Grupo de Investigación de Accidentes
GRIAA
GSAN-4-5-12-035

AERONÁUTICA CIVIL
UNIDAD ADMINISTRATIVA ESPECIAL

FINAL REPORT

ACCIDENT
COL-16-37-GIA

Fuel Exhaustion
AVRO 146-RJ85, Reg. CP 2933
29 November 2016
La Unión, Antioquia – Colombia

NOTICE

This document reflects the results of the technical investigation conducted by the Accident and Incident Investigation Group AIG/GRIAA of the Colombian Civil Aviation Authority, related to the circumstances in which the events object of the investigation took place, with probable causes, consequences and recommendations.

In accordance with the Aeronautical Regulations of Colombia, RAC 114 and ICAO Annex 13, "The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability". Neither the probable causes as well as the safety recommendations are intended to generate presumption of blame or liability".

Consequently, the use of this Final Report for any purpose other than the prevention of future accidents and air incidents associated with the established cause, may lead to conclusions or erroneous interpretations.

NOTE
This is a courtesy of translation into English by GRIAA of the original Final Report. As accurate as the translation may be, the original text in Spanish is the work of reference.

ABBREVIATIONS

AAIB	Air Accidents Investigation Branch
ACC	Area Control Center
AIS	Aeronautical Information Service
AGL	Above Ground Level
ANAC	Agência Nacional de Aviação Civil (Brasil)
APU	Auxiliary Power Unit
ARO	Air traffic services Reporting Office
ATC	Air Traffic Control
CAS	Calibrated Airspeed
CENIPA	Centro de Investigação e Prevenção de Acidentes Aeronáuticos
CSN	Cycles Since New
CSI	Cycles Since Inspection
CVR	Cockpit Voice Recorder
DGAC	Dirección General de Aeronáutica Civil de Bolivia
EASA	European Aviation Safety Agency
EET	Estimated Enroute Time
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FDR	Flight Data Recorder
FIX	Air Navigation Position
FIR	Flight Information Region
FL	Flight Level
GPS	Global Positioning System
GRIAA	Air Accident Investigation Group – AIG COLOMBIA
INAC	National Civil Aeronautics Institute (Venezuela)
ILS	Instrument Landing System
KT	Knots
LLZ	Localizer
LMI	Company Flight Designator
MSL	Mean Sea Level
MDE APP	Medellín Approach (ATC)
NM	Nautical Miles
NVM	Non Volatile Memory
PIC	Pilot in Command
SAFA	Safety Assessment of Foreign Aircraft
SBCH	Airport - Serafín Enoss Bertaso – City of Chapeco (Brasil)
SBGR	Airport - Guarulhos International – São Paulo (Brasil)
SIC	Second in Command
SID	Standard Instrument Departure
SKBO	Airport - Eldorado International – Bogotá (Colombia)

SKRG	Airport - José María Córdoba International – Rionegro (Colombia)
SLVR	Airport - Viru International – Santa Cruz (Bolivia)
SLCB	Airport - Jorge Wilstermann International – Cochabamba (Bolivia)
SLCO	Airport - Capitán Aníbal Arab - Cobija (Bolivia)
SMS	Safety Management Systems
SSP	State Safety Program
TSN	Time Since New
TSI	Time Since Inspection
UTC	Coordinated Universal Time
VOR	VHF Omnidirectional Range

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SYNOPSIS

Aircraft:	AVRO 146-RJ85
Date and time of accident:	29 November 2016, 02:59 hrs[1]
Location:	"Cerro Gordo", Jurisdiction of the Municipality of La Unión, Department of Antioquia - Colombia
Coordinates:	N05°58'43.56" – W075°25'7.86"
Type of Operation:	Commercial Air Transport Passengers – No Regular
Operator:	Línea Aérea Mérida Internacional de Aviación - LAMIA CORPORATION S.R.L
Persons on board:	04 Crew 73 Passengers

Introduction

The Air Accident Investigation Group (GRIAA) of the Colombian Aeronautical Authority was alerted to the disappearance of the AVRO RJ85 aircraft on November 29, 2016 at 03:10. In accordance with local regulations, once the aircraft was located, a team of investigators began the investigation of the event, establishing itself at the accident site at 11:30 hrs.

The GRIAA initiated the investigation of the accident according to the provisions of the Colombian Aeronautical Regulation. Also, in compliance with international aviation accident investigation norms, contained in Annex 13 of the International Civil Aviation Organization (ICAO), the following agencies appointed Accredited Representatives to participate in the investigation. The General Directorate of Civil Aeronautics - AIG (Bolivia), representing the State of Registration and Exploitation; the Air Accidents Investigation Branch - AAIB (United Kingdom), representing the State of Design and Manufacturing of the aircraft; the National Transportation Safety Board - NTSB (United States), representing the State of Design and Manufacturing of the engines; and the Center for Investigation and Prevention of Aviation Accidents - CENIPA (Brazil), representing the States of the persons involved in the accident.

Likewise, the Federal Aviation Administration (FAA) participated as technical advisor to the NTSB and the European Aviation Safety Agency (EASA) as technical advisor to the AAIB. Also, there was assistance from aircraft and engine manufacturer technical advisors.

[1] All hours (hrs.) expressed in this report are UTC. Five (5) hours must be subtracted to obtain the local time in Colombia. Four (4) hours must be subtracted to obtain the local time in Bolivia. Two (2) hours must be subtracted to obtain the local summer time in Brazil.

Summary

The aircraft, an AVRO 146-RJ85, registration CP 2933, was conducting a direct flight[2] from Viru Viru international airport, Santa Cruz - Bolivia (ICAO: SLVR) to José María Córdoba international airport, Rionegro - Colombia (ICAO: SKRG). During a holding descent over GEMLI, to intercept the localizer (LLZ) for the approach to runway 01 of José María Córdova international airport, the aircraft impacted the southern slope of a mountainous terrain located 10 nm south from the threshold of runway 01 of SKRG.

As a result of the accident, the aircraft was destroyed; out of a total of seventy-seven (77) occupants, seventy-one (71) occupants perished and six (6) occupants survived with serious and/or minor injuries.

The aircraft had been scheduled to carry out a Non-Regular Passenger Transport flight from Viru Viru International Airport, Santa Cruz - Bolivia (ICAO: SLVR) to José María Córdoba international airport, Rionegro - Colombia (ICAO: SKRG), with 73 passengers and four (4) crewmembers. There was no post-impact fire. The accident occurred at 02:59, in night time conditions.

The investigation identified the following causal factors:

- Inappropriate planning and execution of the flight, by the Operator, because the quantities of fuel required to fly from the destination airport to an alternate airport, including reserve fuel, contingency fuel and minimum landing fuel were not considered. These quantities of fuel were required by aeronautical regulations for the execution of the type of international flight being conducted by CP 2339.

- Sequential flame-out of the four (4) engines while the aircraft was in a holding descent over GEMLI, this, as consequence of the exhaustion of fuel on board.

- Inadequate decision making on the part of the aircraft operator company management, lacking assurance in the implementation of operational safety in its processes.

- Loss of situational awareness and wrongful decision making by the flight crew, which maintained the fixation of continuing a flight with an extremely limited amount of fuel. The crew was aware of the low level of fuel remaining; however, it did not take the corrective actions required to land at an aerodrome and obtain additional fuel which would allow them to continue the flight safely.

The investigation identified the following contributing factors:

- Premature configuretion of the aircraft for landing during the descent over GEMLI holding pattern, considering the absence of thrust, this configuretion affected the plane's gliding distance to the runway of Rionegro airport.

[2] Flight LMI2933

- Latent deficiencies in the planning and execution of Non-Regular Transport flights by the aircraft operator, related to the insufficient supply of the amount of fuel required.

- Specific deficiencies in the flight planning of CP 2339, by the operator of the aircraft.

- Lack of supervision and operational control of the flight by the Operator, who did not supervise planning of the flight, its execution, or maintaining a follow-up of the flight that would have allowed providing support to the crew with decisions making.

- Absence of timely calls for "priority", or declaring an "emergency" or others by the aircraft crew members during the flight, and especially when fuel depletion was imminent in the descent phase and when performing a holding pattern which would have alerted air traffic services to provide the necessary support.

- Organizational and operational deviations on the part of the Operator in the application of fuel management procedures, as it did not comply in practice with the approval given by the Bolivian DGAC in the process of certification of the company.

- Delay for CP 2933 approach clearance to Rionegro, caused by its late request for priority, and its late declaration of fuel emergency, these added to the traffic density holding over VOR RNG.

The investigation issued eleven (11) safety recommendations.

1. FACTUAL INFORMATION

1.1 History of flight

1.1.1 Background

The aircraft, CP 2933, operated by a Bolivian non-scheduled passenger air transport company, was hired by a Brazilian soccer team and their associated personnel (hereinafter "the passengers"), to perform two (2) non-scheduled passenger transport charter flights.

The first flight was scheduled for November 28 at 14:00. departing from the city of Guarulhos, State of Sao Paulo, Brazil (Guarulhos International Airport - ICAO: SBGR), to the city of Medellín, Colombia (José María Córdoba International Airport - ICAO: SKRG). The second flight should have taken place on December 2 at 07:30, from SKRG to the City of Chapecó, Brazil (Serafín Enoss Bertaso Airport - ICAO: SBCH).

CP 2933 was stationed in Bolivia. On November 27, the company presented two (2) requests to the Brazilian Aeronautical Authority (Agência Nacional de Aviação Civil - ANAC), to carry out the scheduled flights.

These requests were denied because they did not comply with Brazilian[3] and international regulations, which require that charter flights can only normally be conducted by an operator belonging to the country of origin or country of destination.

On November 28 at 13:21, the company made a new flight request to the ANAC Authority, which was again rejected for the same reasons previously mentioned. Thus, the operator, who belonged to the Bolivian State, could not obtain the necessary permission to carry out the flight as planned.

Without the ANAC authorization, arrangements were made for passengers to travel on a regular passenger flight from Guarulhos - Brazil (SBGR) to Santa Cruz - Bolivia (SLVR), and afterwards, they would board CP 2933 in SLVR with destination SKRG.

The passengers boarded flight OB739 at Guarulhos - Brasil airport (SBGR), which had an estimated departure time at 17:45. The flight took-off at 18:21.

At 20:45 Flight OB739 arrived with the passengers in the city of Santa Cruz - Bolivia (ICAO: SLVR).

1.1.2 Route: Cochabamba, Bolivia (SLCB) – Santa Cruz, Bolivia (SLVR)

On November 28, CP 2933 was established in the City of Cochabamba - Bolivia (Jorge Wilstermann International Airport - ICAO: SLCB).

[3] Brazilian Code of Aeronautics and the Chicago Convention - The agreement with Bolivia does not foresee operations as stipulated in the Seventh Freedom of the Air.

CP 2933 scheduled its flight from the City of Cochabamba (SLCB) to Santa Cruz (SLVR) with an estimated time of departure at 17:30. The aircraft took off at 17:19 and landed in Santa Cruz (SLVR) at 17:58 without any incident.

At 20:10 the Dispatcher accompanying the flight presented the flight plan (to SKRG) in the ARO / AIS office at Santa Cruz Airport (SLVR). The flight plan submitted indicated a proposed departure time at 22:00 and a cruising flight level of FL 280. The total flight time and endurance indicated in the flight plan was four (4) hours and twenty-two (22) minutes.

The ARO / AIS office made a filing observation[4] related to the Endurance box, relevant to being the same as the Estimated Enroute Time (EET); however, said observations were not considered by the company and the flight plan was accepted at approximately 20:30.

The passengers arrived in Santa Cruz (SLVR) at 20:45.

1.1.3 Route: Santa Cruz, Bolivia (SLVR) – Rionegro, Colombia (SKRG)

After filing the flight plan and after the arrival of the crew (of CP 2933) to Santa Cruz, according to witnesses' information, the commander had instructed to refuel the aircraft with a maximum fuel load of 9,300 kg. At 18:40 a total of 2,050 liters (1,636 kg) was supplied. During the initial statements taken from one of the survivors, it was learned that the aircraft would be refueled at Cobija airport (SLCO). The airport of Cobija is located near the border between Bolivia and Brazil, and this airport normally operates only during day time hours and at night by prior request[5]. On November 28, 2016, the aerodrome closed operations at 22:43[6].

The passengers boarded the plane in Santa Cruz and engines start-up was at 22:08 hrs. On board, the crew was conformed by the commander, a co-pilot and two cabin crew. Likewise, seventy-three (73) passengers were on board; among which included a technician, a company dispatcher, and a pilot who occupied the observer seat in the cockpit.

The aircraft took off from SLVR runway 34 at 22:18 and it climbed to initial FL260, leveling off at 22:41. At 22:49 it continued its climb to FL280 where it leveled off at 22:58. After 23:54 it climbed to the final cruise level FL300, leveling off at 00:14. The registered cruising speed was 220kt CAS.

During the cruise phase, the CVR recorded several flight crew conversations[7] about the aircraft fuel condition and some conversations related to fuel calculations could also be heard.

[4] ARO/AIS report of 01 december 2016
[5] AIP Bolivia AD 2 SLCO 1 – SLCO AD 2.3 Hours of Operation (12) – The aerodrome had a current NOTAM C1315/16 C1314/16 Runway edge lights and threshold lights out of service.
[6] Although in previous flights permission was processed for night operation, this time no request was made by the operator for the extension of the operation in SLCO.
[7] Appendix 1. CVR transcript

At 00:42:18 one of the pilots was heard stating that they would divert their route to Bogotá (SKBO) to refuel.

At 00:48:49 CP 2933 made the first contact with Colombian ATC (Bogotá Control Center, SE sector) over ARUXA fix on Route UL417:

Time (UTC)	**Source**	**Dialogue**
00:48:49	CP 2933	Bogotá Center LMI2933
00:49:04	BOG ACC SE	LMI2933 Bogotá Control go ahead
00:49:09	CP 2933	Good evening, FL300 squawking 6363
00:49:20	BOG ACC SE	LMI2933 Roger, radar contact FL300 you are cleared to Rionegro vía ARUXA, PABÓN, BOGOTÁ, BOGOTÁ-NIRSO, NIRSO-RIONEGRO
00:49:57	CP 2933	Copied, LM2933

At 00:52:24 shortly after the airplane was transferred to Colombian ATC, another CVR conversation related to the decision of the crew to continue their route to Rionegro (SKRG) took place. At 01:03:01 the crew made the approach briefing to Jose Maria Cordoba Airport (SKRG) Rionegro.

At 01:15:03 the CVR stopped registering information[8].

At 01:16:38 communication was resumed with Bogotá SE Control Center:

Time (hrs)	**Source**	**Dialogue**
01:16:38	CP 2933	Control Bogotá LMI2933 with request
01:16:43	BOG ACC SE	Go ahead 2933
01:16:45	CP 2933	Request deviation to the left due to build-up
01:16:49	BOG ACC SE	Roger LMI2933 deviation to the left approved… advise able to proceed to NIRSO (spelled-out) if cleared of weather
01:17:06	CP 2933	Afirm, direct NIRSO from present position
01:17:10	BOG ACC SE	Okay, cleared of weather, direct NIRSO approved 2933
01:17:17	CP 2933	NIRSO approved for LMI2933

At 02:28:59 Bogota Control Center SE sector, called CP 2933 for transfer to Bogotá Control Center NW sector:

Time (hrs)	**Source**	**Dialogue**
02:28:59	BOG ACC SE	LMI2933 Bogotá

[8] After CVR stopped functioning all communications records were obtained from ATC recordings.

02:29:02	CP 2933	Go ahead
02:29:06	BOG ACC SE	Contact Bogota twenty three seven good day
02:29:13	CP 2933	Bogotá 123.7

At 02:29:13 the crew of flight LMI 2933 contacted Bogota Control Center NW sector:

Time (hrs)	**Source**	**Dialogue**
02:29:13	CP 2933	LMI2933 good evening
02:29:16	BOG ACC NW	LMI2933 go ahead for Bogotá good evening
02:29:21	CP 2933	Flying to NIRSO we are 53 miles inbound
02:29:27	BOG ACC NW	LMI2933 radar contact maintain three zero
02:29:32	CP 2933	Radar contact three zero zero LMI2933
02:33:02	CP 2933	Bogota LMI 2933 we are ready for descent
02:33:09	BOG ACC NW	LMI 2933 descend to FL250 re-cleared to VOR RNG holding pattern
02:33:17	CP 2933	to FL250 now leaving FL300 LMI 2933
02:33:23	BOG ACC NW	Correct LMI 2933 and re-cleared to VOR RNG holding pattern

At 02:33:27, CP2933 began its descent, approximately 80 nm south of Rionegro. Communications were:

Time (hrs)	**Source**	**Dialogue**
02:33:29	CP 2933	To the VOR hold LMI 2933
02:33:33	BOG ACC NW	Correct. Rionegro VOR, LMI 2933
02:36:34	CP 2933	LMI 2933 reaching FL250
02:36:38	BOG ACC NW	Maintain FL250 and proceed to VOR RNG holding LMI 2933 stand-by for descent and expected time for approach
02:36:49	CP 2933	Will maintain FL250 VOR hold LMI 2933

At 02:36:40hrs, the aircraft descended to FL250:

Time (hrs)	**Source**	**Dialogue**
02:39:06	BOG ACC NW	LMI 2933 continue descent to FL240 to VOR RNG holding
02:39:13	CP 2933	Two Four Cero to RNG (spelled out) holding
02:39:18	BOG ACC NW	Correct LMI 2933 contact Medellin approach now 121.1 good night
02:39:39	BOG ACC NW	LMI 2933 contact Medellin approach 121.1
02:39:45	CP 2933	Switching 121.1 LMI 2933

At 02:39:45 ATC transferred CP 2933 to Medellin Approach (MDE APP), who instructed it to descend to FL230 and join the Rionegro VOR holding pattern, (VOR RNG):

Time(hrs)	**Source**	**Dialogue**
02:40:13	LMI 2933	Rionegro LMI 2933 good evening
02:40:17	MDE APP	LMI 2933 control good evening radar contact maintain descend and FL230 join the Rionegro VOR
02:40:28	LMI 2933	For two three cero join Rionegro VOR
02:40:32	MDE APP	Correct
02:40:33	(Source not confirmed)	Confirm has Viva Colombia already approached Jose María Córdova?
02:40:38	MDE APP	the aircraft is on approach
02:40:42	MDE APP to VVC8170	Viva 8170 can you continue your descent?
02:40:46	VVC 8170 to MDE APP	Affirm - starting descent Viva Colombia 8170
02:40:49	MDE APP to CP 2933	Ok

At 02:42:12 the crew (CP2933) was instructed to continue the descent to FL 210:

Time(hrs)	**Source**	**Dialogue**
02:42:12	MDE APP	LMI 2933 continue descent for two…two one cero now
02:42:18	LMI 2933	For two one cero now LMI2933
02:42:22	MDE APP	Correct
02:43:09	LMI 2933	LMI2933 is it possible to hold over GEMLI?
02:43:17	MDE APP a LMI 2933	Approved
02:43:19	LMI 2933 a ATC	Will hold at GEMLI

The aircraft reached GEMLI and at 02:45:03 entered the holding pattern with FL 210. (Figure 1 - each holding pattern has a distance of approximately 24 nm).

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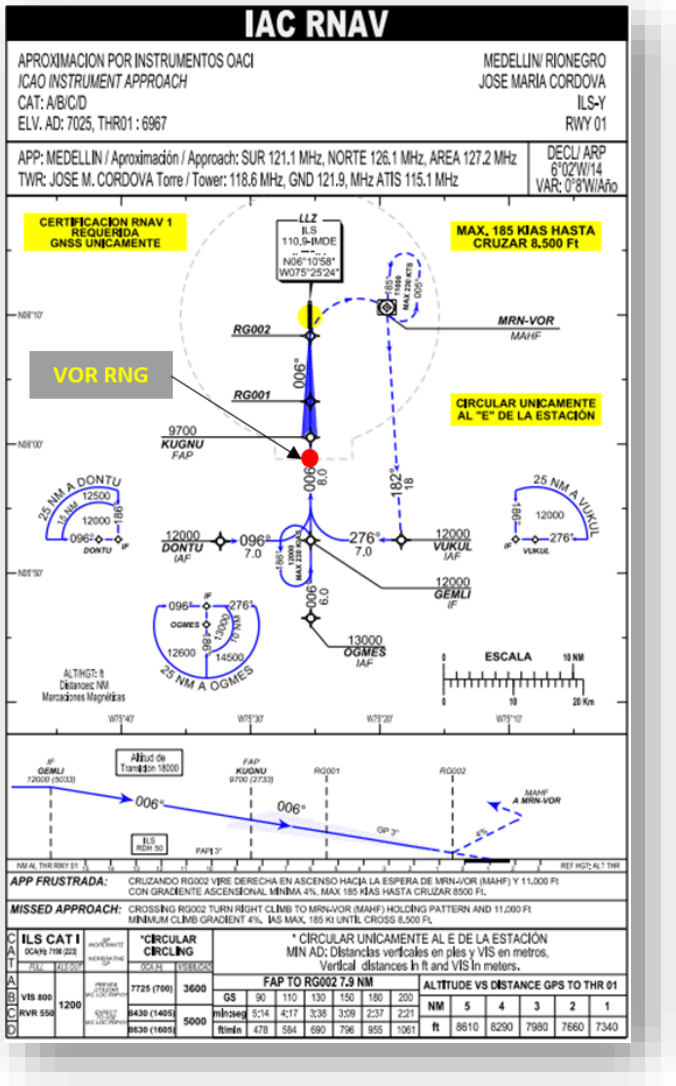

Figure 1. RNAV Approach Chart, RWY 01 SKRG – Source: AIP Colombia AIRAC AMDT 46/16

At this moment, three other aircraft were over the Rionegro VOR holding pattern at FL 190, 18,000ft., and 17,000 ft. respectively[9].

Another aircraft, which had previously requested a deviation to SKRG (VVC 8170)[10], had reported a fuel leakage indication, and at the time, it was beginning its final approach to SKRG RWY 01.

[9] The transition level in Colombia is FL 190 and the transition altitude is 18,000 ft.
[10] Flight VVC8170. At 02:10:07, the crew made a deviation request to SKRG (to the Bogotá Control Center, NW sector), over the ARORO Fix position 150 nm from SKRG.

At 02:43:52 the aircraft leveled at FL 210, flaps were set to 18° and speed was reduced to 180kt CAS. At 02:45:03 the crew informed ATC that they had entered GEMLI holding pattern at FL 210.

Figure 2. Position of CP 2933 crossing GEMLI at 02:44:03 UTC

Later, at 02:49:11, CP 2933 made its first circuit in the holding pattern and while on his second inbound leg to GEMLI[11], the crew of flight CP 2933 requested priority due to a fuel problem:

Time (hrs)	Source	Dialogue
02:47:49	LMI 2933	LMI 2933 inbound
02:49:11	LMI 2933	LMI 2933 FL210 inbound request priority for approach… we have a fuel problem
02:49:37	MDE APP	LMI 2933 I understand you request priority for landing also with fuel problem, correct?
02:49:44	LMI 2933	Affirmative

[11] Figure 3. Of this report.

02:49:49	MDE APP	O.K. stand-by, I will give you vectors to proceed to the localizer for the approach. Estimate 7 minutes to commence approaches.
02:50:00	LMI 2933	Will stand-by for vectors – LMI 2933

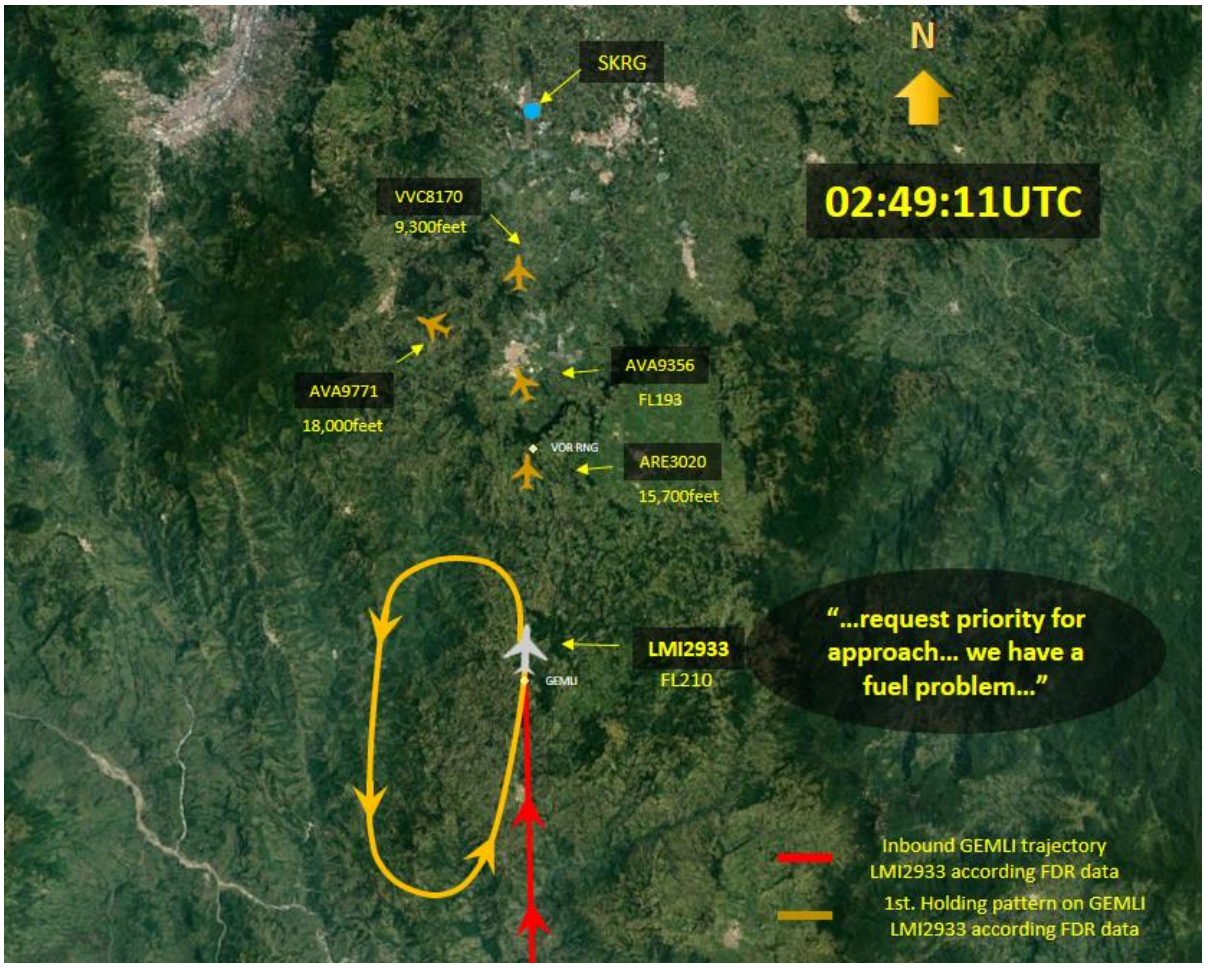

Figure 3. CP 2933 Second inbound leg to GEMLI - 02:49:11

ATC cleared another aircraft holding at 17,000 feet for the approach (02:50:31 - ARE 3020).

Time(hrs)	Source	Dialogue
02:50:57	MDE APP	LMI 2933 report heading
02:51:04	LMI 2933	One…one seven nine outbound
02:51:07	MDE APP	Maintain present heading and stand-by to commence the…to continue your descent.
02:51:12	LMI 2933	Will maintain present heading and standing-by for descent.

02:52:05	LMI 2933	LMI 2933 request inbound vectors…
02:52:18	MDE APP	Stand-by - I have an aircraft below…below you on approach, additionally, they are doing a runway inspection. How much time do you have to remain on your approach LMI 2933?
02:52:26	LMI 2933	We are with fuel emergency…that's why I am asking you at once for final course
02:52:45	LMI 2933	Request immediate descent LMI 2933

Figure 4. CP 2933 Third inbound turn to GEMLI - 02:52:26

ATC canceled the approach clearance to ARE 3020.

02:53:03	MDE APP	LMI 2933 can you make right turn now to begin descent, you have the traffic at one mile below you

At 02:53:07 the power controls of CP 2933 were reduced and the aircraft began to descend. At 02:53:09 the aerodynamic brakes deployed.

02:53:14	LMI 2933	Traffic insight, no factor, request to join the localizer at once.

At 02:53:24 the landing gear selector was selected "DOWN".

02:53:20	MDE APP	Captain, you are showing two one zero, I need to bring you down from that level you would have to maintain…veer right to begin your descent
02:53:29	LMI 2933	Negative…we are already starting descent and (we are) for the localizer

At 02:53:36 the flaps were set to 24° and the aircraft speed began to decrease, and continued to decrease until the end of the FDR recording.

At 02:53:45 engine #3 speed did not coincide with the position of the power controls and began to shut down. 13 seconds later, the same happened to engine #4.

ATC issued new headings instructions to the other airplanes that were in the holding pattern in order to clear the path for CP 2933.

02:54:09	MDE APP	LMI 2933 you have traffic ahead of you, 18,000ft., A320
02:54:19	LMI 2933	Identified on TCAS and we have it above us…and we are on final approach course.
02:54:24	MDE APP	The aircraft (traffic) is at 18,000ft leaving on (your) left, additional you have traffic…ok he already left eighteen five hundred.
02:54:35	LMI 2933	In sight and we are with one eight thousand

At 02:54:36 FDR data registered flaps set at 33°.

At 02:54:47 FDR data indicated low level oil pressure for engines number 3 and number 4 with a MASTER WARNING alert[12]. At the same time, during a period of 12 seconds, the N1 values[13] for engine number 1 were reduced from 39.5% to 29.0%.

At 02:55:04 engine number 2 started to shut down.

02:55:06	MDE APP	Stand-by LMI 2933 seventeen seven hundred continue approach, runway is damp, report VOR one zero thousand as feasible and if you require any ground service.

[12] The drop in oil pressure is a consequence of lack of fuel.
13 N1 is the value that indicates the rotation speed of the First. compressor stage of a turbojet engine

02:55:17	LMI 2933	We will confirm for service on the ground and we are thru one six thousand for the localizer.

At 02:55:19 during a period of 10 seconds, the N1 values for engine number 1 were again reduced from 38.1% to 29.9%.

At 02:55:27 FDR data indicated low level oil pressure for engine number 2 with a MASTER WARNING alert.

02:55:25	MDE APP	Be advised QNH thirty twenty seven
02:55:28	LMI 2933	3027

At 02:55:41 hrs, engine number 1 started to shut down.

After the loss of power in all engines, at 02:55:48 the FDR stopped recording. At this time FDR data shows that the aircraft was with a CAS of 115kt, a ground speed of 142kt and a pressure altitude of 15,934ft MSL.

The aircraft was 15.5 nm south of Rionegro RWY 01 threshold, and 5.4 nm south of the accident site (which had an elevation of 8.516 feet).

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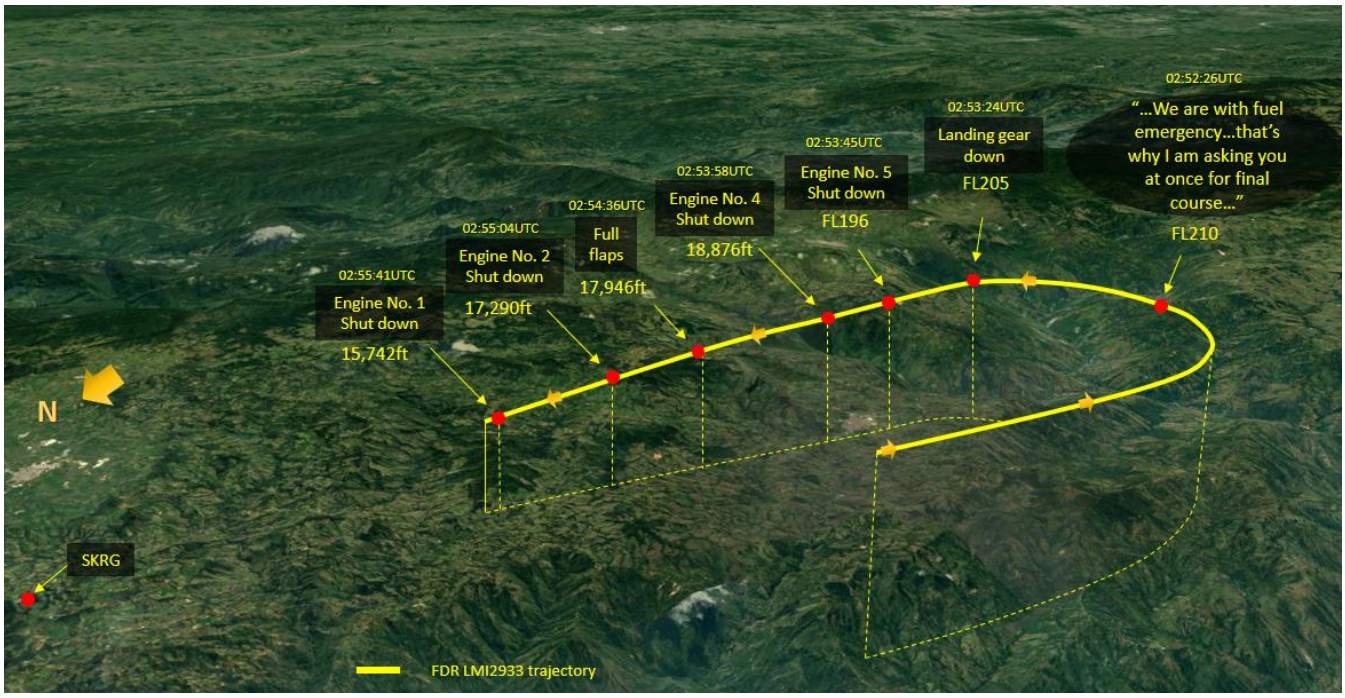

Figure 5. CP 2933 Last sequence of events until 02:55:48 when the FDR stopped recording

Radar traces indicated that "C mode" was lost at 02:55:55 at which time only the aircraft's primary radar signal was displayed.

02:57:10	LMI 2933	… LMI 2933 total electrical failure eh… without fuel…
02:57:29	MDE APP	Runway is cleared and operable, rain over the station LMI 2933 firefighters alerted
02:57:40	LMI 2933	…illegible… Lima Mike India (back ground voice "vectors tell her") vectors… vectors to the runway
02:57:46	MDE APP	lost radar signal, I don't have you - report heading now.
02:57:56	LMI 2933	we are… with heading three six zero, three six zero.
02:58:01	MDE APP	With heading…turn left zero one zero should proceed to the Rionegro VOR localizer, one mile ahead of the VOR, at the moment you are correct, I confirm turn left heading three five zero.
02:58:18	LMI 2933	Left three five zero …
02:58:20	MDE APP	Yes correct you are zero point one mile from Rionegro VOR
02:58:30	ATC a LMI 2933	I don't have your altitude Lima Mike India

02:58:38	LMI 2933 a ATC	Nine thousand feet...
02:58:42	LMI 2933 a ATC	Vectors, vectors
02:58:47	ATC a LMI 2933	You are eight point two miles from the runway

Despite repeated calls by ATC, no further responses were received from CP 2933.

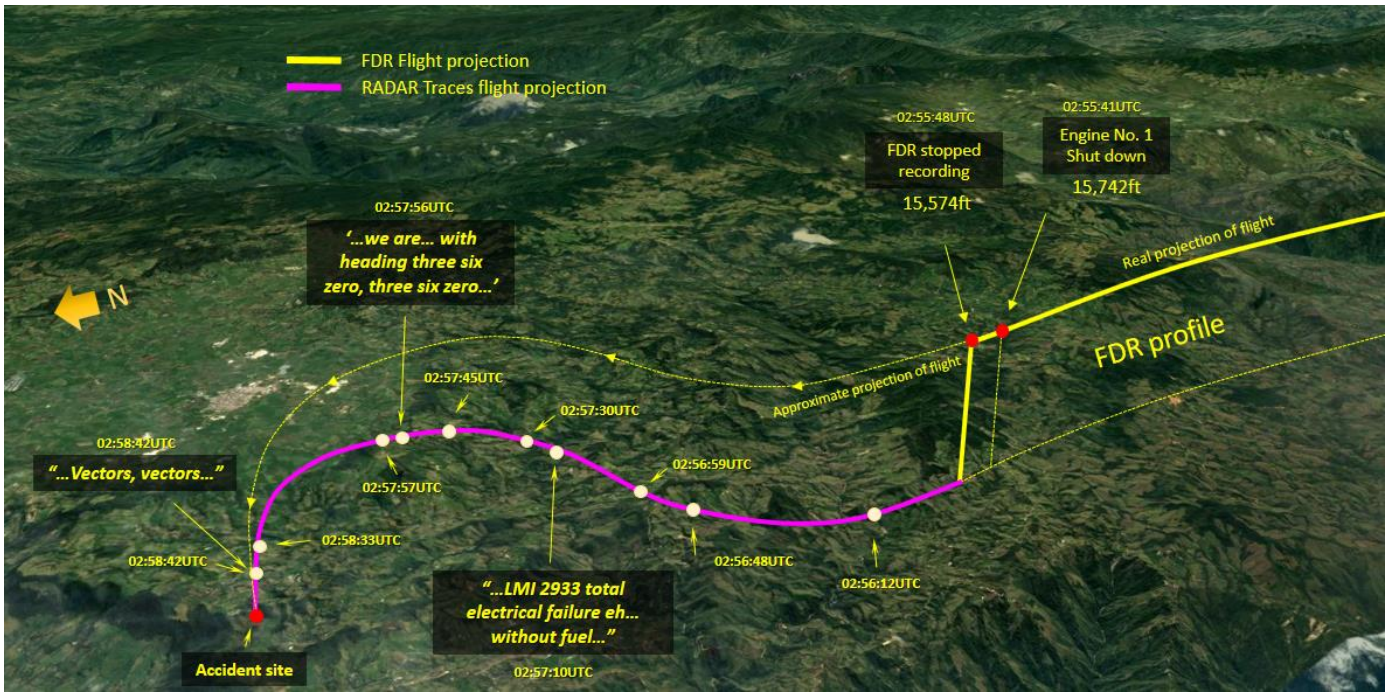

Figure 6. Approximate projection of CP 2933 according to Radar Traces

1.2 Injuries to persons

Injuries	Crew	Passengers	Total	Other
Fatal	3	68	71	-
Serious	1	4	5	-
Minor	-	1	1	-
TOTAL	4	73	77	-

1.3 Damage to aircraft

The aircraft was totally destroyed by impact forces against the ground.

1.4 Other damage

Significant damage to the environment and surrounding vegetation.

1.5 Personnel information

Captain

Age: 36 years

License: Air Transport Pilot

Nacionality: Bolivian

Medial Certificate: Class I

Last check on type: 15 February 2016 (annual)

Total flight hours: 6,692:51Hrs (LAMIA Records 20 Nov 2016)

Total hours on type: 3,417:41Hrs (LAMIA Records 20 Nov 2016)

The pilot in command accumulated experience as a pilot in Bolivian airlines; in 2013 he joined as a Captain and as one of the owners of the company operator of CP 2933.

In the company he exercised dual functions, acting as a Commander and performing administrative tasks.

He had an ATP Certificate with a single-engine and multi-engine rating up to 5700 kg. This license was issued on October 15, 2015. Said license also had an IFR flight instructor qualification (he was a RJ-85 instructor), and he was PIC on the RJ-85 and B462.

He had an ICAO English language Proficiency Level 4 valid until November 4, 2015 (it was expired at the time of the accident). The medical certificate was valid until December 17, 2016 without any limitations.

His last proficiency check as PIC was done in a level "D" RJ-85 simulator on August 3, 2016 in Zurich (Switzerland). He obtained a "*Satisfactory*" result with an observation to *"improve coordination in the cabin / CRM"*.

His last annual check in RJ85 equipment was on February 15, 2016 in Zurich (Switzerland) as PIC with observations of *"... clearly define the control of the aircraft and communications, who does the ..." - "... take the necessary time to prepare the plane in an emergency ... "*.

The company records indicated a total of 4,723:35 Hrs. in Jet type aircraft, and 285:16 Hrs. as an instructor in RJ-85.

First Officer

Age: 47 years

License: Air Transport Pilot

Nacionality: Bolivian

Medical Certificate: Class I

Last check on type: 03 July 2016

Total flight hours: 6,923.32 (LAMIA records 20 Nov 2016)

Total hours on type: 1,474.29 (LAMIA records 20 Nov 2016)

The first officer was trained as an officer of the Bolivian Air Force with a flight experience of 20 years.

He had an ATP certificate with an airplane single-engine land and multi-engine land rating up to 5700 kg.

His certificate was issued on 17 June 2016 and he was qualified as PIC in B426 and F27, SIC in RJ-85 and flight instructor in single-engine airplanes.

His Medical Certificate was valid until 10 November 2017 without any limitations.

His last proficiency check as SIC was done in a level "D" RJ-85 simulator on July 3, 2016 in Zurich (Switzerland). He obtained "*Satisfactory*" results with an observation: *"... The approach configuretions must be more precise ...".*

His last annual check as SIC in the RJ85 equipment was on February 15, 2016 in Zurich (Switzerland). The observations given were: "... in stalls, consider obstacles as a factor ..." - *"... Communication with ATC in emergencies should be punctual (PAN PAN or MAYDAY) as the case may be ...".*

He did not have an English language proficiency level on his license.

Records indicate that he had 6,923:32 total flight hours; 6,304:23 hours in jet type aircraft, and 1,474.29 hours in the RJ-85.

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1.6 Aircraft Information

Manufacturer:	British Aerospace BAE
Model:	AVRO 146 RJ-85
Serial:	E2348
Registration:	CP 2933
Year of manufacture:	1999
Airworthiness Certificate:	No°405
Registration Certificate:	N°834
Total flight hours:	21,640:45Hrs
Total Cycles:	19,737

Figure 7. General appearance of the AVRO 146-RJ85

1.6.1 Aircraft history

The aircraft, registration CP 2933 a jet type BAE Systems AVRO 146 - RJ85, was built by British Aerospace in 1999; it had four Honeywell (LF507-1F) turbo fan engines, with a "T" tail empennage configuretion (horizontal and vertical stabilizers).

The first Type Certificate issued for this type of aircraft was for the model AVRO 146 - 200 (UK CAA BA 16) dated June 3, 1983, with BAE System being the original holder. On April 23, 1993, the aircraft changed its Type Certificate to the denomination AVRO146-RJ85;

and later on June 11, 2008, EASA issued the EASA type certificate A.182 under which the aircraft maintained its airworthiness.

This aircraft was transferred to the United States from its date of manufacture (1999) under an export airworthiness certificate No. E050442/001; and it operated in that country until 2007, with U.S. registration N523XJ.

In June 2007, the aircraft was sent to the State of Ireland, with an Export Airworthiness Certificate No. E322106; in June 2008 it obtained its Irish registration EI-RJK and Airworthiness Certificate No.2296. During the stay in that country the plane was operated by CityJet Aircraft.

In August 2012, the aircraft was transferred to the State of Aruba; where the registration P4-LOR and airworthiness certificate No.BVI-12/012 were granted.

In February 2014, the aircraft obtained a Venezuelan special certificate of registration No.0125, issued on February 5, 2014 by INAC with registration number YV2979; it was valid from March 10 to March 12, 2014. Likewise, INAC issued a new special certificate of Venezuelan Registration No. 0136 on August 21, 2014, with validity until October 7, 2014. Both special registration certificates were issued for the purpose and with authorization only to ferry the aircraft from the City of Cochabamba, Bolivia (SLCB) to the City of Valera, Venezuela (SVVL).

The aircraft entered the State of Bolivia in February 2014 with Venezuelan registration YV2979, complying with the provisions of the Bolivian Aeronautical Regulation (RAB 21 Appendix A), not having an export airworthiness certificate.

The aircraft arrived at the maintenance facilities of Air Maintenance Service "2" (SMA2) belonging to the Bolivian Air Force, an organization that had a certificate for foreign aeronautical maintenance TARE "OMAC-E 616" to perform services to YV2979. From May 25 to October 22, 2014 a major "C" Check and service was carried out[14] taking into account the manufacturer's specifications and the operating company maintenance program. A certificate of release for maintenance and service was issued for the work performed. Also, during this period the Venezuelan registration YV2979 was changed to Bolivian registration CP 2933. The aircraft was later transferred to the city of Santa Cruz de la Sierra, where the operating company had its main base.

The Bolivian DGAC issued three (3) standard airworthiness certificates to CP 2933, before issuing airworthiness certificate (No. 405) which was in force at the time of the accident. The first standard AW certificate No.003648 had a date of issue December 31, 2014 with an expiration date January 10, 2015. The second, No.229 had a date of issue June 19, 2015 with an expiration date June 30, 2015, and the third one No.259 with a date of issue July 31, 2015 and expiring on October 05, 2015.

[14] Service "C": Major Service performed on the aircraft; every two and a half years (2 ½) calendar and/or every 5000 cycles

The aircraft company operator initiated the certification process to obtain an Air Services Operator Certificate (AOC), under Bolivian Aeronautical Regulation "RAB 121"[15] on October 15, 2014 before the DGAC; CP 2933 was listed as the aircraft that the company intended to be certified with.

During the certification process in 2016, records indicate an oversight and follow-up plan with reports and subsequent action plans in the maintenance area by the General Directorate of Civil Aviation of Bolivia (DGAC) and LAMIA Company.

In July 2015, DGAC issued the AOC # DGAC-DSO-AOC-119-01-002 to the company; and later a new AOC dated September 2, 2016 was issued due to translation of its content into English, for an indefinite term. (The latter was the AOC that was in force at the date of the accident).

At the time of the accident, CP 2933 had a current standard airworthiness certificate No.405 issued on January 26, 2016; it also had a valid registration certificate No. 834 with date of issue January 20, 2016.

The maintenance of the aircraft was programmed through a CAMO[16] located in the Country of Ireland called PART TEM Aviation Ltd; said CAMO had a contract with the operating company to provide technical support in airworthiness management, control and planning of the maintenance program.

CP 2933 aircraft was maintained under the Maintenance Program revision No. 2, dated November 16, 2016, which was carried out based on the document "Maintenance Planning Data (MPD)" All Model BAE 146 / Avro 146R 146.01, Rev.52 dated December 15, 2015, and approved by DGAC.

In this program maintenance was established for: the systems and components, structural, zonal, engines, APU and compliance with the airworthiness directive (AD EASA No 2014-0071).

The maintenance organization BACAMS SRL-1 performed the maintenance service to CP 2933 during the 2016 period; in the course of the year, 42 maintenance works were carried out; the last one was done on November 21, 2016, seven (7) days before the accident. The aircraft had one "Zonal inspection program" job done, according to work order No. 141-16, in compliance with the provisions in the company's maintenance program.

In the review made to the Airworthiness Directives "Status Report" performed by the operating company, it was evidenced that they were under control. According to the list of EASA directives, one hundred and ten (110) were identified for the aircraft; and, according to the FAA list, eight (8) Airworthiness Directives for the engines were identified.

[15] RAB 121: Operating Requirements: regular and non-regular domestic and international operations.
[16] CAMO: Continuing Airworthiness Management Organization; Organization for Airworthiness Maintenance Management. CAMO's objective is to provide technical support, airworthiness management, maintenance program control and maintenance planning.

Based on CP 2933 "Status Report" record, the aircraft had the following modifications and / or major repairs:

EASA Number	Descripción	STC Holder
EASA.IM. A.S.02072	Installation of Allied Signal VHF AFIS. *(Instalación de la señal VHF AFIS)*.	Honeywell
ASA.IM.A.S.02113	Installation of digital flight data recorder (DFDR) expanded parameter sensor upgrade. *(Instalación del registrador de datos de vuelo digital (DFDR) Ampliación del sensor de parámetros)*.	Aircraft Systems and Manufacturing
EASA.IM.A.S.02110	Installation of Honeywell Flight Data Acquisition Management System. *(Instalación del Sistema de Gestión de Adquisición de Datos de Vuelo de Honeywell)*.	Honeywell
EASA.A.S.02766	Installation of T2CAS provisions (wiring) with GPS antenna. *(Instalación de las disposiciones T2CAS (cableado) con antena GPS)*.	Delta Engineering
EASA.A.S.02766	Installation of ACSS T2CAS System. *(Instalación del sistema ACSS T2CAS)*.	ACSS

Table 1. Modifications and major repairs aircraft AVRO 146-RJ85

In the inspection of the maintenance books, no annotation or report of failure or corrective action was made to the aircraft over a long period of time, nor annotations related to the supply of oil to the engines and the APU were found.

In the passenger cabin log book, an open report was found related to toilets inoperability[17] without any evidence of corrective action.

1.6.2 Weight and balance

Although the weight and balance manifest record was not located at the accident site, nor was there a copy of it left in Company's office in Santa Cruz de la Sierra, the following were the estimated weights, taking into account the weight and balance manifest in the investigation:

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[17] Aircraft Cabin Logbook – CP 2933 – No. 000019

Item		Weight (kg)	Source
Aircraft Operating weight empty		25,844kg	Operator's Aircraft Description and Status Summary
Estimated Fuel	Fuel remaining from previous flight SLCB – SLVR 28th Nov 2016	7,437kg	Operator's Maintenance Log Book / Flt Log Book ref: LAM-MNT-15-001 / LAM-Ops-15-001 page 000122
	Fuel Uplift 2050litres @ 0.798spg 2050 litros a 0.798spg	1,636kg	Último recibo de combustible en Santa Cruz No. 1382146
	Total fuel	9,073kg	Max fuel that can be loaded is 9,362Kg ref BAES weight and balance manual
Passengers (including non-operational crew)	73 x 85kg/pax	6,205kg	80Kg/pax + 5kg/hand luggage ref LaMia Ops Manual Part A Chapter 9
Checked Baggage	Not fully known	488kg	Weighed luggage recovered from accident site
Minimum estimated Take-off Weight		41,610kg	

Table 2. Weight and Balance AVRO 146-RJ85

Based on the Flight Manual Rev 7.1 of February 2012, adapted (customized) for aircraft E2348 - CP 2933, the MTOW[18] is 41,800 kg. It was estimated that the total weight of cargo and passengers was 41,610 kg. The total number of passengers contemplated in the passengers list was seventy-seven (77).

From the information obtained from the flight that transported the passengers from Guarulhos to Santa Cruz, it was learned that the weight of the passengers luggage was 1,026kg[19]; based on this information, it is considered probable that the actual weight of the luggage on board the aircraft at the time of the accident was greater than the weight of the luggage recovered from the accident site.

This would suggest an estimated takeoff weight of 42,148 kg. The aircraft flight manual maximum takeoff weight allowed is 41,800 kg.

1.6.3 Fuel provided to CP 2933 aircraft

The fuel load report indicated that CP 2933 was supplied fuel twice by the operating company; once at the Cochabamba airport, and again at Viru Viru airport, as follows:

[18] MTOW: Maximum Take-off Weight
[19] BOA Company information – Boliviana de Aviación flight OB739

Date	From	To	Fuel loaded (Ltrs)	Fuel loaded (kg.)
26-11-2016	Cochabamba	Viru Viru	10.572	8.436
28-11-2016	Viru Viru	Cobija	2.050	1.636

Table 3. Fuel loads provided to AVRO 146-RJ85

According to fuel invoices dated November 26 and 28, 2016, the aircraft was supplied with 12,622 liters (10,072 kg.) of JET A1 fuel; of which 10,572 liters were uploaded in the City of Cochabamba (SLCB) on November 26, 2016, and 2,050 liters (1,636 kg.) were uploaded in the City of Santa Cruz de la Sierra (SLVR) on November 28, 2016.

The fuel remaining in the aircraft after the flight from Cochabamba (SLCB) to Santa Cruz de la Sierra (SLVR) was 7,437 kg. [20].

The amount of fuel on board the aircraft, to make the flight from Santa Cruz de la Sierra (SLVR) to Rionegro (SKRG), was 9,073 kg.
The type of fuel supplied to CP 2933 was Jet Fuel A-1. The fuel supplier's report showed that the destination of the flight invoiced the day of the accident corresponded for a flight to Cobija airport (SLCO). The company that supplied the fuel did not know the flight plan of CP 2933 when delivering the fuel.

Fuel samples were taken from where refueling took place in order to analyze its quality, finding no contaminants in its analysis.

1.6.4 Engines

CP 2933 was powered by four (4) Honeywell Turbo Fan engines, model LF507-1F; said engine has two single stage low pressure axial compressors (LPC), a seven stage high pressure centrifugal compressor, one annular combustion chamber, two (2) stage high pressure turbine (HPT) and two (2) stage low pressure turbine (LPT). The LF507-1F engine generates a total of 7,000 pounds of thrust (maximum).

Posición	S/N	TSN	CSN	TSI	CSI	FADEC S/N
1	P07867	19,293	17,607	129	104	3AGT172
2	P07873	18,629	17,084	1,729	1575	9AL6735
3	P07794	18,566	17,449	134	108	8ALT708
4	P07812	16,876	15,622	133	107	9ALG722

Table 4. Powerplant Information AVRO 146-RJ85

[20] Evidence recorded in Maintenance log book sheet and operator's flight log book Ref.: LAM-Ops-15-001 page.000122

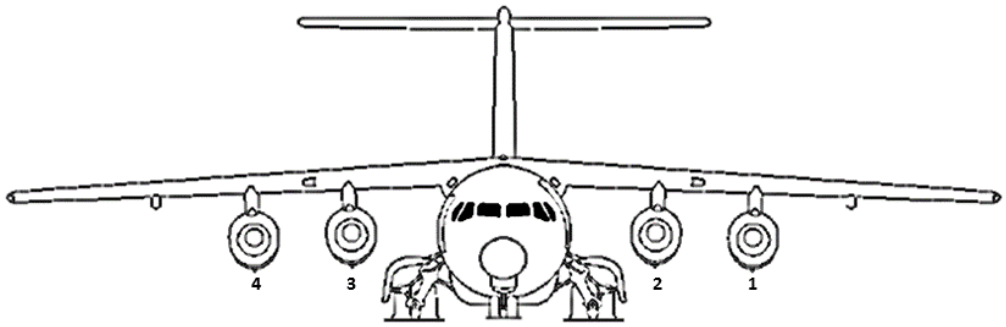

Figure 8. Location and position of the engines on the AVRO 146-RJ85

1.6.4.1 Last repairs made to the engines:

Engine N°1: S/N P07867: Repair made by Honeywell UK Limited on November 24, 2011. Certified EASA FORM 1.

Engine N°2: S/N P07873: Repair made by KLM UK Engineering Limited on July 31, 2011. Certified EASA FORM 1.

Engine N°3: S/N P07794: Repair made by Honeywell UK Limited on August 28, 2010. Certified EASA FORM 1.

Engine N°4: S/N P07812: Repair made by Honeywell UK Limited on April 02, 2011. Certified EASA FORM 1.

According to the operating company maintenance program revision No.2, dated November 16, 2016, chapter 8, "Powerplant Maintenance Program", the frequency of inspection for the engines, was stipulated in intervals of "days" (between 2 and 1825 days), in "hours" (between 15 and 5300 hours) and in "cycles" (between 100 and 25,000 cycles).

1.6.5 Fuel System Description AVRO 146-RJ8521[21]

The fuel system stores fuel and supplies it to the engines and the APU. An overview schematic is shown in figure 9. The system consists of several components as described below:

Tanks: Fuel is carried in three main tanks: the left wing tank, the centre tank and the right wing tank. Two optional auxiliary tanks may be fitted on the top of the fuselage behind the centre tank. The auxiliary tanks are also called pannier tanks.

Each wing tank is divided into four sections: a main compartment, an inner feed tank, an outer feed tank and a surge tank.

[21] AVRO 146-RJ Flight Crew Operation Manual (FCOM), Chapter 02, Topic 10

The centre tank fuel is transferred equally to the left and right wing main compartments. The wing compartment fuel is transferred to the feed tanks.

If auxiliary tanks are fitted, the left auxiliary tank fuel is transferred to the left wing main compartment and the right auxiliary tank fuel is transferred to the right wing main compartment.

Pumps and Feed Valves: Each feed tank contains an electrically driven fuel pump. In normal operation, the inner feed tank pump feeds the inner engine and the outer pump feeds the outer engine.

Each wing has an electrically operated common feed valve. The valve links the feed lines to the inner and outer engines downstream from the pumps. With the common feed open, either pump can feed both engines on that wing.

An electrically operated cross-feed valve interconnects the feed systems in both wings. This allows fuel in one wing to be cross fed to the engines on the other wing.

The APU is normally fed from the left inner pump, but it can be fed from any pump if suitable selections of the cross and common feed valves are made.

Low Pressure Valves: Each engine can be isolated from the fuel system by an associated low pressure valve. The valve is mechanically operated by the engine's fire handle.

The APU is isolated from the fuel system by an electrically operated low pressure valve. The valve is signalled by the APU START/STOP switch.

Fuel Quantity: Fuel quantity indicators for both wing tanks and the centre tank are beneath the engine instruments on the centre instrument panel. Each wing tank quantity indicator includes the quantity of the associated two feed tanks.

If auxiliary tanks are fitted, the left wing tank quantity indicator includes the left auxiliary tank contents and the right wing tank quantity indicator includes the quantity of the right auxiliary tank.

Fuel Transfer: The fuel transfer system ensures that the fuel in the centre tank and main compartments is supplied to the feed tanks. Fuel transfer from the main compartment to the feed tanks is by gravity and jet pump.

Fuel transfer from the centre tank to the main compartments by jet pumps and transfer valves. The left jet pump and valve transfers fuel from the centre tank to the left main compartment, the right jet pump and valve transfers fuel from the centre tank to the right main compartment.

When the left valve is open a white TRANSFER TO L TANK annunciator illuminates on the FUEL panel. A white TRANSFER TO R TANK annunciator indicates that the right transfer valve is open.

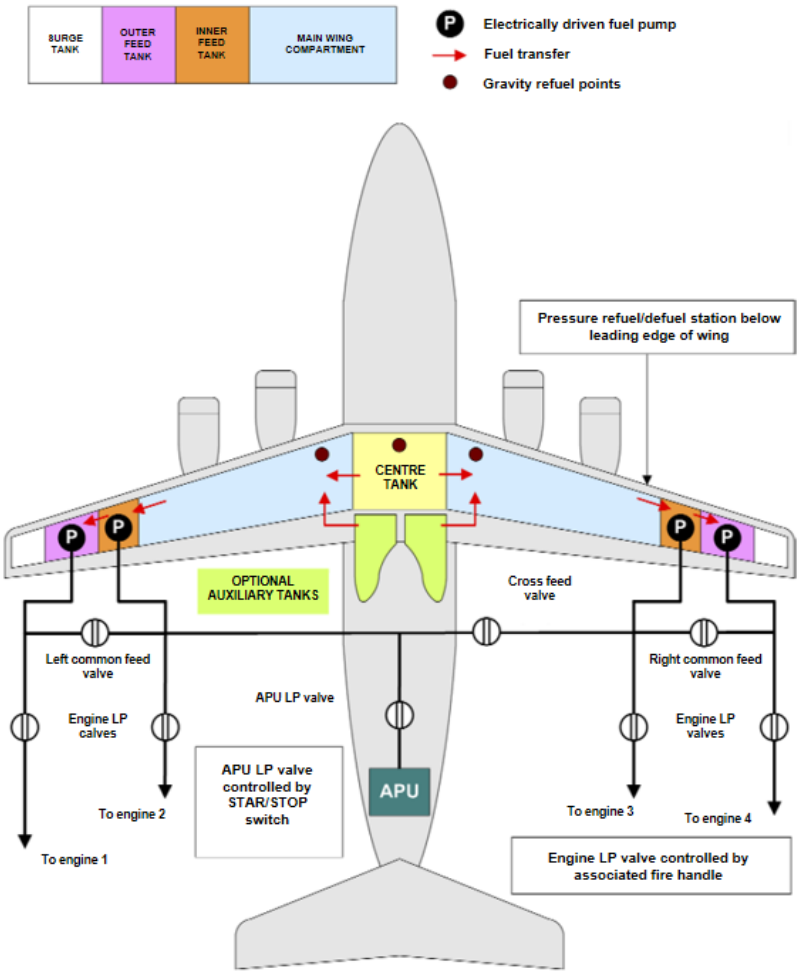

Figure 9. General description of the fuel system (AVRO 146-RJ Flight Crew Operation Manual (FCOM), Chapter 02, Topic 10)

The aircraft has a fuel storage capacity [22] as described in the following table:

Fuel capacity	Imperial Gallons	US Gallons	Liters	Kg	Lb
Right wing	1015	1219	4616	3683	8120
Center	550	661	2500	1996	4400
Left wing	1015	1219	4616	3683	8120
Total	2580	3099	11732	9362	20640

Table 5. Fuel Capacity in Tanks AVRO 146RJ

[22] Aircraft Maintenance Manual (AMM) AVRO 146RJ, Volume 1 – AMM146.192

1.6.5.1 Cockpit fuel indicators panel

At the top of the panel is a row of feed tank gauges: one for each of the four feed tanks. At the bottom of the panel is a switch for each feed tank pump. Above each switch is a LO PRESS annunciator. A LO PESS annunciator indicates that a pump is not working when its switch is at the ON position.

FEED LO LEVEL annunciators are below outer feed tank gauges. The L FEED LO LEVEL annunciator indicates that either the left outer or the left inner feed tank is not full. The R FEED LO LEVEL annunciator indicates that either the right outer or the right inner feed tank is not full.

If auxiliary tanks are fitted, two auxiliary tank not empty annunciators are fitted: L AUX TANK NOT EMPTY and L AUX TANK NOT EMPTY. An auxiliary tank not empty annunciator indicates that the associated auxiliary tank still contains some fuel.

A fuel temperature gauge is on the left side of the panel. It indicates the temperature of the fuel in the right outer feed tank.

A three-position centre tank transfer switch is to the right of the fuel temperature gauge.

The switch controls the transfer of fuel from the centre tank to the wing tanks. The positions are AUTO, SHUT and OPEN. At AUTO, fuel transfer takes place in the air but not on the ground. At SHUT, fuel transfer cannot take place. At OPEN, fuel transfer is forced to take place.

There are two centre tank transfer annunciators above the switch: TRANSFER TO L TANK and TRANSFER TO R TANK. An annunciator indicates that transfer is taking place from the centre tank to the associated wing tank.

To the right of the CTR TANK TRANSFER switch, there is a X-FEED switch. The X-FEED switch controls the cross-feed valve. A NIPS annunciator is immediately above the switch.

Beneath the CTR TANK TRANSFER switch, there are two COMMON FEED switches: one for the left common feed valve and one for the right common feed valve. A NIPS annunciator is beneath each switch.

A switch for the left standby pump is to the left of the common feed valve switches. A switch for the right standby pump is to the right of the common feed switches. A STBY LO PRESS annunciator is beneath each switch.

A REFUEL SELECTED annunciator is above the fuel temperature indicator. A refuel panel is beneath the right wing leading edge. The annunciator indicates that the refuel panel is not in the flight condition.

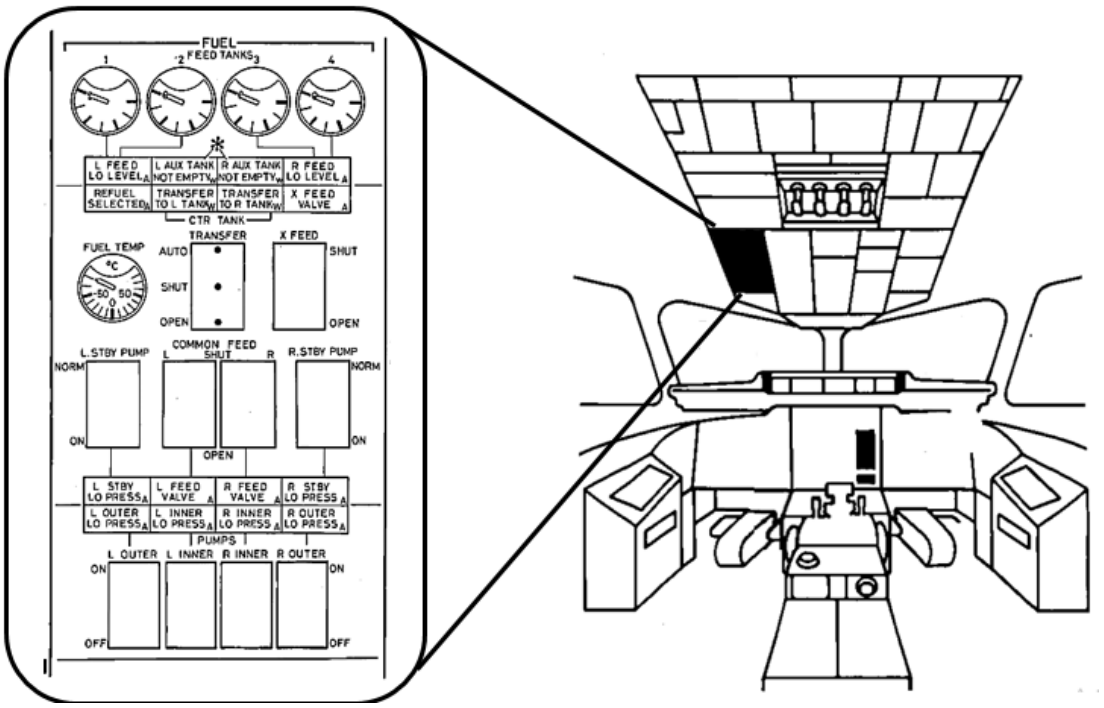

Figure 10. Location of the overhead fuel panel in the cockpit AVRO 146- RJ85

Warnings and their meaning:

Warnings	Significance	Time to warning
L FEED VALVE R FEED VALVE	Common supply valve not in position selected	10 Seconds
X FEED VALVE	Cross feed valve not in position selected	10 Seconds
L OUTER LO PRESS L INNER LO PRESS	Failure of electric pumps left wing tank	Inmediately
R INNER LO PRESS R OUTER LO PRESS	Failure of electric pumps right wing tank	Inmediately
L FEED LO LEVEL R FEED LO LEVEL	**Supply tanks in both wings less than full**	**30 Segundos**
L STBY LO PRESS, R STBY LO PRESS	Failure of standby hydraulic pump	Inmediately
TRANSFER L TANK, TRANSFER R TANK	Fuel transfer, activated	Inmediately

Table 6. Fuel Warnings AVRO 146-RJ85

When there is low fuel level, an amber FUEL↑ caption is shown on the Central Warning Panel accompanied by one-tone sound in the sound warning system of the aircraft and L

FEED LO LEVEL or R FEED LO LEVEL displayed on the FUEL panel on the overhead systems panel.

There are magnetic fuel level sensors inside each tank, which allow checking the amount of fuel in the cockpit's central panel and above the refuel and discharge panel located under the wing.

Although it was not possible to carry out an inspection of the fuel system after the accident due to the devastation of the wreckage, it is presumed that there was no system malfunction according to the available evidence.

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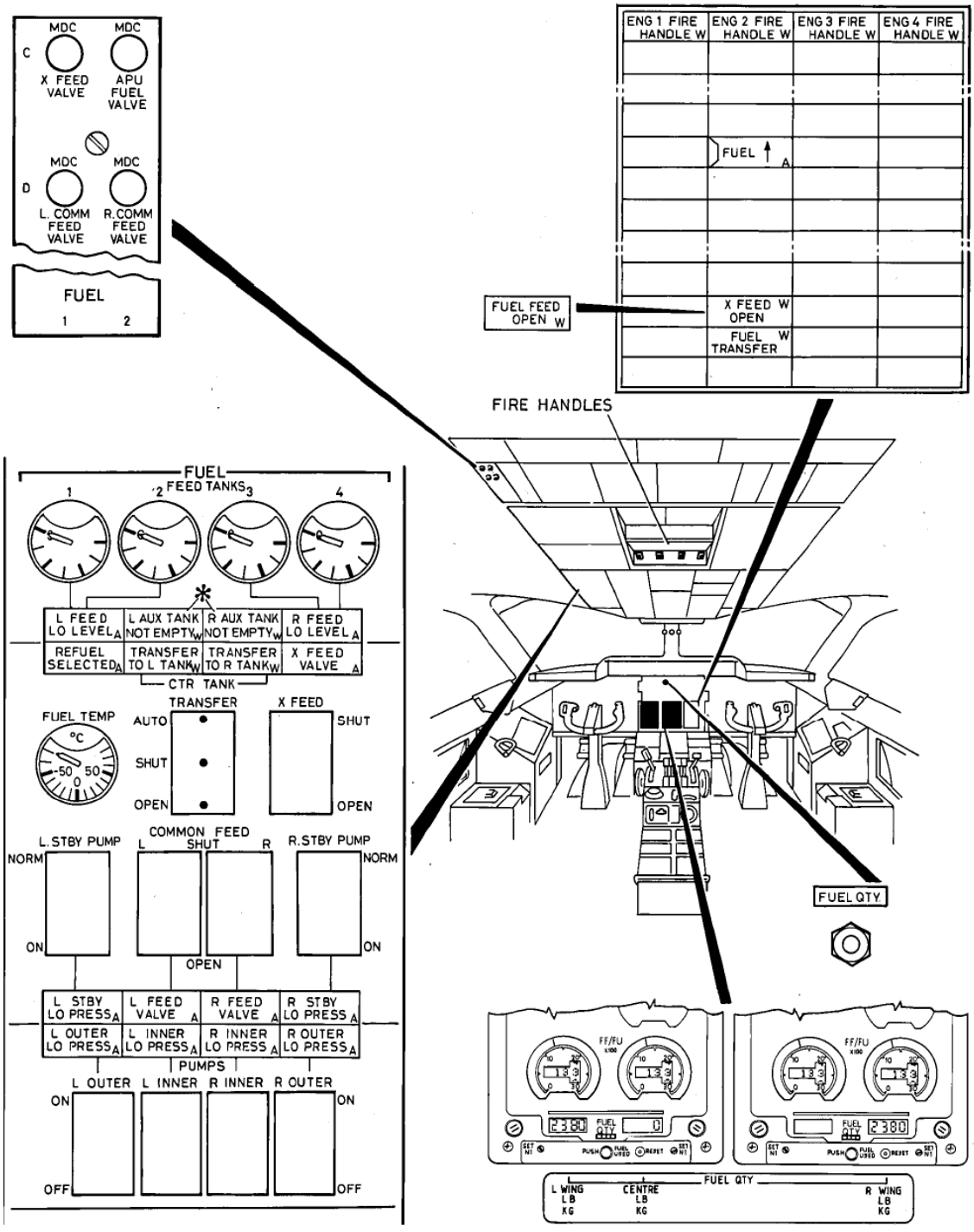

Figure 11. Location of fuel system controls and indicators AVRO 146-RJ85
(Source: Aircraft Maintenance Manual AMM AVRO 146RJ)

1.7 Meteorological information

Rionegro aerodrome (SKRG) meteorological report (METAR) issued on November 29, 2016 at 03:00 indicated the following conditions:

SKRG 290300Z VRB02KT 9999 -DZ BKN015 SCT080 17/16 A3025

Wind variable at 02 knots, visibility more than 10 kilometers with light drizzle, ceiling of broken clouds at one thousand five hundred feet (1,500ft. AGL), and scattered clouds at eight thousand feet (8,000ft. AGL). Temperature of 17° Celsius and Dew Point 16° Celsius, and the QNH was reported as 30.25 Hg. (1025 hectopascals).

No evidence was found indicating that the weather conditions affected the air operations in the Medellin Terminal Area during the period in which CP 2933 flight operated.

1.8 Aids to Navigation

1.8.1 Ground Based Aids to Navigation

José Maria Córdova International Airport (SKRG) had the following navigational radio aids available for approaches and landing:

Instalación (VAR)	ID	FREQ	HR	Localización	Elevación	Observaciones
DVOR	RNG	115,1 MHz	H24	05 58 50 N 075 25 06 W	8.669 ft	Cobertura 100 NM a 10.05 NM del umbral pista 01, rumbo 180°
DME	RNG	CH 98-X	H24	05 58 50 N 075 25 06 W	8.669 ft	Cobertura 150 NM
VOR	MRN	113,0 MHz	H24	06 10 35 N 075 19 26 W	7.054 ft	Cobertura 100 NM
DME	MRN	CH 77-X	H24	06 10 35 N 075 19 26 W	7.054 ft	Cobertura 150 NM
NDB	LI	274 KHz	H24	06 12 26 N 075 25 19 W	7.218 ft	Cobertura 25 NM, del umbral pista 19, rumbo 360°
ILS/LLZ	IMDE	110,9 MHz	H24	06 10 58,27 N 075 25 23,66 W	6.875 ft	
ILS/GP		330,8 MHz	H24	06 09 04,80 N 075 25 19,02 W	7.076 ft	Cobertura 25 NM a 0,55 NM, rumbo 180°
ILS/DME		CH 46-X	H24	06 09 04,80 N 075 25 19,02 W	7.046 ft	Cobertura 25 NM
MM		75 KHz	H24	06 08 22,65 N 075 25 22,63 W		
LM	DE	264 KHz	H24	06 08 23,57 N 075 25 22,18 W		

Table 7. Navigational radio aids available at SKRG – Source: AIP SKRG Colombia

At the time of the accident, the radio NavAids were operational without any malfunctions. The functionality and operability of the ground based aids to navigation were not a contributing factor to the accident.

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1.8.2 Avionics Equipment installed in CP 2933

The aircraft had the following avionics equipment installed:

Descripción	Marca	Modelo
VHF Comm Transceiver (1)	Rockwell Collins	VHF-700B
VHF Comm Transceiver (2)	Rockwell Collins	VHF-700B
ELT	Kannad	Kannad 406-AP
VOR/ Marker Receiver (1)	Rockwell Collins	VOR 700A
VOR/ Marker Receiver (2)	Rockwell Collins	VOR 700A
ILS Receiver (1)	Rockwell Collins	ILS-720
ILS Receiver (2)	Rockwell Collins	ILS-720
ADF Receiver (1)	Rockwell Collins	ADF-700
ADF Receiver (2)	Rockwell Collins	ADF-700
DME interrrogator (1)	Rockwell Collins	DME-700
DME interrrogator (2)	Rockwell Collins	DME-700
Weather Radar Transceiver	Bae Systems	RTA-4A
Radio Altimeter Transceiver (1)	Rockwell Collins	LRA-700
Radio Altimeter Transceiver (2)	Rockwell Collins	LRA-700
ATC Transpoder (1)	ACSS	XS-950
ATC Transpoder (2)	ACSS	XS-950
T2CAS	ACSS	TT-952
FMS(1)	Honeywell	GNS-XLS
FMS(2)	Honeywell	GNS-XLS
IRU (1)	Honeywell	IRU
IRU (2)	Honeywell	IRU
CVR	Bae Systems	SCR500-120
ADC (1)	Honeywell	ADC
ADC (2)	Honeywell	ADC
FDR (Solid State)	Honeywell	SSFDR

Table 8. Avionics equipment installed in CP 2933

Based on the information provided by ATC and the FDR it was learned that the aircraft flew RVSM[23] airspace. The flight plan presented by the flight crew established FL 280 as cruising level; however, the aircraft reached an initial cruising level of FL 260, later continuing its climb to FL 280, and eventually reaching a final cruising level of FL300. The RVSM operating range is between FL 290 and FL 410.

The Bolivian Aeronautical Regulation - RAB 91 "General Operating and Flight Rules", in its Appendix F "Operations in airspace with minimum vertical separation" (RVSM) - Aircraft ",

[23] RVSM: Reduced Vertical Separation Minimum. Term used in aviation to designate the reduction of vertical space between aircraft from 2,000 feet (600 meters) to 1,000 feet (300 meters) at flight levels from 29,000 feet (FL290) up to 41,000 feet (FL410). RVSM was implemented as a means to increase airspace capacity (RVSM airspace)

Section 5 - RVSM Operations, establishes the avionics equipment required to fly in RVSM airspace as follows:

- ✓ Two independent primary altimetry systems. (Avionics equipment installed)
- ✓ SSR transponder mode C. (Avionics equipment installed)
- ✓ Altitude warning system. (Reference: ATA 34 of the MEL (Minimun Equipment List) LAMIA Rev. Original, Oct / 2014).
- ✓ Automatic altitude hold system. (Reference: ATA 34 of the MEL (Minimun Equipment List) LAMIA Rev. Original, Oct / 2014).

Likewise, the aforementioned appendix in section 3, states that: "... The approval for an operator to conduct operations in RVSM airspace is issued under the Operation Specifications (OpSpecs). To issue an RVSM authorization, the ACC must verify that the aircraft has been approved ... ".

Although the aircraft complied with the avionics required to fly RVSM airspace, the aircraft had not been approved under LAMIA CORPORATION S.R.L. operating specifications in effect on September 1, 2016 to perform that type of operation.

The Regional Monitoring Agency (RMA) website for the Caribbean and South America regions "CARSAMMA" (where aircraft approved and / or authorized to fly RVSM airspace are registered) was checked to confirm the approval of CP 2933, and this aircraft was not found listed.

The company's Operation Specifications (OPSPECS) did not have RVSM approval. During the flight, the flight crew told ATC that they had approval to fly in RVSM airspace, according to the following communications transcript:

Time (UTC)	**Source**	**Dialogue**
00:05:03	ATC (Brazil)	'Lima Mike India two niner three three, confirm me, RVSM approved?'
00:05:05	LMI 2933	'Yes maam'
00:05:33	ATC (Brazil)	'Lima India two niner three three amazonic'
00:05:37	LMI 2933	'Yes maam ahhh RVSM approved'
00:05:52	LMI 2933	'Did you copy Amazonic?'
00:05:33	ATC (Brazil)	'Lima India two niner three three roger'

1.9 Communications

CP 2933 was in contact with Medellin Approach South Sector (ATC) on VHF frequency 121.1 MHz. There was no malfunction or interference during air to ground or ground to air transmissions during the flight phases. The last transmission received from CP 2933 was at 02:58:42, stating *"... Nine thousand feet ... vectors, vectors "*, seconds before impact with the terrain.

All transmissions between the crew and ATC were recorded and make part of the material recovered to complete the history of the flight.

No evidence of malfunctioning or difficulties in the use of ground / air, ground / ground and navigational surveillance systems attributable to the ATS provider was found.

1.10 Aerodrome information

The accident did not occur on an aerodrome ground. The aircraft was flying to José María Córdova International Airport (IATA: RNG - ICAO: SKRG) located in the Municipality of Rionegro - Antioquia.

SKRG, the destination aerodrome, is located on coordinates N06 ° 09'52.06 "W075 ° 25'22.80" at an elevation of 7.025ft, it has one runway - 01/19 – 3,500mts long and 45mts wide. The aircraft impacted a mountain ridge 10 nm south of SKRG airport.

At the time of the accident, the runway in use for takeoffs and landings was runway 01. The aerodrome has CAT I ALS approach lights and runway lights which were operative and functioning at the time of the accident.

1.11 Flight Recorders

The aircraft was equipped with a CVR and a FDR. Both were powered by Essential AC Bus, which required that one or more engines of the aircraft, or the APU, be running. Both recorders were recovered and sent to the Air Accident Investigation Branch (AAIB) laboratories for data download and interpretation, under the supervision of the Colombian Air Accident Investigation Group (GRIAA).

The CVR and FDR custody was transferred to the AAIB at Bogota Eldorado International Airport on December 5, 2016. The units were transported to the AAIB in the United Kingdom; GRIAA guaranteed that both recorders were not X-rayed.

Both recorders arrived at the AAIB on the afternoon of December 6, 2016 and were secured until the arrival of GRIAA on December 9, 2016.

1.11.1 Flight Data Recorder (FDR)

The aircraft was equipped with an Allied Signal / Honeywell solid state flight data recorder (FDR), part number 980-4700-003 and serial number 4204. The recorder has a storage capacity of at least 50 hours of operation at 64 words per second. Prior to data downloading, the AAIB laboratory units and software were tested for required procedures, and were found to be fully functional.

1.11.1.1 Recovery of FDR

The FDR was recovered by GRIAA from the accident site. The FDR was found in the main wreckage of the aircraft towards the rear of the fuselage and very near to its original position, detached from its mounting brackets.

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Figure 12. Condition of FDR upon recovery

1.11.1.2 FDR data readout

On December 9, 2016, the FDR was read under the supervision of GRIAA. Given the good condition of the memory module and its connector, it was decided to connect the memory module in the laboratory unit of the AAIB and download the data according to the procedure described for that purpose.

A total of 53 hours 57 minutes and 12 seconds of data was recovered. Several flight parameters were recorded including the flight controls positions, the autopilot and auto-throttle modes of the engines, aircraft attitude, the speed of the engine fan (N1) and the throttles position. The fuel flow for each engine was recorded every 64 seconds. The operation of the APU, the amount of fuel, caution alerts and fuel quantity status warnings were not recorded. Using unprocessed information from the recorder, a series of graphs was prepared with the most significant data on this flight. (Appendix 2).

1.11.2 Cockpit Voice Recorder (CVR)

The aircraft was equipped with a British Aerospace Systems Equipment (BASE) / Meggitt Avionics SCR500-120 solid state voice recorder in the cockpit (CVR), part number 299412-100 and serial number 99SRP146.

The SCR500-120 can record up to four audio inputs, consisting of three voice channels (typically P1, P2 and third occupant) and another channel for the Cockpit Area Microphone (CAM). The 2-hour recording consists of the three crew channels combined on a single channel and the CAM recorded as a second channel.

During the last 30 minutes of audio, flight crew channels are recorded on separate channels. The recording is stored in a solid-state memory protected inside a shock-proof assembly. Prior to downloading, the AAIB laboratory units and software were extensively tested for the required procedures and were found to be fully functional.

1.11.2.1 Recovery of CVR

The CVR was recovered by the GRIAA from the accident site. Like the FDR, the CVR was found in the main wreckage towards the rear of the fuselage and very near to its original position and also detached from its mounting brackets. The CVR did not show signs of fire. There were some dents on the outer casing due to impact. The circuit breaker marked VOICE REC in the COMMUNICATIONS panel was closed.

1.11.2.2 CVR Readout

The CVR was downloaded successfully and it recorded about two hours of operation[24]. Using Coordinated Universal Time (UTC) the CVR was aligned in time with ATC and FDR recordings and it was determined that the recording started at 23: 08: 33 on November 28, 2016. The following two hours corresponded to the accident flight. The recording ended at 01:15:03 when the aircraft was about 550 nautical miles from Rionegro and at one hour forty minutes and forty-five seconds (1:40:45) before the FDR recording ended.

There was no discussion (in the CVR) amongst the flight crew regarding the operation of the CVR. It was not possible to determine the reasons why the recorder stopped working early. The last communications recorded were:

01:14:57: *"If anything… if they switch me - I'm going to move (change) here ..."*
01:15:03: "*Alright…*"

1.11.2.3 Maintenance history

The manufacturer confirmed that the CVR had been returned to its facilities on July 18, 2011 when it was installed on EI-RJL (aircraft registration number). It had been removed from this aircraft reporting that it had stopped working after 15 minutes of operation. The manufacturer performed a full ground test and a 96-hour "soak" period test and subsequently considered the unit fit for operation. The CVR was later sent back to the operator.

According to the information provided by the company, the CVR S / N 99SRP146 was inspected on January 18, 2016 and no malfunctions were detected. The company did not

[24] The transcript of the CVR voices recorded is found in Appendix 1.

provide additional information on any other maintenance performed to the CVR before the accident.

1.11.2.4 CVR Bench-Check acceptance procedures

The CVR was taken to the manufacturer's test bench. The test bench allows you to check the recorders that have been repaired for return to service. The test bench system has a self-test function, which indicated that it was functioning normally. Several tests were performed, including:

✓ Power Supply Consumption Test
✓ CAM preamp power test
✓ Self-test of the unit
✓ Audio frequency tests
✓ Recording interruption test
✓ Bulk erasure test

The memory module was not used for these tests. A spare module was used since some of the tests involve overwriting the memory. Despite the damage suffered to the casing by the accident, the CVR passed all these tests.

The aircraft's FCOM makes reference to a daily CVR test in accordance with Chapter 12 and the crew's checklist. The complete cockpit security check by the pilots is necessary for the first flight of the day and, if necessary, after some type of maintenance is carried out.

In case there is a test failure, section 23-71-24 of the Aircraft Maintenance Manual makes reference to the removal / installation procedure of the CVR. If there is a failure of the recorder in flight, there will be no indication to the flight crew. The only way to establish if a failure has occurred would be to perform the daily test of the recorder; however, there was no evidence of such test found.

1.12 Wreckage and Impact Information

The accident area is a mountainous terrain, located in the Central Mountain Range (Cordillera Central) of Colombia, with average elevations of 8500 feet.

The accident site is known as "Cerro Gordo", and it is jurisdictionally located in the Municipality of La Union, Department of Antioquia, Colombia.

1.12.1 Location of First Impact with Terrain

The first point of impact was identified on the southern slope of a mountain, just below the mountain ridge, with an aircraft heading of approximately 310°. After the initial impact, an energy dissipation trajectory was generated along a magnetic course of 296°, and it

continued for 140 meters downhill on the northern slope side of the ridge, where the majority of the aircraft wreckage came to rest.

The geographic coordinates of the initial impact were recorded at N05 ° 58'43.56 "-W075 ° 25'7.86" at an elevation of 8700 feet.

Figure 13. Initial direction of Impact

The airplane wreckage was disturbed during the search and rescue operations after the accident. Access to the accident site was limited for several days, and no special equipment was used to hoist any parts of the aircraft because it was not available.

The largest piece located at the initial impact site was the empennage section together with the rudder and both elevators. The empennage was detached from the main fuselage at the point of the pressure bulkhead structure. The leading edges of the horizontal and vertical stabilizers were in good condition with little evidence of damage. The aerodynamic brakes were near the tail and were held together by electrical wiring.

INTENTIONALLY BLANK SPACE

Figure 14. Location of CP 2933 main wreckage

The components of the hydraulic and Environmental Control System (ECS) sections were also found at the initial impact site. Among elements found were the hydraulic reservoirs and a heat exchanger for the air conditioning units.

The reservoir push rod was also identified at the site. This reservoir is normally installed in the upper part of the avionics bay, below the cabin floor.

Other noteworthy parts that were identified at the initial impact site were a main landing gear door, a section of the accessories gearbox for one of the engines, a hydro-mechanical unit from one of the engines, a rear section of the right wing exterior fairing, and a passenger seat a cover.

1.12.2 Engines

Engines No. 1 and No. 4 were found near the initial point of impact. Engine No. 1 on the left, and No. 4 on the right. Engines No. 2 and No. 3 were found in the area of the main wreckage, engine No. 2 on the left, and engine No. 3 on the right (Figure 15). Engine No. 3 was found supported by a tree that was ripped from the ground on a slope that was considered unstable, so it was not possible to thoroughly examine the engine on site.

Figure 15. Location of engines in wreckage pattern.

The field inspection of engines No. 1, 2 and 4, showed no evidence of fire or internal failure in them. There were different types of damage to the engines and they all had abundant vegetation, dirt and tree debris in their intake sections. None of the engines showed any

abrasions on the spinners. The engines examined indicated that, at the moment impact with terrain, they were not generating power.

1.12.3 Main wreckage location

The approximate GPS position of the final resting point of wreckage was located on coordinates N05 ° 58.725 ', W75 ° 25.138'. This area was located approximately 140 meters from the site of initial impact.

Among the major aircraft parts that could be identified, were the cockpit, the front part of the fuselage, the wings, the rear section of the fuselage and engine No. 2. The remains slid downhill through the vegetation in mountainous terrain (Figure 16).

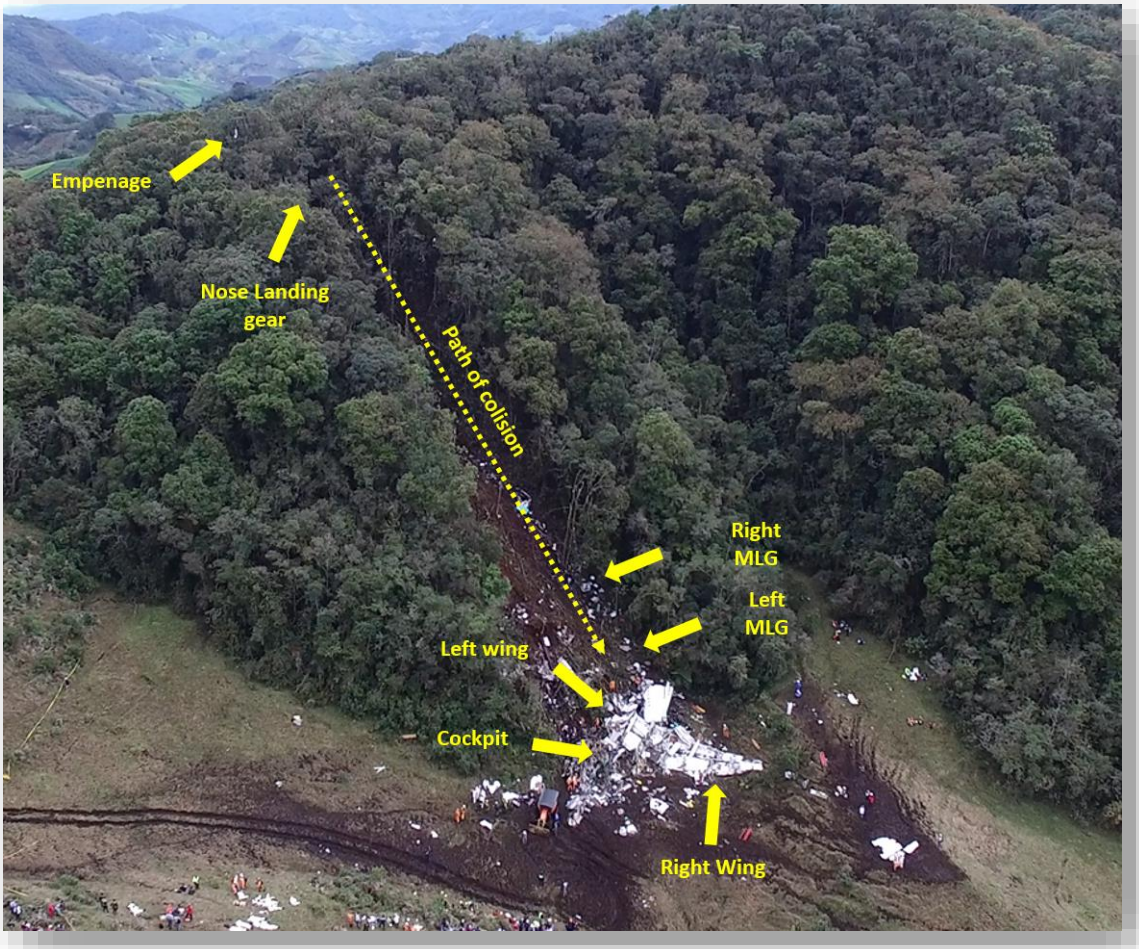

Figure 16. Location of post-impact path and main wreckage

The wings remained attached to the central section (center fuel tank) in direction of movement and in inverted position.

The orientation of the wings indicated that the center of the fuselage rotated 180 ° after the empennage section was separated. The rear section of the fuselage was in upright position, but it was pointing in opposite direction from the travel path. A large portion of the pressure bulkhead in the rear section of the fuselage remained attached to it.

The left main landing gear was identified very close to the rear section of the fuselage. The lateral tensioner was secured, indicating that the landing gear was DOWN at the time of the accident.

The cockpit was destroyed and it had been touched during search and rescue operations. Therefore, the position of the switches and levers, at the time of the accident, could not be determined.

The central console and the thrust levers quadrant could be identified.

The aerodynamic brakes lever was positioned slightly back from the IN position.

All four thrust levers and the flap selection lever were broken by the accident. The remains of the thrust levers were staggered and the remaining section of the flap lever was in position 30°.

The cockpit overhead panel was identified in such a position indicating that this section of the cockpit ended up inverted.

On both wings, it was evident that the flaps screw-jacks were fully extended, indicating that the flaps were set at 33°, fully extended at the moment of impact. One of the left wing screw-jacks could not be evidenced due to the final condition of the remains.

The right wing aileron was complete with the servo, and the trim tabs remained partially attached to the wing. It was not possible to determine the aileron position at the time of the accident. The left wing was badly damaged and it was not possible to examine the left wing aileron.

The rudder and both elevators were attached to the empennage structure. It was not possible to determine the position of the control surfaces when the accident occurred.

The aerodynamic brakes on the empennage surface were slightly deployed. The nose gear assembly was identified approximately 15m from the initial point of impact, in the direction of travel.

1.12.4 Fuel

The right wing fuel tank was torn during the accident. With the exception of a slight smell of fuel near the fuel tanks, there was no apparent evidence of fuel in the entire area of the accident site.

The refueling panel (Figure 17) showed a fuel load of 9,300 kg[25]. The three fuel quantity indicators in the panel indicated zero, a condition that is expected when the power supply is lost. The three fuel valve selection switches were in PRE-SELECT position. This position is not correct since the switches should have been in SHUT position according to the refueling procedure described in the Aircraft Maintenance Manual (AMM), Chapter 12-10-28, Item 5. (D) (9).

Figure 17. Wing Refueling Panel

1.13 Medical and Pathological Information médica y patológica

As a result of the impact and deceleration forces of the aircraft, seventy-one (71) occupants (including the 4 crew members) suffered fatal injuries. These injuries consisted of multiple trauma, fractures, bruises, abrasions and lacerations.

There were six (6) survivors; five (5) of which had serious multiple injuries and one (1) suffered minor injuries with minor bruises and lacerations.

The survivors were initially transferred to six local hospitals in the municipalities of La Ceja and Rionegro (department of Antioquia) where they received treatment.

According to the expert opinion, the cockpit crew presented blunt high-energy trauma in the accident. There was no evident presence of toxic substances in the biological samples obtained from the crew.

[25] According to the Aircraft Maintenance Manual (AMM) chapter 12-10-28 item D Calibration Tables, the actual amount of fuel in the main tanks can be affected by the fuel density and the inclination of the aircraft with respect to terrain or the apron, resulting in the actual amount of fuel in the tanks to be less than the indicator pre-selected total amount on board.

1.14 Fire

There was no evidence of fire occurrence neither before or after impact with the terrain.

1.15 Survival Aspects

The AVRO 146 RJ85 had the classic seats configuretion in the passenger cabin. The cockpit had three (3) seats for pilot, co-pilot and observer.

Figure 18 shows the configuretion of the aircraft cockpit and passengers' seats and the approximate seating location of the surviving occupants. The approximate probable location of the passengers was based on interviews conducted with them after the accident.

Person	Aprox. Location (According to survivors statements)	Injuries
1	Right AFT section	Lacerations, Contutions
2	Left AFT section	Polytrauma
3	Near to Right Wing	Polytrauma
4	Near to Right Wing	Polytrauma
5	Near to Right Wing	Polytrauma
6	Rear fuselage section	Polytrauma

Table 9. Location of passengers in relation to injuries

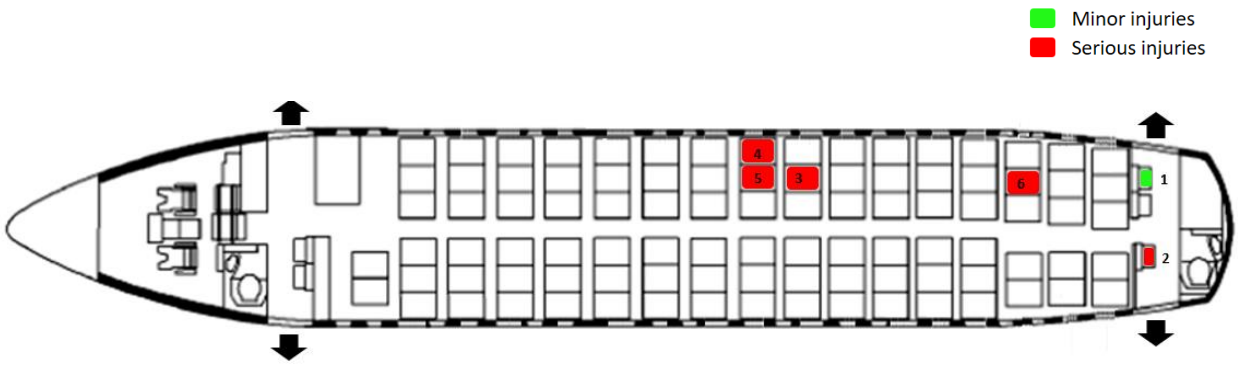

Figure 18. Approximate distribution of minor and serious injuries on CP 2933

The passengers who occupied the positions marked with red and green colors, located on the right side - the right wing section - and in the back section of the aircraft had survival

capacity (3, 4, 5, 6); in turn, those survivors located in the most rearward section (1, 2) suffered the least serious injuries.

1.15.1 Rescue of occupants

At 03:00, after several calls from ATC to CP 2933, the alert to Aircraft Rescue and Fire Fighting crews (ARFF) in SKRG was activated. ARFF took position on taxiways B, C, D, while waiting for new information. At the time, the aircraft was inbound and approximately 7 minutes away from the runway. When communications were lost with the aircraft, a search was activated on the approach path to the aerodrome.

At 03:07, a telephone call was received from the community of the Municipality of La Union, reporting the possible location of the crash. The firefighters in the Municipality of Rionegro were also alerted.

At 03:12, the fire engines returned to ready the equipment and rescue personnel and to establish the PMU (Unified Command Post) in the jurisdiction of the Municipality of Rionegro.

At 03:45, a resident of "Cerro Gordo" (Municipality of La Unión) reported the accident site to the National Police, who in turn informed the firefighters of the Municipalities of La Unión and SKRG ARFF. After confirmation, an operation with Search and Rescue crews (SAR) was deployed to the accident site.

Residents of the area and Colombia National Police officers provided first responder services to several of the survivors at the accident site. In most cases, these first responders helped locate those occupants who still showed signs of life, providing company and support while the rescue agencies arrived at the site to carry out the extraction of injured occupants from the wreckage of the aircraft.

At 04:05, ground rescue personnel arrived at the site of the accident through steep terrain, lush vegetation and narrow trails which were plowed by hand moments after the accident. The majority of rescue agencies focused their attention on the location and rescue of survivors. The rescue operation was carried out in mountainous terrain without daylight, in rainy conditions and with low visibility.

At 04:30, two (2) survivors were rescued and transferred by land to nearby health care centers. Another survivor (1) was rescued and transferred to a nearby health care center at 06:00.

At 06:13, two more (2) survivors were rescued and transferred by land to nearby health care centers. At 09:00 the last survivor was rescued and transferred to a nearby health care center.

After a futile search for more survivors, between 09:00 and 11:00, recovery of bodies with fatal injuries was carried out.

At 15:00 a Colombian Air Force Helicopter arrived to the accident site and assisted with the transport of bodies to Enrique Olaya Herrera Airport (SKMD) located in the City of Medellín (Antioquia). The recovery work was finished on November 29 at 19:30.
The following organizations participated in the search, rescue and recovery operations:

- Departamento Administrativo de Gestión del Riesgo de Desastres (DAGRD)
- Policía Nacional de Colombia
- Bomberos Municipios La Ceja, Rionegro, La Unión, Marinilla, El Retiro, Medellín
- Fuerza Aérea Colombiana (FAC)
- Ejército Nacional de Colombia
- Búsqueda y Rescate Aeronáutico (BRAC)
- Defensa Civil Colombiana
- Servicio de Extinción de Incendios (SEI) Aeródromo SKRG
- Cruz Roja Colombiana

1.16 Test and Research

Throughout this Investigation, technical assistance was provided by the Air Accidents Investigation Branch - AAIB (United Kingdom) and the aircraft manufacturer BAE Systems who assisted in the decoding and reading of the flight recorders (FDR and CVR) and the fuel consumption analysis. The National Transportation Safety Board - NTSB (United States) helped with on-site inspection of the power plants and the decoding and reading of the FADEC component.

1.16.1 Fuel consumption

Data obtained from the Flight Data Recorder (FDR) was analyzed to determine fuel consumption. The initial review identified that the FDR parameters were recording the expected values during the cruise phase, according to the conditions flown, the resolution of the parameters and the engine type installed.

The Flight Crew Operation Manual (FCOM) provides a fuel consumption value of 1,000 lbs/hr (453.59 kg/hr); On the other hand, the FDR data indicated a consumption of 1,066 lbs/hr (456.52 kg/ hr) for the cruise phase (FCOM long-range with FDR data of 236kt IAS, -6° C of Standard Air Temperature (SAT), an altitude of 27000ft and N1 of 86.5%).

With the assistance of the manufacturer BAE Systems, the FDR data review was completed to determine the position of the flight, where the low level fuel warning was triggered in the cockpit (L FEED LO LEVEL, R FEED LO LEVEL), and where the tanks low level feed system (FEED TANK LOW LEVEL) would have been activated.

This is how - according to the FDR fuel consumption data - it was determined that the low fuel level indication event occurred approximately 40 minutes before the end of the FDR recording.

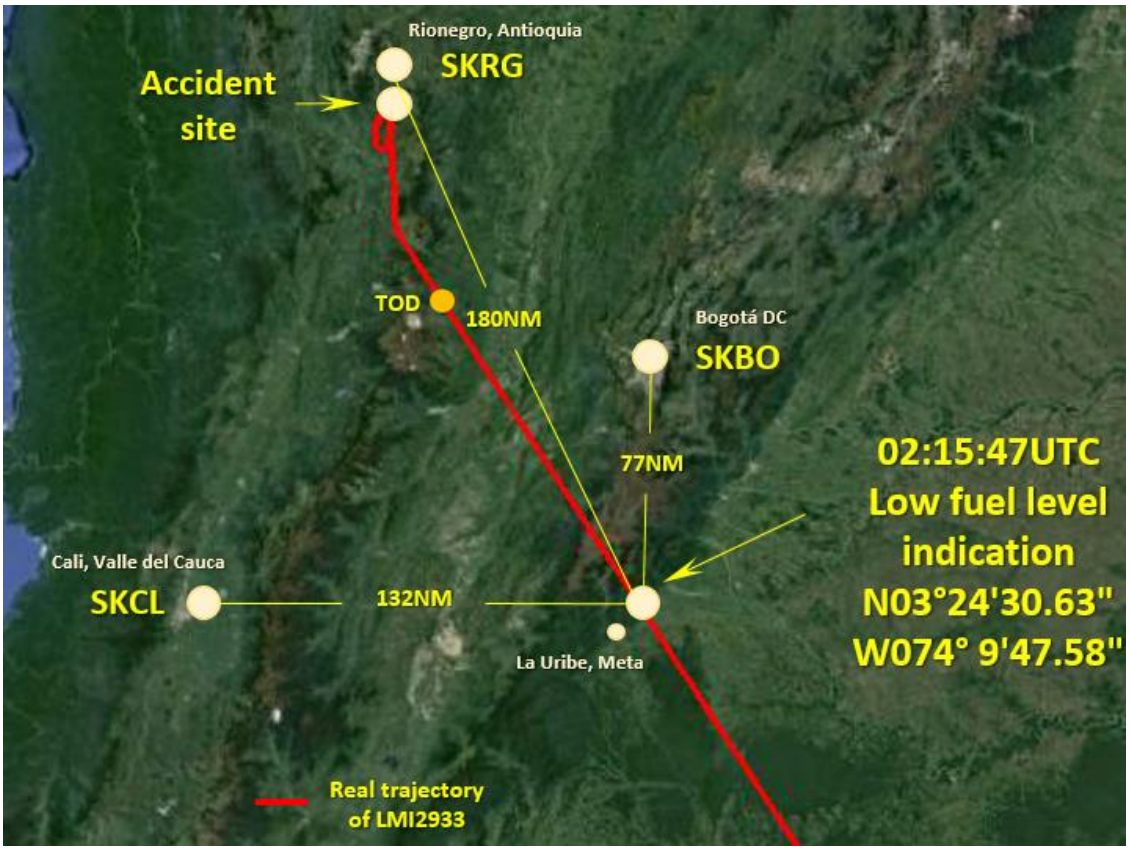

Figure 19. Approximate position of CP 2933 where low fuel level indication occurred.

When observing the frequency of recording from the parameters in the FDR, it was not possible to determine with certainty which of the low level feed systems, L or R, would have worked first; however, it is likely that the two systems might have entered into operation within two minutes apart.

The aircraft FCOM checklist item 9.06[26], describes that after an indication in the low level fuel warning system, there is enough fuel to fly for 23 minutes, in cruise condition, or with enough fuel to descend, approach, make a low pass (go around) and land.

The low fuel feed system works when the amount of fuel in the feed tanks falls below its maximum capacity of 75 gallons / 600lb. Taking into account that the fuel flow may vary depending on the power settings used in different phases of the flight (cruise, descent and holding), the calculation made based on information from the FDR, that the plane flew for 40 minutes in conditions of low fuel level, is an approximate, but not exact, determination.

The indication of low fuel level came at 02:15:47, at cruising level FL300, approximately 18 minutes before TOD (Top of Descent) - N03°24'30.63 "- W074°09'47.58"), and 29 minutes and 16 seconds from GEMLI, which was reached at 02:45:03.

[26] FCOM, Volume 3, part 3, emergency checklist and abnormal procedures

It should also be noted that, according to this analysis, the low fuel level indication would have flashed in cockpit before flying over the outskirts of Eldorado Airport, SKBO, the alternate en-route aerodrome that was viable at the time of the warning indication.

1.16.2 FADEC[27] inspection

In order to determine any failure during the operation of the aircraft's power plants, the FADEC units installed in the engines were inspected in coordination with the National Transportation Safety Board (NTSB), the manufacturer of the Honeywell engines and the manufacturer of FADEC's in the United States of America.

These units contained non-volatile memory with the ability to record any failure code of the aircraft's propulsion system. During the inspection of these components, all the information was downloaded and analyzed satisfactorily, concluding that there were No FADEC faults occurred during the accident flight.

1.17 Organizational and Management Information

1.17.1 LAMIA CORPORATION S.R.L

The Company LAMIA CORPORATION S.R.L was a company constituted with NIT No 288334023 according to registration No. 00316874, under license No 302333 of Bolivia's Registry of Commerce.

It was being managed by its Legal Representative, who at the time arranged the certification process before the Directorate General of Civil Aviation (DGAC).

The company began its certification process in 2014, and was subsequently granted its first AOC Certificate No. DGAC-DSO-AOC-119-01-002, on July 31, 2015; This Certificate was ultimately renewed on September 2, 2016, through the granting of the AOC No. DGAC-DSO-AOC-119-01-002, with an indefinite expiration date.

The operation was defined to provide commercial air services, under RAB 121, performing non-scheduled passenger transport service, including mail and cargo services, both nationally and internationally to corporate, private, and governmental entities.

The Company began its business with CP 2933, which had been taken on commercial lease.

Regarding the organizational and management factors, for compliance with the requirements of its AOC certificate, (renewed on September 2, 2016), it had an organic structure as referenced below:

[27] FADEC (Full Authority Digital Engine Control). The FADEC is an engine control system in which the primary functions are provided electronically and the electronic engine control (EEC) unit has full-range authority over the engine power or thrust.

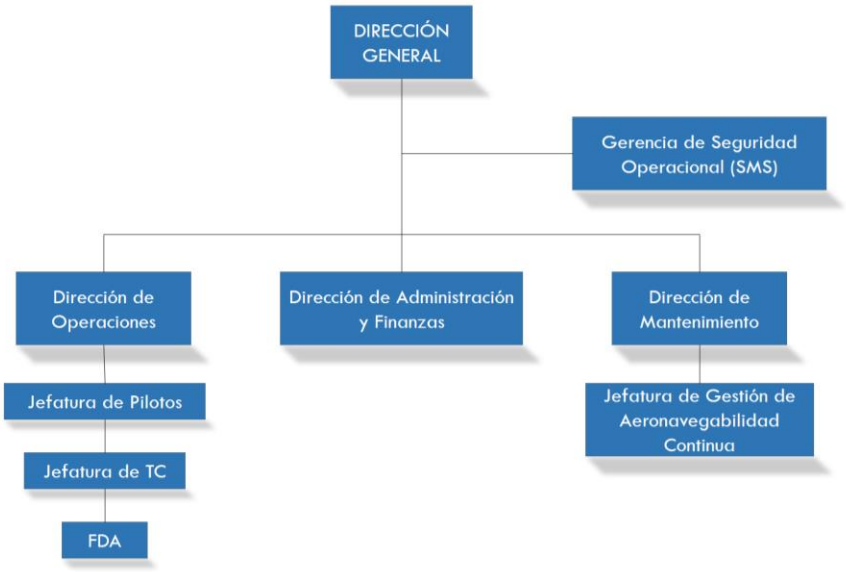

Figure 20. LAMIA S.R.L Organization chart

According to the company, although she had presented this organization chart, it did not reflect the reality, because the SMS Management and FDA area had not been implemented. With Operation authorized by Administrative Resolution No. 410 dated July 30, 2015, it began its certification process on October 6, 2014, under RAB 121 requirements with a team of approximately five (5) persons in its organizational structure based at El Trompillo airport in the city of Santacruz de la Sierra - Bolivia.

Phase 3 of the Certification Process was approved on May 4, 2015, with the approval of the SMS manual, the MCO manual, the MCM manual and others required.

The company, on the date of the event and according to the Organization Chart, which was included in the Operations Manual, did not define in its structure, an area that would reference the Quality Management System (operational assurance), as referred to in Part A of the Operations Manual. Clearly, in the practice of its operations, it could not be demonstrated that a quality management process existed or was being carried out. The Company Management, showed evidence of delays in the payments for public services as well as not making the social security contributions payments to cover personnel working for this same company.

On the other hand, it was evidenced that there was a delay in the payment to the Bolivian Air Force (FAB) for the maintenance and logistic services provided to their aircraft. In 2015, a flight was made from Norwich - England to Gran Canaria Island (Spain) where a ramp inspection was performed by SAFA[28] on September 24, 2015 at 9:30 p.m finding several operational deficiencies which included inadequate fuel management[29].

[28] SAFA - Safety Assessment of Foreign Aircraft
[29] Ramp Inspection Report No. AESA-E-2015-0871

The company had established in Part A, Section 3.3.1 of its Operations Manual, an Operations Control Center (CCO), an area in charge of ground supervision of its flights, a task that was performed by the Operations Coordinator who also worked as Manager of QSMS.

Likewise, the company had certain operating specifications dated September 1, 2016 which did not give specific approvals for transportation of dangerous goods, operations in low visibility, RVSM, EDTO or navigation specifications for PBN operations.

1.17.2 Maintenance

The operator had a Maintenance Control Manual (MCM), DMMCM-001-16, revision No.00 dated July 26, 2016; which had been accepted by the DGAC, in November, 2016. This manual contained information on the organization, type and scope of maintenance, responsibilities, general policies, and procedures for methods and techniques that should be used in the maintenance to be performed for CP 2933.

Organizationally, regarding the maintenance area of the operator, it was made up of a General Director, under which the Quality Assurance Department and the Maintenance Department directly depended; an Organization for the Airworthiness Maintenance Management (CAMO PART TEM) and an OMA Maintenance Organization 145; likewise, it had a Continuous Airworthiness Headquarters which depended on the Maintenance Department.

The company contracted maintenance services with the following maintenance organizations approved and certified under the Bolivian Aeronautical Regulation RAB 145[30]:

- ✓ BACAMS S.R.L / OMA N°- 001
- ✓ Servicio de Mantenimiento Aéreo "2" (SMA2) / OMA N°145-1-007-14

1.17.3 General Directorate of Civil Aviation – Bolivia DGAC

The General Directorate of Civil Aviation, is the Bolivian Aeronautical Authority, established under law No. 2902 of October 29, 2004, stipulates in Chapter II, Article 9 (f), that through the Bolivian Aeronautical Regulations (RAB), supported by work procedures for its management as an Aeronautical Authority, including procedures for certification, inspection, oversight and control of air operators and other aerial activities, among which are the issuance of authorizations for the entry or exit of non-schedule, international charter is included, in the context of this investigation.

The Aeronautical Authority in the Plurinational State of Bolivia includes RAB 119 in its regulations, which deals with the certification of air service operators, and RAB 121, which establishes the requirements for regular and non-regular domestic and international operations, under which The Company LAMIA Corporation SRL, was authorized its certification as an air operator.

[30] RAB 145: Regulation on Approved Maintenance Organizations (OMA)

According to RAB 119, (last revision dated September 5, 2013), Part 119.29 (a), (b), (c) and (d), "Quality Control Program", LAMIA Corporation SRL, should have a quality control system promoting the assurance of the operational safety objective established in the authorized AOC. Lamia Corporation S.R.L was a company certified with an AOC, to provide Non-Regular, Domestic and International Air Services for Passenger Transport, Cargo and Mail, operating Airplanes (Large) Transport Category.

The Oversight and Control Authority (ATT sic.) of Bolivia, authorized the operating permit for LAMIA CORPORATION S.R.L.

The General Directorate of Civil Aviation of Bolivia (DGAC) had a safety oversight plan 121-129-175 applicable from August to December 2016. During 2016, there was evidence of a surveillance plan in the area of airworthiness and there was no evidence of reports arising during the certification process in the area of operations.

Similarly, it was learned in the investigation that the Bolivian State[31] grants a subsidy to the value of fuel to all aircraft that make flights among airports of the Bolivian State, that is, regional or national, and that are registered in the Bolivian State, identified as CP.

When the aircraft was in SLVR, it was supplied with a total of 2,050 liters of fuel, according to the supply receipt[32] and it was registered that the destination was national (Cobija - CIJ), when in the flight plan and in the knowledge of the crew, the flight would be made directly to Rionegro, international flight, which would not have subsidy according to what is established in the Supreme Decree.

1.17.4 Administración de Aeropuertos y Servicios Auxiliares a la Navegación Aérea – AASANA

The Administración de Aeropuertos y Servicios Auxiliares a la Navegación Aérea (AASANA), was created by supreme decree No. 08019 dated June 21, 1976, as an entity of the State, and in its article 2 has as its object the planning, direction and administration of airports open to public service; implement in the Bolivian territory, the organization of the airspace and the control of its transit according to Annex 2 of ICAO.

Later it was raised to the level of Law No. 412 dated October 16, 1968, in this law in its article 164 it is stated that "the responsibility of the entity that provides services to air navigation begins when the aircraft is taken under its protection or control and ends when it transfers the same to another entity that provides services to air navigation with respect to the aircraft, or when they have completed the operations for which it was required ".

The aircraft CP 2933 took off from the Viru Viru Airport of the City of Santa Cruz-Bolivia, with the air navigation control of the Santa Cruz de La Sierra control tower.

[31] Decreto Supremo N° 28932 - Estado Plurinacional de Bolivia
[32] Fuel supply receipt No. 1382146

The flight plan was submitted and accepted to be processed by the ARO / AIS office, this being a process that relates the operational elements of air navigation and allows to develop the operation in the assigned airspace or control condition in any airspace.

1.17.5 Clearance of international non-scheduled flights in Colombia

Based on the Colombian Aeronautical Regulation RAC 3.6.3.5.6, regulations that rule regulatory management of assessment , approval and verification of non-scheduled international flights of charter type and under which the Colombian Civil Aviation Authority, a request from CP 2933 was processed before the CCAA to the flight requirement of a FBO company in Colombia, dated November 28 at 13:36 , which included the corresponding formats that contain technical information such as aircraft features ,routes , weight, number of passengers, passengers on board POB , data referring to operational performance.

This information and formats were evaluated based on Colombian Aeronautical Regulations RAC and regulatory documents which provide rules of application in the aeronautical industry for non-scheduled international charter flights such as the flight of the CP 2933, which was authorized and registered in the charter flight request form dated November 28, 2016.

During the process of assessment and approval of non-scheduled international charter flights (request for non-scheduled charter flights), the concept of the Secretariat of Operational Safety and Civil Aviation (formerly the Secretariat of Air Safety) was not issued, nor a study and an exhaustive analysis of the current insurance of the aircraft was carried out which contained an exclusion clause for operation in Colombia.

The request was authorized on November 28, 2016 by the Aeronautical Authority.

1.18 Additional Information

1.18.1 International fuel planning according to company

The company's Operations Manual[33] approved and in force at the time of the accident provided the guidelines for the supply of fuel for international operations:

> *"9.5.3 MINIMUM FUEL REQUIREMENTS: AIRCRAFT PROPELLED BY TURBINES, OTHER THAN TURBOPROP: REGULAR AND NON-REGULAR INTERNATIONAL OPERATIONS*
>
> *No Flight Operations Officer (EOV) may release a flight and no Pilot may take off an aircraft of LAMIA CORPORATION SRL, powered by turbines (other than turboprop aircraft) unless, considering the wind and other expected weather conditions, said aircraft has sufficient fuel:*
>
> - *To fly to and land at the airport to which it will be released.*
> - *Then, to fly for a period equivalent to 10% of the total flight time required operating from the airport of departure and land at the airport to which it will be released.*

[33] Manual de operaciones LAMIA, Part A, Chapter 9, Operational procedures, 9.5.3

- *Next, to fly and land at the most distant alternate airport specified in the flight release, if an alternate is required; and,*
- *Then, to fly for thirty (30) minutes at the speed of the holding pattern over the alternate airport (or over the destination airport if an alternate aerodrome is not required), under standard temperature conditions.*

No person can release an aircraft from LAMIA CORPORATION SRL, to an airport for which an alternate aerodrome is not specified, unless it has sufficient fuel, taking into winds and other expected weather conditions to be able to fly to that airport and then to fly at least for two (02) hours at normal cruise consumption.

The minimum amount of fuel (Q) calculated for an International operation is defined as:

Q = Fuel for taxiing + Fuel to destination + Contingency Fuel (10% of the total flight time) + Fuel to the farthest Alternate + Final Reserve Fuel (30' at 1,500 feet above the alternate or destination airport at holding pattern speed).

a	b	c	d	e	Cantidad Mínima de Combustible (Q)
Fuel para taxeo	Fuel al destino	Fuel de Contingencia. 10% del tiempo total de vuelo	Fuel al alterno más lejano	Fuel de reserva final. 30' a 1.500 pies a velocidad de holding	a + b + c + d + e

Table 10. Minimum quantity of fuel according to company operations manual (Extracted from Manual de operaciones LAMIA)

The company manual did not contain guidelines to establish minimum fuel quantities for landing.

1.18.2 Information on fuel planning

Prior to the flight, on November 28, 2016 at 13:25 , the operator had sent the flight information to a planning company so that a Flight Plan could be created from SLVR (Santa Cruz) to SKRG (Medellin)[34].

The profile of the planned flight was the same as the operator presented in the Flight Plan to the ATC, and its total distance was 1,611 nm. The fuel requirement for this trip was 8,658 kg.

Additionally, when presenting the Flight Plan to the ATC, the company added an amount of 200 kg of fuel for taxiing. This resulted in a total of 8,858 kg of fuel required for the flight, which did not take into account the fuel required for an eventual diversion to an alternate airport neither the reserve fuel nor the contingency fuel.

[34] Flight plan Ref. 3078 – Appendix 3

The flight plan had a cruising level of FL 300 and a take-off weight of 32,991 kg. The registered plan required an increase in fuel requirements of 64 kg for each additional 1,000 kg above the initially planned weight.

Other flight plans with different routes were found in the wreckage of the aircraft. These included three flight plans created on November 26, 2016, for flights from São Paulo to Santa Cruz, Santa Cruz to Cobija and from Cobija to Rionegro.

The flight plan from Cobija to Rionegro contemplated Bogotá as an alternate airport and included a deviation fuel requirement of 837 kg and a 30-minute 800 kg holding pattern fuel requirement (holding).

The flight planning company provided the flight plans prepared for the company LAMIA on November 28, 2016 for the investigation. The flight plans created and the planned destinations are summarized below:

Reference	Computing time (UTC)	Estimated Time of Departure (ETD)	Route	Total Time
3072	04:50	16:00	SLVR/SKRG	04:23
3076	13:08	23:00	SLVR/SBCT	02:25
3077	13:12	23:00	SLVR/SBCT	02:33
3078	13:25	16:00	SLVR/SKRG	04:22
3084	15:09	16:00	SLVR/SLCB	00:34
3085	15:11	16:00	SLVR/SLCB	00:34

Table 11. Flight plans computed by the company on November 28, 2016

1.18.3 Previous operations carried out between SKRG - SLVR

According to operation flight records from the Airport Administration and Auxiliary Services to the Air Navigation of Bolivia - AASANA, during the last four (4) months prior to the accident, aircraft CP2933 registered a total of three (3) landings at Viru Viru International Airport, Santa Cruz - Bolivia from José María Córdoba International Airport, Rionegro - Colombia, on August 23, 2016, October 30, 2016 and November 5, 2016 respectively.

When reviewing the three (3) flight plans presented in Rionegro SKRG, it was found that, for those dates, the proposed final destination was the Cobija SLCO aerodrome and not the Viru Viru SLVR aerodrome where each flight was finally completed.

The Viru Viru SLVR aerodrome was proposed as alternate aerodrome in each flight plan and the SLCB Cochabamba aerodrome as second alternate.

The flights carried out had the following ratio of endurance and total time en route (EET) in the respective flight plans:

Flight Plan Date	Endurance	Total Route Time
August 22, 2016	04:20 hrs	03:15 hrs
October 29, 2016	04:15 hrs	03:11 hrs
November 04, 2016	04:20 hrs	03:15 hrs

1.18.4 Passenger post-accident statements

Some survivors were interviewed. The surviving members of the soccer team, said that it was evident that at the last minute the plan for their flight was changed, adding the trip from Sao Paulo (Brazil) to Santa Cruz de la Sierra (Bolivia).

They agreed in their statements on aspects related to the disorganization of the company in terms of logistics and decision making.

The interviews showed that, at the time of the event, many passengers were asleep and that suddenly the noise of the engines stopped during the descent. They also reported that in the cockpit the lights went out and that the emergency floor lights were turned on.

In one of the statements, a survivor said he felt that the aircraft began to descend with uncontrolled movements, from one side to the other, on its own axis, and began to hear a sound like a "beep beep beep ..." that came from the cockpit. After a few seconds, he felt that the aircraft changed the climb rate until the accident occurred.

According to the statements, it was evident that at no time did the pilots inform the passengers what was happening, or what safety procedures should be followed.

1.18.5 Passenger cabin crew member post-accident statement

The Crew member of passenger cabin was interviewed after the accident. He said that the flight took place under normal conditions without any calls from the cockpit crew about any abnormality or emergency. He commented that he only received the information from the pilot giving the intentions to land and that he also made the announcement to the passengers to prepare the passenger cabin for landing.

He added that before the event, the lights in the cockpit went out, the engines of the aircraft stopped working and that afterwards there was a decrease until the accident occurred.

The crew member in her statement commented that the company owed them wages. According to the interview, this aircraft had previously made a flight to SKRG with the very same pilot in command and recalled that they made a stopover in Cobija (Bolivia) to refuel.

1.18.6 Post-accident statement of an on-board technician

The technician on board was interviewed after the accident. In his statement, he commented that the company was undecided in the flights scheduling since they frequently changed the schedules of the flights.

He commented that in Santa Cruz (Bolivia), he received the instruction to ensure the supply of fuel with full tanks of the aircraft to Cobija (Bolivia).

He said that after this procedure, he was surprised that the company decided to carry out the migration process since an order to proceed directly to Colombia had been given.

He assured that the flight developed under normal conditions. During the descent, he observed that the cabin crew prepared the cabin for landing and after that, the lights went out together with the aircraft engines until they hit the ground.

1.19 Useful or effective research techniques

No special investigation techniques were required to conduct this investigation. The investigation followed the techniques and methods recommended by ICAO document 9756, Part III.

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2. ANALYSIS

2.1 Operational procedures

According to the factual information, it is determined that there was poor flight planning, low situational awareness in its execution and wrong decision making, all of them influenced by the desire to fulfill a transportation contract.

The crew did not comply with the provisions of the company`s general operations manual in relation to the determination of the minimum amount of fuel required to carry out international flights.

Not only did the crew miss a component of that calculation. In fact, the planning of the operation did not take into account several components of the minimum fuel calculation required, namely: the fuel required for an eventual diversion to an alternate airport, the reserve fuel and the contingency fuel. The flight started in illegitimate conditions with regard to the amount of fuel on board.

It is evident, within the investigation, that there was an indication of low fuel level (L / R FEED LOW LEVEL) at approximately 02:15:47 hrs[35] when the aircraft was flying at a cruising level of 30,000 feet, and when it was approximately 18 minutes before reaching the starting point for the descent (TOD).

Despite the alarm warming, the crew did not perform any action, nor carried any communication procedure or made any request to the ATC to let her know about their situation in order to be able to handle it accordingly to the operational situation being faced.

The emergency checklist and abnormal procedures FCOM[36] of the aircraft, as a regular practice, describe the procedures that pilots must perform when alarms such as a low fuel level indication (L / R FEED LO LEVEL) are activated. According to the FCOM, after performing the procedures established by the checklist, the L / R FEED LOW LEVEL warning alarm continues, the manual states that the landing is required as soon as possible.

In effect, the procedure describes that once the system warns the crew of the indication of L / R FEED LOW LEVEL, as an immediate measure it must land as soon as possible since the fuel remaining in each "feed tank" and in the corresponding fuel line, can feed the engine to:

- A minimum of 23 minutes continued operation at cruise power, or
- A descent from high level, an approach, a go-around and a further approach to landing.

[35] 1.16.1 – Fuel consumption
[36] FCOM, Volume 3, part 3, Abnormal procedures and emergency checklist, page 9.06

As evidently shown within the investigation, the crew of flight CP 2933 had considered SKBO as an alternate aerodrome; however, the criteria that the crew used to make the decision to continue the flight to SKRG could not be evidenced, even knowing that SKBO was only 77 nm since there was no record of the cabin voice recorders (CVR), for that moment.

When continuing the flight with the condition of low level of fuel indication, a congested airspace in the approach to SKRG gave an obvious connotation of delay in this approach phase which the crew had not foreseen.

On several occasions (02:33:09 hrs. - 02:40:17 hrs.), the aircraft was instructed by the ATC to proceed to a holding pattern on Rionegro VOR, with the information collected by the crew, without any observation or objection despite the fact that as explained the aircraft was flying in a low fuel condition.

At the low fuel level indication point, flight CP 2933 was approximately 180 nm from SKRG. According to FDR records, at 02:15:47 hrs., a low level indication was shown, and at 02:45:03 hrs, the aircraft reached the GEMLI position giving a total flight of 29 minutes, 16 seconds and a journey of 169 nm, from the indication of low fuel level to GEMLI.

From the start of the holding pattern at GEMLI (02:45:03 hrs.) due air traffic delays until the beginning of the shutdown of the engines (02:53:45 hrs. - engine No.3), it took 08 minutes and 42 seconds, and the plane traveled 44 nm.

All the above means that the CP 2933 flight traveled a total of 213 nm from the low fuel level warning until the engines shut off.

On the other hand, from the GEMLI position to the threshold of the SKRG runway 01, there is a distance of 16.30 nm. This means that, if the crew had let known the ATC of the precarious situation of fuel before arriving at GEMLI, had not perform a holding pattern and had approached directly, the remaining fuel would have been sufficient to cover the necessary distance, that is a total of 185.3 nm.

Given the alternatives in the development of the operation, with the aggravation of continuing a flight with limited fuel, it is highly probable that if there hadn`t been a delay in GEMLI, the aircraft could have reached the runway. However, it was evident the absence of criteria of the crew to continue the flight and accept a holding pattern (initially announced by the ATC on RNG VOR and then requested by the crew in GEMLI), without reporting on time the operational conditions of the low amount of fuel to the ATC, which was found with an unforeseen delay to start the approach.

When starting the approach phase to RNG VOR, the crew requested to join GEMLI and again, the crew omitted any communication of the critical fuel situation being experienced by the aircraft.

The aircraft reached GEMLI, made a holding pattern, and on the second approach at 02:49:11 hrs. reported: "... Lima Mike India two nine three three, two one zero, on approach and requested priority for the approach... We have a fuel problem ..."

This request for "priority" did not correspond to declaring "Minimum Fuel Status" or MAYDAY for fuel as indicated in Annex 6 of ICAO; at this moment, more than 13 minutes had passed since the ATC of Bogotá (02:33:09 hrs.), had instructed the crew that they should proceed to a holding pattern on RNG VOR.

The ATC announced to CP 2933 that it would provide vectors and communicated a seven-minute (7) estimate to begin the approach. Faced with this instruction, which denoted a considerable delay for the flight, under these conditions, the crew members contacted at 02:50:00 hrs.: "... I will be attentive for the vectors Lima Mike India two nine three three ...", showing a passive condition on the part of the crew before such a critical situation.

Later, during the third holding pattern at GEMLI, the crew finally reported their emergency condition at 02:52:26 hrs: "... We are in a fuel emergency ... that's why I am requesting final course ...". This communication was not made according to the wording contained in the ICAO Annex 4 Regulation.

According to the regulation of Annex 6 of the ICAO, numeral 4.3.7.2.3:

> *"…The pilot-in-command shall declare a situation of fuel emergency by broadcasting MAYDAY, MAYDAY, MAYDAY, FUEL, when the calculated usable fuel predicted to be available upon landing at the nearest aerodrome where a safe landing can be made is less than the planned final reserve fuel…"*

Obviously, at no time did the crew declare MAYDAY MAYDAY MAYDAY, FUEL in the frequency. This situation could be directly related to a previously identified finding during the proficiency checks made to the crew.

The pilot had the observation in his proficiency check *"to improve coordination in the cockpit / CRM" and in "... clearly define the control of the aircraft and communications, who does what ..." - "... take the necessary time to prepare the aircraft for an emergency ..."*

The co-pilot, in turn, was made the following observation in his proficiency check: *"The configuretions on approach must be more precise" - "... Communication with the ATC in emergencies must be specific (PAN PAN or MAYDAY) according to the case…".*

All the observations given in the annual checks and proficiency tests (supervision) were spotted in a timely manner; however, it was evident that they were not improved, corrected or supervised, all of this led showed a permissive behavior during a flight under critical fuel conditions, the lack of a communication that was not timely, and not foresee the necessary time to prepare the aircraft for an emergency.

Within the operations analysis, taking into account the findings at the accident site and the recordings of the flight data (FDR), it was determined that the crew configured the aircraft prematurely, with an extended landing gear (02:53:24 hrs.) and 33 ° of flaps (02:54:36 hrs.) before the engines shut off.

This operational situation greatly affected aerodynamics and critically penalized the aircraft's gliding factor as there was an aerodynamic increase in drag which contributed to the abrupt loss of altitude in the last leg of the flight.

Similarly, taking into account the evidence of the occupants surviving the accident, the corresponding calls were not made by the cabin crew to get cabin ready before an imminent fuel starvation and emergency descent.

It was clear from the findings gathered during the investigation that the crew performed a flight with limited fuel and that noticing the operational situation, did not declare the situation in sufficient time to the ATC.

Another evident noncompliance to the planned operational procedures was verified in the last (3) flights made to the Viru Viru SLVR aerodrome on August 23, October 30 and November 5, 2016. As evidenced, the aircraft CP2933 had planned SLCO as destination aerodrome; however, in all these above mentioned flights the crew did not land in Cobija SLCO and continued the operation towards Viru Viru SLVR which corresponded in the flight plans to the alternate aerodrome.

When the crew decided to proceed to the alternate airport, it is likely that they were not complying with the minimum fuel required.

2.2 Operational procedures according to the CVR analysis

During the course of the flight, arguments in the cockpit about fuel management were evident in the CVR recordings in relation to fuel optimization during the cruise phase.

At 23:34:43 hrs., located in the North of Bolivia in the vicinity of the border, the crew assured that the SLCO airport was a safeguard to refuel which is why they had this refueling option since the beginning of the flight.

At 00:37:52 hrs.107 nm before entering Colombian airspace, the crew members learned about the fuel insufficiency situation commenting: *"... this thing is screwed ..."*. There, at this point they thought about the possibility of entering Leticia and Bogotá. Finally, the decision of the crew was to proceed to Bogota.

After contacting ACC BOG, instructions were given to CP 2933: *"... Lima Mike India two nine three three received you are in radar contact flight level three zero zero, I confirm your route is authorized to proceed to Rionegro via ARUXA, PABÓN, BOGOTÁ, BOGOTÁ NIRSO, NIRSO RIONEGRO…"*. After this instruction from the ATC, the pilot commented on the CVR recordings at 00:51:22 hrs: *"... they are already directing us brother ..."*.

Faced with an evident deficiency in the management of the fuel during the flight, with evident comments on the matter, the ATC instruction probably generated an excess of confidence in the crew knowing that the route would be shortened at some points. This situation was known in the recordings when at 00:56:21 hrs., on the CAM channel, they

asked the pilot: *"... are not you going to go down to Bogotá? ..."* to which the pilot replies: *" …no …"*.

At 01:01:21 during the recordings, the calm and safety of the crew were more evident, despite the situation when the pilot affirms: *"... the good thing is to take the decisions calmly, we analyzed it, we already saw it …"*; to which the pilot responds: *"... we have already analyzed it, we have already seen it ..."*.

After the completion of the CVR recording at 01:15:03 hrs., within the operational procedures, it was learned that the crew requested a holding pattern at RNAV GEMLI position. Within the Operational Specifications (OPSPECS), the company did not have PBN approval so the flight had to be carried out under the rules of conventional navigation.

Likewise, it is evident, after listening to the communications the crew members had with the ATC, that the crew did not use the standard phraseology and the procedures that are used to declare "minimum fuel status" or the one of "MAYDAY MAYDAY MAYDAY" due to an emergency. The priority request was used by the crew at (02:49:11 hrs.) and at 02:56:26 hrs., declaring fuel emergency.

2.3 Qualification of the crew members and others

It is noteworthy that, English is the official language internationally required for the operation of aircraft worldwide and so must be specified individually in the license issued by the Aviation Authority. Regarding the crew of flight CP 2933, it was evident that the control and oversight over the documentation required to carry out international flights, had an apparent flaw because the pilot had an expired language proficiency license and, the crew member who fulfilled co-pilot duties did not have a valid language proficiency license (English), which is an indispensable requirement for international flights since in this case, an airspace that did not handle the Spanish language was flown.

In the cockpit (jumpseat) there was a person who was neither a passenger nor a crew member; However, due to the evidence found at the accident site, it was determined that the occupant was a pilot, but he did not work as such for the company. Neither was it possible to determine the reason why he was on board and, also, the functions he performed, even though he was included in the "General Declaration" as co-pilot without being one; However, in the CVR recording it was established that he was indeed there in the development of the flight and he even had the opportunity to ask the pilots about the fuel status.

2.4 Aircraft and maintenance logbooks

The records evidenced in the maintenance logbooks of the company left reasonable doubts in the sense that what was recorded there, did not correspond to reality. These doubts are based on the fact that no type of fault report or corrective action was found on the aircraft over a long period of time nor was the supply note of the oils added to the engines and the APU evident., this situation demonstrates poor procedures and lack of quality control in the company.

In addition to the foregoing, in the passenger cabin report logbook, a report was found that was never answered as "corrected" or "deferred" and did not have the signature of a maintenance technician; being this a requirement for the operation of any aircraft, because for the day of the accident, there was no certainty that the toilet of the aircraft CP 2933 was operative, considering a long haul flight with 77 passengers on board.

2.5 Operational Manual

As it was evidenced, the aircraft had not approved in its OPSPECS some operations such as RVSM and PBN, among others; and even before this situation, the crew affirmed the ATC that the aircraft was authorized to fly in RVSM airspace, and in addition, requested to perform a holding pattern at RNAV GEMLI. When carrying out a detailed study of the documents approved by the Bolivian Authority it was found that the Manuals and approvals were changed by the company, informally and quickly, at the request or need of the operator; however, this did not mean that they were really certified for that purpose.

2.6 Fuel management

During the investigation, it was determined that, in Bolivia, all aircraft that make flights between airports in that country, i.e. regional or national, and that have Bolivian State registration identified as CP are granted a subsidy in the value of fuel[37]; and on the contrary, if these CP aircraft, carry out international flights, they do not have the aforementioned benefit or subsidy.

In the refueling carried out to aircraft CP2339, at SLVR, the fuel subsidy was applied, based on the information that it would make a stopover in another national airport, at SLCO, and that there would be another refueling of an international flight; that is, in such a situation, the greatest amount of fuel to be used in the international flight was already in the tanks of the aircraft, since it had been replenished at the airport of origin.

But the plan to proceed to SLCO was canceled by the crew, and already when the fuel had been supplied, the crew decided to proceed directly to Colombia since the SLCO airport would be closed for operations at the time the aircraft estimated to arrive there.

The planned amount of fuel initially to make the flight from SLVR to SKRG, required a technical stopover at an airport on or near the selected route, with the sole purpose of replenishing the aircraft with more fuel and being able to comply with regulations and approvals that the company had in the Operation Specifications and thus safely end the flight to SKRG.

The flight was initially planned like this:

Origin:	SLVR (Viru Viru), Bolivia.
Initial destination:	SLCO (Cobija), Bolivia. (Technical Scale/Refueling).
Final destination:	SKRG (Rionegro), Colombia.

[37] Decreto Supremo N° 28932 - Estado Plurinacional de Bolivia

The handling of fuel was made based on the aforementioned subsidy so that the tanks were filled to their maximum capacity, although it was not necessary since this first leg of the flight did not require such a quantity of fuel. Upon landing at the initial destination airport (SLCO), the missing fuel would be added to replenish the tanks and thus resume the flight from the initial destination, SLCO, to the final destination, SKRG.

However, due to the delay in the departure of the flight and according to the actual departure time of SLVR, the initial plan was not fulfilled because SLCO airport (Cobija), located in the extreme north of Bolivia and close to the border with Brazil, it would be closed for operations and no coordination had been made for the extension of the operation of the airport by the company. Because of this, the initial planning was changed and the decision was made to carry out the direct flight without stopovers.

According to the recordings of the voice recordings in the cockpit, during the development of the flight the crew tried to optimize fuel consumption and at some point they even considered using the Eldorado International Airport of Bogotá (SKBO) as an alternate airport en route to carry out refueling. In the same way it was evidenced that the crew was aware that the fuel was not enough to reach the final destination (SKRG). Likewise, from the comments made by the crew about the enroute airports, their capacities and conditions, it can be deduced that there was no adequate planning of the flight and that the crew did not know the data and information that would support the operation.

When entering Colombian airspace, conditions became increasingly critical in terms of consumption and remaining fuel; however, the ACC instructed the crew to fly directly to the NIRSO position, located 38 NM south of the RNG VOR; This clearance to fly directly to the airport of destination opened for the crew the possibility of saving some fuel, and generated an excess of confidence that made them forget the possibility of proceeding to SKBO as an alternate airport enroute. However, the flight continued, as it had started with an insufficient amount of fuel which did not meet the amount needed to proceed to the alternate airport, neither with the reserve fuel nor with the contingency fuel.

The lack of compliance with fuel policies by the company and its mismanagement by crews not only was evidenced by this accident. An operational deficiency in this regard had previously been identified, when in September 2015, the SAFA made an annotation to the company in this regard. This shows a "standard deviation" by the company in terms of fuel policy which was not corrected or supervised over time, making this practice a latent risk within the operation.

As part of the investigation carried out, the flight record of aircraft CP 2933 was inspected. It was verified that it had flown on the Cobija (SLCO) - Barranquilla (SKBQ) route on October 18, 2016. On the aircraft logbook No 000105 corresponding to that date, a flight time of 03:59 hrs., was recorded, a block time of 04:09 hrs. and fuel consumption of 7,800 kilos. A fuel supply of 8,800 kg was indicated at the beginning of the flight, with a TOW of e 40,000 kilos, and a remnant of 1,000 kg of fuel at the end of it.

This amount of fuel did not meet the minimum required to proceed to an alternate airport located 30 minutes away, (approximately 900 Kg), plus reserve fuel for 30 minutes

(approximately 750 kg), plus contingency fuel (780) Kg), plus the minimum landing fuel not included in the Operations Manual. That is, at the time of shutting down engines, the aircraft had to have approximately 2400 kg of fuel on board.

2.6.1 Fuel consumption

An analysis of fuel consumption was made on the way from Santa Cruz, Bolivia (SLVR) to Medellin, Colombia (SKRG) in order to establish the capacity of the aircraft for this type of long-distance charter flights.

Three possible scenarios were evaluated, on the amount of fuel needed, supplied and used on the flight, using the information sent by the operator to the flight planning company (Flight Plan Ref. 3078), the provisions contained in the Operations Manual of the company and the information provided by the FDR data.

The values assumed for the 3 scenarios were:

Subject		Value	Reference
Route length		1611 nm	Flight plan Ref. 3078
Flight level		30,000ft	Flight plan Ref. 3078
Cruise conditions		Long range and 380kts TAS	Flight plan Ref. 3078
En-route conditions		ISA +14°, 10 kt Headwind	Flight plan Ref. 3078
Weights	**Operational Empty Weight**	25,884kg	Operator documentation on the aircraft description and conditions.
	Passengers	6,205kg	80 Kg/pax + 5kg/hand luggage Ref: Operational Manual LAMIA, Part A, Chap. 9.
	Luggage	1026Kg	According BOA Load datasheet

Other values assumed were the following:

- ISA +15 en-route temperature
- 10 kt headwind
- Start and taxi out fuel ■ = 200kg as per company SOP
- Approach and Landing Fuel ▲ = 143kg according FCOM
- Hold fuel (Final reserve) for 30 minutes at 1,500 feer AGL
- 10% Fuel contingency as per company SOP ⬣ = estimated as 899Kg
- Diversion to the alternate SKRG-SKBO, 126nm away at an altitude of 20, after initial approach to SKRG.

Scenario 1 – Actual fuel calculation according to flight plan 3078

This calculation was made to coincide with the flight plan prepared by the company prior to the flight (Flight Plan Ref. 3078), that is, counting only the fuel needed to fly from the origin to the destination, without considering alternate airport, fuel reserve or contingency.

Using the fuel planning information contained within the FCOM, the weight of the aircraft without fuel (ZFW + PAX + LUGGAGE) was obtained:

Item	Weight (kg.)
Operational Empty Weight	25,844
Passengers	6,205
Luggage	1,026
Total Zero Fuel Weight	**33,075**

For 10 kt headwind, the FCOM V2 Chapter 2, Item 3, page 4 was used, and thus to get equivalent still air distance. The result was that the aircraft would have fuel to fly 1,657 nm. The planned distance was 1,611nm.

For Long Range, the FCOM Chapter 2, Topic 4, pages 144, 146 was used; interpolation for temperature, altitude and arrival weight provides the following:

- Fuel required: 8,937 Kg
- Time required: 272 minutes

The total weight of the aircraft with this configuretion was 42.012 Kg, that is, 212 Kg above the MTOW.

Scenario 2 – Calculation of fuel according to the company's Operations Manual

In this scenario, the required fuel was calculated, including fuel for recommended reserves, diversion and holding pattern according to the company's Operations Manual.

In the fuel policies, the Operator did not consider the minimum landing fuel.

The fuel for the phases of flight, climb, cruise and descent was established from the detailed information of the FCOM, assuming ISA +15 and wind against:

Fuel phase	Weight (kg.)	Time (min)
Climb	1733	32
Cruise	7114	215
Descent	140	13
TOTAL	8986	260

The fuel required for holding according to FCOM V2-009B Chapter 2, Item 5, page 1 was calculated, provides a value of = 744 Kg for 30 min.

The fuel required for diversion to the alternate aerodrome according to FCOM V2-009B Chapter 2, Item 6, pages 4, 5, was calculated, provides a value of ● = 937 Kg of diversion fuel and 27min.

In this way, the total fuel required was calculated according to the Company's Operations Manual, including fuel reserve, and without the minimum landing fuel, not included in its Manual, as follows:

Fuel to	Weight (kg.)	Time
Final approach and landing	143 ▲	5min
10% sector contingency	899 ⬢	0min
30 minutes to hold	744 ◣	30min
Diversion to alternate	937 ●	27min
Approach before diversion	143 ▲	5min
Total Climb, Cruise, Descent	8986 ◆	260min
Taxi before take-off	200 ▮	0min
TOTAL	**12052**	**327min**

Trip Zero Fuel Weight is ▮ 33,075 kg, which equates to a Take-off Weight of 45,127Kg for the trip, once the required fuel was supplied.

This weight is greater than the maximum takeoff weight (MTOW) certified corresponding to 41,800 kg; it would be exceeded by 3.327 kg. And, on the other hand, the total calculated weight of the fuel, 12,052 kg exceeds the maximum total allowable fuel capacity for the aircraft (9,362 kg).

Scenario 3 – Actual fuel consumption according to FDR data

The FDR data was analyzed to calculate fuel consumption for the whole flight until the FDR stopped registering parameters. The initial review identified that the FDR parameters were recording the expected values in the cruise phase condition within the minimum variations due to the flight conditions.

The FCOM contemplates a value of fuel consumption per engine, of 1000 lb. / hr. (453.59kg / hr.); and FDR data indicated that engine consumption was 1066 lb. / hr. (456.52kg / hr.) under the following conditions: long range cruising according to FCOM, FDR data = IAS 236 kt, SAT -6 ° C, altitude 27000ft and N1 86.5%.

It is necessary to consider that this difference in consumption between that contemplated in the FCOM and that registered in the FDR is probably due to the uncertainty about the real weight of the aircraft, some small inaccuracy of the FDR data and variations in atmospheric and flight conditions.

The analysis carried out under this scenario showed that the total fuel consumption from the start-up of the engines until the end of the FDR recording was 20,011 lbs. (9,076.83 kg), which coincides with the total amount on board, once that the aircraft was refueled at SLVR.

The analysis of these three scenarios leads us to conclude that the flight required a minimum quantity of 12,052 kg of fuel to fly directly between SLVR and SKRG, complying with all the parameters established in the FCOM and by international standards for the class of flight that it was done. The required amount exceeded the capacity of the aircraft tanks by 3,327 kg. Therefore, the flight had to be planned, and carried out with an intermediate point of refueling.

The airplane started the flight with 9,073 kg of fuel; figure lower in 2,979 kg, to the minimum amount required for the flight.

All fuel on board was consumed on the flight, according to the information obtained from the FDR.

The aircraft was always well below the amount of fuel required to arrive safely and comply with regulations to its destination; there was no fuel saving in flight that would allow such a situation.

2.7 Air traffic management

The LMI 2933 flight took off from the Viru Viru airport in Santa Cruz de la Sierra, Bolivia (SLVR) to the José Maria Córdova airport in Rionegro, Colombia (SKRG). The aircraft, an RJ85, entered the Colombian airspace at 00:48 hrs. by ARUXA FIX, located north of Leticia (Colombia), with FL 300 (route RNAV UL-417) according to the submitted Flight Plan, and It was authorized by the Bogota Control Center SE sector, to fly to the destination aerodrome via ARUXA, PABON, VOR / BOG, NIRSO and VOR / RNG.

Approximately 18 minutes after entering Colombian airspace, CP 2933 requested the sector of SE area of Bogota ACC deviation to the left of the trajectory due to bad weather, being cleared to proceed according to the request and after overcoming the bad time was authorized to fly directly to FIX NIRSO, a point located within the terminal area of Medellín that would connect it to the VOR / RNG and the approach procedure to the IFR runway that served the Jose Maria Cordova Airport of Rionegro.

The trajectory finally followed by the flight LMI 2933, led it to fly from the PABON FIX direct to the NIRSO FIX, as could be verified in the radar video registers. The aircraft entered the terminal area of Bogotá diverted 30 nm southwest of the route initially authorized by the ATC, with a direct route to the FIX NIRSO.

After verifying the distance traveled by the LMI 2933 flight in the Colombian airspace, it was evidenced that the aircraft transited a total of approximately 659 nm to the GEMLI FIX, point where the holding pattern started, in vicinities of the VOR / RNG.

As it was mentioned in the history of the flight, being 02:10:07 hrs., another aircraft had requested the deviation to SKRG (flight: VVC8170), due to an indication of probable fuel leak, which for that moment did not demand special treatment, according to stated by the crew to the NW sector of the ACC.

At 02:29:50 hrs., the Medellin approach sector gave priority to the landing of flight VVC8170 and for that moment, flight LMI 2933 was overflying lateral to VOR Bogotá, maintaining flight level 300. In this position, flight LMI2933 was cleared to contact NW sector of the upper area of the Bogotá ACC to continue its flight to the SKRG airport. Four minutes later, at 02:33:02 hrs., when it was at 68 nm of the RNG VOR, CP 2933 requested to start the descent and was authorized to descend to FL 250 with permission limit to holding pattern of Rionegro VOR, clearance was read back by the crew of flight LMI2933.

As evidenced in the findings, for this flight leg LMI 2933 flight was already flying in a low fuel condition, and although the ATC instructed it to proceed to a holding pattern of RNG VOR, the crew accepted the holding pattern and did not notify about its precarious fuel condition.

At 02:36:40 hrs the crew of flight LMI 2933 informed that it reached a FL 250 and that it required to continue descent, being instructed by the ATC to maintain the FL 250 and stay in the holding pattern of Rionegro, pending the issuance of the estimated time of approach, which had not been reported to ACC Bogotá by the Medellin approach control.

Again, even though the ATC instructions entailed an additional delay for its approach and landing the CP 2933, accepted the instructions and did not notify the ATC that it required to land immediately.

At 02:39:18 hrs, flight LMI 2933 was cleared by NW sector of ACC Bogota to descend to FL 240, join the holding pattern of Rionegro VOR and communicate with the Medellin approach office on frequency 121.1 MHz, control sector responsible for authorizing approach to the José María Córdova airport

At 02:40:13 hrs, when LMI 2933 flight was 24 nm south of the RNG VOR with FL 240, it contacted the Medellin approach office on frequency 121.1 MHz, a unit that reported having it on radar contact, reiterating the permit limit for Rionegro VOR holding pattern, clearance that was read back by the crew, once again, without advising the ATC its emergency condition.

Flight LMI 2933 was not informed by the Medellin approach office that the cause of the delay was due to the priority treatment that was being given to flight VVC8170, nor it was provided with an estimated approach time. At that time, flight VVC 8170, was 22 nm northwest of the RNG VOR with clearance to approach runway 01 of José María Córdova airport in Rionegro, maintaining an altitude of 16,000 feet. It should be clarified that during this situation, the ATC was unaware of the emergency condition of flight LMI 2933.

Other aircraft were under the control of the Medellin approach office, namely: flight AVA9771 (A-320) that was being incorporated from north into the holding pattern of RNG VOR through FL 220 in descent for FL 210, with an estimated time of approach of 03:05 hrs; and LAN 3020 (A-320) descending to 17,000 feet through 18,200 feet, 10 miles south of RNG VOR, bound for holding pattern with an estimated time of approach 03:00 hrs.

Additionally, flight AVA 9356 (A-320), was entering the terminal area of Medellin by the same route used by flight LMI 2933, 17 nm behind flight LMI2933, with FL 200, and that had not yet made contact with approach control. Later, aircraft AVA9356 was cleared while waiting for RNG VOR, with an estimated time of approach 03:10 hrs.
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It should be emphasized that, at this moment, the ATC was still completely unaware of the emergency situation of the LAMIA aircraft.

It was clear that LMI 2933 flight was not provided with an estimated approach time, and his turn in the approach sequence was not shown. At 02:42 hrs., the approach control cleared flight LMI 2933 to continue descent to FL 210.

At 02:43:09 hrs., when LMI 2933 flight was still en route 9 nm south of the RNG VOR maintaining FL 210, it requested and received clearance from Medellin approach control to perform holding pattern at FIX GEMLI FIX[38], located 6.3 nm south of the RNG VOR.

The reason the crew had to perform holding pattern at this point, and not at RNG VOR was not known. However, the crew lost several opportunities to report their emergency situation and request an immediate approach before initiating a holding pattern.

For that moment, LMI2933 flight entered Medellin approach sector airspace that was with a high influx of air traffic that entered RNG VOR and that in the flight situation, delays were expected on approach phase.

When aircraft CP2933 crossed GEMLI at 02:43:43 hrs.,with FL210, the other aircraft maintained 12,000 feet (VVC9170), 18000 feet (AVA9771), 17000 feet (LAN 3020), and FL200 (AVA9356) respectively.

The use of GEMLI FIX as a route holding point is only enabled as an element to fly RNAV approach and arrival procedures, but it is not enabled to be used as en route holding pattern, counting only with the RNG VOR for that purpose.

ATC cleared approach to flight VVC8170 and the next aircraft that would approach runway 01 would be flight ARE3020.

At 02:49:11 hrs., the crew of flight LMI 2933 after performing a holding pattern at GEMLI and being in the approach phase at level 210, one (1) nm south of GEMLI, finally informed ATC of the precarious situation of fuel shortage requesting priority: *"... Lima Mike India two nine three three, two one zero in approach and request priority for approach ... we have a ... a fuel problem ..."*. By this time, flight VVC 8170 was at the end of runway 01 at 5 nm from the threshold.

El ATC confirmó la solicitud de prioridad del CP 2933, y a las 02:49:49 hrs le informó: "*O.K. atento entonces le daré vectores para proceder al localizador y efectuar la aproximación se estima aproximadamente en siete minutos iniciar las aproximaciones*". A lo que el CP 2933

[38] The FIX GEMLI is published in the Colombia AIP only as an IF of the ILS Y RNAV approach procedure.

responde: *"Estaré atento para los vectores Lima Mike India dos nueve tres tres"*. La tripulación aceptó la instrucción de demora de siete (7) minutos más de vuelo para iniciar la aproximación y conociendo el entorno de alta concentración de tráfico, omitió nuevamente, declararse en emergencia.

The ATC confirmed the priority request of CP 2933, and at 02:49:49 hrs. let him know: "O.K. Please be attentive then I will give you vectors to proceed to the localizer and approach estimated in approximately seven minutes to start ". To which CP 2933 responds: "I will be attentive on vectors Lima Mike India two nine three three". The crew accepted the seven (7) more minute delay instructions to begin approach and knowing the environment of heavy traffic, omitted again, to declare an emergency.

It is likely that in this situation, there was a significant time gap in the management of air traffic to organize traffic, which was largely influenced by receiving acceptance by the crew of flight LMI2933 before the seven (7)-minute estimated approach time.

At 02:50:22 hrs, that is, one minute and eleven seconds after receiving the first request of priority from LMI 2933 flight due to a fuel problem, the Medellin approach control authorized to approach the same runway to flight ARE 3020.

At 02:52:26 hrs, that is, 3 minutes and 15 seconds after having requested priority for approach, the crew of flight LMI 2933 finally declared the emergency condition, calling: "We have a fuel emergency ... that's why we I am requesting final course "requiring to be authorized to return to the course of the runway final approach, observing the radar video record, how LMI 2933 flight was turning immediately after the notification, to the approach section.

At 02:53:29 hrs., CP 2933 reported that it was beginning the approach descent to LLZ and approach control issued permits to the aircraft that were already finishing the approach turnaround, which were now below and ahead of flight LMI 2933 in approach section so that they left holding pattern towards W maintaining levels and authorized altitudes, canceling approach clearance to LAN 3020 flight, which was reauthorized to fly towards E of the holding pattern.

At 02:55:06 CP 2933 was authorized by Medellin approach control to continue the approach: "... Lima Mike India two nine three three, seventeen seven hundred continue approach on wet runway, call VOR one zero thousand in practicable and if any ground service is required "and the crew responded:" We will confirm you for ground service and we are through one six thousand for the localizer ".

Between 02:55:32 hrs. and 02:57:10 hrs., approach control communicated with the other aircraft under its control (ARE 3020, AVA 9771, AVA 9356), so that they could return to RNG VOR holding pattern.

Subsequently, after reporting total electrical failure without fuel, at 02:57:46 hrs., the ATC reported the loss of radar identification to flight CP 2933 and at 02:58:01 hrs., the

approach control provided a vector guide to the flight in emergency assigning a course to intercept the LLZ. At 02:58:55 hrs., aircraft CP 2933 did not respond to the calls of the ATC.

After reviewing available evidence in the investigation, which was analyzed in the light of the Colombian State Regulation, Procedures and Monitoring Control Manuals in addition to documents that contain applicable national and international operational procedures, it was found that LMI 2933 flight that entered the Colombian airspace by route UL417 (ARUXA FIX) was served by Bogota ACC, applying the operational procedures as established in the Colombian Aeronautical Regulations and in the applicable operational air traffic control manual.

The control permit granted by the ACC Bogota allowed to route CP 2933 by the most direct route possible from the point of entry to the Bogota FIR to the fixed approach to the airport of intended destination and the deviations experienced by the flight on its route, were not caused by the ATC.

When comparing the proposed route within the Bogotá FIR that was documented in the FPL at the airport of origin, (662 nm) and the route finally made by the LMI flight 2933 within the Bogotá FIR, (659 nm) it was found that they were Similar.

The situation of granting priority to flight VVC8170 generated delays in the approach to SKRG to several aircraft including LMI2933, which delayed its declaration of priority and emergency, even though the crew knew about the delays.

LMI 2933 Flight went through a very particular condition; when it reported total electrical failure, following FCOM provisions V3 5.07 of the aircraft, when the power supply is lost, batteries provide power to the aircraft for navigation instruments ILS 1, VOR 1 and ADF 1. At this point, the flight crew notified flying at 9000 feet when the sector that it was flying over corresponded to a mountainous area, where only IFR flights are allowed above 11000 feet (AMA) and 10000 feet (MVA).

Even though ,there is no evidence to indicate that performing a holding pattern on GEMLI has affected operational safety or confusion on CP 2933 flight nor affected other flights that performing a holding pattern at RNG VOR , the use of the GEMLI FIX as a holding point en-route, does not comply with procedures formally authorized and published by the Colombian Civil Aviation Authority and may constitute a risk factor, considering that confusion may arise in the ATC to discriminate several aircraft that perform simultaneous holding pattern at the said point and at RNG VOR that are separated 6,3 nm.

The situation that took place on SKRG approach where delays were generated to aircraft that reached RNG VOR and the management of air traffic during the evolution of traffic, following the objectives of the air traffic control service, was not causal factor of the accident.

LMI2933 flight crew had several opportunities to notify ATC of their precarious fuel situation, and lastly, in the face of a delay in the approach to SKRG, it notified priority and

3 minutes 15 seconds the emergency, giving a very short time gap for the management of the ATC.

2.8 Cockpit Voice Recorder

In view of the fact that the Voice Recorder in the CVR cockpit did not register the whole flight, ending its operation one (1) hour, 40 minutes and 45 seconds before the cessation of the operation of the FDR, an analysis of all the information available was made to know the reason of a possible malfunction or interruption in the recording.

During the reading of the CVR, taking into account the good condition of the memory module and the connector, it was decided to connect the memory module in the test unit and download the information according to the AAIB procedure. When the lab unit was turned on and the download software was run, two error messages were produced indicating a mass erasure of the CVR.

The fact that the AAIB software has read the serial number of the unit and the 'Time elapsed since the last active mass erasure' confirmed that it was possible to communicate with the memory protected against failure.

The damaged CVR was removed and the laboratory unit was again tested; no errors were found in the test unit. It was then established that it was likely that the damaged unit had been erased in some way. AAIB contacted the manufacturer Meggitt Avionics which has the ability to recover data from the SCR-500 recorders.

The CVR SCR-500 recorded in its memory the time elapsed since the last 'massive erasure' of the recorder's audio. The memory module of the CVR was returned to the AAIB for download. The SCR-500's discharge equipment was reexamined and the standard procedure was followed successfully.

Two recordings were made; the first was the recording of 2 hours of the three channels of the crew combined in a single channel and the CAM registered as a second channel. The second recording was for the last 30 minutes of audio with the crew channels recorded on separate channels.

2.8.1 Loss of recording

There were two research areas concerned with determining the results of the loss of the CVR recording: the first, that the CVR had been intentionally erased and the second, that the CVR stopped recording in advance due to technical problems.

The ability to erase the CVR is common in modern aircraft and this is usually achieved with a switch in a cockpit panel. To prevent the CVR from being erased during the operation of the aircraft, the CVR button must be pressed for at least two seconds, the aircraft must be on ground (compressed undercarriage shock absorbers - Weight on wheels) and at least

one of the entrance or service doors must be open. Under these conditions, it seems unlikely that the CVR had been deleted during the accident flight.

It is likely that there was a technical problem with the CVR recorder that caused the loss of the recording.

2.8.2 Early end of the recording

After listening to the recordings which lasted two hours and 30 minutes, the GRIAA confirmed that the recording belonged to the accident flight. It was also determined that the recording ended just when the plane entered Colombian airspace (approximately 550 nm from destination). It could be established that the 30-minute recording coincided with the last 30 minutes of the 2-hour recording and that the 2-hour recording was in fact a continuous recording. Likewise, some of the ATC radio-telecommunications transmissions coincided with the audio recorded in the CVR. In this case, the recorder had successfully fulfilled its function of recording 2 hours of audio, but had stopped early.

There are several reasons why this may have occurred, including the loss of signal from the aircraft (loss of power supply by the circuit breaker panel or other), loss of audio signal, a loose connection between the recorder and the aircraft or a failure of the recorder itself.

This type of recorder has internal monitoring and can report when it has suffered a failure. It is unknown if during the operation of the aircraft by the operator there was an internal failure warning. No discussion was recorded by the crew about the CVR in the recording.

The recordings of the voice recorder in the cockpit worked properly until approximately 1:45 hours before impact, at which point the CVR stopped recording. In the electrical circuit board of the aircraft, it was found that the flight recorder's circuit breaker (FDR) was out of its normal operating position, that is, without power to operate; and on the other hand the circuit breaker of the voice recorder (CVR) was in the correct position, that is, energized.

However, the position in which these circuits were found did not coincide with the reality of functionality of these recorders, since the flight recorder (FDR) worked until the aircraft was energized (total electrical failure), very short time before the impact and on the contrary, the voice recorder (CVR) stopped working for long time before being in total electrical failure.

It is likely that the circuit breaker of the FDR was opened as a result of the impact or during the recovery of the corps by the personnel who accessed the accident site. The CVR stopped working 1:40 hours before it presented the total electrical failure, which would give about an hour before the low-fuel light went on. It should be noted that, according to the technical features of the equipment operation, it is not possible to erase the CVR in flight.

The reasons why the CVR ceased to recording early were unknown. Despite the tests carried out, the GRIAA could not conclude the reasons why the cabin voice recorder stopped working in advance.

2.9 Organizational aspects

The company had a General Manager and a support team consisting of approximately five people, among whom the owners were identified (Operations Director and Chief Pilot). This organization did not identify a balance between production and protection, reflected in decision making: economic, human resource management, operations planning, risk management, and commercial management.

Taking into account all the information gathered in the investigation from diverse aeronautical, state and company sources, it was evident the existence of conditions that produced errors and violations in the workplaces, both on ground and in the cockpit caused by decisions made at different levels of the organization, from its management area through the administrative area to the operational control area.

The day of the accident, there was no operational control by the company. The dispatcher was on board and from the company, there was no back up other than the indicated oversight, planning and monitoring failures.

These managerial and operational decisions as well as the conditions of the workplace (both on the ground and in the cockpit), were a result of a lack of financial resources required to guarantee this type of operation.

Thus, the company operated a non-regular international passenger flight, with a multi-engine jet aircraft, a complex operation that requires adequate risk management which had to be anticipated from the initial certification process for the company in order to grant it the AOC certificate and subsequently for the surveillance that should have been carried out during its operation as an RAB operator 121.

These conditions generated standardized deviations as part of the management policies, and their acceptance as part of the existing corporate culture with effects on operations, maintenance, and support activities that became a factor in a systemic manner contributing to the accident, evidencing great weaknesses in the defenses of the analyzed aviation system (procedures, training, technology), before and during the development of the flight of the CP 2933 aircraft.

The nonexistent defenses of the company and its degree of exposure to risk were analyzed.

Defense 1. Regulations – Procedures
The procedures used by the operator were not effective in avoiding standard deviations which generated a negative safety corporate culture in terms of lack of self-control by crews and ground support personnel.

Defense 2. Training
In relation to human performance, top management, administrative personnel, operational control and especially the crews of the company, it is clear that the training required for a safe operation was not implemented properly and was not effective to fulfill its objective to guarantee competitiveness in each working position, especially for crew personnel, in an effective decision-making process based on risk management and the increase of situational awareness and self-control.

Defense 3. Technology
This defense, almost non-existent within the administrative and operational management of the company did not prevent accepted normalized deviations within the corporate culture from being alerted and controlled in time. There was no operational follow-up of the flights from ground and there were no technological aids that provided information for a better decision making by the crews and flight oversight agencies[39].

The organization was responsible for assigning human resources and machines as well as carrying out planned activities in the existing environment. The acceptance of risks by not guaranteeing the allocation of financial, administrative and human resources represented by competent human resources (administrative staff, flight and crew support personnel), managing controlled processes (organizational factors), operating reliable machines (aircraft operated under operational and technical limits), generated organizational influence becoming a contributing factor for this accident.

The mission could simply be to fly from point A to point B, but the choice regarding time, route, fuel minimums and other conditions to reduce anticipated risks created the scenario for the events that ultimately led to the accident. Adequate defenses had to be managed in time to have managed the risks assumed, and could have avoided the accident presented.

2.9.1 Organizational Factor according to Machine-Environment Relationship

Based on the lessons learned from accidents that occurred under similar administrative and financial conditions, it can be evidenced that an international civil aviation operation was carried out operating exclusively Non-Regular, International Charter flights, under regulatory requirements RAB-121 (Medium) operating categorized aircraft as "heavy" (Machine).

Said operation did not include a regularity of itineraries, and therefore did not have sufficient economic income which would guarantee economic viability to afford robust operational control and maintenance processes that are required to operate transport category aircraft.

These economic resources were essential to ensure acceptable levels of operational safety, which, had they existed, would have prevented the occurrence of catastrophic events.

[39] RAB 121 and Annex 6 ICAO, PART I, 3.5 Flight Following

Within the specific context analyzed by the current investigation, it can be seen that the operation of the company was allowed despite its financial stability deficiencies and in its administrative processes, all of this made leadership and orientation impossible to maintain a balance between protection and production.

2.9.2 Organizational Factor according to Man-Environment Relationship

The company for flight CP 2933 and other previous flights (September 24, 2015 from Norwich England-Gran Canarias Spain, October 18, 2016 from Cobija to Barranquilla), allowed standardized deviations, the main deviation being the lack of operational control required for the type of mission (international non-scheduled flights, under regulatory requirements RAB-121), specifically in the follow-up of procedures for the control of the operation and administration of fuel without complying with international standards and recommended operational limits by the manufacturer for minimum fuel.

The process of certification and oversight on the ANS service provider was not effective; consequently, the required decision-making process in order to exert control by the ANS service provider showed weaknesses in the acceptance of the flight plan processed by the company, defense that could have also mitigated the operational risk.

Prevailing corporate culture within the human resource of the company led to those who made the decisions (management and leadership), who were always focused on fulfilling the mission to ignore risk management and its implications within civil aviation.

Monitoring and control process for international charter flights evidenced weaknesses in the control of the authorization and exhaustive verification of all the documentation for the entry of the aircraft CP 2933, interpreting in a wrong way regulations (RAC number 3.6.3.5.6), in such a way that an international charter flight was authorized without a specialized technical concept, under the idea that the requirement was applicable only for national companies.

2.9.3 Organizational Factor according to Man-Machine Relationship

The decision making by the crew and the dispatcher was inadequate during the management of flight CP 2933, without taking into account the performance of the aircraft, in terms of distance and minimum fuel requirements. This evidenced the lack of situational awareness due to absence in risk management processes and training in human factors.

2.10 Bow-tie analysis

In order to analyze probable causes that caused the accident, the Bow-tie model was used. The model consist of a hazard, an event, threats, mitigation measures, consequences and controls that prevent threats from materializing associated with the management of consequences.

A hazard is an existing factor that, if not controlled, can cause harm. An event, describes the situation in which the control of a hazard has been lost. A hazard always materializes in an event. Threats  are the avenues through which hazards  can materialize where there should be preventive controls  that should prevent the event from  happening.

Preventive controls can be regulations, practices, equipment or people with the intention of stopping the progress of the causal chain of threats before they become an event. Consequences describe the effects of an event and represent the culmination of a causal chain. Mitigation measures  in turn, have the objective of preventing or minimizing the consequences of an event  .

This model can demonstrate the way in which a systemic inherent hazard in the operation is materialized through threats, triggering in an event as well as its consequences.

In order to establish the accident causes, this tool is useful to identify systemic threats as well as preventive controls, and estimate the operation of preventive controls in a given situation.

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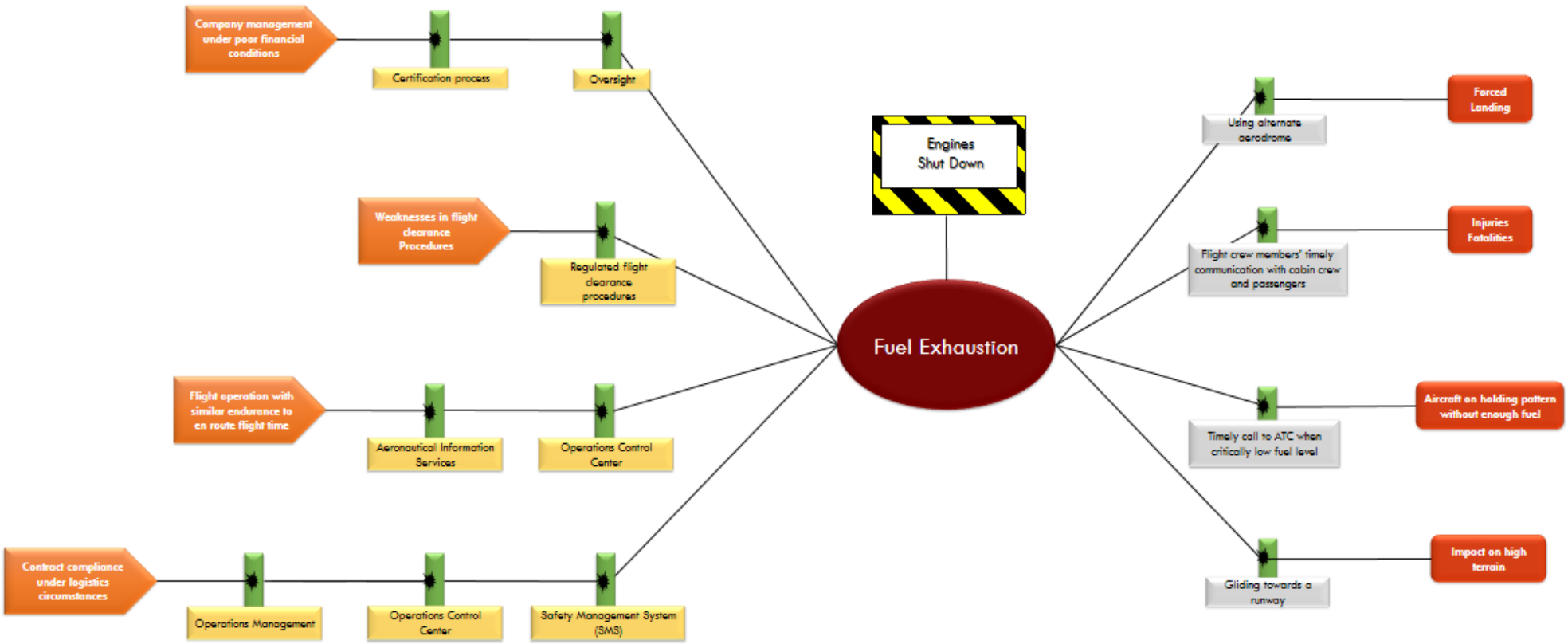


Figure 21. Bow-tie diagram applied to accident CP 2933

2.10.1 Threats and preventive controls

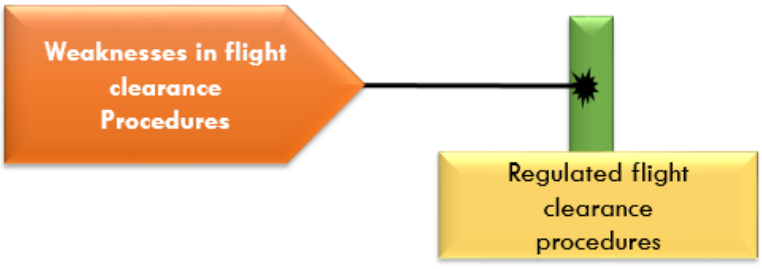
2.10.1.1 Company Management under poor financial conditions

The first identified threat corresponds to a latent operation of the company with a deficient economic situation that was evident in the later statements of the personnel and in some documents that supported the delay in the payments to the personnel of the company. This precarious situation which was latent in the organization, maintained preventive controls (defenses) that at the time had no impact to correct economic performance.

As part of the company's certification process, the company's verification had to be strengthened as an effective control not to allow the performance of multiple positions within the organization by the same individual; likewise, within the SMS manual, attention to risk management was not considered a main factor which in this case was absent in the financial side.

This threat directs the company to operate under standardized deviations that are directly related to an economic saving that, in turn, leads to neglecting another effective control, oversight, a defense so as not to materialize a threat of an event. A sample of this was a finding spotted a year ago related to inadequate fuel management by SAFA. There, the organizational symptoms of a lack of company oversight and effective compliance with the oversight plan of the Aeronautical Authority were evident.

2.10.1.2 Weaknesses in flight authorization procedures



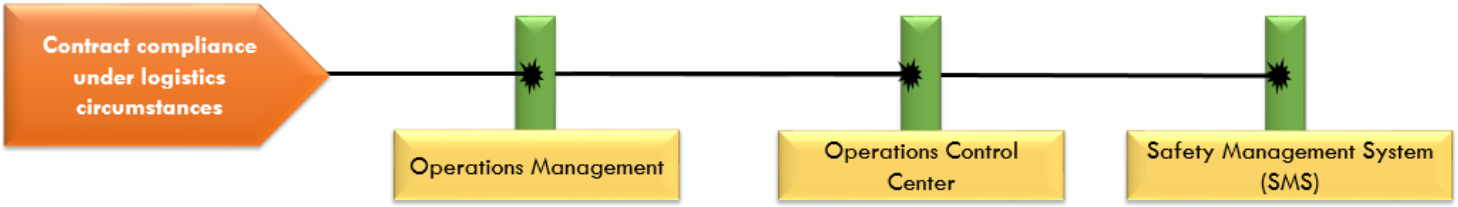
Another latent threat was related to the weakness in flight authorization procedures. Effective control for this weakness was directly related to the verification of the operating conditions of a Non-Regular flight (Charter), according to the regulations applicable in the Colombian

Regulation, RAC 3.6.3.5.6. It was evident that although the request was processed in accordance with the provisions of the regulations, the procedure presented weaknesses since an exhaustive study of the documentation provided by the company for its scheduled flight was not carried out, nor were the necessary concepts included. Strengthen flight clearance procedures and manage properly risk during the operation.

2.10.1.3 Flight operation with similar endurance to en-route flight time

The crew scheduled a flight similar endurance to en-route flight time. The effective controls to not materialize the threat constituted first, in the filter made by the ARO / AIS Aeronautical Information Service during the presentation of the flight plan, to which apparently objections were made, and which was finally accepted as they were not considered by the company. The control of the operations constituted the last barrier to not allow the evolution of the threat; however, there were weaknesses in the control of flights, prioritizing compliance with the contract and generating permissiveness on the part of the company by not evaluating the risk and executing a flight under those circumstances.

2.10.1.4 Contract compliance under logistics circumstances



The contract between the company and the soccer team was intended to carry out two flights; one between Sao Paulo (Brazil) and Medellin (Colombia) on November 28, 2016 at 2:00 p.m., and another flight on December 2, 2016 at 07:30 hrs.

Faced with the impossibility of carrying out the flight from Brazil, last-minute logistics arrangements were made by the company, which constituted a threat by neglecting organizational aspects of the operation for the fulfillment of the contract.

Given the situation, the company had a Director of Operations and a Manager who had to organize and do the planning and fulfillment of the contract under the circumstances of operation from Brazil. However, with a critical and latent situation of standard deviations, this

logistical situation was permissive and carried out at the last minute without evaluating the risks inherent in the operation.

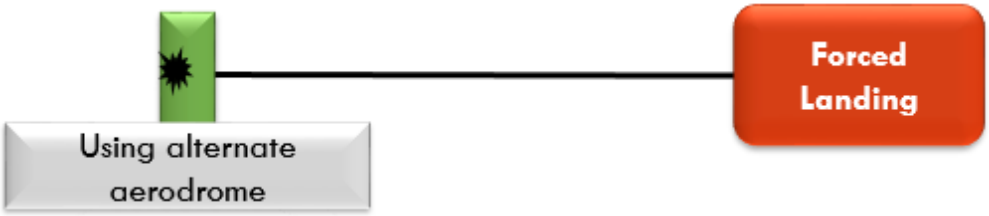
The fulfillment of the contract, under the new circumstances, required the realization of a technical stopover for fuel supply. The crew inherently had the defense mechanism to anticipate the fuel supply, and did not execute it. That was another effective control that had a direct impact to avoid the materialization of the threat.

The Operations Control Center, an area that supervised flights from ground had to foresee the provisions of the contract and plan the technical refueling stopover; however, this activity was not carried out, making the defense insufficient for the threat.

Had a mature and efficient Safety Management System been in place, the company's Operational Safety Management (SMS) would have made a timely risk management in the face of the logistical circumstances of the operation's hurry, and in this way maintain a barrier for the threat.

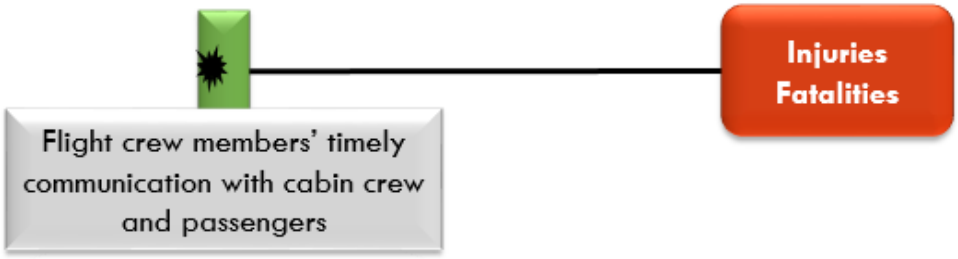
2.10.2 Mitigation measures and consequences

2.10.2.1 Use of an alternate aerodrome



In the event of an imminent exhaustion of fuel, the mitigation measure consisted in proceeding to an alternate aerodrome that would allow the refueling of the aircraft. This obstinate attitude of continuing the flight to the destination, even with a fuel system warning, 40 minutes before the accident, did not allow to prevent or mitigate the consequence of a forced landing given the conditions of a night flight, heavy traffic and the over flight on a mountainous terrain.

2.10.2.1.1 Flight crew members' timely communication with cabin crew and passenger communication during fuel exhaustion



Another preventive measure to mitigate the consequence of a hazard was the timely communication of the crew to the passengers about exhaustion fuel situation and shutdown of the engines in flight. This measure which was not carried out prevented the execution of emergency procedures in the passenger cabin before the imminent event during the flight.

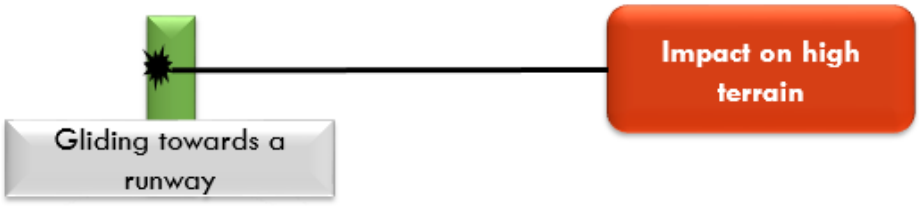
The situation of not preparing the cabin before an emergency situation on the part of the crew was a previously identified symptom in the flight checklist process by one of the crew members, to whom an annotation had been made that was directly related to the preparation of the aircraft in emergencies: *"... take the necessary time to prepare the aircraft in an emergency situation..."*.

2.10.2.2 Timely calls to the ATC in the precarious situation of low fuel level

A further defense before the imminent exhaustion of fuel in flight corresponded to the timely communication of the crew to the ATC of the situation on board. Timely communication could have allowed rapid management of the ATC so as not to maintain the approach to SKRG, however, as was evident in the investigation, on multiple occasions the crew was instructed to carry a holding pattern at RNG VOR, and the Flight crew of LMI2933 acknowledged instructions without letting the ATC know of the critical condition of low fuel level.

This situation of not making timely calls, led to the aircraft performing a holding pattern maneuver at GEMLI without sufficient fuel.

2.10.2.3 Gliding towards a runway



When the engines shut down in flight, the last mitigation measure was to carry out a gliding maneuver of the aircraft to the SKRG airport. If appropriate procedures and safety-based decision-making had been carried out, as a last measure, the aircraft's gliding could have been a mitigation measure to avoid the consequence of an impact on ground. However, the early and unnecessary configuretion of the aircraft, the traffic of other aircraft in the descent area, the environmental conditions such as flying in a mountainous terrain, at night and with inoperability of the instruments due to a lack of power supply led to the generation of a chaotic environment in the cockpit when the impact against the ground was inevitable.

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3. CONCLUSION

The conclusions, the probable causes and the contributing factors established in this report were determined according to the factual evidences and the analysis contained in the investigative process.

The conclusions, probable causes and contributing factors must not be interpreted with the aim of indicating guilt or responsibility on organizations nor individuals. The order in which the conclusions are exposed, the probable causes and the contributing factors do not represent a hierarchy or level of importance.

The present investigation is of a purely technical nature with the sole purpose of preventing future accidents.

3.1 Conclusions

The crew had their technical licenses and current medical certificates for the flight.

The pilot in command`s language proficiency certificate had expired, necessary requirement for an international flight, that would fly over a State whose language was different from the Spanish language. The co-pilot did not have a language proficiency certificate in his license.

The pilot-in-command, in his last check of proficiency, had been made the observation "improve coordination in the cockpit / CRM" and "... clearly define the control of the aircraft and communications, who does what ..." - "... take the time necessary to prepare the airplane in emergency ... ".

The co-pilot, in turn, had been made, in his language proficiency check, the following observations: "Approach configuretions must be more accurate", "Communications with ATC in emergencies must be precise l (PAN PAN or MAYDAY) according to the case ... ".

The aircraft complied with the inspection program ordered by the manufacturer. There were no systems failures or systems malfunctions before the flight. In view of the lack of records during part of the flight, and the state of the components after the accident, it was not possible to determine or rule out the occurrence of possible faults during the flight.

After the accident, it was not possible to carry out an inspection of the fuel system, due to the state of destruction in which it was left, although according to available evidence it is presumed that there was no malfunctioning of this.

The financial condition of the aircraft operator was deficient as a consequence of the lack of regularity of the flights and evident in the lack of a complete organization and delayed payments to its employees.

The organization of the aircraft operator as to operational safety was deficient, without a clearly implemented Operational Safety Management System, without risk management and

without tools that would allow adequate decision making to maintain an adequate balance between productivity and safety.

The aircraft operator did not comply with the fuel policies established in the Operations Manual, in relation to the minimum quantities to be procured for international flights.

In 2015, a SAFA (Safety Assessment of Foreign Aircraft) inspection performed on an aircraft of the Operator revealed several operational deficiencies, including inadequate fuel management.

In 2016, the Operator made a flight between Cobija (Bolivia) and Barranquilla (Colombia), with an amount of fuel lower than that required for an international flight.

In August, October and November 2016, aircraft CP2933 made three (3) flights from Rionegro (SKRG) to Viru Viru (SLVR). In these operations, according to the flight plan, the destination aerodrome corresponded to Cobija (SLCO), however, crew continued the flight to Viru Viru (SLVR) that corresponded to the alternate aerodrome. When the crew decided to continue the flight to the alternate airport, it is likely that they were not complying with the minimum fuel required.

The General Directorate of Civil Aviation, DGAC, of Bolivia had a monitoring plan for aircraft operators, planned and implemented; however, no inspection records were found in the area of operations by the DGAC of Bolivia to the aircraft operator.

The aircraft operator was hired by a Brazilian soccer team to carry out two charter flights, one between Sao Paulo (Brazil) and Rionegro (Colombia) and another between Rionegro and Chapecó (Brazil). The flight would be carried out on the Avro 146 RJ-85 aircraft with registration number 2933.

In compliance with regulations, Brazil twice denied authorization for the CP 2933 charter flight, as a foreign operator, to proceed from Brazilian territory to a third country.

The Operator, then, planned the start of the flight from the city of Santa Cruz, Bolivia, and arrangements were made for the transportation of the passengers, in another airline from Sao Paulo, Guarulhos, to Santa Cruz.

The crew that was scheduled for the flight was different from the one that had been proposed in the previous procedures.

The aircraft operator planned the direct flight from Santa Cruz to Rionegro, without stopovers, and without complying with the requirements of minimum amount of fuel to carry out an international flight, since it did not take into account the fuel required to fly to an alternate airport, the contingency fuel, the reserve fuel nor the minimum landing fuel.

The Operator managed the request of the charter flight to the Colombian Aeronautical Authority, which did not have the technical concept of the Air Safety Secretariat, nor made a

careful study of the current insurances of the aircraft which contained an exclusion clause for the operation of the aircraft in Colombia.

The CP 2339 aircraft was in the City of Cochabamba (SLCB) and, the same day of the flight to Rionegro, it was taken to Santa Cruz, to start the international flight.

When the aircraft operator submitted the flight plan from Santa Cruz – Rionegro, apparently the ARO / AIS office, noted an inconsistency, since the Estimated Time in Route (EET) was similar to the Endurance Time. This observation was not considered by the aircraft operator and the Flight Plan was accepted around 20:30 hrs.

The aircraft was supplied with 1,636 kg of fuel in Santa Cruz, for a total fuel on board of 9,073 kg. That amount was insufficient to complete the flight between Santa Cruz and Rionegro since the minimum amount should be 12,052 kg., above the aircraft's fuel capacity.

Neither the aircraft operator nor the crew made the decision to land at an airport en route to refuel and complete the minimum amount to proceed safely to the final destination.

According to the estimated calculation of weight and balance, the aircraft took off from Santa Cruz with a weight of 42,148 kg, that is, with 348 kg over the MTOW certified for the aircraft which was 41,800 kg.

There was no evidence of a copy of the weight and balance manifest at the operator's office in Santa Cruz, for the accident flight, or in the inspection of the remains after the accident.

During the development of the flight, and according to the records of the CVR, the comments of the crew about the administration of fuel were repeated in relation to the optimization of it in the cruise and descent phases and also the possibility of landing in Bogotá, Colombia, to refuel.

The aircraft flew RVSM airspace. Although the aircraft complied with the technical requirements required for this purpose, said operation had not been approved in the current operating specifications.

Bogotá`s ACC provided air traffic services in accordance with the regulatory precepts and other operational regulations applicable in the Republic of Colombia. The aforementioned control unit authorized the most direct route available from entry point of flight CP 2933 to the FIR / UTA Bogotá until its entry into the terminal area of Medellin.

The clearance given to CP 2933 by ACC Bogota to proceed directly to the NIRSO position, near the destination, motivated the crew to definitively rule out the landing in Bogota, according to the analysis of the CVR.

The CVR recording ended early, when the aircraft was about 550 nautical miles from Rionegro, 01:40 minutes before the accident. It was not possible to determine the reasons why this recording was interrupted.

When the aircraft was approximately 180 nm from RNG VOR, and approximately 40 minutes before the last FDR registration, an indication of low fuel level was evidenced. The aircraft was then 77 nm South of Bogotá and 135 nm to the East Cali airport.

The crew did not call ATC on the critical fuel condition.

Meanwhile, the ATC was serving an aircraft that had reported and solved an indication of fuel leakage, and that decided to proceed to land at Rionegro. This situation delayed approach to four aircraft that were coming to Rionegro, including CP 2933, whose fuel situation was unknown.

When CP 2933 aircraft contacted Medellin Approach Control, and was 68 nm from the RNG VOR, the ATC instructed it to proceed to hold perform a holding pattern on this navigation aid, without providing it with an Approximate Approach Time.

The crew did not call ATC on the critical fuel condition.

When the aircraft was within 24 minutes of the RNG VOR, the crew requested the ATC to perform a holding pattern at GEMLI, without alerting the ATC about the critical fuel condition.

The crew requested the ATC to fly and perform a holding pattern GEMLI RNAV; the crew did not have approval in its OSPECS to fly PBN procedures.

The aircraft joined the holding pattern at GEMLI, without alerting the ATC about the critical fuel condition.

Aircraft CP 2933 made one (1) holding pattern at GEMLI and before starting the second circuit, requested priority to approach due to fuel problems.

ATC announced that it would provide vectors to the Localizer and that the approach would begin in seven (7) minutes.

CP 2933 crew members accepted the instructions and did not declare an emergency due to fuel problems.

One minute and eleven seconds after receiving the first request from CP 2933 flight regarding priority due to a fuel problem, ATC cleared to approach another aircraft that was in a holding pattern.

The ATC requested other aircraft that were on holding pattern at RNG VOR to stay in the circuit and turn to the approach section and to CP 2933, which was performing a holding pattern at GEMLI, she told crew members to maintain course of distance southwards of the holding pattern.

During the second holding pattern at GEMLI, three minutes and fifteen seconds after the priority request, the crew of CP 2933 declared the emergency without the use of standard phraseology.

CP 2933 immediately veered to the left, towards the GEMLI approach section, and abandoned FL 210. The ATC told other aircraft to abandon the holding pattern to the West, and canceled approach clearance that had been granted.

When starting the descent, CP 2933 extended aerodynamic brakes; then at an altitude of 20,500 feet the landing gear was extended; and at approximately 18,000 feet the flaps were deployed up to 24°.

The ATC cleared CP 2933 to approach, warned crew members about wet runway and asked they needed any service. She also warned crew members about other aircraft that were ahead and below them.

Flight CP 2933 engines began to give indications of failure.

At an altitude of 19,600 feet, engine No. 3 shut down.

At an altitude of 18,876 feet, engine No. 4 shut down.

At an altitude of 17,946 feet, flight CP 2933 crew members extended full flaps.

At an altitude of 17,290 feet, engine No. 2 shut down.

At an altitude of 15,942, engine No. 1 shut down.

Seven seconds after the last engine shutdown, FDR stopped recording; at this point, the aircraft was at 15.5 nm from the threshold of runway 01 of Rionegro airport, 5.5 nm from the accident site, with CAS 115 kt, GS 142 kt and an altitude of 15,934 ft.

FDR worked properly and recorded a total of 53 hours 57 minutes and 12 seconds of data, until the aircraft power was down.

Subsequently, the crew members reported total electrical failure, without fuel, and began to repeatedly request, "vectors".

The ATC informed CP 2933 that it had lost it from the Radar signal. Flight CP 2933 reported that it was on a 360° heading; the ATC instructed the flight to turn to 010° heading, and then to 350° heading.

Upon the ATC's warning to CP 2933, that it did not have its altitude, it responded with nine thousand feet, and made a final request for "vectors". The ATC informed crew members that it was 8.2 nm from the runway.

No more calls were received from flight CP 2933 or responses to calls made by ATC.

Aircraft CP 2933 hit the southern slope of a mountainous terrain, just below the ridge of the mountain, with an approximate 310° heading. Subsequent to this impact, a trajectory of

energy dissipation was generated from the initial point of impact with a 296 ° heading which continued 140 meters downhill on the north
slope of the hill until the lower part, where most of the aircraft debris were found at a site located at 8,240 feet.

The accident occurred at 02:59 UTC on November 29, 2016, in nighttime conditions.

As a result of the accident, the aircraft was destroyed, 71 people died, and there were 6 survivors.

3.2 Probable causes

Inappropriate planning and flight execution because the amount of fuel required to fly from the airport of destination to an alternate airport nor a quantity of reserve fuel nor the contingency fuel nor the minimum fuel of landing were taken into account, these fuel quantities are required by aeronautical regulations for carrying out this type of international flight like the one made by CP 2339 aircraft.

Sequential shutdown of the four (4) engines while the aircraft was in descent performing a holding pattern at GEMLI as a result of the exhaustion of fuel on board.

An inadequate decision-making process by the aircraft operating company management as a result of a lack of operational safety assurance.

Loss of situational awareness and mistaken decision- making process by the crew who insisted on continuing a flight with an extremely limited amount of fuel. The crew was aware of the low level of remaining fuel; however, the crew members did not take the corrective actions required to land at an aerodrome and refuel, fact that would allow them to continue the flight safely.

3.3 Contributing Factors

Premature configuretion of the aircraft for landing during descent in holding pattern at GEMLI since considering the absence of thrust, this configuretion affected the plane's glide distance to Rionegro airport runway.

Latent deficiencies in the planning and execution of non-regular transportation flights by the aircraft operator related to insufficient supply of the required amount of fuel.

Specific deficiencies in the planning of the flight involved in the accident by the aircraft operator.

Lack of oversight and operational control of the flight by the Operator, it did not supervise the planning of the flight nor its execution nor it made a follow-up of the flight that would have allowed to support the crew in making decisions.

Absence of timely calls for "priority", or declaring an "emergency" or others by the aircraft crew members during the flight, and especially when fuel depletion was imminent in the descent phase and when performing a holding pattern which would have alerted air traffic services to provide the necessary support.

Organizational and operational noncompliance by the aircraft operator in the implementation of fuel management procedures, as it did not comply in practice with the approval of the Bolivian DGAC in the process of the company certification.

Delay in the approach of CP 2933 to Rionegro runway caused by its late priority request, and late emergency declaration for fuel added to heavy traffic at RNG VOR when on holding pattern.

ICAO Taxonomy

Fuel Management – FUEL

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4. SAFETY RECOMENDATIONS

The current investigation has evidenced several aspects that although they were not causal in the accident, were considered the object of safety recommendations.

TO DGAC BOLIVIA

REC. 01-201637-1

Review its policies and procedures for the surveillance of air operators, so as to ensure they are planned on the basis of a risk assessment exercise.

REC. 02-201637-1

Strengthen normal criteria on financial, operational and technical requirements, both during the certification process and in the surveillance of air operators providing transport services, whether domestic or international and whether for cargo or passengers, particularly for aircraft classified as 'large'.

REC. 03-201637-1

Strengthen regulatory criteria for inspection, certification and surveillance of international non-scheduled air charter operations in order to verify compliance with the rules, subsequent to the granting of Air Operator Certificates (AOC).

REC. 04-201637-1

Strengthen regulations on certification, inspection and monitoring of Air Navigation Services (ANS) and the extent of the resource that performs these functions.

REC. 05-201637-1

Publish a document that emphasizes air operator's strict compliance with the regulations related to the planning and administration of fuel for all types of flight, especially in relation to the minimum amount of fuel on board required to make a flight.

REC. 06-201637-1

Review the procedures for granting and control of language proficiency in the English language so that crews carrying out international flights comply with this requirement.

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TO ADMINISTRACION DE AEROPUERTOS Y SERVICIOS AUXILIARES A LA NAVEGACION AEREA DE BOLIVIA, AASANA

REC. 07-201637-1

Optimize ARO / AIS management through the implementation of a control mechanism that allows verifying flight autonomy and time in order to approve it or reject it in compliance with regulations.

Also, it should strengthen the Operations Manual and review the adequacy of the available human resources for provision and supervision of Air Navigation Services (ANS).

TO INTERNATIONAL CIVIL AVIATION ORGANIZATION - ICAO

REC. 08-201637-1

Review the Annexes to the Convention and relevant ICAO Documents and issue guidance to States in relation to financial, administrative and safety requirements which should be required of international charter operators, which are carried out on aircraft classified as 'large'.

TO COLOMBIA UAEAC

REC. 09-201637-1

Conduct a review of RAC 3.6.5.6 regulations and GSAC 2.0-12-017 procedure which deal which deal with the authorization of charter flights, with the instruction to improve and ensure compliance with legal, regulatory and operational safety by operators performing such flights.

REC.10-201637-1

Improve coordination between the Directorate of Air Navigation Services (DSNA) and the Centre for Aeronautical Studies (CEA), in order to ensure that the academic programme at the latter that is given to ATC personnel corresponds to current operational needs and similarly, to review the Manuals to ensure that they incorporate the lessons learned from this accident and other events that have already occurred involving the provision of ATS.

REC. 11-201637-1

Publish, through the Secretariat of Operational Safety and Civil Aviation a document that emphasizes to air operators the strict compliance with the regulations related to the planning and administration of fuel for all types of flights, especially those related to the minimum amount of fuel on board required to carry out a flight.

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APPENDICES

1. Cockpit Voice Recorder Transcription

Below is the transcript of the cockpit voice recorder British Aerospace Systems Equipment (BASE) / Meggitt Avionics SCR500-120, Serial number 99SRP146 installed on CP-2933 aircraft crashed in the Union, Antioquia, Colombia on November 29, 2016.

Sources description

CAM:	Sound of cockpit area microphone
HOT:	Sound or voice from audio panel from crew members in the cockpit.
RDO:	Radio transmissions of CP-2933
INT:	Aircraft intercom sound (or public announcement system)
ATC:	Air traffic control radio transmission
-1:	Voice identified as the pilot in command
-2:	Voice identified as the first officer
*:	Unintelligible
#:	Expletive
[ ]:	Editorial insertion
( ):	Questionable insertion

Note 1: Times are expressed in universal time coordinated hrs.

Note 2: Generally, only radio transmissions to and from aircraft are transcribed unless required to clarify context.

Note 3: Only the most relevant conversations of the two hours of the accident flight are transcribed.

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Time	Source	Internal Communication
23 :20 :56	HOT 2	This is critical
23 :20 :59	HOT 1	We have to climb
23 :21 :05	HOT 1	That`s to say, VILUX cross, we are intercepted, we request
23 :21 :09	HOT 1	We need 200 kilos more
23 :21 :11	HOT 2	To make it
23 :21 :12	HOT 1	To make it
23 :21 :15	HOT 1	On descent we are going to expedite
23 :21 :18	HOT 1	Save fuel
23 :21 :28	HOT 2	She must get us down to four zero to four zero, they are getting down ,they are the only ones who had it in five on climb, she must get us down.225 speed varies
23 :21 :32	HOT 1	It is ok now, now that we get in****
23 :21: 45	HOT 2	*****
23 :21: 53	HOT 1	Six three hundred, we already have four, five, six one hundred, now six three hundred.
23 :22 :02	HOT 2	We will continue struggling to see what happens.
23 :22 :05	HOT 1	****
23 :22 :09	HOT 2	Three more *** northern of different kinds***
23 :32 :19	HOT 2	Wind zero, climb speed three sixty two.
23 :34 :47	HOT 2	That was a safeguard, wasn`t it ?
23 :34: 51	HOT 2	We must pretend to get in (daytime)
23 :34 :55	HOT 1	The plans got screwed at this speed*** ,this is (our last)
23 :35 :08	HOT 2	*** it has already gone up to three seven four
23 :35 :13	HOT 2	fuel ?
23 :35 :17	CAM	(Unidentified sound)
23 :38 :36	HOT 1	This is way too slow
23 :39 :15	HOT 1	It was perfect to get into Cobija
23 :40 :05	HOT 1	We are going to climb with one hundred
23 :50 :32	RDO 2	La paz center Lamia two nine three three Rio Blanco two eight zero level continues ESBUk
23 :50 :41	ATC	Roger ,change now to one two six five Amazonic center so long
23 :50 :45	RDO 2	one two six five Amazonic center Lamia two nine three three.
23 :51 :33	RDO 2	Lamia two nine three three good evening
23 :51 :47	RDO 2	Amazonic center lima mike india two niner three three good evening
23 :52 :03	ATC	Lima mike india two niner three three Amazonic center maintain flight level two eight zero squack ident
23 :52 :11	RDO 2	two eight zero squack ident final level three zero zero.
23 :52 :19	ATC	Roger standby
23 :53 :29	ATC	Lima mike india two niner three three climb and maintain flight level three zero zero.
23 :53 :45	RDO 2	Climb flight level three zero zero.
23 :55 :21	HOT 2	we have five thousand ok ,transfer zero check
23 :55 :32	HOT 1	Check five thousand one hundred
23 :55 :41	HOT 2	We need hummm.
23 :55 :42	HOT 1	That`s why it is climbing

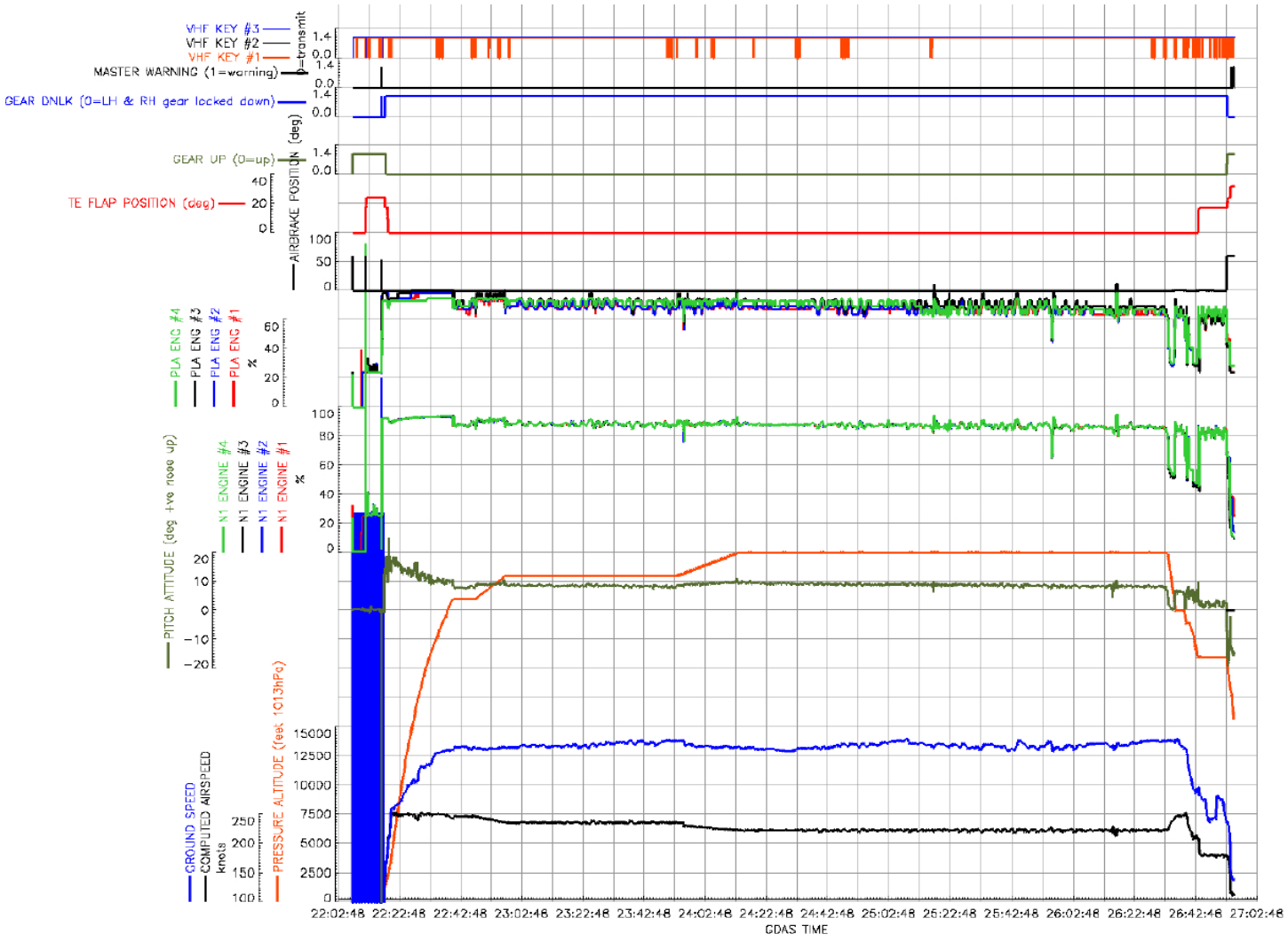
Time	Source	External Communication
23 :56 :12	CAM	Is it so to use less fuel?
23 :57 :45	HOT 2	Fuel comsumption has decreased speed ,it has gone down seventy one seven seven
23 :57 :54	HOT 1	We have decreased fuel flow to one thousand eight hundred eighty
23 :57 :56	HOT 2	*** five hundred five we are still here ,ok now
23 :59 :07	CAM	How much fuel remaining are you going to have once there ?
23 :59 :10	HOT 1	Enough fuel for twenty minutes ,no forty five minutes to the alternate airport
23 :59 :22	HOT 1	The thing is that our alternate is closer
23 :59 :40	HOT 2	Leveled up ,we are going to increase speed and we are going to make it with that consumption.
23 :59 :42	HOT 1	Calm down ,that is a good speed
00 :00 :26	RDO 2	After romeo charlies oscar is ESBUK ARTIK PUDBU TENUG DOGLO ARUXA
00 :00 :29	ATC	(roger)
00 :00 :30	HOT 1	Quite a lot of cargo, we are almost three thousand kilos cargo.
00 :01 :39	HOT 2	How did we dare to depart from La Paz with that low temperature, no #
00 :01 :47	CAM	Is it that high?
00 :02 :05	HOT 2	No wonder we have a gain of about one hundred two hundred
00 :02 :21	CAM	One hundred two Hundred what?
00 :02 :22	HOT 1	Fuel kilos
00 :02 :27	CAM	How long do we gain with that?
00 :02 :30	HOT 1	In terms of time
00 :02 :33	CAM	Because of the cargo ? or ::?
00 :02 :36	HOT 1	Because if we use two thousand at sixty ,two % by thirty ,fifteen ,in five hundred, yeah about six minutes, maybe it adds up more
00 :05 :33	ATC	Lima india two niner three three amazonic
00 :05 :37	RDO 2	Yes, ma`am ahh RSVM approved
00 :05 :52	RDO 2	Did you copy amazonic?
00 :05 :58	RDO 1	Lima india two niner three three amazonic roger.
00 :13 :14	HOT 2	One hundred for altitude and we have to increase
00 :13 :33	HOT 1	Altitude capture
00 :13 :34	HOT 2	Captured
00 :17 :45	INT	Mikey, mikey, question, How much longer is it going to take? Two hours?
00 :17 :50	HOT 1	Two hours ***
00 :17 :53	INT	Two hours thirty
00 :17 :55	HOT 1	We are experiencing strong winds
00 :18 :23	HOT 1	Tail winds
00 :18 :26	HOT 1	Not tail, critical
00 :18 :42	ATC	Lima mike india two niner three three***present position
00 :18 :52	RDO 2	After present position is pabon sierra oscar alfa Mike quebec uniform romeo november golf and sierra kilo romeo golf
00 :19 :11	ATC	Roger roger
00 :19 :30	HOT 2	This is going to be enough for one hour and a Half.
00 :32 :49	ATC	Lima mike india two niner three three change code to six three six three
00 :32 :51	RDO 2	six three six three Lima mike india two niner three three
00 :33 :11	ATC	Lima mike india two niner three three change frecuency to one two four decimal five five if unable one three four decimal one five
00 :33 :21	RDO 2	one two four decimal five five if unable one three four decimal one five Lamia eh two niner three three. Good night ***thank you
00 :33 :49	RDO 2	Amazonic lima india two niner three three good evening
00 :34 :01	ATC	Lima mike india two niner three three maintain flight level three zero zero.
00 :34 :05	RDO 2	Maintain flight level three zero zero. Lima mike india two niner three three.

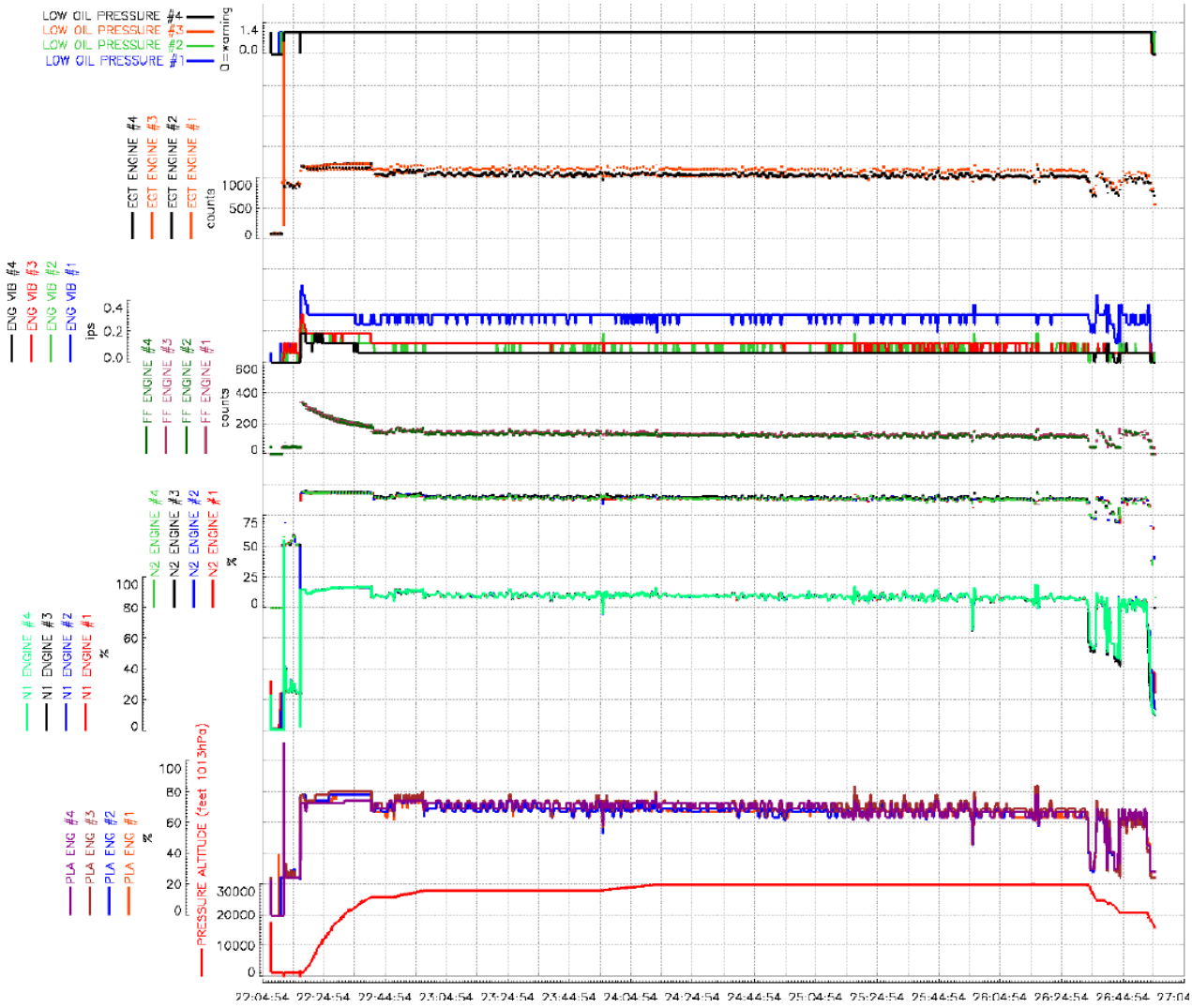
Time	Source	Internal Communication
00 :37 :52	HOT 1	This thing is screwed
00 :38 :24	HOT 2	To make it to Bogotá we have one thousand kilos
00 :38 :27	HOT 1	That is not enough.
00 :38 :59	HOT 1	What city is right before Bogotá?
00 :39 :06	HOT 2	Leticia
00 :39 :18	HOT 2	Do you think it is operative?
00 :39 :24	HOT 2	Is Leticia an international one?
00 :39 :43	CAM	(The recording is paused for about a second)
00 :39 :52	HOT 2	Now it is two thousand nine hundred, now it is two thousand nine hundred. We are inside, can`t you see? With eight hundred is quite enough, right over there we will maintain.
00 :40 :06	HOT 1	We are en route which is good since SOA is right there in Bogotá.
00 :41 :26	HOT 1	We are not paying ,it doesn`t matter.no #
00 :41 :32	HOT 1	Start this # # why me?
00 :42 :15	HOT 1	Bogota I believe, we have Cali and all that stuff at the end.
00 :44 :04	HOT 1	Do we have handling in Bogotá or stuff?
00 :44 :10	CAM	There it is ,there it is the handling
00 :44 :17	HOT 1	Do you have any frequency in your***
00 :44 :20	CAM	No
00 :44 :25	HOT 1	No, we are getting into Bogota, I believe
00 :44 :30	HOT 1	No, nothing. We can barely get it. In Bogotá we have to we have to call , we refuel and pay.
00 :44 :43	CAM	We must call Medellin first.
00 :44 :47	HOT 1	Uhhmm, ok
00 :44 :50	HOT 1	We don`t need FOB or anything like that ,there we refuel and continue our flight
00 :44 :59	HOT 1	Because right now at Leticia it makes no sense
00 :45 :03	CAM	No Leticia*** in Colombia
00 :45 :59	HOT 2	In Bogotá there are more services available.
00 :46 :13	HOT 1	No no once we get in we go straight to Bogotá.
00 :46 :25	HOT 1	Even more fuel to Bogotá
00 :46 :50	HOT 2	Let`s see one thousand, one thousand, one thousand ,one thousand five hundred, three thousand.
00 :46 :56	HOT 1	Once we reach Bogotá, we will decide whether we request holding or descent ***
00 :46 :59	HOT 2	The departing point is PABON, isn`t it? There we have to decide.
00 :47 :27	ATC	Lima mike india two niner three three Amazonic
00 :47 :36	RDO 2	Go ahead for Lima mike india two niner three three.
00 :47 :40	RDO 2	Lima mike india two niner three flight level three zero zero radar service *** two decimal.
00 :47 :49	RDO 2	Maintain flight level three zero zero and bogota center one two eight decimal eight Lima mike india two niner three three good night ma`am thank you.
00 :48 :24	HOT 2	Now, where can we fly direct to? Isn`t there a place? Via Peru there is no.
00 :48 :34	HOT 1	PABON, just give the level three zero zero and the squawk.
00 :48 :49	RDO 2	Bogota center Lima mike india two niner three three
00 :49 :04	ATC	Lima mike india two niner three three bogota center go ahead.
00 :49 :09	RDO 2	Good evening level three zero zero responding six three six
00 :49 :16	ATC	Lima mike india two niner three three roger you are on radar contact flight level three zero zero, I confirm your route is cleared, proceed to Rionegro via ARUXA, PABON BOGOTA, BOGOTA, NIRSO, NIRSO RIONEGRO.
00 :49 :57	RDO 2	Roger Lima mike india two niner three three.

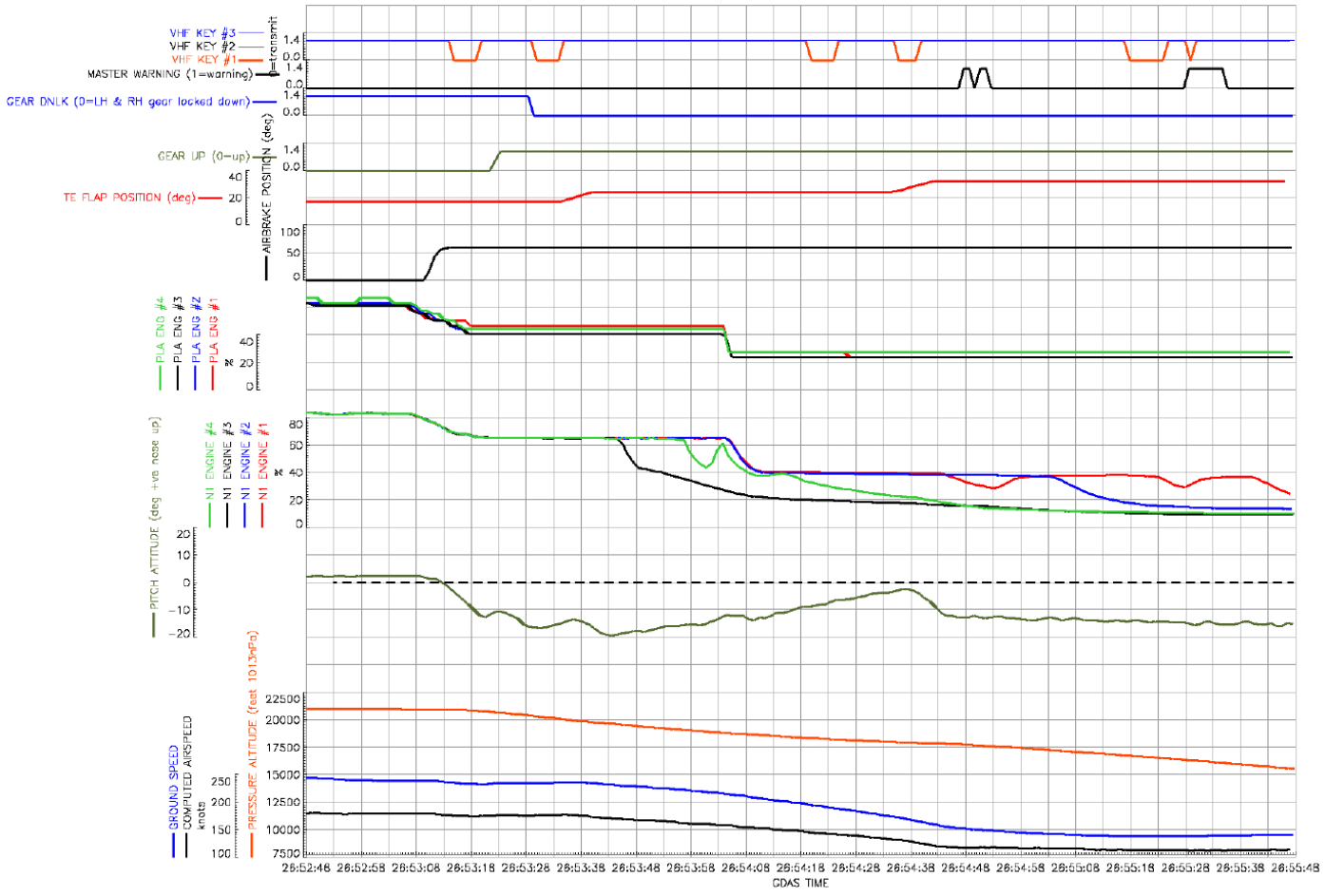
Time	Source	Internal Communication
00 :51 :05	CAM	there are two hours left
00 :51 :22	HOT 1	They are getting us direct bro.
00 :51 :27	HOT 2	Better ,uh ,which one are we suppressing ,we have to suppress some points
00 :51 :42	HOT 1	Mariquita MQU, where is MQU out, Rionegro, isn`t it? NIRSO Rionegro ok.
00 :51 :45	HOT 2	Ok NIRSO Rionegro
00 :51 :54	HOT 2	No problem ARUXA PABON NIRSO Rionegro and descent
00 :52 :03	HOT 1	Is it going to be enough for descending?
00 :52 :05	HOT 2	Ok three thousand three hundred, right. Right now we have three thousand two hundred
00 :52 :21	HOT 2	Let`s maintain then
00 :52 :22	HOT 1	Let`s maintain
00 :52 :30	HOT 1	I am going to the toilet; you are in charge of the radio. I am going to the toilet, be right back.
00 :52 :31	HOT 2	Ok
00 :54 :28	HOT 2	three thousand two hundred, one thousand three thousand one hundred three thousand two hundred, we are ok.
00 :56 :20	CAM	Aren`t we going to Bogota?
00 :56 :21	HOT 1	Hum?
00 :56 :21	CAM	Aren`t you going down to Bogota?
00 :56:22	HOT 1	No
00 :56 :41	CAM	(conversation between pilot in command and a passenger) We are far, one hour forty eight, quite windy
00 :01 :10	CAM	(End of conversation between pilot in command and a passenger)
00 :01 :21	HOT 1	It is good making decisions in a calm way, we already analyzed it, we already thought about it
00 :01 :26	HOT 1	It is good making decisions in a calm way, we already analyzed it, we already thought about it
00 :01 :33	HOT 2	We already analyzed it, we already thought about it.
00 :01 :41		Whatever***we are in seven we are going to descend as close as possible.eh?
00 :01 :43	HOT 2	There is more than one hundred, one hundred one hundred and so much on descent ok
00 :01 :50	HOT 1	Here we go five hundred six hundred
00 :01 :54	HOT 1	#Hey dude# I had no clue
00 :01 :59	HOT 2	That`s what I said #, when we made the first calculation we are not going into Bogotá.
00 :02 :00	HOT 1	no
00 :02 :10	HOT 1	Tough
00 :02 :11	CAM	What is tough?
00 :02 :14	HOT 1	Poor weather conditions, we are getting in.
01 :02 :22	CAM	Storm or rain?
01 :02 :26	HOT 1	Storm
01 :02 :59	CAM	(Crew members start approach briefing to RNG)
01 :08 :31	HOT 1	Now to save more fuel we can go directly to the most extreme point(during approach briefing)
01 :11 :15	CAM	a passenger gets into cockpit ,..is interrupted.
01 :11 :28	CAM	(passengers` voices)
01 :11 :51	CAM	The picture is without flash, that picture is not going to come out ok with flash.it is not going to come out ok but that way it is going to come out ok.
01 :11 :56	CAM	(crew members are heard setting approach phase in the flight management system)
01 :14 :57	HOT 1	If anything… if they switch me - I'm going to move (change) here ...
01 :15 :03	HOT 2	Alright…

End of recording

2. Flight Data Recorder Graphics (FDR)




LOW OIL PRESSURE #4
LOW OIL PRESSURE #3
LOW OIL PRESSURE #2
LOW OIL PRESSURE #1
0=warning
1.4
0.0
EGT ENGINE #4
EGT ENGINE #3
EGT ENGINE #2
EGT ENGINE #1
counts
1000
500
0
ENG VIB #4
ENG VIB #3
ENG VIB #2
ENG VIB #1
ips
0.4
0.2
0.0
FF ENGINE #4
FF ENGINE #3
FF ENGINE #2
FF ENGINE #1
counts
800
400
200
0
N1 ENGINE #4
N1 ENGINE #3
N1 ENGINE #2
N1 ENGINE #1
%
100
80
60
40
20
0
N2 ENGINE #4
N2 ENGINE #3
N2 ENGINE #2
N2 ENGINE #1
%
75
50
25
0
PLA ENG #4
PLA ENG #3
PLA ENG #2
PLA ENG #1
%
100
80
60
40
20
0
PRESSURE ALTITUDE (feet 1013hPa)
30000
20000
10000
0
22:04:54
22:24:54
22:44:54
23:04:54
23:24:54
23:44:54
24:04:54
24:24:54
24:44:54
25:04:54
25:24:54
25:44:54
26:04:54
26:24:54
26:44:54
27:04


VHF KEY #3
VHF KEY #2
VHF KEY #1
MASTER WARNING (1=warning)
0=transmit
GEAR DNLK (0=LH & RH gear locked down)
GEAR UP (0=up)
TE FLAP POSITION (deg)
AIRBRAKE POSITION (deg)
PLA ENG #4
PLA ENG #3
PLA ENG #2
PLA ENG #1
%
N1 ENGINE #4
N1 ENGINE #3
N1 ENGINE #2
N1 ENGINE #1
PITCH ATTITUDE (deg +vs nose up)
GROUND SPEED
COMPUTED AIRSPEED
knots
PRESSURE ALTITUDE (feet 1013hPa)
GDAS TIME

3. Flight Plan Ref. 3078

```
PLAN 3078  LMI2933      SLVR TO SKRG RJ85  LRC/F  IFR  11/28/16
NONSTOP COMPUTED 1325Z  FOR ETD 1600Z   PROGS 2806NWS  CP2933   KGS


                              LAMIA

FUEL PLAN
GROUND DIST 1611NM   AV WC M008 (342/M008) MXSH 04/TOD    AVG ISA P14
TRIP                8658  4:22  . . . .  MIN DIV      0
ROUTE RES 0PCT         0  0:00  . . . .
ALTERNATE              0  0:00  . . . .
HOLDING                0  0:00  . . . .
MIN T/O FUEL        8658  4:22  . . . .  T/O ALTERNATE:
TAXY                 200        . . . .
EXTRA                  0        . . . .  LBO 000000
TOTAL FUEL          8858        . . . .  FUEL LOADED
TAKEOFF FUEL    . . . .
USED FUEL       . . . .
REMAIN FUEL     . . . .

CAPT [redacted]            FO [redacted]       FE

DISP [redacted]            TEC.CREW . . . . . EXTRA CREW. . . . . .

ROUTE             FL300

ACTUAL WEIGHTS
TOW  32991 KG    ZFW  24233 KG    LWT  24333 KG    PL 00000 KG     PAX . . . . .

MINIMUM FUEL PLN -   8658                                TOTAL OWNERS . . . . .
FUEL CONSUMPTION - PLUS  09.0 PCT/HR/ENG
WEIGHT CHANGE P1000 KG  FP   64 KG  TRIP FUEL

ATC CLEARANCE REQUESTED

SLVR UN420 RCO UL417 PABON UQ111 SOA..MQU..RNG..SKRG

FL  300

ROUTE TO FIRST ALTERNATE

ATC CLEARANCE ISSUED
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GRIAA
GSAN-4.5-12-035

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UNIDAD ADMINISTRATIVA ESPECIAL