR data is not available.

1.16.18.4 The *stick pusher* causes the control stick to move forwards, which produces a nose down pitch attitude. According to the information extracted from the FDR, the stick pusher was activated five times due to the command stick being in a pushed back position. The first activation was at 21:17:29 (FDR Time ) with an AOA of 19 °(LH vane ), and the last was at 21:17:42:30. In the analysed data, it was found that the crew had tried to neutralise the activation of the stick pusher system (override).

1.16.18.5 The last information from the FDR comes from 21:17:55, when the aircraft was cruising at 10,300 ft with a nose down pitch angle of 26° and levelled wings.

1.16.19 Aspects related to aviation medicine and FHOs

1.16.19.1 Methodology

In order to have access to as much information and data as possible, the following methodology has been used:

1. Notes from the National Institute of Aviation and Space Medicine's (INMAE) employee files concerning the psycho-physical history of crew.

2. Verbal interviews - undocumented and anonymous - with the pilots from the company where the Commander worked at the time of the accident, and at the previous airline, Dash.
3. The Commander's wife was interviewed.
4. Respecting the wishes of the co-pilot's father, his family was not interviewed.
5. The psychologist that had authorized the pilot's most recent files was interviewed.
6. The Chief of Staff of INMAE, Buenos Aires, and the Director of the INMAE were interviewed.
7. The audio transcription was reviewed with the professional assessment of the Department of Audiology of the Argentine Federal Police (emotions were detected in cockpit voices).
8. A video animation of the flight and the CVR audio was presented to a licensed and authorized aviation psychologist (Argentina).
9. The previous flight (DOZ - NQN, operational attitude) was analysed.

An interview was performed with a co-pilot who had accompanied the pilot on a previous NQN-CRV flight that had experienced in-flight icing, in order to analyse the operational conduct that had been adopted at that time.

11. An time line was established and analysed in collaboration with the investigator.
12. The Company's Operational Security Manager was interviewed.
13. Visits and interviews were conducted at the company’s maintenance area.
14. Visits and interviews were conducted at the company’s operational area.
15. There were meetings with the aircraft manufacturer's staff, the Swedish Board of Investigations' staff, the NTSB's staff, the FAA, and a representative from the engine manufacturer.

1.16.19.2 The Crew

There is no evidence or verification of any of the crew members suffering from a sudden in flight incapacitation in this case. No evidence of intoxication or illness has been found, nor were there any evident symptoms or signs of acute or chronic illness among the crew members.

There are no waivers or limitations in the crew's psychological reports which could be related to the accident.

The crew's clinical documentation, filed by the company’s medical officer, shows no history of any disease that could be related to the accident.

1.16.20 Meteorology

1.16.20.1 With the information which the NMS provided, and in accordance with the assumptions regarding the mechanics of flight in icing conditions, more information regarding this data was requested. From the information provided it is noted that:

1. ICING: is defined as an accumulation of ice on different parts of an aircraft that can cause dangerous situations in flight. In general, it can be determined by a combination of disturbances, namely:

- An increase in air drag
- Stalling
- A loss in propeller traction
- Vibrations
- An increase in fuel consumption
- The commands locking
- The landing gear locking
- A reduced in cabin visibility
- A partial or total disablement of the antennas
- Instruments showing incorrect indications
- Structural damage caused when shedding ice; and
- The formation of ice in the turban compressor - where a partial vacuum is produced to cool the air through adiabatic expansion - causes the values to decrease below the level which is required to operate correctly.

2. ETA-NMS MODEL: The following can be understood from the report obtained on the ETA-SMN model, vertical Trelew, at 00:00 UTC from 19 May:

- The turbulence between the site of the accident and Trelew was not strong.
- The zero degree isotherm was at approximately 7500 ft.
- The cold front air had the same, or a slightly lower temperature to, the air which the aircraft was flying in. Thus, the detour to Trelew did not cause a significant change.
- The air between 8,000 and 32,000 ft had a high level of humidity, and was almost saturated in layers of clouds.
- The speed of the aircraft did not decrease icing via kinetic heating.
- All of these levels signalled that the probability of icing was very high.
- In order to prevent the accumulation of ice, the crew should have descended to below 6300 FT, where the temperature was above zero and the air was cooler.

1.16.20.2 In the satellite image GOES 12 IR, which was taken on 18 May 2011 at 23:50 UTC with regard to cloud tops temperature and water vapour, it can be observed that the sky was completely covered in low and middle stratiform clouds, with some vertical developments of cumuliform clouds. It can also be inferred that the cloud tops were between -32° and -40° C and that they were a product of a cold frontal system that had entered into central and northern Patagonia. The wind speed was between 20 and 25 kts. In the National Weather Service's detailed analysis, the following statement regarding in-flight icing stands out: "Due *to the range of temperatures, the dew point temperature, the relative humidity and the distribution of* *clouds between FL190 and FL080, there was a high probability of icing.* This report has come out after the accident.

1.16.21 Air traffic - HF (High Frequency) Communication Equipment

1.16.21.1 On 29 June 2010, under file No. 0227346 /2010, the operating company requested ANAC's (the National Civil Aviation Administration) authorisation to incorporate into its fleet two (2 ) types of SF34 aircraft which were similar to aircraft which the company was operating already. One of these aircraft had the registration LV-CEJ, and did not have high frequency (HF) communication equipment.

1.16.21.2 On 5 July 2014, under file no. 523/2010, the Aviation Authority gave the company authorisation to use the new aircraft without HF communication equipment until 31 March 2011, subject to certain limitations. One of these limitations was the following:

a) *"The Aircraft Commander should ensure that VHF communications are maintained with air traffic control units within the jurisdiction."*

1.16.21.3 The Aviation Authority- ANAC issued the Resolution No° 141/11 on 3 March 2011, which established the new Argentine Instrument and Equipment Requirements for Motorized Civil Aircraft with Standard Certification of Airworthiness.

This resolution amended the RAAC 91.205 ( d) (2 ) and ( e) (6 ) which stated that high frequency communication was no longer mandatory.

1.16.21.4 According to resolution No° 523/2010, in the absence of available HF equipment, operations should be subject to the limitations that were cited when the authorization was granted.

*"b) "The Aircraft Commander must ensure that, during the operation of the aircraft, VHF communications are maintained with air traffic control units that correspond to the route that the aircraft is to follow."*

## 1.17 <u>Organisational and Managerial Information</u>

1.17.1 The aircraft belonged to a company that had an Air Operator Certificate, authorising it to offer regular domestic and international scheduled air transport, scheduled and non-scheduled services with passengers, cargo and mail with a large aircraft such as the SAAB 340, in accordance with the Certificate CRA No. 319.

1.17.2 In addition to the aircraft which was involved in the accident, the company had five SAAB 340 aircraft. The aircraft with the registration number LV-CEJ belonged to the company, in accordance with what is stated in Annex I of the Resolution 156/2010. The technical crew were also belonged to the same company, in accordance with Annex II of the Resolution 156/2010, which was issued on 28 April 2011.

1.17.3 As stated in the operator's specifications approved by the Aviation Authority in Part A - Section A.004 in point A.004.1: *"In the National and International general order, rules and regulations apply as determined in Annexes 2 and 6 of the ICAO. In addition, the rules in the RAAC (Argentine Federal Aviation Regulations) parts 61,63,64,65,67,91,119 and 121 apply ... "*

1.18 Additional information

1.18.1 On 12 July 2011, the JIAAC issued a recommendation on operational security, (in accordance with the provisions in paragraph 6.8 of ICAO Annex 13), related to operating alternative-powered aircraft and turbo-propeller engines in cold weather or in possible icing conditions.

1.18.2 Similar incidents - involving this type of aircraft, related to loss of control due to structural ice accumulation, and which had been investigated in other parts of the world - were studied so as to issue safety recommendations and proposals for possible modifications to the aircraft; for example the following incidents:

- 11/11/98, Eildon Weir, Victoria, Australia, investigated by the ATSB (Australian Transport Safety Bureau).
- 18/06/04, Albury, Victoria, Australia, investigated by the ATSB.
- 02/01/06, San Luis Obispo, California, investigated by the NTSB (U.S.A).

From the information obtained in these reports, it can be noted that in these incidents mentioned above, less ice was accumulated, which meant less interference with the aerodynamic response of the aircraft.

According to the aircraft's manufacturer and the certification authorities, the three events mentioned above could have been avoided if the crew had followed the operating procedures for icing conditions, which are established in the Flight Manual and the Operation Manual.

The manufacturer took into account the safety recommendations issued by the investigation agencies regarding the incidents which have been referred to, and included these in the procedures for operation in icing conditions, in accordance with the requirements of FAR 25 Appendix C.

Using the flight data registers, the NTSB (U.S.A) carried out a comparative study of the aerodynamic degradation (increased resistance, decreased lift) of the three incidents mentioned previously and the LV-CEJ's flight mechanics data.

Using the results, it is possible to hypothesise that the accident may have been the result of the aircraft being subjected to icing conditions which were more severe than the ones set out in the certification standard FAR 25 Appendix C. That is, the icing conditions were so serious that the ice prevention and defence systems were not effective enough, even when operating at their best.

This hypothesis cannot be analytically proven, as it is not possible to obtain the quality of information in terms of parameters and variables necessary to determine the size of the droplets of humidity which were inside the cloud mass, and which followed the aircraft's entire route (see 1.18.3.1).

1.18.3 Ice protection systems

1.18.3.1 El Saab 340 A is an aircraft which is certified under FAR 25 (Type Certificate A52UE) for air transport. In accordance with the certification requirements for transport aircraft, the aircraft had ice protection systems to protects it against the formation and accumulation of ice (ref. CFR 14 FAR 25.1419, in accordance with the European Authorities requirements). All of the on-board equipment constitutes the technological defence available to the crew when there is a danger of icing.

The protective equipment comprises:

- Electric Heater on the edges of the propeller blades. Electric engine air intake heater.
  Pneumatic de-icing boot systems on the edges of the wings.
  Pneumatic de-icing boot systems on the edges of the tailplane assembly (vertical and horizontal surface). Electric wind shield heater

The Saab 340A meets the requirements of Appendix C, "Special Requirements for certification - Operating in Icing Conditions." However, it should be taken into account that the requirements of the regulation consider 99% of the possible icing conditions as "moderate icing". The regulation does not establish any specific requirements for severe icing conditions.

Appendix C of FAR 25 sets out that, in a zone of moderate icing which an aircraft is to pass through, sub-cooled droplets may not exceed 50 microns.

In light of the restrictions imposed by the certification, the defence that should be employed when facing severe icing conditions (or when severe icing conditions are expected) is to plan the flight and evaluate the conditions en route.

1.18.3.2 The Aircraft Flight Manual (AFM), Saab AFM 340A Rev. 53 from 26 February 2010, as well as the Aircraft Operational Manual (AOM) has the necessary information regarding flying in these conditions. In accordance with these documents, the aircraft is fit to fly safely in 99% of the conditions set out in Appendix C of FAR 25.

Supplement No. 1 of the AFM "Operations in Cold and Icing Conditions" develops the concepts, procedures and techniques for safe flight in these conditions. Initially, flight in icing conditions is divided into two typical scenarios:

Maximum Intermittent Condition: flight variables which are presented in an atmosphere of cumuliform clouds. - Maximum Continuous Condition: understands variables in an atmosphere of stratiform clouds.

Identifying the atmospheric conditions with regard to the types of cloudiness, requires that the content of liquid water ($g/m^3$) and the size of the water droplets is determined; then it can be assessed whether or not the conditions are suitable for a safe flight.

1.18.3.3 Operating the aircraft / minimum speeds

According to the aircraft manuals, the optimal gradient with a clean profile when climbing, is achieved with VCLEAN + 5 kts. In icing conditions, speed should be increased to VCLEAN + 15 kts (1.4 x$V_S$).

The Aircraft Operational Manual (AOM, on page. 26 37/1 - Table 1 "Mínimum speed in icing conditions") states which speeds are required for a straight and level flight, according to the following information:

| | *Minimum speed (indicated speed expressed in knots - KIAS)* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Gross weight (1000 pounds)* | | | | | | | | | | | |
| | *18* | *19* | *20* | *21* | *22* | *23* | *24* | *25* | *26* | *27* | *28* | *29* |
| Flap 0 (Vclean + 15) | 121 | 124 | 127 | 130 | 133 | 135 | 137 | 140 | 142 | 144 | 146 | 148 |
| Flap 7 ($V_{MM}$ | 138 | 138 | 138 | 140 | 142 | 145 | 146 | 149 | 151 | 153 | 155 | 157 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| + 10) | | | | | | | | | | | | |
| Flap 15 ($V_{MM}$ | 133 | 133 | 133 | 135 | 137 | 140 | 141 | 144 | 146 | 148 | 150 | 152 |
| Flap 20 ($V_{MM}$ | 123 | 123 | 123 | 125 | 127 | 130 | 131 | 134 | 136 | 138 | 140 | 142 |
| Flap 35 ($V_{REF}$ + 15) | 113 | 113 | 113 | 113 | 114 | 116 | 118 | 120 | 122 | 124 | 126 | 128 |

Calculating the speed that is required for operating in icing conditions is done in relation to the weight of the aircraft. According to the flight plan and the weight and balance manual, which was presented prior to the flight, the predicted values and performances were as follows:

Using the previously presented table of minimum speeds, having compared the weight data, and knowing the phases and configurations of the flight, the minimum speed at which the aircraft should have flown was determined as the following: 144 KIAS to 146 KIAS.

Using the propulsive system: according the AOM, when an aircraft is experiencing icing conditions and when the power which has been selected (or required for the phase of flight or operation) does not reach the indicated and required speed values, the power may be increased to gradually reach this value. If necessary, the crew should not hesitate in applying the maximum continuous power or the maximum take-off power temporarily, in order to escape the situation. Continuing the flight with MAX CLIMB or MAX CRUISE power, will damage the aircraft's performance.

According to the aircraft manuals, this speed corresponds to a straight and level flight, not taking any manoeuvres or actions into account. The AOM states that, through experimentation (test flights and analysis) it has been possible to determine that the stall speed increases by 10% when appropriately 1/2 inch of ice is accumulated on the leading edge.

The severe formation and accumulation of ice poses a high-risk threat to the safety of the aircraft. The aircraft's stall alarm is programmed in accordance with the values in the table; though it should be noted that ice formation is extremely variable, and as such, buffeting can be considered a "natural" stall alarm. Aeroelastic trepidation occurs prior to stalling, even when the aircraft is 25 % above the calculated stall speed. In these types of conditions, the flight procedures require the pilot in command to firmly take charge of the flight and deactivate the autopilot (which should be operating in IAS mode only), and then control the operation manually.

According to the AOM, the power should be increased with the aim of maintaining the speed above the minimum speed limit.

1.18.3.4 Using the on-board systems Heating system

for the propeller blades:

The de-icing systems are made up of electronic heating surfaces that protect the edges of the blades, from the bottom of the blade up to approximately 45% of its length. When the system is activated, it has two modes of use: normal and maximum. The system is not able to fully melt the ice; rather, it reduces the ice's adhesion to the blade, which then falls off due to the influence of the centrifugal force. The system should not be turned on in temperatures over -5$^{o}$ C.

It is not recommended that the system is used in maximum mode when the temperature is over the recommended level. The propeller blades are of mixed material, and therefore, they have low thermal conductivity. Thus, if the temperature at the leading edge increases, there will not be enough conductivity to eliminate the ice on the surface of the blade, meaning the ice will remain on the blade and accumulation will continue.

A natural way of protecting the blade is by using the centrifugal force; in the event of a significant accumulation of ice, increasing the propeller revolutions generates a proportional increase of centrifugal force which assists in the removal of ice. The protective heating system has been optimised to be used during the climb and normal cruising, and its function is combined with the physical factor of centrifugal force.

In icing conditions, when the system is in use, there is always some ice residue left on the blade behind the heated surface. This residue is known as "run back ice", and depending on the amount of run back ice which is accumulated, the blade's aerodynamic response can be detrimentally effected, and lose up to 30% of thrust.

The Aircraft Operations Manual (AOM) requires that the blade heaters are activated when the formation of ice has been observed, and when temperatures are at -5$^{o}$ C or below. The system should be in "NORM" mode when the OAT is between -5$^{o}$ and -12° C, and in MAX mode when the temperature is -13° C or below.

IN the AFM - OPERATION IN ICING CONDITIONS, it is noted that:
"Increasing the blades' RPM will increase the chances of dislodging the ice from the blade and the fan spinner. Select MAX PRPM if severe icing conditions are encountered or expected.

Anti-ice system for engine:

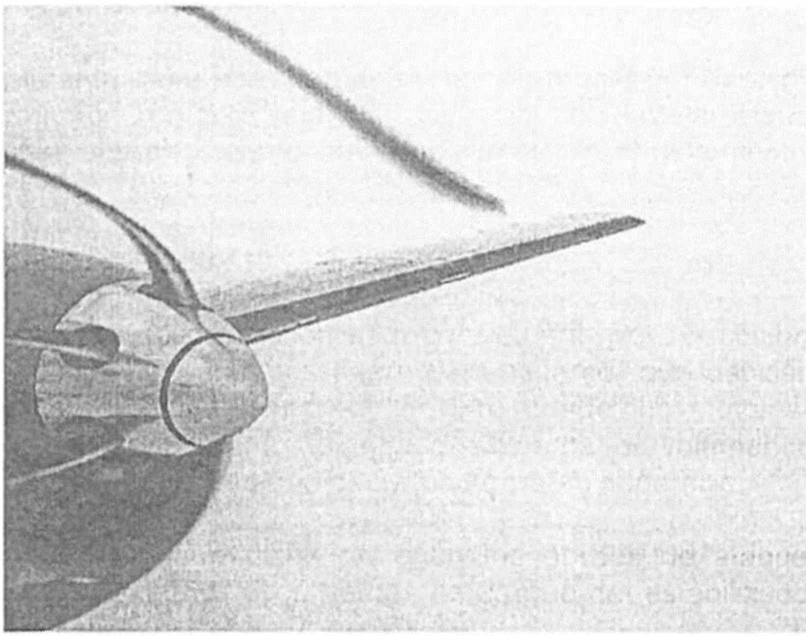
The engine's ice protection system is designed to prevent the accumulation of ice at all times. It is an electrical thermal system, with altering current, which is powered by the engine's own generator.

The system must be operated at temperatures below +5° C. The minimum response is continuous use for at least 5 minutes, until the aircraft is out of the icing conditions or of the adverse atmospheric conditions.

De-icing boot system:

This protection system consists of a set of resistant, hollow, rubber leading edges (inner tubes) , which are associated with the pneumatic system of the aircraft. They cyclically bleed air from the engines, and inflate and deflate. While inflated, the volume of the leading edges increase, which then dislodges ice which was formed on its surface.

These pneumatic boots protect the wing's leading edges (internal as well as external) and the leading edges of the vertical and horizontal stabiliser.



*An example of the location of the leading edge's de-icing boots in a similar aircraft.*

According to the AFM, in order for the boot system to be properly effective, it should be put into operation as soon as there is the slightest formation of ice. The correct use and cycle of the system prevents the formation of "ice bridging", which is a phenomena that occurs when the boot is not fully effective, which causes the formation of ice residue to stick to the leading edge, progressively aggravating the situation. However, the AFM states that the chances of this happening is very low.

According to the AFM, the boot system should be activated as soon as the aircraft is in icing conditions; that is to say: when the OAT is +5° C or less, and there is humidity in the air (cloudiness, fog, rain, snow); when the formation of ice is either known or seen; when there are no certainties regarding the atmospheric conditions and the potential of icing.

In the AOM, Supplement No.1 "Operations in cold weather and icing conditions", paragraph 4.6, states that the de-icing boot system should be operated in "CONT" mode, meaning the automatic continuous cycle mode, during which the system periodically inflates and deflates the boots. However, in severe icing conditions, it is necessary to operate the boots manually, in parallel with the continuous mode. Via the manual mode, the crew has the option of inducing a boot cycle as often as the deem it necessary, before they inflate automatically, and then to continue with the " CONT " mode until the aircraft leaves the unfavourable atmospheric conditions.

The boot system can only be deactivated when the temperature is +5° C or over, and when there are no atmospheric conditions that cause ice formation.

1.18.4 In addition, there is a modification to the autopilot system (Mod. No. 2650), that allows the security margin to be increased for flights in icing conditions. The modification allows different speeds to be programmed for the stall alarm and the stick pusher system. This system is a requirement of the Canadian aviation authority for operating in icing conditions. This kit does not apply to the aircraft S/N° 025.

1.18.4.1 The described technology, which is called the "Ice Speed System", involves configuring the stall alarm (Stick Shaker) so that it is activated at a greater stall speed than that of a clean, ice-free aircraft. The calculation is based on an estimated ice accumulation of one inch on the sides of the leading edge.

1.18.4.2 The aircraft that have this system installed, also have different speed limits in the AFM. Similarly, the Flight Manual of the aircraft in question, states that when it operates in icing conditions, with both engines on, and flaps withdrawn, and when climbing, cruising, descending, waiting and approaching, the aircraft's minimum speed must be 160 KIAS (indicated speed, expressed in knots) -climb mode-. In addition, the same document states that during in flight icing conditions, the IAS autopilot mode must be used.

1.18.5 The aircraft manufacturer issued an informative video aimed at the operators of Saab 340s and 2000s, regarding how to operate these aircraft in icing conditions. The video didactically shows the procedures that are regulated by the Flight Manual, in relation to operating in such conditions. According to the manufacturer, the video has been available since 2008, on DVD and through their website.

1.18.6 The operational dispatch staff that carried out the dispatch of flight OSL 5428, offered their services to a company that outsourced their operational dispatch and traffic services to the affected airline.

According to the contract, in which the responsibilities of both parties are framed, and which was signed on 2 August 2010, between the service provider and the airline, the following is stated:

1 - " The service provider shall appoint qualified professionals to assist in the operational dispatch and to coordinate the operations which the company carries out during stopovers... "

7- "The service agrees to provide and maintain the required service with qualified personnel who are under contract and who will undertake to comply with all legal and regulatory requirements of the service provided ..."

It was concluded that the contract did not state that the instruction / training of aircraft dispatchers was the responsibility of the airline.

1.18.7 Assessment of the Meteorological Conditions and Information Services

1.18.7.1 According to the interviews carried out with the crew from the same airline who had just flown the same route but in reverse, from Neuquén to Comodoro Rivadavia, the pilot had stated that the route's meteorological conditions were good at flight level 140, with no ice formation or VMC (visual meteorological conditions).

1.18.7.2 At the accident site, there were three unqualified witnesses who stated in their interviews that the meteorological conditions were good at the time of the accident: half of the sky was covered with high clouds, but it was clear towards the east. The estimated temperature was 10° C.

1.18.7.3 The NMS was consulted on the availability of meteorological information in the AD Neuquén. The organisation stated that the Meteorological Office of Neuquén was open from Monday to Friday, from 09:00 to 16:00 UTC (information also published in Argentina AIP AD 2.11) However, the NMS stated that AD Neuquén's meteorological protection was carried out by the head of the FIR Ezeiza via the Meteorological Monitoring Office of the Jorge Newbery Aeropark.

1.18.7.4 In October 2010, the Commander of the aircraft involved in the accident presented a report to the company regarding a flight that had been carried out on route between CRV -NEU which had experienced severe icing conditions. According to his statement, the flight was realized at FL 200, and crossed areas with temperatures of -25 ° C during which the aircraft experienced severe icing (clear ice). In the report, the pilot stated that the de-icing systems for the left engine and the right propeller experienced a fault. As a defensive measure, upon noticing that the aircraft continued to accumulate ice and loose speed, the pilot stated that he descended to FL 120, without managing to exit the layer of clouds, until 100 NM from NEU. Prior to the flight taking-off, the Commander had ordered that the amount luggage be reduced, so as to not exceed the operating weight of the aircraft. If the take-off had proceeded as initially planned, the flight would have marginally exceeded the weight and balance terms.

1.18.8 The company developed a set of manuals, in accordance with the RAAC 119, defining the operational policies, responsible actors, provisions, procedures and routes, known as the Operational Manual (OOM), and which has complementary manuals:

In the OOM VOL. 1 "Policies and Administration", approved by the Aviation Authority in December 2010, in Chapter 1, Section 1.3 Responsibilities and Obligations of the Operations Staff, 1.3.1 The Operations Management
Is responsible for: "... *Scheduling the crew, supervising, developing and amending the Operations Manual as well as the Aircrew Training Manual...".* The document states that all operations must be performed in accordance with legislation and with the company's instructions.

1.18.9 According to the Operations Manager, the managerial staff in his charge did not schedule the aircrew's activities.

1.18.10 With regard to scheduling the pilot's activities, the airline's programme coordinator stated during an interview that, in order to make the crew's schedule, he received information regarding each pilot, co-pilot, cabin attendant, from the Head of Operations, Fleet Chief, and Head of Training. With this information the programme coordinator made the crew's monthly schedule, taking into consideration the constraints of Decree 671/94, Provisions 26/2000 and 26/2003, that regulate the aircrew's activities. Upon completing the schedule, it was made public to all the company's staff.

1.18.11 However, the programme coordinated stated that, for the flight involved in the accident, one of the crew members (Co-pilot), who performed the operation from Rosario, was changed after having requested it.

1.18.12 In the OOM VOL. 1 "Policies and Administration", Chapter 7, Operation Procedures, Section 7.12.8.3 Icing Conditions it states that *"...if there are severe icing conditions, the rules in the MVA should be followed ..."*

1.18.13 The OOM VOL 7 SOP "SAAB 340 STANDARD OPERATION PROCEDURE", approved by the Aviation Authority in August 2006, does not match the manual which the company gave to the pilots. In the latest Manual Rev. 2 15 May 2010, none of its chapters mentions operating in icing conditions, or using of autopilot in these conditions.

1.18.14 In the operation specifications, provided by the National Aviation Administration, with approval no. 204 form 29 December 2010:

1.18.14.1 Annex B1: "Areas and Internal Routes" does not include the NQN-CRD route.

1.18.14.2 Annex C1 "Authorised Aerodromes" does not include an update of the Aerodromes used by the company.

1.18.14.3 Annex B1, Section 1 "Authorised routes for regular and supplementary operations"
*"...conducting operations which involve carrying passengers, cargo and mail on the routes which are specified in the "Authorised Internal Routes" section* of this Annex, is authorised. "All new routes and areas that are assigned to .... must be added to the list, the operation specifications must be amended, and then these require authorisation from the Aviation Authority."

1.18.14.4 Annex B1, Section 2, the NQN-CRD route,..., is not on the list of authorised internal routes. The route from NQN to CRD had not been authorised as a regular air route, and as such, the airline should have sent a monthly request to the SSTA in order for the route to be authorized as an irregular route. This is known as the 121 supplementary operation, and is covered by the RAAC regulation, part 121.

1.18.14.5 Annex C3, Section 1 "Authorised routes for regular and supplementary operations"
"...conducting *operations which involve carrying passengers, cargo and mail at the aerodromes which are specified in the "List of Authorised Aerodromes"* of this Annex, is authorised. "All new aerodromes that are assigned to .... have to be added to the list, the operation specifications have to be amended, and then these have to be authorised by the Aviation Authority."

Annex C3, Section 2, the aerodromes NQN and CRD are not on the list of authorised aerodromes.

1.18.15 All the procedures and information regarding operational dispatch for the Aircraft Dispatchers can be found in the OOM VOl 2 "Technical Dispatch Manual".

1.18.15.1 In Chapter 5 - Flight Preparation,
In Section 5.2, point 1) Flight Preparation, the aircraft dispatcher is given guidance regarding the available meteorological information, and it is stated that when meteorological information is not available, it should be sought via another company.

1.18.15.2 On page 5.3, there is a list of the minimum information which the Aircraft Dispatcher must provide the crew, and for the stopover at NQN this information was: the current MET METAR / QAM / TAF, the AER DEPARTURE, AER DESTINATION, PRIMARY Alt, SEC Alt, DES Alt, Route Alt, Arfor of the FIR, Satellite Photos, land chart, Wind and Temperature.

1.18.15.3 In the OOM VOL 2 "Technical Dispatch Manual" - Annex A "Regulated Take-off Weights", the runway analysis tables are not published with regard to the airports: Mendoza MDZ, Neuquén NQN y Comodoro Rivadavia CRD. In addition, it can be verified that in the tables that exist, the weight is expressed in pounds, while in the weight and balance manual form that is used, the weight was expressed in kg.

1.18.15.4 In the weight and balance manual form, *despatch release* used for this flight kg, the weight is expressed in kg.
The weight and balance manual form, which can be found in the approved Manual, Annex B "Load sheet", page B1, is not the same as the one used by the aircraft dispatcher to dispatch the flight OSL 5428.

1.18.16 All the procedures an information on operational security, can be found in the OOM VOL 1, "Policies and Administration of Operations", Chapter 8 "Operational Security"

1.18.16.1 In point 8.14 of the PREVAC Program (page 8-26), the company develops a program to prevent accidents, with the following objectives:

"...Prevent and reduce incidents and accidents, and avoid injuries and damage to persons and property outside of the company, that are results of our operations. *Identify and eliminate risky situations* and hazardous operating conditions. Investigate accidents, incidents and potentially dangerous events. Collaborate to develop the SOPs (Standard Operational Procedures). Always evaluate with safety and/or modifications of procedures and operations in mind.

1.18.16.2 The company has an internal system of reporting risks, incidents and accidents.

1.18.16.3 From the Operational Safety Department:

According to the department, reports of icing had been received, and it responded that this was mentioned as additional information in a report, regarding problems related to MTOW, which PREVAC sent via e-mail. (Report submitted on 20 October 2010). This report was filed by the pilot that would later be the commanding pilot of flight OSL 5428.

Before the new routes to Mendoza, Neuquén and Comodoro Rivadavia were incorporated, the Operation Safety Department did not consider it to be hazardous/threatening for the pilots to operate in cold weather and icing, as the commander's level of experience operating in Patagonia in winter and summer was acceptable.

1.18.16.4 The Operations Department issued a memo regarding the flights to the south, but did not mention the flight that had experienced icing conditions while cruising, nor the operational procedures for operating in these conditions.

1.18.17 Instruction/Training

1.18.17.1 The initial theoretical training, and the recurrent and practical training for the pilots, the cabin crew and the dispatchers, are outlined in the Operations Manual VOL. 3. 3 "Training Manual", approved by the ANAC with No.° 00000204 from August 2006 and amended in July 2008.

The company carried out training for the Pilots/Cabin Crew/Dispatcher at the Training Centre, set up in accordance with the Provision No. 90/09.

The Maintenance Staff received their training at the Company's training centre.

The inspectors and instructors are exclusively appointed by the Operations Department, in accordance with the terms of the Training Manual, Chapter 1 Section 1.10.

1.18.17.2 Initial Training

According to RAAC 121.400: Training is required for crew members and aircraft dispatchers that have not been authorized, or that have not served in the same capacity on another aircraft of the same group.

According to the Airline: Initial training will be given to all Pilots, Cabin Crew Members (CCM) and Aircraft Dispatcher that start working at the company.

1.18.17.3 Recurrent Training

According to RAAC 121.427: Recurrent training is carried out repetitively to keep the crew and aircraft dispatchers trained and properly updated with regard to the aircraft, as well as the tasks and duties of the position which they occupy.

According to the Airline

Pilots: all pilots receive recurrent training as to no lose their authorisation or ability. Recurrent Theoretical Training: For Pilots and Co-pilots, every 12 months, Recurrent Practical Training in a Simulator: Pilot in Command every 6 months, Co-pilots every 12 months OOM VOL. 3 "Training Manual" Chapter 3, Section 3.7 - Recurrent Training

Cabin Crew Members, between eight and twelve months OOM VOL 3 "Training Manual" Chapter 3, Section 4.3.5.2 Repetitive Training.

Aircraft Dispatchers, once a year OOM VOL 3 "Training Manual" Chapter 5, Section 5.1 General Information.

1.1.8.18. Instructing the pilots

Initial Theoretical Training: The company has developed plans and programmes to train pilot staff in the OOM VOL. 3 Training Manual, Chapter 3, Initial Training for Pilots, the courses meet the requirements established in RAAC 121. 415, 121.419.

At Basic Training level (RAAC 121.415), one of the courses that the Aviation Authority requires is Meteorology; the course is assigned a workload that equates to four hours of lecturing.

The meteorology course is meant to be taught during the initial training. The company's training centre intends for the course to be taught by a one of the company's pilots, in accordance with the OOM VOL. 3, List of Instructors.

In Aircraft Systems (RAAC 121. 419), the de-icing system is taught in different modules: Ice and rain protection, Flight directors and Autopilots, are two of them.

1.18.18.1 Flight simulator training

Upset Recovery

According to the AOM - FLIGHT PROCEDURES FLIGHT CHARACTERISTICS

In Section 3. STALL, it states:

"When *this aircraft stalls, it starts as mild buffeting just before the stall, and is followed by a nose-down movement. The stall may be followed by a roll (left or right), depending on the flight controls and the power applied. The roll WILL NO BE UNDER CONTROL until the angle of attack is decreased to below the point of loss. Due to these stall characteristics, the aircraft has been provided with a stall alarm (stall warning) and a stick pusher, in order to minimize the chances of stalling.*

According to the AOM - FLIGHT PROCEDURES TRAINING 25/12 (page 1)

Recovering from a Stall Warning (Stick Shaker):

The traditional recovery from a stall warning is to reduce the speed while maintaining the altitude. When the stick shaker is activated, power should be increased while the altitude is maintained and recovery is made without loss of altitude.

In icing conditions, there is less power available due to the formation of ice on the propellers. In addition, the drag increases due to the ice accumulation, the stall speed increases, and the time between the activation of the stick shaker and the stall is reduced. The time between the activation and the stall may be significantly reduced, and in some cases the stall may occur before the activation of the stick shaker.

When the stall alarm and the "stick shaker" are activated, or when natural buffeting occurs, it is important to increase the speed any way possible, in order to obtain a safe margin and to avoid a stall.

*The recommended procedure is: when recovering from a stall warning (stick shaker or natural buffeting), the nose should be slightly lowered by approximately 5° - unless restricted by the proximity to the ground - while simultaneously applying the MAX power. When a safe speed has been achieved, the aircraft may return to its initial altitude.*

*The aforementioned procedure is the safest for recovering from a stall and is recommended in both cases of a clean aeroplane as well as one with ice accumulation so as not to confuse the pilots with two procedures.*

In many cases, aircraft that are suffering ice contamination may begin to stall before the activation of the stick pusher, and roll deeper. In extreme cases the roll may exceed 90°, and be accompanied by an excessive nose drop. At safe altitudes, this will not impede recovery, *if the pilot is properly trained.* Therefore, it is recommended that this technique be included in the recurrent simulator training.

Recuperation procedure

NOTIFICATION: "STALL-MAX

POWER"
POWER: use all the available power in high altitude situations

PITCH: Lower the nose by approximately 5°, or if the aircraft is now being controlled by the stick pusher, do not fight against the stick pusher. Do not try to exchange altitude for speed, and avoid dropping altitude at all costs.

SPEED: Accelerate at least 1,3xVs. With ice contamination on the wings 1,4xVs (as a rule accelerate at least 30 Kts above the speed at which the aircraft was travelling when it began stalling.) In the beginning of the recovery, do not pull back quickly. Consider the fact that you could enter into a secondary stall.

1.18.18.4 According to the company's flight simulator instructors, who were in charge of instructing and training the pilots of the aircraft SF34, the stall recovery training and the upset recovery training was carried out in accordance with the procedures established in the Flight Safety Manual (SAAB 340 PILOT TRAINING MANUAL - MAY 1998), regarding maintaining the altitude at which the stall occurs.

Procedure:
Approach and recovery
The initial indication (clacker/shaker/buffet)

1. Adjust the pitch, advance the power lever to "Max Power"
2. Maintain altitude and heading
3. Check the landing gear and the upper flaps

Upset recovery procedure

If the aircraft has an excessive nose-down attitude (applicable in this case)

1. Reduce the power levers to "flight idle"
2. Level the wings (stop the roll)
3. Gently raise the nose above the horizon
4. Increase power as necessary

1.18.18.5 Upon interviewing the company's flight simulator instructors, and asking them how they trained the pilots regarding the stall recovery manoeuvres in clean configuration, the general response was the same; the traditional method, i.e., recovering from the stall without dropping in altitude.

1.18.18.6 As expressed by the Aviation Authority's (ANACs) instructors during the licensing inspection for that type of aircraft and with regard to the stall recovery in clean configuration, one of the evaluation points was to ensure that the pilot lost as little altitude as possible (+-100 ft); however, this manoeuvre was not obligatory, despite being stipulated in form 023/2003.

1.18.19 Other state participation in this report.

In accordance with Chapter 4 and 5 of Annex 13 of the Convention on International Civil Aviation (Chicago/44), the following countries, via their respective investigation organisations, participated in the revision and correction of the Final Report:

- EASA (European Aviation Safety Agency)
- SHK (Swedish Accident Investigation Authority)
- NTSB (National Transportation Safety Board, USA.)

Each of the investigation agencies received technical support from their advisors: Federal Aviation Administration (FAA), Saab, General Electric Engines y Dowty.

All of the contributions that were made by the participating States were taken into account and included in this report.

1.19 Useful or effective investigation techniques

1.19.1 Analysing the performance in icing conditions

1.19.1.1 With the data obtained from the flight data recorder, both the NTSB and the manufacturer, Saab, developed two separate aerodynamic analyses regarding performances which were related to the meteorological conditions at the time of the accident.

1.19.1.2 In accordance with the analysed information, the aircraft was probably flying in icing conditions, in which the supercooled droplets were larger than the droplets which had been considered in the aircraft's certification (FAR 25 Appendix C). The analysis is consistent with the weather report issued after the accident, which indicates that there were severe icing conditions in the flight area from FL070 to FL18,

1.19.1.3 The National Meteorological Service was consulted regarding the possibility to determine, analytically or empirically, the size of the drops, in order to clarify the extent of the icing conditions. Based on the existing data, the NMS specialists confirmed that it was not possible to conclusively determine the size of the supercooled droplets.

1.19.2 Animating the flight involved in the accident

1.19.2.1 With the information that was processed in the NTSB's laboratory, and under the supervision of the SHK and the JIAAC, the flight was recreated using animation at Saab's facilities, located in Linköping, Sweden. The "Flightscape" system was used, which interpreted the flight mechanics using the FDR data and then inserted the CVR conversations in a coordinated way.

1.19.2.2 The animation shows a view of the cockpit, the instruments and commands, with all the movements and information as they were during the actual flight. A top view shows the progress of the aircraft's trajectory and the transcript of the CVR above. The audio corresponds to the CVR's cockpit microphone.

### 1.19.3 Recreating the flight in a simulator

At the Oxford Aviation Academy's facilities in Arlanda, Sweden, the flight was recreated using the flight simulator "fu11 motion" of the model SF 340A, which simulated similar conditions and parameters to those taken from the FDR of the flight which was involved in the accident. The simulator was operated by an operative investigator from the JIAAC, who had extensive experience of flying turboprop aircraft, and a flight instructor, who worked for the manufacturer. They tested the possibility of regaining control after having carried out abnormal manoeuvres. It should be made clear that the simulator emulated ice contamination in terms of gaining weight, but it was not possible to recreate the aerodynamic degradations that ice contamination also causes.

## 2 ANALYSIS

### 2.1 Analysing the technical aspects related to security

### 2.1.1 Maintenance of aeronautical products involved

Air worthiness:

Cell: In accordance with the maintenance registration, the organisation's documentations, previous incidents, and the manufacturer's established plan which was approved by the aviation authority, no information was found that could have influenced the accident. Nor were structural failures or failures of on board systems detected which could have influenced the performance of the aircraft in flight.

Engines: In accordance with the maintenance registration, the organisation's documentations, previous incidents, and the manufacturer's established plan which was approved by the aviation authority, no information was found that could have influenced the accident. Nor was there any evidence of power loss, overheating or otherwise which might have suggested any failure prior to the aircraft's impact with the ground. In addition, and in accordance with the findings on the ground and the information extracted from the flight data recorders, both engines were generating power at the time of the accident.

Propellers: Having analysed the wreckage on the ground, it was determined that the propellers were destroyed on impact. Through looking at the technical documentation, and at the information provided by the Directorate of Airworthiness, it was determined that the Airworthiness Directives (AD) AD 2008-0033 y AD 2009-0005 had not been filled out at the time of the accident. Although there are no indications of these failures being related the non-completion of the documentation, the propeller that was installed on the left hand side, P/N° R389/4-123-F/25 - S/N° DRG8770/84 (Hub P/N° 660714259 - S/N° CW1255), deviated from airworthiness standards. In addition the propeller that was installed on the right hand side, S/N° DRG 1728/84, was not in compliance with AD 2008-0033 (Service Bulletin SF340-61-A106), and therefore also deviated from the airworthiness standards.

No new maintenance, which may have been linked to the aircraft's anti-icing systems, was found. All of the evidence, found during the course of this investigation, indicates that the technological defences worked in accordance with expectations throughout the duration of the flight which ended in the accident.

2.1.2 Organisation and maintenance

Using the gathered information, it can be determined that the company's maintenance department was capable and equipped to handle the tasks that were within its scope and capacities.

With regard to the registry system of the Airworthiness Directives, at the time of the incident, the organisation had combined two departments (Quality and Engineering), and there was only one member of staff handling the registration of this documentation. The investigation found that the ADs were in the system; however, there was no function for triggering an alert in the event of compliance issues. As such, the staff were not alerted when the ADs were on the verge of expiring.

A set of latent faults (threats to the system) were detected, and as a result of this investigation, the following measures were taken regarding the aforementioned fault: the departments were separated, and each department was assigned appropriate tasks, with the required staff and necessary training. The consequence of this has been that the tasks are more effectively carried out and the potential risks have been minimized in that area.

2.2 <u>Operational Aspects</u>

2.2.1 With regard to meteorology

2.2.1.1 With the meteorological information that was available when flight OSL 5428 departed, such as METAR, TAF, Arfor FIR EZE, Arfor FIR CRV, a technical analysis predicted minor icing between FL 030/150. As such, the crew conducted an adequate risk assessment based on the information which they had prior to departure and were therefore surprised by the amount of icing which they encountered on the route.

2.2.1.2 Information obtained about the opening hours of the meteorological office at Neuquén Airport revealed that the office was closed when flight OSL 5428 departed, and that the SAVIMA system was down. These two circumstances probably contributed to the fact that the meteorological situation that they found themselves in was not what they had expected.

2.2.2 With regard to operational dispatch

2.2.2.1 The meteorological information that was provided during the operational fight dispatch, NQN-CRD, did not include the ARFOR of the FIR CRV, updated at 15:00 UTC, with the satellite images of the cold front which was affecting the route. It can thus be deduced that the information provided was incomplete, and that it did not meet the requirements of the Operator’s Manual, VOL. 2 (enforced at the time of the accident), on page 5.3, on which there was a form regarding the minimum information which the Aircraft Dispatcher needed to provide the crew with.

2.2.2.2 The ARFOR of the FIR CRV from 15:00 UTC was absent among the information that was given to the crew, and we can thus assume that it would not have alerted the crew with regard to the level of icing prevalent on the route NQN-CRD.

2.2.2.3 Upon technical analysis of the meteorological information given to the crew during the briefing regarding the specific meteorological conditions at the departure, arrival - or alternatively, the Arfor of the FIR EZE - the Aircraft Dispatcher's evaluation, and the comments which the crew from flight CRD-NQN made regarding the meteorological conditions of the route, it can be concluded that the operational decision to initiate the flight was correct.

2.2.2.4 According to the maintenance staff at the stop-over in NQN (Neuquén), who assure that the cargo was 2,500 kg, as per the CVR transcription, the weight analysis, and the air drag analysis (Section 1.16.9, 1.16.10), it can be assumed that, at take-off, the aircraft weighed more than what was declared on the load sheet, but less that the certified maximum take-off weight (MTOW).

2.2.3 With regard to the flight

2.2.3.1 Considering the fact that the crew on the prior flight (CRD-NQN) selected the autopilot modes CLIMB LOW, MED and HIGH during the climb, while the crew on flight OSL 5428 (NQN-CRD) only selected CLIMB LOW mode, it can be deduced that the crew sought to obtain the best climbing rate to reach the desired level (FL 190) in the shortest time and distance as possible.

2.2.3.2 Using the data obtained from the FDR regarding the ITT values (approximately 820°), as specified in the SOP Rev 2 from 2010, the crew were found to have used the ITT method constantly in order to control the power levels; however, they did not make the necessary adjustment when the aircraft reached FL150, in accordance with the AOM in Section 26.1 page 2, nor did they use the available power (Max Climb Power), in order to reach the desired flight level, FL 190.

2.2.3.3 Upon analysing the satellite image of the FIR EZE's Arfor from 23:45 UTC, the transcription from the CRV from 21:02, the weight analysis, the air drag (Section 1.16.9, 1.16.10), the flight trajectory and the pilot's experience in a similar situation, the conclusion is that the aircraft should not have accumulated a significant amount of ice prior to the activation of the ENG ANTI ICE system at an altitude of 17,140 ft, and with an outside air temperature of -11. The activation of the ANTI ICE system was timely.

2.2.3.4 After the ENG ANTI ICE system had been activated, the autopilot continued in CLIMB LOW mode, despite the AOM stating that the autopilot should be used in IAS mode. The use of the autopilot in that mode caused the aircraft to ascend at an indicated speed of less than 144/146 kts. Thus, it can be concluded that the procedures in the Aircraft Operation Manual (AOM, page 26 37/1 -. Table 1 "Minimum Speed in icing Conditions ") were not followed.

2.2.3.5 Three factors being: the failure to increase power upon surpassing FL 150, the activation of the ENG ANTI ICE, which reduces torque, and the failure to make use of the available power, resulted in the aircraft reaching an operational ceiling of 17,800 ft. with regard to the conditions of the aircraft and the weather at that time. As such, the aircraft was unable to reach the desired altitude level of FL 190. This is attributable to the failure to use maximum continuous power, in accordance with the manufacturer's instructions.

2.2.3.6 During level flight at 17,800 ft, the autopilot used the Vertical Speed (V / S) mode in order to increase the speed. This continued until it was deactivated at 21:08 (time from FDR) only to be reactivated two minutes later in the same mode, to begin the descent to flight level FL140. During this section of the flight, the average flight speed was 140 kts and the minimum speed was below 130 kts.

2.2.3.7 During this phase of the flight, the aircraft was flying at a slower speed (130 kts), and subsequently began to stall (137 kts). In this condition, with less power, the artificial stall warning, the stick shaker, was activated. In addition, and in accordance with the CVR communications (21:03:35/21:03:38 time from CVR), it is possible to deduce that during this segment of the flight, the ice formation was beginning to develop.

The ice formation increased towards the end of level flight at this altitude. The obtained satellite image regarding the meteorological conditions, which the aircraft's route was laid on top of, and which most likely coincided with the on-board radar's display of the front, would have indicated that the aircraft was coming out of the clouds. This, as well as the conversation with the pilot of flight OSL 5427, who explained that he had taken the same route, but in the other direction with FL 140 without any problems, would probably have influenced the decision to change flight level to FL 140 and stay on course.

2.2.3.8 Upon descent, the power was reduced to 58%, and a descent rate of 750 ft. / n was selected. This made the aircraft descend at an average speed of 173 kts and with a pitch angle of 2/3°, nose down. This led to ice forming on the bottom part of the airframe, which increased the aircraft's weight and determinately affected the aerodynamics of the aircraft.

2.2.3.9 Based on the analysis of the FDR data from the last phase of descent from 21:16 (time from FDR) and the CVR transcript, it seems that the icing conditions increased very quickly. In addition, it appears that the aircraft rapidly lost speed upon reaching the pre-selected flight level of FL 140, despite power being increased, and reached a speed of 129 kts (lowest speed during the stall).

2.2.3.10 The fact that the crew increased the propeller rpm to the max when they felt the aircraft vibrate, indicates that the crew interpreted the vibration (the natural stall warning) as a result of ice accumulation on the propellers. After this, the artificial stall warning was activated, which confirmed their supposed hypothesis.

2.2.3.11 13 seconds passed between the aircraft experiencing buffeting (natural stall warning) at 145 kts, and the stick shaker being activated at 137 kts.

In those 13 seconds, the crew noted the decrease in speed, but did not significantly increase power. The aircraft's buffeting was interpreted as a result of propeller vibrations and thus, the crew increased the propeller RPM to the max.

The crew acted in stages, as it perceived the changes which indicated that the situation was deteriorating.

The aforementioned information demonstrates that, due to the crew's failure to recognize that the aircraft had begun to stall, it did not carry out the right procedure to ensure that the aircraft did not continue to stall.

2.2.3.12 The ice accumulation and the deterioration of the aircraft's aerodynamic functions were significant. The rate of loss increased by 37%, significantly exceeding the 10% which was stated in the AOM - Supplement 1 Operation in Cold Weather and Icing Conditions, and which had been established during test flights.

The difference in speed, between the initial buffeting (145 kts) and the activation of the stall warning and stick shaker (138 kts), was 7 kts, i.e. 5% less than what is stipulated in the AOM, which stipulates 25% when the aircraft is free of ice.

2.2.3.13 When the autopilot was spontaneously deactivated (data extracted from the FRD), the aircraft commenced a series of uncommanded rolls with a nose down attitude.

The crew performed the following manoeuvres after losing control of the aircraft:

Initially, the crew followed the sequence of upset recovery (pitch down), which involves reducing the engine power to avoid the drop being aggravated.

The rolling could not be stopped in either direction (levelled wings). The nose down attitude could not be altered, despite increasing the power to its max. It was necessary to change both of these developments in order to recover from the unusual aircraft attitude. Although the crew carried out satisfactory procedures to counter the rolls and the nose down attitude, the measures were not effective, because the control surfaces (ailerons and elevators) were not sufficiently aerodynamic as a result of severe icing.

Furthermore, due to the crew's excessive focus on attempting to change the nose down attitude, they induced and entered into a secondary stall and caused the stick shaker to activate five times.

The crew were not able to level the wings and regain ground. This was probably due to the accumulation of ice on the surface of the wing (the area in front of the ailerons), which led to behaviour such as erratic, uncommanded rolls, as well as the excessive focus on the transverse axis.

Using the aforementioned information, and on Section 1.16.18.2 it was concluded that the crew recognised the direction of the rolls and the nose-down attitude, without being able to recover from the unusual aircraft attitude, during its fall.

2.2.3.14 Based on the flight mechanic's analysis, the entry into stall, and the unusual aircraft attitude, it can be concluded that the aircraft behaved in accordance with the manufacturer's description in the AIM-Supplement 1 - Operations in Cold Weathers and Icing Conditions.

2.2.3.15 Based on the aircraft's impact, it is probable that the aircraft continued a sequence of uncontrolled rolls, with a nose down attitude, throughout the entire fall.

## 2.3 Aviation medicine, human and organizational factors

Aviation medicine

2.3.1.1 The Crew:

At the time of the accident, all the crew members had valid psycho-physiological certificates, as did the CTA and the Aircraft Dispatcher.

In this case, none of the crew members were found to have suffered from sudden in-flight incapacitation. There was no evidence of intoxication nor illness. There were no waivers or limitations in the crew's psycho-physiological reports which could be related to the accident.

In accordance with the prior revelations, the crew's clinical documentation, filed by the company’s medical officer, shows no history of any disease that could be related to the accident. From the interviews carried out with the pilot's doctor, no information was revealed that could be related to the cause of the accident in the last four psychophysical tests.

The dispatcher, the mechanic that approved the flight, and the air traffic controller at the airport in Neuquén, all had valid psycho-physiological certificates at the time of the accident.

2.3.1.2 Based on the aforementioned information, and on everything that has been investigated, no medical cause emerges in this case.

2.3.2 Human and organizational factors

2.3.2.1 In CVR transcription it emerges that, during the climb, the company's operational routines - such as excess weight being a recurring operational problem - were discussed. This rules out a complacent or careless attitude regarding air operations.

2.3.2.3 It is important to highlight that the pilot's personality and renowned professionalism is not compatible with complacent behaviour, despite the colloquial language spoken in the cockpit.

2.3.2.4 In line with the aforementioned information, and based on interviews with fellow pilots at the company, as well as ex-colleagues at the previous company where he had worked, a general impression emerges of a very professional pilot who was strict about the rules; rather uncommunicative and reserved. The psychologist who evaluated the pilot for four years prior to the accident, stated that the pilot adhered strictly to procedures and was very responsible.

2.3.2.5 As mentioned above, the captain was respected amongst his peers and his performance as a pilot was never questioned. Bearing in mind the commander's personality, he is assumed to have rigorously followed all rules, as he was not the type of pilot who would violate procedures.
These types of pilots usually perform very well in rather rigid and structured organizational cultures. Training, regulations, and procedures are excellent systematic defences for these types of crew members.

2.3.2.6 The co-pilot had an outgoing and communicative personality and was influential within the company, due to his role as a maintenance technician with excellent knowledge of aircraft systems, and having developed instructor activities for these systems.

In reference to operational skills, the co-pilot had little experience of aircraft as he had only been approved to fly without an instructor one month prior to the accident.

In this event, the co-pilot had to follow the operational decisions of the commander, due to the significant difference in flight experience between the two.

Due to the characteristics of his personality, the co-pilot sought external help for the operational difficulties he experienced. He is heard to be very communicative on the CVR.

The operational decisions of the crew were made in a context in which the pilots could not use their expertise due to: a design fault (lack of technology in the aircraft which called attention to the autopilot mode, upon activating the de-icing systems), and the organisation (the company, as it failed to carry out a risk analysis at the time when it incorporated the route, and did not offer adequate training for its pilots regarding this operational contingency, and did not provide a dispatch that was updated with regard to the weather conditions which the pilots encountered on their route).

Severe icing was not considered during the operational dispatch. Therefore, the operational context which the crew encountered in flight was totally different from what they expected. This may be why there was a lack of adequate briefing and a failure to allocate tasks which are typically allocated in these type of meteorological conditions.

"The rule of experience" emerges when the level of theoretical knowledge of a real situation is not good enough to equate to what experience dictates. The problem is that situations change and thus, the rules are undermined. The decision to descend to FL 140 was probably only influenced by experiences in similar situations.

Pilots perform differently at night, compared to the day. This is especially so in cases such as this, where visual perception is important to gauge the depth of a problem; night increases stress and decreases confidence.

The pilot was very experienced. However, the level of specific knowledge of flying in icing conditions was not high enough for the pilot to have reacted any differently.

Operational aptitude can be defined as a combination of aeronautical skills and technical skills, acquired through appropriate training (technical aeronautical knowledge), and practice. As such,

could the pilot perceive danger, carry out an adequate risk assessment, and make a decision regarding operational conduct appropriate to the situation?
In this case, the crew was operationally unfit to handle the situation that it found itself in.

2.3.2.10 The decisions that were made have to be understood in light of the lived experiences of the pilots; not on the limited 20-minute view offered by the CRV/FDR. These can be used to assess what happened, but not why it happened.

2.3.2.11 The icing worsened during the descent to FL 140. This unexpected situation made the crew increasingly stressed regarding the uncertainty of the meteorological conditions. This could have affected the crew's concentration and memory, causing it to get distracted, and consequentially to ignore the flight control parameters.

When decisions are made under duress, the likelihood of the decision-maker choosing a risky alternative - or making a hasty decision - increases. In addition, it is more probable that pilots tolerate the "ambiguity" of staying in an intermediate position when stressed, as did the Commander in this case (that is, to remain at FL 140). When under pressure, there is a decrease in productive thinking and an increase in distracting thoughts, which explains the crew’s failure to increase power. The greater the pressure, the greater the impact on threat perception and the ability to reason.

2.4 <u>With regard to training</u>

2.4.1 According to the obtained documents regarding the crew's training, the following was found:

a) Pilot

From the time he joined the airline in 2007 until the time of the accident in 2011, the pilot had not received practical training in the flight simulator regarding the "upset recovery" manoeuvre, despite this being mandatory and stipulated by the company in the OOM VOL. 3, Training Manual.

During the recurrent flight simulator training, the pilot had not received the full amount of Line Oriented Simulator (LOS) training. As such, it can be determined that the airline did not comply with the provisions of the existing regulations RAAC 121.407 - Appendix G, or with its own Training Manual.

As it was not a part of the company's curriculum, nor a requirement of the Civil Aviation Authorities of the South American Region's regulations (RAAC), in the last four years, the pilot had not received refresher training in meteorology, nor classes/extracurricular workshops with regards to operating in cold/hot weather.

b) The stall recovery techniques regarding stall approach manoeuvres in different configurations, which were taught to the crew during their flight simulator training, (STALL

RECOVERY), corresponded to the traditional method. I.e., the technique intended for the aircraft to recover from the stall without losing altitude.

c) In the AOM, FLIGHT PROCEDURES TRAINING 25/12 (page 1), the manufacturer describes a different stall recovery technique, and in addition provides a number of ideas with regard to upset recovery, which should have been taken into consideration, and incorporated during the instruction process and the flight simulator training.

2.4.1.2 The company had not adapted their training methods in accordance with the manufacturer's advice in the aircraft's AOM, with regard to upset recovery.

2.4.2 No documentation was presented with regard to the recurrent training courses, carried out by the operative dispatchers in 2009 and 2010, as established in the OOM VOL. 2, Training Manual, and in RAAC 121.427.

## 3 CONCLUSIONS

### 3.1 Definite facts

3.1.1 The crew had appropriate licenses and qualifications to carry out this flight.

3.1.2 At the time of the accident, the aircraft did not comply with the Airworthiness Directives.

3.1.3 No evidence of technical failure were found, nor any causes linked to a lack of proper documentation. The performance of the aircraft in flight conformed to that of the certified design.

3.1.4 At the time of the accident, the aircraft did not have the No. 2650 - *Ice Speed System* installed (recommended but not mandatory).

3.1.5 The route on which the aircraft was travelling, and specifically the area in which the accident occurred, lacked effective VHF communications coverage.

3.1.6 The aircraft never reached the desired flight level of FL 190. The crew did not use the remaining power available to try to reach the desired flight level.

3.1.7 The airline's power management procedure was the Constant ITT method.

3.1.8 No significant changes in power were recorded during the flight, until the aircraft reached the flight level FL 140.

3.1.9 The crew were aware of the formation of ice on the aircraft from the beginning.

3.1.10 The anti-ice protection systems were activated upon detection of the icing conditions. According to the investigated data, the devices worked adequately.

3.1.11 According to the meteorological information provided at the time of take-off, weak icing was forecasted.

3.1.12 The aircraft encountered severe icing conditions on its route.

3.1.13 During the main part of the flight in icing conditions, the speed was registered as being lower than the speed which the manufacturer recommended for these types of conditions.

3.1.14 The crew did not use the maximum available power in order to increase the speed during the stall.

3.1.15 The aircraft began to stall due to a progressive and prolonged speed reduction, in combination with the ice formation, and the crew were not registered as carrying out any corrective measures.

3.1.16 Faced with the imminence of the stall, the warning systems (the stick shaker) were activated.

## 3.2 Cause

During a commercial, domestic passenger flight, while cruising, the crew lost control of the aircraft, which uncontrollably impacted the ground due to severe ice formation caused by the following factors:

> Entering an area with icing conditions without adequately monitoring the warning signals from the external environment (temperature, cloudiness, precipitation and ice accumulation) or the internal (speed, angle of attack), which allowed for prolonged operations in icing conditions to take place.

> Receiving a forecast for slight icing - given that the aircraft encountered sever icing conditions - which led to a lack of understanding regarding the specific meteorological danger.

> Inadequately evaluating the risks, which led to mitigating measures such as adequate briefing (distribution of tasks in the cockpit, review of the de-icing systems, limitations, use of power, use of autopilot, diversion strategy etc.) not being adopted.

> Levels of stress increasing, due to operations not having the expected effects, which led the crew to lose focus on other issues.

> Icing conditions that surpassed the aircraft's ice protection systems, which were certified for the aircraft (FAR 25 Appendix C).

> Inadequate use of speed, by maintaining the speed close to stall speed during flight in icing conditions.

> Inadequate use of the autopilot, by not selecting the IAS mode when flying in icing conditions.

> Partially carrying out the procedures established in the Flight Manual and the Operations Manual, when entering into areas with severe icing conditions.

> Realizing late that the aircraft had started to stall, because the buffeting that foretells a stall was confused with the vibrations that signify ice contamination on the propellers.

> Activation of the Stick Shaker and Stall Warning at a lower speed than expected in icing conditions.

> Using a stall recovery technique which prioritized the reduction of the angle of attack at the expense of altitude loss, and which was inappropriate for the flight conditions.

> The aileron flight controls reacting in an unusual manner when the aircraft lost control, probably due to the accumulation of ice in the surfaces of these, which made it impossible for the aircraft to recover.

The increasingly stressful situation of the crew, which affected its operational decision-making.

*Potentially dangerous conditions that did not cause the accident*

Pre-existing conditions

*The airline's organisational and operational context*

- The airline's outdated operating specifications
- Only partially fulfilling the regulations established in the RAAC 121.133 a) with regard to updating the Operator Operation Manuals (OOM).
- The crew being scheduled by an external management organisation.
- Not updating aircraft manuals
- Training Manuals not including the manufacturer's advice regarding stall recoveries.
- Only partially fulfilling the regulations established in the RAAC 121.407, Appendix G, with regard to the airline offering Line Oriented Simulation training.
- Not fulfilling the Airworthiness Directives related to the propeller maintenance.

*Systematic Context*

- Lack of VHF coverage on the route which the aircraft was travelling on. The meteorological services not being accessible during all of the company's operating hours at all of the stop-over points.

## 4 SAFETY RECOMMENDATIONS

### 4.1 To the International Civil Aviation Organisation (ICAO) - Division AIG.

In order to spread and promote the analysis of these findings, presented in this report by Aviation Authorities from around the world, and in accordance with the interest of the FAA (USA) and SHK (Sweden), it is recommended that the AIG Division transfer the following to the appropriate authorities:

1. PROPOSAL

The purpose of this report is to promote a "NEW CONCEPT of INSTRUCTING AND TRAINING" of the flight crews, which, at present, is not fully covered by the regulations. It involves information on *recognition of and recovery from stalls and upsets being fully considered, alongside the aircraft's systems of warning, protection and automation.* This will be done via recommendations from the Aviation Authorities, Aircraft Manufacturers, Airline Companies, Training Centres and Flight Simulator Training Centres, with the objective of improving the operational security of air transport.

The recommendations made in this report are conceptual and general. The programme's details should originate from, and expand on, topics that are based on real situations and potential scenarios, that allow for the flight manoeuvres to be carried out, and not just mechanically. It is in these situations, above all others, in which piloting and knowledge should be focused on achieving greater expertise

2. BACKGROUND

In light of the analysis of the aircraft LV-CEJ, which was involved in the accident, and in accordance with the documentation on record, it has become necessary to make a recommendation which aims to evaluate the feasibility of amending the training methods, which is detailed further on.

3. FOUNDATIONS

- There have been too many LV-CEJ aircraft that have experienced similar types of accidents, with one of the main contributing factors being the following: *"late, or no identification of the degradation of the flight characteristics, or late, or no identification of the development of the aerodynamic condition of a total stall."*

- The investigations have demonstrated that the loss of control in these cases *led the aircraft to adopt abnormal flight attitudes that, in most cases, could not be recovered from;* in these events, special piloting skill and specific methods are required, especially in IMC conditions.

- In most cases, this phenomena is exasperated in icing conditions, because the aircraft's behaviour is not predictable; it acts outside of the certification envelope.

- In addition, the stall warning and the aircraft's stick pusher *are not always properly understood* in terms of their performance characteristics and regarding the performance certification. The same is true with regard to the autopilot and auto throttle operating systems and the pilots' ability to employ them in unusual situations.

- The automatic nature of the new generation of aircraft leads to flight crews losing regular contact with the flight characteristics of the aircraft, even in simulator sessions. This is found to be more so with regard to the less experienced pilots who under present conditions undergo an abrupt transition from light aircraft.

- Some aircraft demonstrate particular stall characteristics, which could surprise even experienced pilots (for instance pitch up, rolls with high angular velocities, yaws etc.).

- The manufacturer's information pamphlets, which are available to all users, are not always enough, as the certification processes only includes what has been specified in the rules of implementation.

- In this field, acquiring as much competence as possible, *both theoretical and practical,* is important in order to respond appropriately to the threats which arise regarding the aforementioned areas.

- The current training curricula are not extensive enough to meet the requirements, as this report has revealed, which means that there are vital gaps in the training of flight crews.

- Based on this fact, there is a need to strengthen the training of technical crews (PIC and SIC) , in order to address these critical situations that affect flight safety.

- This training, offered in training centres, should be as homogeneous as possible and cover all types of air transport, without ignoring the characteristics of each separate aircraft's instruction system.

- Finally, in order for this new training method to achieve the desired results, the following organisations must participate:

➢ *Aviation Authorities* (to modify the curricula and the inspection and control systems).

➢ *Manufacturers* (to provide the most appropriate information).

➢ *Air operators* (to modify the training programmes).

➢ *Flight Simulator Training Centres* (to modify and adapt training programmes, and if necessary the software, to the new requirements).

## 4.2 TO THE AVIATION AUTHORITIES

Consider implementing changes to the compliance requirements with regard to the crew's instruction and training, related to flight manoeuvre that are carried out during operations with a large angle of attack or with abnormal flight attitudes.

Consider making the following manoeuvres obligatory during the training and the licensing inspection (in flight simulators), in accordance with the aircraft:

a) Recognising when a stall commences and how to prevent it from happening.

b) Recognising and recovering from an artificial stall warning

c) Recognising and recovering from a total aerodynamic stall

*d)* Practising how to recover from typical abnormal flight attitudes.

## 4.3 TO THE AIRCRAFT MANUFACTURERS

Provide all the detailed information, which should be in the Aircraft Manuals AOM/FTCM/AFM, which describe the special features of each area which needs to be fulfilled in order to achieve certification (if applicable) in regard to the following:

a) Recognising when a stall commences and how to prevent it from happening.

b) Recognising and recovering from an artificial stall warning

c) Recognising and recovering from a total aerodynamic stall

d) Recovering from typical abnormal flight attitudes

e) Using and understanding the behaviour of the automatic flight systems and engine during the aforementioned manoeuvres

## 4.4 TO THE TRAINING CENTRES/ FLIGHT SIMULATOR TRAINING CENTRES

Consider adapting the course curricula of the theoretical and practical training, so that they include all of the manufacturer's manoeuvres in accordance with the "NEW CONCEPT", as well as including the piloting techniques adapted to each particular aircraft.

Modify, improve and adapt flight simulator software for each aircraft type so that flight simulation become more realistic, and so that specific requirements can be tested.

## 4.5 TO THE AIR OPERATORS

Modify the training programmes (theoretic and practical) so that the initial, promotional, and recurrent courses are obliged to include the following manoeuvres:

a) **Recognising when a stall commences and preventing it from happening** (activation of the Stick Shaker and Warning light or Clacker), in different configurations (which would be the case if separation with the ground would be compromised, e.g. during take-off, approach and landing) - *Recovering maintaining altitude*

b) **Recognising and recovering from an artificial stall warning** (activation of the Stick Pusher and Push light) in clean configurations (which would be the case if separation with ground would not be compromised), e.g., while climbing, cruising or descending - *Recovery decreasing the angle of attack.*

c) **Recognising and recovering from a total aerodynamic stall**, for aircraft that do not have systems such as Stick Pushers, in clean configuration - *Recovery decreasing the angle of attack*

d) **Practising how to recover from typical abnormal flight attitudes**, in a way that ensures that the pilot does not only carry out the manoeuvres, but also becomes familiar with interpreting the flight instruments, controlling the aircraft, and recovering in the most effective way possible.

e) In all of the aforementioned situations, the behaviour of the aircraft's **automatic flight control systems and motor** should be demonstrated.

f) All of the aforementioned situations should also **include unusual emergency procedures for cases in which system failure occurs**.

g) The process of **slowing down the aircraft** to achieve the aforementioned situations must be carried out with a ratio of approximately 1 kts/sec in order to properly represent the conditions for certification and comply with the manufacturer's information (both regarding flight characteristics and performances).

4.6 To the National Civil Aviation Administration - National Directorate of Operational Safety

4.6.1 It is recommended that effective control be exercised over the updates in the Operator's Operations Manual (OOM), which all air operators are required to follow, in accordance with the RAAC 121.133.

4.6.2 It is recommended that a system which tracks compliance with regulations is implemented, in accordance with the growth and development of the air operators and the service providers.

4.7 To the To the National Civil Aviation Administration - Directorate of Personnel Licensing
- Department, Educational Control

4.7.1 In order that the operating personnel (pilots, dispatchers, etc.) are properly prepared for assessing and managing the risks inherent in flight, the following is recommended:
to make it a requirement that theoretical courses which are taught at air operators' training centres, with regard to specific subjects such as meteorology, have to be taught (or supervised) by professionals with experience in the field of expertise.

4.7.2 to incorporate the requirements set forth in the preceding paragraph into the applicable RAAC regulations.

4.7.3 to make UPSET RECOVERY a mandatory part of the flight simulator training curricula, which is to be practised both during the initial and the recurring courses and evaluated during the suitability inspection.

4.7.4 With the aim of increasing the quality of the flight crew training, the authorities are recommended to establish a workshop programme for instructors who teach initial and recurrent training for commercial airline operators, during which technical and didactic subjects are taught, that directly focus and relate to operational security.

4.8 To the National Meteorological Service

4.8.1 Consider the possibility of extending the service hours of the aerodrome's meteorological offices, to cover all the hours that these aerodromes operate, and to provide updated information that effectively contributes to Operational Safety.

4.8.2 Consider modifying the aeronautical information system so that an aviation area forecast (arfor) which remains the same is not merely updated as NOSIG, but repeats the information of the previous arfor.

4.9 The Argentine Air Force - General Directorate of Air Traffic Control

4.9.1 To establish an efficient network of aeronautical communications, it is recommended that a system be implemented which ensures that aeronautical communication traffic works both ways, in areas where this is deficient. In additions, the benefit of establishing, implementing and maintaining an effective VHF communication network, with permanent national coverage, should be evaluated.

4.9.2 To establish clear guidelines regarding the requirements of on-board communication equipment, a proper study on aircraft traffic communication should be conducted, in order to determine the need for aircraft to be equipped with HF frequency communication devices.

4.10 To the SHK (Swede)

4.10.1 4.10.1 To review the possibility of recommending that the aircraft manufacturer has Special Safety Bulletins, with the findings of this investigation and those of three similar incidents that have previously occurred.

4.10.2 To evaluate the possibility of recommending that designers of flight simulator software and hardware, include simulations of various situations in icing conditions (general, disrupting aerodynamic functions, blocking control surfaces, affecting the flight attitude due to a shift in CG, etc.), in order to provide better training with regard to recognising these flight situations, as well as the techniques that need to be employed in these situations.

4.10.3 With the aim of increasing the aircraft's technological defences, the possibility of incorporating a warning system which inhibits the use of the climb mode in autopilot upon the activation of the de-icing system, should be evaluated.

4.11 To the Operator - Operational Area/ Operational Safety.

4.11.1 In order to increase the level of operational safety, it is recommended that the company's Safety Management System (SMS) programme includes severe icing as a specific danger, so that the defences (technological defences, standards, procedures and training) can mitigate the risks.

4.11.2 Using the aircraft's original flight manual is also recommended, so as to avoid the use of adapted versions that do not contain all of the required information. In addition, you are reminded to comply with the regulations established in the RAAC 121.133 a) with regard to updating the Operator Operation Manuals (OOM).

4.11.3 Another way of improving security can be to establish means, resources and procedures which intend to emphasize the theoretical and practical instruction/training of upset and stall recovery. As such, new training practices are created, that involve the flight crew effectively identifying the signs and the aerodynamic phenomena that occur during the flight, prior to stalling (aeroelastic trepidation, among others), in accordance with the manufacturer's instructions.

4.11.4 With the aim of establishing better internal communication channels, the necessary measures should be established in order for the management to implement an effective method of wide dissemination and strict compliance between the crews as established in the Aircraft Operation Manual Supplement No. 1 *"Operations in cold and icing conditions".* It is also recommended that an effective method is established to evaluate the results of the training/instruction, in order to ensure that the pilots have adequate knowledge and practice, in accordance with the procedures established in the AOM and AFM, SOP (Supplement No. 1 *"Operations in cold and icing conditions",* using the autopilot, etc.)

4.11.5 To consider the possibility of integrating modification No. 2650, "Ice Speed System", in all of the Saab 340 aircraft, as it is a tool that increases safety by alerting the crew of abnormal speed conditions during flights in icing areas.

## 5 ADDITIONAL REQUIREMENTS

Natural or legal persons to whom the recommendations - which were set forth by the Civil Aviation Accident Investigation Board - are addressed, should inform the AVIATION AUTHORITY within sixty (60) working days, as of the day that they receive the Final Report and the Resolution which supports, with regard to the implementation of the measures which have been put in their charge (Provision No. 51/02 Commander of Air Regions 19 JUL 02 published in the Official Bulletin on July 23, 2002).

This information should be sent to: National Civil Aviation Administration (ANAC) Av. Azopardo 1405, esquina Av. Juan de Garay (C 1107 ADY) Ciudad Autónoma de Buenos Aires or to Email: "info@anac.gov.ar"

BUENOS AIRES, 10 MAR 2015

Operations Investigator: Alberto ROCCHI
Operations Investigator: Carlos H. SARDI
Operations Investigator: Daniel BARAFANI
Technical Investigator: Pedro BERTACCO
Technical Investigator: Augusto DE SANTIS
Technical Advisor: Horacio LARROSA Technical
Advisor: Humberto REYNOSO

Lic. DANIEL OSCAR BARAFAN
Dep. Manager Invest. Operative
J.I.A.A.C.

Ing. Aer. HUGO H. CIFALA
INV. MANAGER TECHNOLOGY AND SUPPORT
J.I.A.A.C.

IIW. AUGUSTO JAVIER DE SANTIS
Director JIAAC's National Accident Investigations