



AIRCRAFT ACCIDENT FINAL REPORT
AAIA# AO-20-000282

Loss of Control Ground (LOC-G)

Embraer EMB-145LR
N674RJ American/Envoy Flight 4194
Grand Bahama International Airport
Freeport, Grand Bahama, Bahamas

24th October 2020





Publishing information

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ABOUT THE AAIA

THE AIRCRAFT ACCIDENT INVESTIGATION AUTHORITY (AAIA)

The Aircraft Accident Investigation Authority (AAIA) is the independent accident investigation agency under the Bahamas Ministry of Transport & Local Government (MOT&LG) charged with the responsibility of investigating all aviation accidents and incidents in the Bahamas.

The AAIA's function is to promote and improve safety and public confidence in the aviation industry through excellence in:

- Independent investigation of aviation accidents and other safety occurrences
- Safety data recording, analysis and research
- Fostering safety awareness, knowledge and action.

The AAIA does not investigate for the purpose of apportioning blame or to provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the AAIA endeavors to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

The AAIA performs its functions in accordance with the provisions of the Aircraft Accident Investigation Authority Act, 2019 and Regulations, 2021 and the International Civil Aviation Organization (ICAO) Annex 13 and, where applicable, relevant international agreements.

The AAIA is mandated to investigate air transportation accidents and incidents, determine probable cause(s) of such accidents and incidents, issue safety recommendations, study transportation safety issues and evaluate the safety effectiveness of agencies and stakeholders involved in air transportation.

The objective of a safety investigation is to identify and reduce safety-related risk. AAIA investigations determine and communicate the safety factors related to the transport safety matter being investigated. The AAIA makes public its findings and recommendations through accident reports, safety studies, special investigation reports, safety recommendations and safety alerts.

Unless otherwise indicated, recommendations in this report are addressed to the regulatory authorities of the State having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken.

When the AAIA issues a safety recommendation, the person, organization or agency is required to provide a written response without delay. The response shall indicate whether the person, organization or agency accepts the recommendation, any reasons for not accepting part or all of the recommendation(s), and details of any proposed safety action(s) resulting from the recommendation(s) issued.



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Abstract

This report explains the accident involving an Embraer EMB-145LR aircraft, United States Registration N674RJ, operating as American/Envoy Flight 4194 under Title 14 US Code of Federal Regulations Part 121 as a scheduled commercial flight. AA4194 departed the Miami International Airport (KMIA), Miami, Florida, United States of America (USA) at 11:33 AM EDT (1533 UTC¹) with twenty-five (25) passengers and three (3) crew on board.

The aircraft landed runway 06 at the Grand Bahama International Airport (MYGF), Freeport, Grand Bahama, Bahamas at 11:56 AM EDT (1556 UTC). After touchdown, both pilots described experiencing uncommanded braking of the aircraft. Attempts to control the aircraft on the runway were unsuccessful as it veered to the right of runway centerline, eventually exiting the runway at a distance of approximately 3,715 ft. from the runway threshold. The left main gear collapsed during the event and the aircraft eventually came to rest approximately 15 ft. from the right of the runway's edge. The Loss of Control – Ground event resulted in substantial damage to the aircraft.

This investigation was done in accordance with Annex 13 to the Convention on International Civil Aviation and the Aircraft Accident Investigation Authority Act 2019 and accompanying Regulations. The investigation is intended neither to apportion blame, nor to assess individual or collective liability. Its sole objective is to draw lessons from the occurrence which may help to prevent future accidents.

Consequently, the use of this report for any purpose other than for the prevention of future accidents, could lead to erroneous conclusions.

¹ UTC - Coordinated Universal Time abbreviated to UTC, is the primary time standard by which the world regulates clocks and time. It is within about 1 second of mean solar time at 0° longitude; it does not observe daylight saving time. To convert from UTC to Eastern Daylight Time subtract 4 hours from UTC time displayed. All times in this report will refer to local time.

Aircraft Accident Investigation Authority

CONTENTS

| | |
|--------------------------------------------------------------|----|
| About the AAIA | 3 |
| The Aircraft Accident Investigation Authority (AAIA)..... | 3 |
| Executive Summary..... | 7 |
| Title..... | 8 |
| Abbreviations & terminology..... | 9 |
| Definitions | 10 |
| 1.0 Factual Information..... | 12 |
| 1.1 History of the Flight | 12 |
| 1.2 Injuries to persons | 13 |
| 1.3 Damage to Aircraft..... | 13 |
| 1.4 Other Damage | 13 |
| 1.5 Personnel Information..... | 14 |
| 1.5.1 Captain..... | 14 |
| 1.5.2 First officer | 14 |
| 1.5.3 Flight Attendant..... | 15 |
| 1.6 Aircraft Information..... | 15 |
| 1.6.1 General | 15 |
| 1.6.2 Brakes System..... | 15 |
| 1.6.3 EMERGENCY/PARKING BRAKES..... | 16 |
| 1.7 Meteorological Information | 19 |
| 1.8 Aids to Navigation | 19 |
| 1.9 Communications..... | 19 |
| 1.10 Aerodrome Information..... | 19 |
| 1.11 Flight Recorders | 21 |
| 1.12 Wreckage and Impact Information..... | 22 |
| 1.13 Medical and Pathological Information..... | 22 |
| 1.14 Fire | 22 |
| 1.15 Survival Aspect | 23 |
| 1.16 Tests and Research..... | 23 |
| 1.16.1 Brake Control Unit Test | 23 |
| 1.16.2 Parking brake valve test | 24 |
| 1.16.3 Parking brake pressure switch test | 26 |
| 1.16.4 Emergency Parking Brake handle and Cable | 26 |
| 1.17 Organizational and management information..... | 27 |
| 1.17.1 Operator | 27 |

Aircraft Accident Investigation Authority

| | |
|-------------------------------------------------------------|----|
| 1.17.2 Regulatory oversight | 28 |
| 1.18 Additional Information..... | 28 |
| 2.0 Analysis..... | 29 |
| 2.1 Braking action..... | 29 |
| 2.2 COMPONENT EXAMINATIONS..... | 29 |
| 2.2.1 Brake Control Unit | 29 |
| 2.2.2 Emergency parking brake handle and cable | 29 |
| 2.2.3 Emergency parking brake valve | 30 |
| 2.2.4 Emergency parking brake pressure switch | 30 |
| 3.0 CONCLUSIONS..... | 31 |
| 3.1 Findings..... | 31 |
| 3.2 Probable cause..... | 32 |
| 4.0 Safety Recommendations..... | 32 |
| 5.0 Appendices..... | 33 |
| Appendix A – flight data recorder readout..... | 33 |
| Appendix B – cockpit voice recorder summary..... | 39 |
| Appendix C – brake control unit test summary..... | 42 |
| Appendix D – emergency parking brake valve test report..... | 43 |

EXECUTIVE SUMMARY

On the 24th October, 2020 at approximately 12:05 PM EDT (1605 UTC), the AAIA was notified by Bahamas Air Navigation Services Authority (BANSAs), Nassau air traffic control, that an American/Envoy Embraer EMB-145LR aircraft had a runway excursion after landing at the Grand Bahama International Airport (MYGF), Freeport, Bahamas.

The scheduled commercial flight operated as American/Envoy Flight 4194 under Title 14 of the US Code of Federal Regulations Part 121. It departed the Miami International Airport (KMIA), Miami, Florida, USA at 11:33 AM (1533 UTC) with a total of twenty-five (25) passengers and three (3) crew members on board enroute to the Grand Bahama International Airport. According to the pilots, the flight was uneventful up and until the point of landing.

The aircraft landed on runway 06 at Grand Bahama International at 11:56 AM EDT (1556 UTC). Immediately upon touchdown, both pilots described experiencing an un-commanded braking of the aircraft. Attempts to control the aircraft on the centerline of the runway were unsuccessful as it veered to the right of the runway centerline, eventually exiting the runway to the right. The left main landing gear collapsed during the runway excursion event with the aircraft coming to rest approximately 15 ft. from the right of the runway's edge and a distance of approximately 3,715 ft. from the threshold of runway 06.

Passengers and crew evacuated the aircraft and Airport Crash and Fire Rescue, Emergency Medical Services and Police services responded in the aftermath. Seven (7) of the passengers and two (2) crew received minor injuries. Two passengers were transported via ambulance to hospital for medical attention. Substantial damages were documented to the aircraft's nose and left main landing gear, the underside of the fuselage (main spar), and the left wing.

Based on evidence gathered, crew statement, cockpit voice recordings and a series of component analysis conducted by the investigation team, as well as representatives of the manufacturer of the aircraft, the cause of the uncommanded braking action could not be replicated.

The probable cause of the heavy braking action which resulted in the runway excursion is undetermined.

Aircraft Accident Investigation Authority

TITLE

Registered Owner: American Airlines INC

Manufacturer: Embraer

Aircraft Type: EMB-145LR

Nationality: United States of America

Registration: N674RJ

Place of Accident: Grand Bahama International Airport, Freeport, Grand Bahama, Bahamas

Date and Time: 24th October 2020, 11:56 AM Eastern Daylight Time

Notification: CAA-B, CENIPA, FAA, ICAO, NTSB

Investigating Authority: Aircraft Accident Investigation Authority,
Ministry of Transport & Local Government

Investigator in Charge: Mr. Kendall Dorsett Jr.

**Accredited
Representatives:** Mr. Michael Hauf (NTSB) USA
Mr. Thiago Alexandre Lirio (CENIPA) (Brazil)

Technical Advisors: Mr. Michael Bauer (NTSB) – Systems Specialist
Mr. David Keenan (FAA)
Captain David Lawrence (NTSB) – Operations
Kyle Garner – (NTSB) Flight Data Recorders
Michael Portman – (NTSB) Cockpit Voice Recorders
Emily Gibson – (NTSB) Survival factors
Mr. Paulo Ribiero (Embraer)
Mr. Paulo Razaboni (Embraer)
Captain Edward Delehant – (Envoy)
Captain Brandon Courier (Airline Pilots Association)

Releasing Authority: Aircraft Accident Investigation Authority

**Date Final
Report Publication:** 18th October, 2021

Aircraft Accident Investigation Authority

ABBREVIATIONS & TERMINOLOGY

When the following terms are used in this report, they have the following meanings:

| | |
|-----------------|------------------------------------------------------------------------|
| AAIA | Aircraft Accident Investigation Authority |
| AIP | Aeronautical Information Publication |
| AGL | Above Ground Level |
| ATC | Air Traffic Control |
| BANSA | Bahamas Air Navigation Services Authority |
| CAA-B | Civil Aviation Authority Bahamas |
| CENIPA | Centro de Investgção e Prevenção de Acidentes Aeronauticos (Brazil) |
| DME | Distance Measuring Equipment |
| EDT | Eastern Daylight Time (-4 hours to convert from UTC) |
| FAA | Federal Aviation Administration (USA) |
| ICAO | International Civil Aviation Organization |
| IMC | Instrument Meteorological Condition |
| IFR | Instrument Flight Rules |
| KIAS | Knots Indicated Airspeed |
| MET | Meteorological Office / Department |
| METAR | Weather Report furnished by Meteorological Department |
| MSL | Mean Sea Level |
| NM or nm | Nautical Miles |
| NTSB | National Transportation Safety Board (USA) |
| PIC | Pilot in Command |
| RBPF | Royal Bahamas Police Force |
| USA | United States of America |
| UTC | Universal Coordinated Time |
| VFR | Visual Flight Rules |
| VMC | Visual Meteorological Conditions |
| VOR | Very High Frequency Omnidirectional Range |

DEFINITIONS

When the following terms are used in the Standards and Recommended Practices for Aircraft Accident and Incident Investigation, they have the following meaning:

Accident. An occurrence associated with the operation of an aircraft that takes place between the times any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which: a) a person is fatally or seriously injured as a result of:

— being in the aircraft, or

— direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or

— direct exposure to jet blast, except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or

b) the aircraft sustains damage or structural failure which:

— adversely affects the structural strength, performance or flight characteristics of the aircraft, and

— would normally require major repair or replacement of the affected component, except for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennas, tires, brakes, fairings, small dents or puncture holes in the aircraft skin; or

c) the aircraft is missing or is completely inaccessible.

Note 1.— For statistical uniformity only, an injury resulting in death within thirty days of the date of the accident is classified as a fatal injury by ICAO.

Note 2.— An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

Accredited representative. A person designated by a State, on the basis of his or her qualifications, for the purpose of participating in an investigation conducted by another State.

Aeronautical Information Publication. Means an official publication containing aeronautical information.

Adviser. A person appointed by a State, on the basis of his or her qualifications, for the purpose of assisting its accredited representative in an investigation.

Aircraft. Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

Causes - Actions, omissions, events, conditions, or a combination thereof, which led to the accident or incident.

Flight recorder - Any type of recorder installed in the aircraft for the purpose of complementing accident/incident investigation.

Investigation - A process conducted for the purpose of accident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and, when appropriate, the making of safety recommendations.

Investigator-in-charge - A person charged, on the basis of his or her qualifications, with the responsibility for the organization, conduct and control of an investigation.

Aircraft Accident Investigation Authority

Note - Nothing in the above definition is intended to preclude the functions of an investigator-in-charge being assigned to a commission or other body.

Operator - A person, organization or enterprise engaged in or offering to engage in an aircraft operation.

Preliminary Report - The communication used for the prompt dissemination of data obtained during the early stages of the investigation.

Risk Analysis - The use of available information to estimate the risk to individuals or populations, property or the environment, from unsafe conditions.

Risk Assessment Process - A process of risk analysis and risk evaluation to identify the estimated level of risk for each unsafe condition/underlying factor.

Safety Deficiency - An unsafe condition or underlying factor with risks for which the defences are less-than-adequate.

Safety recommendation - A proposal of the accident investigation authority of the State conducting the investigation, based on information derived from the investigation, made with the intention of preventing accidents or incidents.

State of Design - The State having jurisdiction over the organization responsible for the type design.

State of Manufacture - The State having jurisdiction over the organization responsible for the final assembly of the aircraft.

State of Occurrence - The State in the territory of which an accident or incident occurs.

State of the Operator - The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

State of Registry - The State on whose register the aircraft is entered.

Note. — In the case of the registration of aircraft of an international operating agency on other than a national basis, the States constituting the agency are jointly and severally bound to assume the obligations which, under the Chicago Convention, attach to a State of Registry. See, in this regard, the Council Resolution of 14 December 1967 on Nationality and Registration of Aircraft Operated by International Operating Agencies which can be found in Policy and Guidance Material on the Economic Regulation of International

1.0 FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On 24th October 2020, at approximately 11:56 AM EDT, (1556 UTC) an American Airlines/Envoy Embraer EMB-145LR, United States registration N674RJ, operating as flight number AA4194 was involved in a loss of control – ground event resulting in a runway excursion and landing gear collapse after experiencing uncommanded braking abnormalities upon touchdown at the Grand Bahama International Airport (MYGF)², Freeport, Grand Bahama, Bahamas. The flight departed the Miami International Airport (KMIA), Miami, Florida, USA at 11:33 AM EDT with a total of twenty-five (25) passengers and three (3) crew members on board.

According to crew interviews and statements, the airplane pushed back from the gate at KMIA about 11:01 AM EDT. The taxi time was about 32 minutes and takeoff took place at approximately 11:33 AM. The climb to a cruise altitude of 11,000 feet (ft.) mean sea level (msl) was normal. The Captain was the pilot flying (PF) and the First Officer was the pilot monitoring (PM). Miami Center Air Traffic Control (ATC) then cleared the flight to descend to 4,000 ft. msl, and advised the pilot to contact the Nassau approach control. Upon contact, the Nassau approach control further cleared the flight to descend to 2,000 ft. msl. Weather at MYGF was reported as winds from 100 degrees at 8 knots, with visibility greater than 7 statute miles, few clouds at 1,800 above ground level (agl) were reported, with scattered clouds reported at 12,000 ft. above ground level (agl). After receiving the weather, the pilots planned for an RNAV³ approach to runway 06.

About 5 miles before the final approach fix⁴ (FAF), the Captain called for flaps 9, and about two and a half miles from the FAF the Captain called for landing flaps 22. At the FAF, the Captain disengaged the autopilot and hand-flew the remainder of the approach in visual conditions. According to both pilots, the approach was normal and stable.

Upon landing, the Captain stated that he felt “unusual braking of the aircraft immediately” and the nose of the airplane was “coming down pretty fast due to the braking action.” He further stated that he corrected by pulling back on the yoke to reduce the descent of the nose. According to the pilot, the airplane began swerving left and right, as he attempted to use differential rudder pedal input. The captain further stated that the airplane then began to veer to the right of the runway, and he attempted to use left rudder input with differential braking. However, the airplane continued along that trajectory, ultimately exiting the runway, and coming to rest to the right of runway 06. The passengers and crew then evacuated the airplane via over wing exits and the main cabin door.

Passengers and crew evacuated the aircraft. Airport Crash and Fire Rescue, Emergency Medical Services and Police services responded in the aftermath. Seven (7) of the passengers and two (2) crew received minor injuries. Two passengers were transported via ambulance to hospital for medical attention. Substantial damages were documented to the aircraft’s nose and left main landing gear, the underside of the fuselage (main spar), and the left wing.

² MYGF airport code is a 4 letter unique identifier that is assigned to the airports by the International Civil Aviation Organization (ICAO).

³ RNAV or area navigation, is a method of navigation that permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

⁴ Final Approach Fix - The fix from which the final approach to an airport is executed and which identifies the beginning of the final approach segment.

1.2 INJURIES TO PERSONS

| Injuries | Crew | Passengers | Total |
|--------------|----------|------------|-----------|
| Fatal | 0 | 0 | 0 |
| Serious | 0 | 0 | 0 |
| Minor | 2 | 7 | 9 |
| None | 1 | 18 | 19 |
| TOTAL | 3 | 25 | 28 |

1.3 DAMAGE TO AIRCRAFT

Assessment of the aircraft in the aftermath of the occurrence identified substantial damages to both wings, center fuselage, and the right, left, and nose landing gears.



Below is a listing of aircraft parts that received damages as a result of the occurrence:

| Left Wing | Left Main Gear | Right Wing | Right Main Gear | Nose Gear | Fuselage |
|---------------|----------------------------|------------|----------------------------|----------------|----------------------|
| Aileron | Main Landing Gear assembly | Right Wing | Main Landing Gear assembly | Wheel Assembly | Center Belly Fairing |
| Inboard Flap | Gear Door | | Gear Door | | Aft Belly Fairing |
| Outboard Flap | Side Strut | | Side Strut | | Keel Ski |
| | Maneuvering actuator | | Maneuvering actuator | | |
| | Trunnion Bearing | | Trunnion Bearing | | |

Table 1: Damages to Aircraft

1.4 OTHER DAMAGE

Apart from damages noted in 1.3 no other damage was reported.

1.5 PERSONNEL INFORMATION

1.5.1 CAPTAIN

The Captain was 33 years old and resided in Miami Lakes, Florida. His date of hire with Envoy Air was July 3, 2017, and he was based at Miami. His background included flight instruction, and former flight deck crew in the U.S. Navy.

A review of the Federal Aviation Administration (FAA) Program Tracking and Reporting Subsystem (PTRS), Accident/Incident Data System (AIDS) and Enforcement Information System (EIS) showed no records or reports of any previous aviation accidents or incidents involving the Captain.

1.5.1.1 The Captain's Pilot Certification Record

The captain held an Airline Transport Pilot Certificate with multi-engine ratings and with limitations of circling approaches in the EMB 145 aircraft for VMC only. He also held a ground and flight instructor certificate.

1.5.1.2 The Captain's Training and Proficiency Checks Completed

The captain was hired by Envoy Airline in 2017 and upgraded to captain on the EMB-145 in 2020. His most recent recurrent training was conducted on 2 April, 2020, with the proficiency check and pilot line check conducted on 25th September, 2020.

1.5.1.3 The Captain's Flight Times

The captain had 3,103 total hours, and 1,523 total PIC time. His total time in the EMB-145 was 1,517 hours. In the last 24 hours, 30 days, 90 days and 12 months, the pilot logged 1.5, 10, 27 and 383 hours respectively on the aircraft.

1.5.2 FIRST OFFICER

The First Officer was 31 years old and resided in Oakland Park, Florida. His date of hire with Envoy Air was March 12, 2018, and he was based at Miami. Prior to his employment at Envoy Air the First Officer was a flight instructor.

A review of the FAA PTRS, AIDS and EIS database showed no records or reports of any previous aviation accidents or incidents involving the First Officer.

The First Officer was issued an airline transport pilot (ATP) certificate on the 11th May 2018 by the FAA with type rating for the EMB-145 airplane. He held a first-class medical certificate with no limitations attached. Additionally, he held a flight instructor certificate with ratings for single, multi-engine and instrument airplanes.

The First officer was hired by American/Envoy on 12th March 2018 and transitioned into the role of First Officer on 31st May 2018. At the time of the accident, he had accumulated approximately 2,388 hours of total flying time, with 887 hours on the EMB-14 as second in command (SIC).

1.5.2.1 The First Officer's flight times

The flight times documented by the pilot based on his records obtained from the airline includes, total time of 2,388 hours and PIC time of 1,416 hours. His SIC time was logged as 887 hours. His total flying time on the EMB aircraft was also documented at 887 hours, 0 of that being logged as PIC. In the last 24 hours, 30 days, 90 days and 12 months, the pilot logged 1.5, 19, 84 and 282 hours respectively on the aircraft.

1.5.3 FLIGHT ATTENDANT

The flight attendant was 72 years old. Her initial date of hire was April 6th, 1986 with American, eventually transferring into subsidiary Envoy. She flew with the company in the capacity as a flight attendant since January 2000 and completed her last recurrent training prior to the accident on the 23rd January 2020.

1.6 AIRCRAFT INFORMATION

1.6.1 GENERAL

The accident airplane was an Embraer EMB-145LR, registration number N674RJ, serial number 14500801, and was manufactured in 2004. It had an airworthiness certificate dated September 14, 2011. It was a fixed wing multiengine airplane with two Rolls Royce AE3007 SER engines, and was registered to American Airlines, Inc. in Ft. Worth, Texas. According to a review of the accident flight's dispatch release, the only deferred item on the Minimum Equipment List (MEL) was a DV (cockpit side window) pull up shade (MEL 25-14A).

1.6.2 BRAKES SYSTEM

The braking system consists of the normal brake system, emergency/parking brake system, and gear-retracting-in-flight braking. The normal brake system is supplied by hydraulic systems 1 and 2. It is electronically commanded and monitored. The emergency/parking brake system is supplied only by hydraulic system 2 and is mechanically actuated. Normal braking is controlled by the pedals. Emergency braking is controlled by the emergency/parking brake handle. Gear-retracting-in-flight braking is controlled by both hydraulic systems and by a mechanical stop within the nose gear wheel well. This braking is electronically commanded and monitored. Braking through the pedals incorporates some protections not available when using the emergency brake handle.

The normal brake system is operated by brake pedals attached to the rudder pedals. The brakes are powered by two independent hydraulic systems. It is controlled and monitored by the Brake Control Unit (BCU). The BCU receives signals from the pedal position transducers and commands the four Brake Control Valves (BCV) to modulate required pressure to the wheel brakes. BCVs 1 and 4 control the hydraulic pressure from system 1 to the outboard wheels. BCVs 2 and 3 control the hydraulic pressure from system 2 to the inboard wheels. The hydraulic system 1 and the ESS DC BUS 1 supply the main brake system for the control of the outboard wheels. The hydraulic system 2 and the ESS DC BUS 2 supply the main brake system for the control of the inboard wheels. Pressure and wheel speed transducers send signals to the BCU so that it can monitor brake performance and send the appropriate signals to the crew alerting system and other systems. The BCU also receives signals from the landing gear position and condition, air/ground situation, and hydraulic system status.

The system displays messages on the EICAS⁵ to indicate a failure in one pair of brakes or a failure in a single wheel brake (brake degraded performance). In the event of brake system failure, the BCU will shut down the affected hydraulic system through the shutoff valves. The shutoff valves are energized whenever the landing gear is extended and de-energized after landing gear retraction. Protective functions controlled by the normal braking system include anti-skid protection, locked wheel protection, and touch-down protection.

⁵ Engine-Indicating and Crew-Alerting System (EICAS) is an integrated system used in modern aircraft to provide aircraft flight crew with instrumentation and crew annunciations for aircraft engines and other systems.

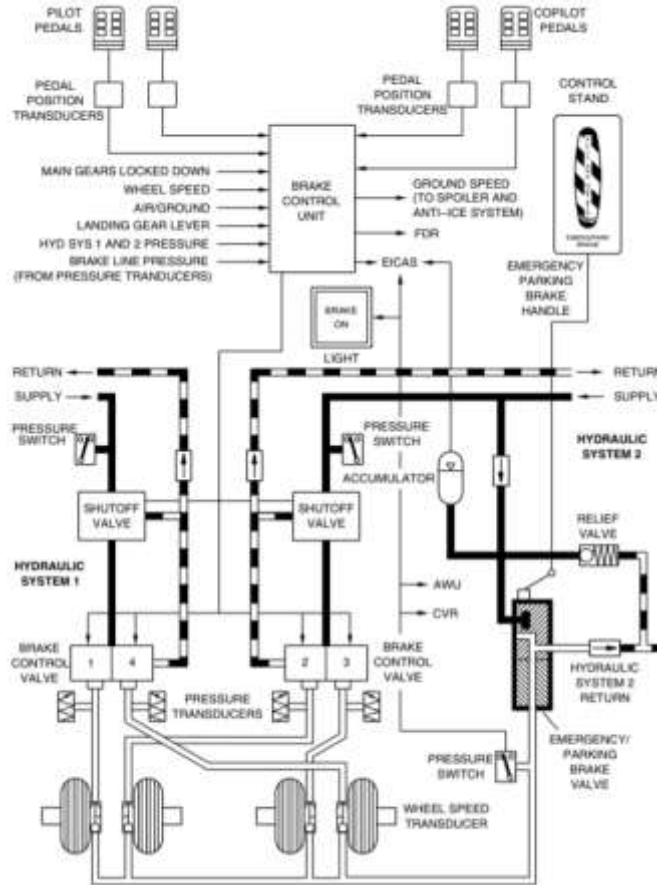


Fig.1 Brake Schematic taken from Embraer Airplane Operations Manual

1.6.3 EMERGENCY/PARKING BRAKES

The emergency/parking-brake circuit is controlled independently of the normal brake circuit. Hydraulic system 2 supplies the emergency parking-brake system. In normal conditions, the emergency/parking brake circuit has the functions of maintaining the wheels stopped while the airplane is parked.

The emergency/parking brake handle is on the left side of the control pedestal and operates the emergency/parking brake valve. Operation of the emergency/parking brake valve allows hydraulic pressure to increase and activates a pressure switch, which in turn causes the "BRAKE ON" indication lights to illuminate on the main panel and on the ramp panel. If the airplane is on the ground, and any thrust lever angle is above 60 degrees, the pressure switch will also activate an aural warning sound to alert the crew that the airplane configuration is unsuitable for takeoff.

1.6.3.1 COMPONENTS

PRESSURE ACCUMULATOR - The pressure accumulator is of the piston type with an oil chamber and a gas chamber. An isolation sliding piston with a "T" seal separates the two chambers. The accumulator has a volumetric capacity of 1,600 cc. The gas chamber connects a pressure gauge and a pressure recharging valve. When the pressure of the hydraulic system 2 is released, a check valve, on the outlet line of the accumulator, keeps it pressurized. It permits supplying the emergency/parking brake circuit.

ACCUMULATOR PRESSURE SWITCH - The accumulator pressure switch is of the sealed type. It feels the low pressure in the emergency/parking brake accumulator and operates with pressure below 2,200 psi. When it occurs, the message "EMERG BRK LO PRESS", on the EICAS, comes into view.

THERMAL RELIEF VALVE The thermal relief valve is on the right hydraulic rack. The relief valve prevents the parking brake circuit from a pressure increase. It occurs when there is a thermal expansion of the fluid contained in the pressure accumulator. The relief valve opens with a pressure above $3,700 \pm 50$ psi. The valve closes at 3,200 psi.

CHECK VALVES - One check valve on the accumulator inlet pressure line closes when the two pumps of the hydraulic system 2 are off. This condition causes a blockage of some pressure in the accumulator. The pressure in the accumulator supplies the emergency brake circuit after a complete failure of the system pressure supply. The second check valve makes sure that the pressure from the general return line does not interfere with the brake operation.

OIL DISCHARGE VALVE - The oil discharge valve interconnects the accumulator fluid chamber with the return line and this valve fully release the hydraulic accumulator. The oil discharge valve is installed in the hydraulic compartment (hydraulic system 2).

EMERGENCY/PARKING BRAKE VALVE - The emergency/parking brake valve is a spool-type valve, manually operated by a sector/cam actuator mechanism. The cam proportionally moves the spool to transmit the operating force through the piston and regulating spring. When the control cable moves 15 mm, the spool and washer cause a blockage of the return port. This permits the regulating spring to operate the sleeve. The regulating spring starts to operate. When it occurs, the spool lifts the poppet off its seat by the force transmitted through the push pin. It permits the supply pressure to pressurize the brake assembly port. At a given displacement of the sector, a specified fluid pressure is transmitted to the brake ports. The regulator spring operates when the pressure gets the correct value and keeps this pressure. The regulator spring also permits all over-pressurization to be bled to return line. This inlet port does not open to the return line. This causes the potential of the accumulator charge to increase to its maximum value in emergency conditions. When the valve is at the fully operated condition or at parking brake position, the pressure at the brake port is at pressure supply level. When the valve is at the non-operated position, the brake port is open to the return line. The emergency/parking brake valve is installed in the nose wheel well.

BRAKE APPLICATION/PRESSURE SWITCH- The outlet pressure of the emergency/parking brake operates the pressure switch when the pressure is above 150 ± 5 psi. Two "BRAKE ON" lights come on to show the emergency/parking brake condition:

- One is installed on the main panel.
- The other is installed on the ramp panel.

The takeoff aural warning system also operates with the emergency/ parking brake.

1.6.3.2 OPERATION

EMERGENCY/PARKING BRAKE CIRCUIT

The hydraulic fluid, under a pressure of 3,000 psi from hydraulic system 2, flows through the check valve. At the same time, it goes to the pressure accumulator and to the parking brake control valve. If hydraulic system 2 does not operate, the accumulator supplies the parking brake control valve. The thermal relief valve prevents the components from a too much increase of pressure, caused by thermal expansion. In normal conditions, this valve stays closed. When the emergency/parking brake handle is operated, the brake control valve connects the supply hydraulic line to the brake assemblies. When the actuation handle is released, the hydraulic fluid of the utility lines goes to the return line. At this condition, the supply inlet line closes. On the brake-control-valve utility line, the brake application/pressure switch controls relay K0212. The two "BRAKE ON" lights come on. This pressure switch also operates the takeoff aural warning system, according to the conditions of the logic block diagram. The accumulator pressure switch operates the "EMERG BRK LO PRESS" light on the "EICAS" when the pressure of the accumulator is below 2,200 psi.

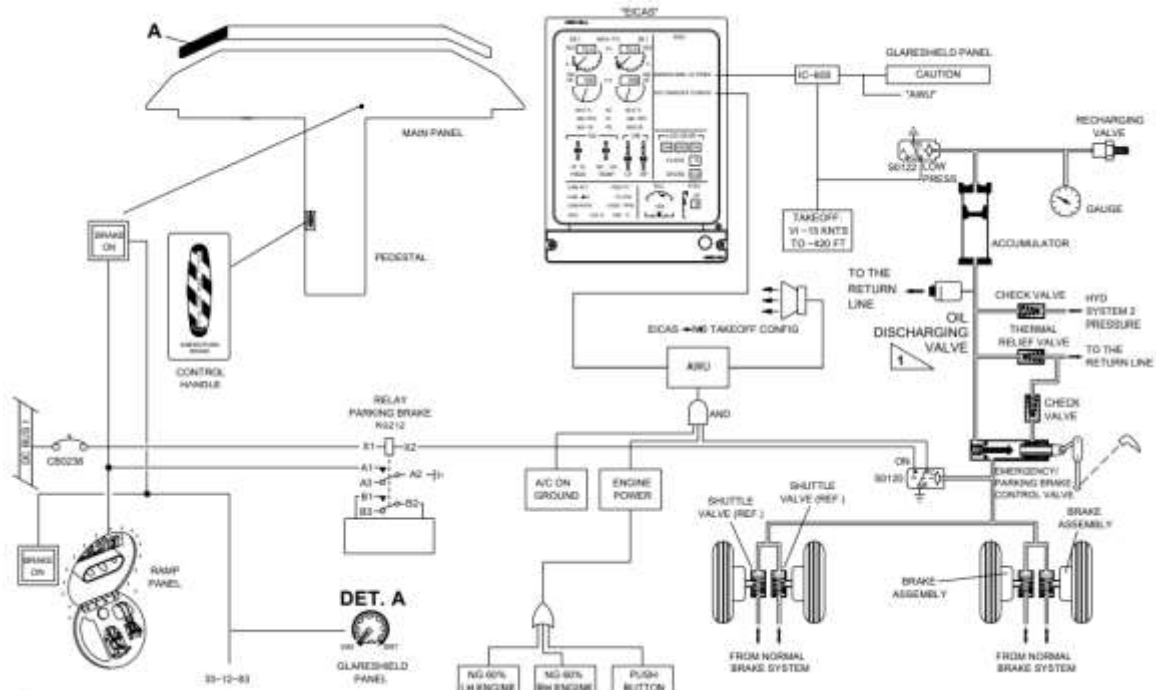


Fig.2 Emergency/Parking Brake Operation Schematic from Embraer Airplane Operating Manual



Fig. 3 Controls on center console

1.6.4 AIRCRAFT WEIGHT & BALANCE

| | |
|----------------------------------------|-------------|
| Basic Operating Weight | 28,410 lbs. |
| Passenger Weight (25) | 4,600 lbs. |
| Baggage/Cargo Weight (Shown on Form) | 830 lbs. |
| Baggage/Cargo Weight (Actual Wreckage) | Unknown |

Aircraft Accident Investigation Authority

| | |
|-----------------------------------------|-------------------|
| Zero Fuel Weight | 33,840 lbs. |
| Maximum Zero Fuel Weight | 40,564 lbs. |
| Fuel Weight | 5,700 lbs. |
| Ramp Weight | 39,540 lbs. |
| Maximum Ramp Weight | 50,044 lbs. |
| Taxi Fuel Burn | 414 lbs. |
| Actual Take-off Weight | 39,126 lbs. |
| Maximum Take-off Weight | 49,823 lbs. |
| Estimated Fuel Burn to Accident Site | 1,192 lbs. |
| Estimated Landing Weight | 37,934 lbs. |
| CG | 30 |
| CG Limits | 14-42 |
| Take-off Stab Trim | 7 |
| Take-off Flap Setting | 9 |
| Take-off Speeds s (V_1 V_R V_2) | 116/117/130 knots |
| Landing Flaps | 22 |
| V_{REF} | 128 |
| Estimated MYGF landing distance | 3,676 ft. |

1.7 METEOROLOGICAL INFORMATION

METAR⁶ issued for the Grand Bahama International Airport at 11:00 AM indicated winds from 100° at 8 knots, visibility greater than 7 statute miles, few clouds at 1,800 ft. above ground level (agl), scattered clouds at 12,000 ft. agl. Temperature was 29° C and dew point 24° C and altimeter 29.98 inches of Hg.

The weather at the time of the accident was visual meteorological conditions and deemed not a factor in this occurrence.

1.8 AIDS TO NAVIGATION

Navigational Aids were not a factor in this accident.

1.9. COMMUNICATIONS

There were no communication issues between the aircraft and Air Traffic Control facilities at Miami and Freeport, Grand Bahama.

1.10 AERODROME INFORMATION

The destination aerodrome was the Grand Bahama International Airport (ICAO Code MYGF). MYGF is situated on the island of Grand Bahama, Freeport city, within the Commonwealth of The Bahamas. The center of the airport located at coordinates 26 33 31.27 N 078 41 43.99 W at an elevation of 7 ft. AMSL. It serves as a port of entry aerodrome and is one of main gateways into The Bahamas.

The aerodrome is serviced by one runway, 06/24 surfaced with asphalt. Runway 06/24 is 10, 979 feet long and 150 feet wide. Air traffic control services are provided between the hours of 1100 – 0300 UTC and MET weather briefing available between 7:00 AM – 8:00 PMLCL. Customs and immigration processing and handling is facilitated on a 24 hr. basis (if required, upon request).

⁶ METAR or Aviation Routine Weather Report is an observation of current surface weather reported in a standard international format.

Aircraft Accident Investigation Authority

Freeport approach control is transmitted on frequency 126.500 MHz, Freeport tower on 118.500 MHz, Freeport Ground on 121.700 MHz and Freeport radio 122.300 MHz. Radio navigation and landing aids for the aerodrome include a VOR⁷/DME⁸, identifier ZFP on frequency 113.200 MHz and an Instrument Landing System⁹ (ILS) runway 06, identifier IZFP on frequency 109.700 MHz.

The Grand Bahama Airport control zone is Class D airspace extending upward from the surface to 1500 ft. AMSL within a 15 NM radius of Grand Bahama International Airport while the control tower is in operation. During the hours that the control tower is not in operation the airspace becomes Class E airspace extending upward from 700 ft. AGL within 15 NM radius of Grand Bahama International Airport.

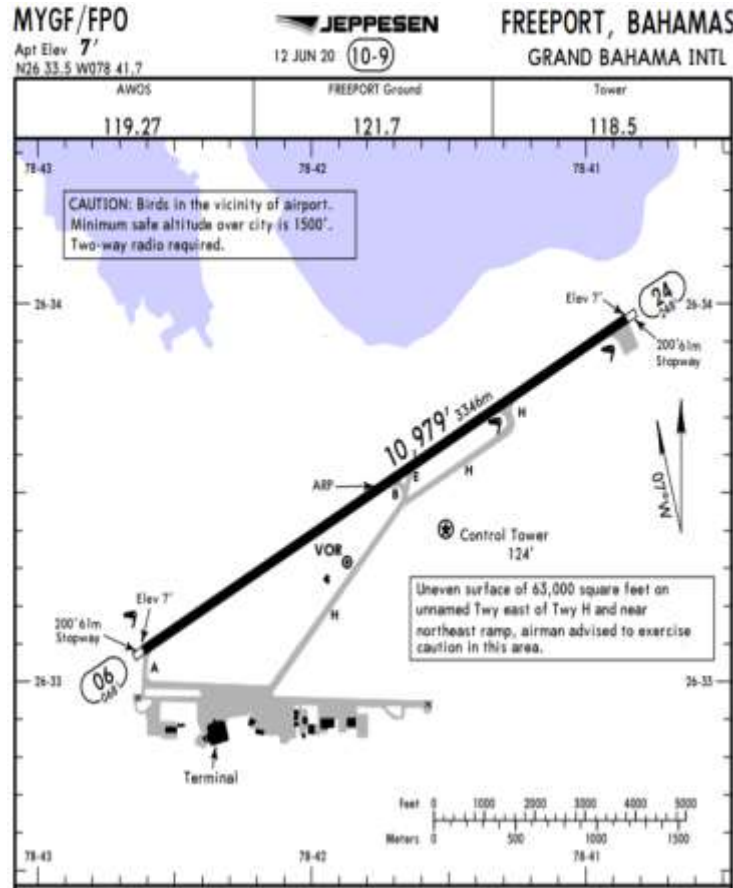


Figure 4: Diagram of Grand Bahama International Airport by Jeppesen

⁷ VHF Omnidirectional Radio Range (VOR), is an aircraft navigation system operating in the VHF band. VORs broadcast a VHF radio composite signal including the station's Morse Code identifier (and sometimes a voice identifier), and data that allows the airborne receiving equipment to derive the magnetic bearing from the station to the aircraft. This line of position is called the "radial". Alternatively, the VOR radial may be combined with magnetic heading from the aircraft compass to provide a bearing relative to the aircraft axis, which can be used to home to the beacon.

⁸ Distance Measuring Equipment (DME), is a radio navigation technology that measures the slant range (distance) between an aircraft and a ground station.

⁹ Instrument Landing System (ILS), navigational system that provides aircraft with precision vertical and horizontal navigation guidance information during approach and landing.

1.11 FLIGHT RECORDERS

1.11.1 COCKPIT VOICE RECORDER

| | |
|-----------------------------|----------------|
| RECORDER MANUFACTURER/MODEL | HONEYWELL 6022 |
| RECORDER SERIAL NUMBER | CVR120-06529 |

Per federal regulation, turbine engine powered aircraft operating under Title 14 US Code of Federal Regulations Part 121 must be equipped with a cockpit voice recorder (CVR) that records a minimum of the last 2 hours of aircraft operation; this is accomplished by recording over the oldest audio data. When the CVR is deactivated or removed from the airplane, it retains only the most recent 2 hours of CVR operation.

In support of this investigation, a solid state cockpit voice recorder (CVR) was sent to the National Transportation Safety Board (NTSB) Vehicle Recorder Division for evaluation.

This model CVR, the Honeywell 6022, is a solid-state CVR that records 120 minutes of digital audio. Specifically, it contains a 2-channel recording of the last 120 minutes of operation and separately contains a 3-channel recording of the last 30 minutes of operation. The 120-minute portion of the recording is comprised of one channel that combines three audio panels sources and a second channel that contains the cockpit area microphone (CAM) source. The 30-minute portion of the recording contains 3 channels of audio information: one channel for each flight crew and one channel for a cockpit observer.

Upon arrival at the laboratory, it was evident that the CVR had not sustained any heat or structural damage and the audio information was extracted from the recorder normally, without difficulty.

In agreement with the Investigator-In-Charge and the Accredited Representative, a CVR group did not convene.

The first approximately 19 minutes of the recording captured the previous flight's approach, landing, and taxi-in to MIA. The captured events of the previous flight were uneventful. Recording for the accident flight began at 1415:24. At this time, the captain was aboard completing various preflight tasks and checklists.

1.11.2 FLIGHT DATA RECORDER

| | |
|-----------------------------|-------------------------|
| RECORDER MANUFACTURER/MODEL | HONEYWELL 4700, 256 WPS |
| RECORDER SERIAL NUMBER | SSFDR09828 |

The accident aircraft, N674RJ, was manufactured in 2004 and was operating such that it was required to be equipped with an FDR that recorded, at minimum, 88 parameters as cited in Title 14 US Code of Federal Regulations Part 121.344(f).

The Honeywell solid-state flight data recorder (SSFDR) records airplane flight information in a digital format using solid-state flash memory as the recording medium. The SSFDR can receive data in the ARINC 573/717/747 configurations and can record a minimum of 25 hours of flight data. It is configured to record 256 12-bit words of digital information every second. Each grouping of 256 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 256-word intervals.

Aircraft Accident Investigation Authority

The recorder was in good condition and the data were extracted normally from the recorder. The FDR recording contained approximately 27 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The accident flight was the last flight of the recording and its duration was approximately 24 minutes.

1.12 WRECKAGE AND IMPACT INFORMATION

At a distance of approximately 2,478 ft from the threshold of runway 06, aircraft signature markings shifted significantly to the right of runway centerline and continued along that trajectory. The aircraft exited runway 06 and came to rest at a distance of approximately 3,715 ft. from the threshold of runway 06. The tail section of the aircraft was the most exposed to the active runway as it came to rest approximately 15 ft. from the runway's edge. Significant rubber markings from both main landing gear tires were noted on the runway from the point of touchdown to the point of runway excursion.

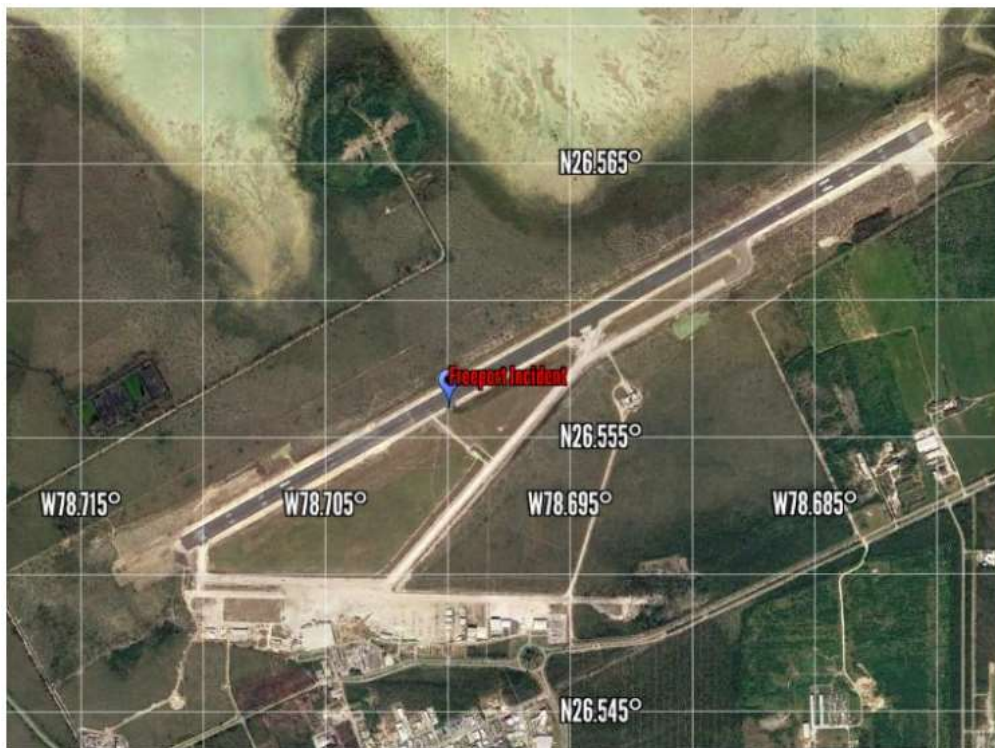


Fig. 5 Position of N674RJ at the Grand Bahama International Airport

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

No tests were conducted to determine whether the performance of any of the personnel involved was degraded by physiological factors.

1.14 FIRE

No fire was reported as a result of the runway excursion.

1.15 SURVIVAL ASPECT

The accident sequence that included the unexpected braking of the aircraft and subsequent runway excursion and landing gear collapse, resulted in minor injuries to seven (7) passengers and two (2) crewmembers.

Passengers began an un-commanded evacuation of the aircraft prior to the crew making safety assessments and providing instructions to aid in the evacuation process.

Envoy's procedures for emergency evacuation covers both planned and unplanned events, and in this situation where the accident sequence of events were unexpected, the procedure allows the flight attendant to assess the situation and if warranted, initiate the evacuation without waiting for instructions from the flight deck.

Prior to the flight attendant assessing the situation and initiating evacuation procedures, passengers initiated the evacuation themselves, as the flight attendant witnessed several passengers already on the left wing prior to her giving the command to evacuate the aircraft. Additionally, the captain advised that before carrying out the ground evacuation checklist, he noticed to the left of the plane, passengers had already evacuated and he immediately shut off the aircraft engines with the engine selector switches to avoid a potential safety hazard.

1.16 TESTS AND RESEARCH

1.16.1 BRAKE CONTROL UNIT TEST

In support of the investigation, the Brake Control Unit (BCU) was sent to component manufacturer Crane Aerospace for inspection and analysis. AAIA Investigators and Technical Advisors to the Accredited Representatives from the USA and Brazil convened virtually on December 2, 2020 to observe and provide oversight of the BCU non-volatile memory (NVM) and Acceptance Test Procedure (ATP) testing.

The Brake Control Unit was shipped to the Crane facility and quarantined by Crane Aerospace until the time of the examination. On the date of the examination, the box was opened, and the unit was inspected and tested by Crane Aerospace personnel and witnessed via remote operations by the team. The team was provided with the NVM data, tests results, and photographs taken during the inspection.

Based on information from maintenance records provided by Envoy, the BCU was installed and removed five times in its' service history.

| Aircraft | Installed Date | Removal Date | Hours | Cycles | Reason for Removal |
|----------|----------------|--------------|--------|--------|----------------------------------------|
| 923 | 4/30/05 | 6/15/10 | 13,358 | 11,797 | Unit needed for another aircraft |
| 941 | 6/15/10 | 1/8/13 | 6,869 | 5,292 | Brakes Locking up during taxi |
| 659 | 8/20/13 | 9/16/13 | 199 | 147 | On Taxi out brake outboard inoperative |
| 659 | 4/18/14 | 11/22/14 | 1,390 | 1,274 | On Taxi out brake outboard inoperative |
| 674 | 1/15/15 | 11/13/20 | 11,569 | 10,673 | Accident Flight Removal |

Based on information from repair records provided by Crane Aerospace, the BCU was returned for repair four times in its' service history, not including the inspection/testing for the current accident.

Aircraft Accident Investigation Authority

| Date Returned | Date Returned to Service | Reason for Return (Summarized) | Repair Disposition (Summarized) |
|----------------------|---------------------------------|---------------------------------------|-----------------------------------------------------------------------|
| 12/21/04 | 4/30/05 | Brake Degrade | Failed outboard card/cold solder joint |
| 1/17/13 | 1/27/13 | Brake Lockup | Failed ATP, minor repair of electrical components |
| 9/22/13 | 10/3/13 | Brake Outboard Inop | Unit inspected and passed ATP five times, returned no fault found |
| 11/30/14 | 12/17/14 | Brake Outboard Inop | Unit inspected and passed ATP multiple times, returned no fault found |

The external visual inspection did not reveal any anomalies to the unit's case. The cannon plug connector pins were intact and in good condition. The lockwire on the cannon plugs retaining nuts was present and secure. The tamper seals on the rear cover were found cut, consistent with the rear cover being opened.

The NVM download and ATP testing was conducted per Component Maintenance Manual (CMM) 32-43-79 Revision 2, dated 6/30/16.

The ATP test was successfully completed with no faults found. The unit was disassembled, and each circuit card assembly (CCA) was visually inspected. All cards and ribbon cables were clean with no visible anomalies. There were small amounts of dirt and debris on the exterior side of the cannon plugs.

1.16.2 PARKING BRAKE VALVE TEST

In support of the investigation, the Parking Brake Valve was shipped to the manufacturer's (Tactair) facility and quarantined by them until the time of the examination. AAIA Investigators and Technical Advisors to the Accredited Representatives from the USA and Brazil convened virtually on January 12, 2021 to observe and provide oversight of the Parking Brake Valve ATP testing and inspection.

Based on information from maintenance records provided by Envoy, the parking brake valve was installed and removed four times in its service history, including the accident.

| Aircraft | Installed Date | Removal Date | Hours | Cycles | Reason for Removal |
|-----------------|-----------------------|---------------------|--------------|---------------|---------------------------------------------------------------------------------|
| 819AE | 02/16/02 | 10/22/03 | 3,940:52 | 3,696 | Unknown |
| 850AE | 10/16/04 | 11/19/08 | 10,583:37 | 8,410 | Hydraulic fluid leaking from nose wheel bay. |
| 806AE | 12/11/09 | 02/20/15 | 12,314:59 | 10,725 | Parking brake will not set. Aircraft moved forward with handle in set position. |
| 674RJ | 11/28/17 | 11/13/20 | 5,951:13 | 5,520 | Removed for accident investigation. |

Based on information from repair records provided by Tactair, the Parking Brake Valve was returned three times to Tactair during its service history, not including the inspection/testing for the current accident.

Aircraft Accident Investigation Authority

| Date Returned | Reason for Return (Summarized) | Repair Disposition (Summarized) |
|---------------|--------------------------------|----------------------------------------------------------------------------------------------------------|
| 11/14/03 | Leaking from weep hole | Failed incoming ATP. Overhauled replacing sleeve, all seals and minor hardware. |
| 12/01/08 | Leaking from neck | Failed incoming ATP. Overhauled replacing body, all seals and minor hardware. |
| 02/25/15 | PB would not Set | Failed incoming ATP. Overhauled replacing piston end cap, flanged bushing, all seals and minor hardware. |

Testing was conducted using procedure ATP 9067-2 Rev B. Tactair's DMIR¹⁰ was present during the ATP testing. The unit was packaged in a soft-sided FedEx envelope. The unit was dirty, and all safety wire/security seals were present. The data plate was verified for the unit under test.

Prior to the test a "patch" test was conducted to check for any contaminants in the residual hydraulic fluid in the valve. The unit exterior was cleaned with a denatured alcohol solution prior to the "patch" test, to minimize the risk on contamination of any residual fluid inside the unit. During removal of the caps on the three ports, it was noted that the threads contained some grit and contaminants. The ports appeared "dry" and no usable fluid samples were present for the patch test. Each port was swabbed with a cotton swab to collect any fluid in the ports. All swabs were "moist", and the return port swab was more discolored than the Pressure and Brake port. The swabs were labelled and retained for possible further microscopic examination.

The port fittings, which are typically not attached to a returned valve were removed and placed in labelled containers for possible further examination of contaminants if necessary.

All tests except for the following passed:

Slight deviations were noted on operational test, brake pressure vs. stroke within chart limits. The pressure deviated slightly outside of the limits, with a majority of the curve being within the expected range. The curves were stated to be better than most valves returned for overhaul and would have minimal effect on brake pressure application.

Internal leakage in the "Off" position – 4 drops in 5 min (requirement: not to exceed 1 drop in 5 min). The manufacturer and Embraer stated that this issue would have no effect on braking performance but could result in excessive hydraulic pump operations in order to maintain system pressure.

The valve was then removed from the test stand and subject to a teardown and internal inspection. There were no notable marks on the inner bore of the dry bay around the return spring assembly. An area of contamination was noted around the area of the plunger past the seal/scrapper. There were no signs of hydraulic fluid in the dry bay.

The valve contains a ball/seat arrangement on the pressure supply port. The seat where the ball rest had some areas of scoring. The manufacturer noted that this scoring would result in the failed result seen during the internal leakage test in the "Off" position.

¹⁰ DMIR – Designated Manufacturing Inspection Representative is an individual appointed in accordance with 14 CFR §183.31. A DMIR conducts conformity inspections during the manufacturing process. DMIRs also issue certificates such as airworthiness certificates for aircraft, export certificates for aircraft and parts, and special flight permits. A DMIR must possess aeronautical knowledge and experience, be employed by a Production Approval Holder (PAH), or a PAH's approved supplier, and meet the qualification requirements of Order 8000.95

1.16.3 PARKING BRAKE PRESSURE SWITCH TEST

AAIA Investigators and Technical Advisors to the Accredited Representatives from the USA and Brazil convened virtually on January 19th 2021 to observe and provide oversight of the Parking Brake Pressure Switch ATP testing and inspection.

The Parking Brake Pressure Switch was shipped to the manufacturer’s (Hydra-Electric) facility and quarantined until the time of examination. On the date of the examination, the box was opened, and the unit was inspected and tested by Hydra-Electric personnel and witnessed via remote operations by the team.

Testing was conducted using procedure FTP-15851 Rev A. No damage was noted to the shipping container. The data plate was verified for the unit under test. There were “nicks” and “dings” noted on the nut on the hydraulic end of the unit.

Prior to the hydraulic tests, the vent hole on the pressure switch was inspected via a microscope and no blockage of the vent hole was noted. All tests conducted were passed.

1.16.4 EMERGENCY PARKING BRAKE HANDLE AND CABLE

AAIA Investigators and Technical Advisors to the Accredited Representatives from the USA and Brazil convened virtually on March 23, 2021 to observe and provide oversight of the Parking Brake Handle and Cable inspection.

The Parking Brake Handle and Cable were shipped assembled to the Embraer office in Fort Lauderdale, then to the Embraer factory in Brazil and quarantined until the time of the examination. On the date of the examination, the unit was inspected and tested by Embraer personnel and witnessed via remote operations by the team.

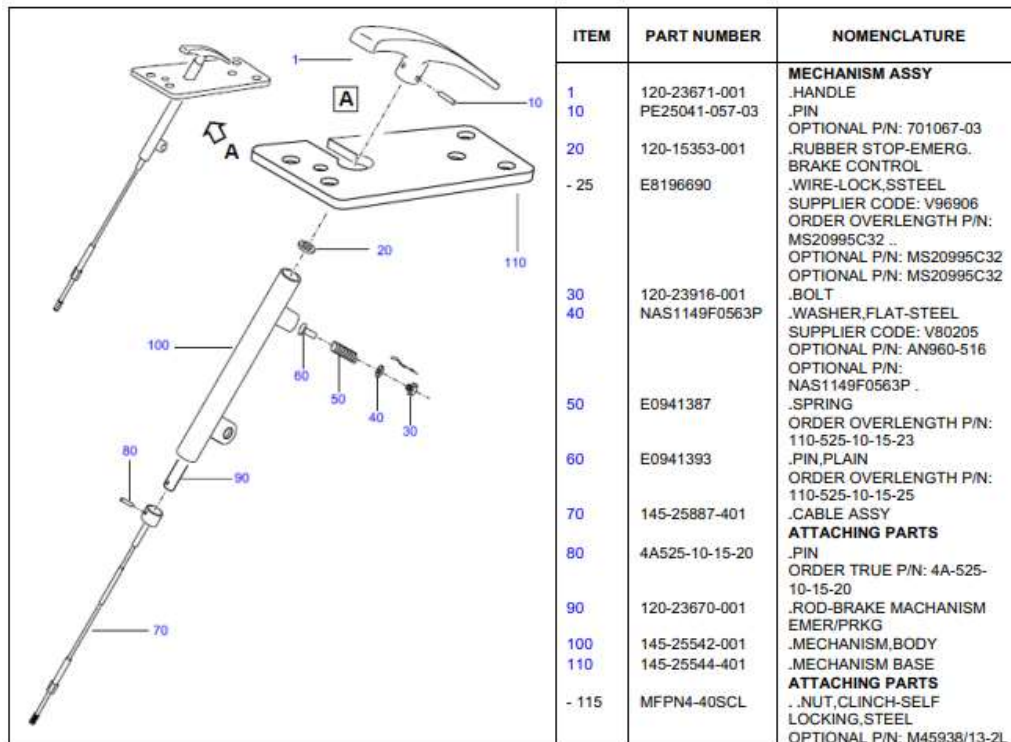


Fig. 6 Parking Brake Handle and Cable subset parts

Aircraft Accident Investigation Authority

As these parts are not mechanically complex, besides assembling tests for checking stiffness, operational tests are carried out together with the parking brake subsystem in the aircraft, when the part is assembled for the first time. As part of the analysis schedule, the parts were verified for stiffness and they presented no difficulty or jamming, as the handle could be gently operated. Some visual checks were done, as follows:

Housing: external appearance looks good and no signs of inadequate removals were noticed. There were still some signs of the original graphite-based oil used to lubricate the moving parts.

Steel cable integrity: visual check and cloth test revealed no identifiable wearing, nor loose strands.

Missing part: [20] Part Number: 120-15353-001- RUBBER STOP-EMERG. BRAKE CONTROL could not be found. It provides a resilient seat to avoid vibration, and its absence does not affect the operational properties of the subset.

Removing the lock wire and the bolt [30], it was possible to get access to the guiding mechanism parts, pin [60] and spring [50]. Both pin and spring were found broken, probably due to the handle [1] being pulled misaligned to the body. From the wearing signs, this damage was judged as not recent. Nevertheless, even this damage presented no contribution for jamming the axle. Although damaged, the assembly was still functional, still guiding the L-shape slot and keep the movement in its desirable limits, as broken parts were kept in position.

If emergency/parking brake is actuated to the extent that the pressure is raised above the setpoint for the pressure switch to be ON (thus producing a visual indication on the instrument panel), the brake monitoring system triggers an aural alert (“TAKEOFF-BRAKES”) when advancing the Throttle (TLA – Thrust Lever Angle) or pressing the TAKEOFF CONFIGURATION CHECK SWITCH. Therefore, it is not likely that for some reason the handle would have been partially or totally actuated during taxi/takeoff phases.

As per the visual analysis and the tests performed, this subassembly was still operational, even with the damage noted to some of its parts/components; no scenario could be created that would point to this subassembly as contributing to the reported event, due to any potential malfunction.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

1.17.1 OPERATOR

As per the operator’s company website, Envoy Air Inc. is a wholly owned subsidiary of American Airlines Group (NASDAQ: AAL) operating more than 185 aircraft on 1,000 daily flights to over 150 destinations. The company’s more than 18,000 employees provide regional flight service to American Airlines under the American Eagle brand and livery and ground handling services for many American flights.

The company was founded in 1998 as American Eagle Airlines, Inc. following the merger of several smaller regional carriers to create one of the largest regional airlines in the world. Envoy is headquartered in Irving, Texas with large operations in American’s hubs, including Dallas/Fort Worth, Chicago, Miami and Los Angeles.

On April 15, 2014 the company changed its name to Envoy Air Inc. to distinguish the company from the American Eagle brand, under which several carriers operate regional flight service for American. American Airlines Group is the holding company for American Airlines, US Airways, and Envoy.

1.17.2 REGULATORY OVERSIGHT

As this aircraft was operated under Part 121 of Title 14 US Code of Federal Regulations, regulatory oversight was provided by the Federal Aviation Administration via a Certificate Management Office (CMO). The Envoy CMO, located 8700 Freeport Parkway, Irving, Texas, USA, is tasked with Certificate management oversight responsibilities.

1.18 ADDITIONAL INFORMATION

Not applicable

2.0 ANALYSIS

There were no indications on the aircraft flight data recorder or cockpit voice recorder of an abnormal or emergency situation related to an aircraft system malfunction prior to landing.

2.1 BRAKING ACTION

According to statements by the flight crew, immediately after touchdown, there was a sudden and unexpected braking of the aircraft. On site investigation, as well as post-accident investigation, documented heavy braking action from tires of both main landing gear on the runway from the point of touchdown to the point of the runway excursion.

Heavy braking signature marks are indicative of possible brakes being engaged at the point of landing and throughout rollout, up to the point of runway excursion.

As a result of evidence of heavy brake signature markings, additional analysis were conducted of several components related to the braking system of the aircraft, which were suspected of being contributory to the accident.



Fig.7 N674RJ tire signature markings on runway

2.2 COMPONENT EXAMINATIONS

The brake control unit (BCU), parking brake valve, emergency parking brake handle and cable, and the emergency parking brake pressure switch were all removed, quarantined, and then shipped to their respective manufacturers for testing and analysis.

2.2.1 BRAKE CONTROL UNIT

As an integral component of the EMB-145's brake system, the Brake Control Unit (BCU) is responsible for controlling and monitoring the normal brake system of the aircraft and facilitates sending appropriate signals to the crew alerting system and other systems in the event of a malfunction.

The component examination conducted was to identify, via analysis of non-volatile memory (NVM) data and testing, any system defects or anomalies that may have contributed to the accident sequence of events. The testing conducted found no faults and there were no irregularities with the data analyzed. This result is consistent with the flight crew's statement as well as the CVR and FDR analysis in that there were no aural or visual indications, via the crew alerting system, of any braking system failure or malfunction.

2.2.2 EMERGENCY PARKING BRAKE HANDLE AND CABLE

The emergency parking brake handle and cable serves as the mechanism that actuates the emergency parking brake valve via hydraulic pressure. To set the parking brake, the handle is pulled and rotated to the fully-actuated position.

Testing of both the handle and cable was conducted to assess the operability of the components and additionally, the extent to which a partial or total actuation could have taken place independently during taxi or takeoff phases.

A thorough visual inspection and testing of the components indicated that the parts were functional and presented no difficulty in use. As such, the component was ruled out as contributory to the occurrence of the accident.

2.2.3 EMERGENCY PARKING BRAKE VALVE

A series of tests were conducted to determine the functionality of the component and the presence of any evidence indicating a failure or malfunction of the part.

The only test to not pass was the internal leakage test which produced four (4) drops in five minutes but was not to exceed one (1) drop in five minutes. It was determined that this result was of no consequence in relation to the aircraft's braking performance.

2.2.4 EMERGENCY PARKING BRAKE PRESSURE SWITCH

During bench testing of the emergency brake pressure switch, there were no abnormalities or irregularities found and testing was completed satisfactorily.

During normal system operation, once emergency parking brake is engaged, there are two visual warning indication lights, one on the main panel and the other on the ramp panel.

3.0 CONCLUSIONS

3.1 FINDINGS

1. The aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures.
2. The aircraft was airworthy when dispatched for the flight.
3. The mass and the center of gravity of the aircraft were within the prescribed limits.
4. There was no evidence of any defect or malfunction in the aircraft that could have contributed to the accident.
5. Both pilots indicated that there were no aural or visual warning indications of a system failure or malfunction.
6. The flight crew/pilot/co-pilot was licensed and qualified for the flight in accordance with existing regulations.
7. Flight crew indicated experiencing a sudden braking of the aircraft immediately after landing touchdown.
8. The weather at the time of the accident was visual meteorological conditions and not a factor in this occurrence.
9. Passengers evacuated the aircraft prior to flight crew initiating emergency checklists and protocols.
10. The aircraft received damages to the underside of the center fuselage, both wings, both main and nose landing gears.
11. There were minor injuries sustained by seven (7) passengers and two (2) crew members.
12. Component analysis and testing conducted on the brake control unit (BCU), emergency parking brake pressure switch and the emergency parking brake cable and handle all passed and yielded satisfactory results.
13. Component analysis and testing conducted on the parking brake valve passed and yielded satisfactory results except for the internal leakage test. However, it was determined that this would have no effect on braking action.

Aircraft Accident Investigation Authority

3.2 PROBABLE CAUSE

Based on evidence gathered, CVR and FDR data analysis and analysis conducted of suspected components, the probable cause of the heavy braking action that resulted in the runway excursion could not be replicated or determined.

Results of functional tests of components suspected of contributing to the heavy braking action that occurred are as follows:

- Brake control unit (BCU), PASS
- Emergency parking brake pressure switch PASS
- Emergency parking brake handle and cable PASS
- Parking brake valve – all tests passed except for internal leakage in the “Off” position – 4 drops in 5 min (requirement: not to exceed 1 drop in 5 min). The component manufacturer and Embraer stated that this issue would have no effect on braking performance but could result in excessive hydraulic pump operations in order to maintain system pressure. Additionally, slight deviations were noted on operational test but this was determined to have minimal effect on brake pressure application.

Cause of Accident – Undetermined

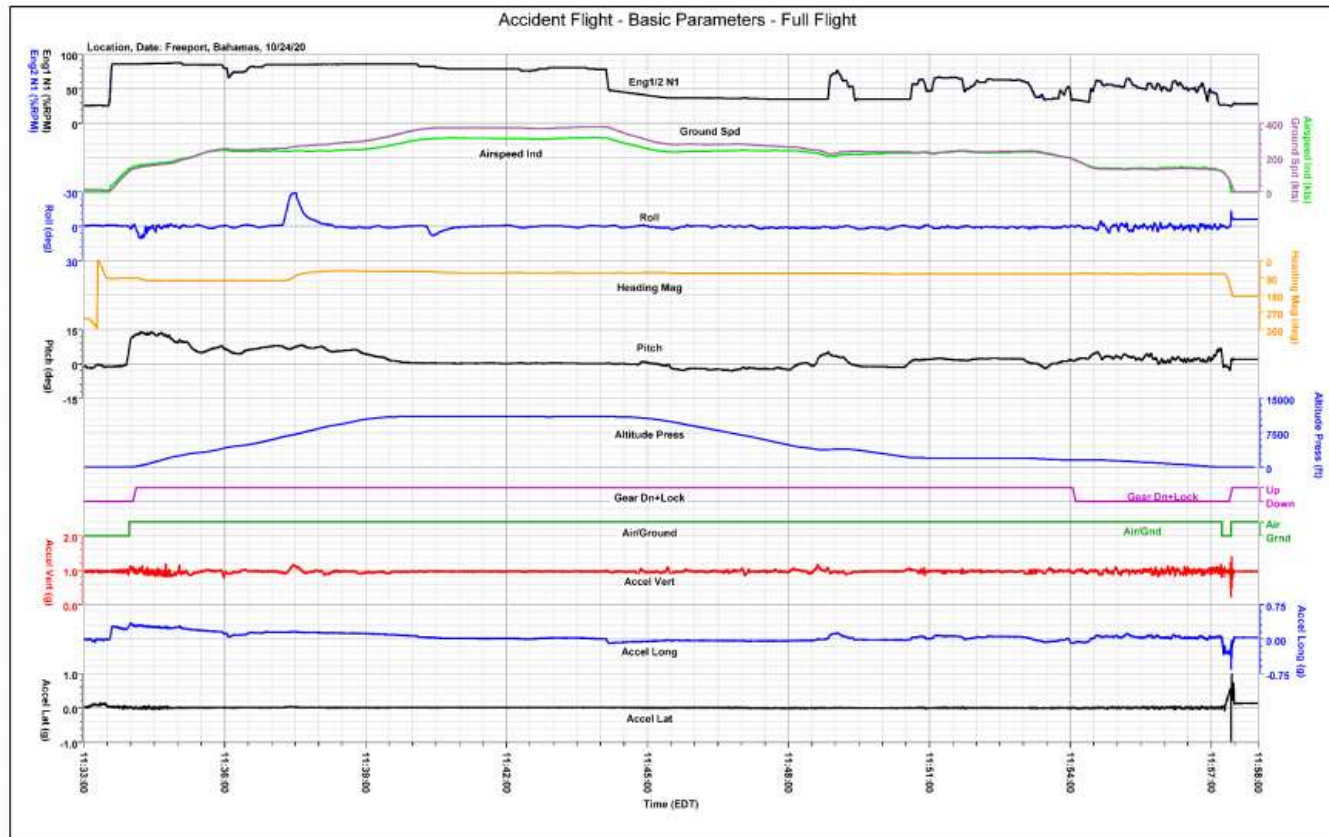
4.0 SAFETY RECOMMENDATIONS

No safety recommendations were issued by the Aircraft Accident Investigation Authority in relation to this occurrence.

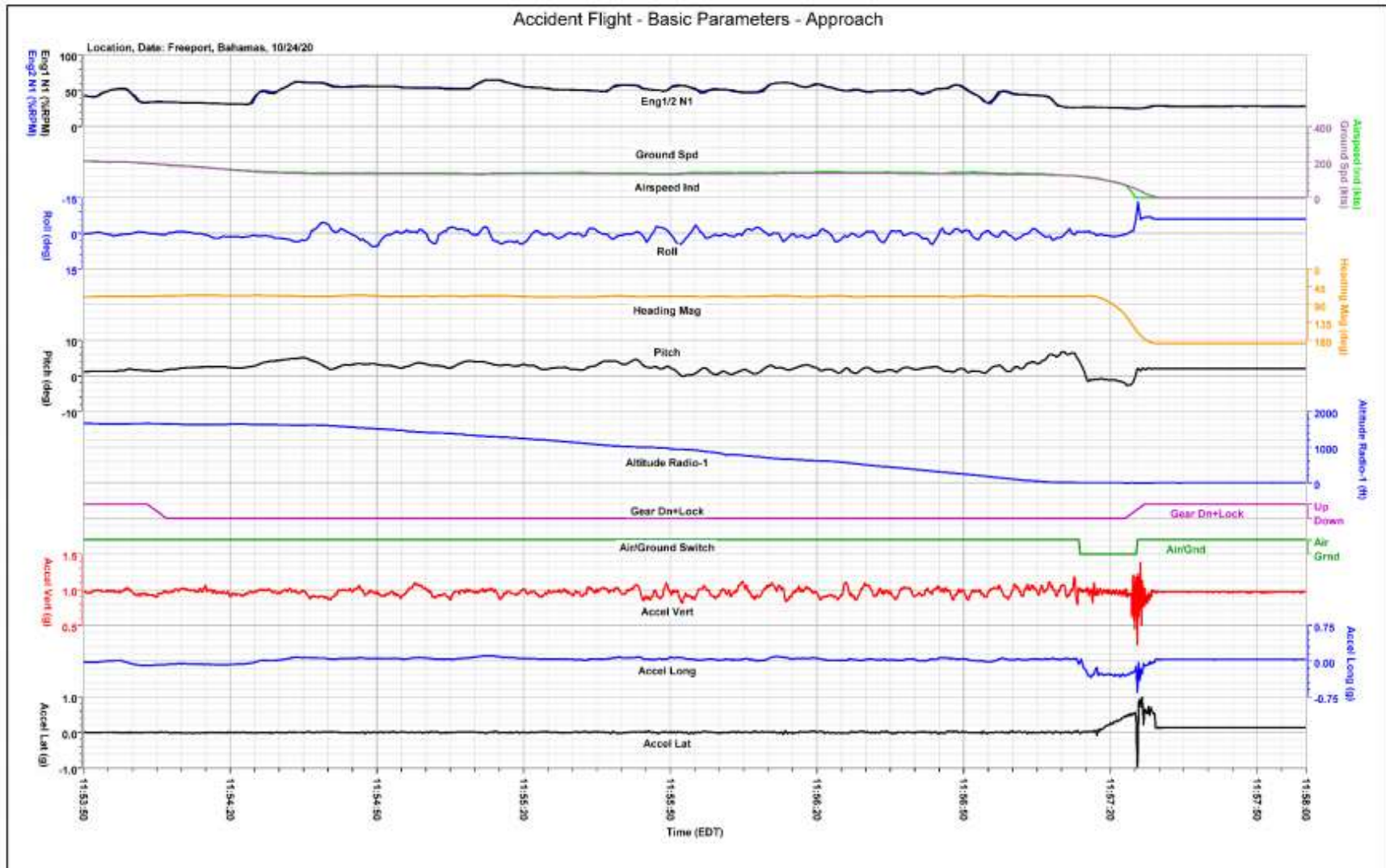
5.0 APPENDICES

APPENDIX A – FLIGHT DATA RECORDER READOUT

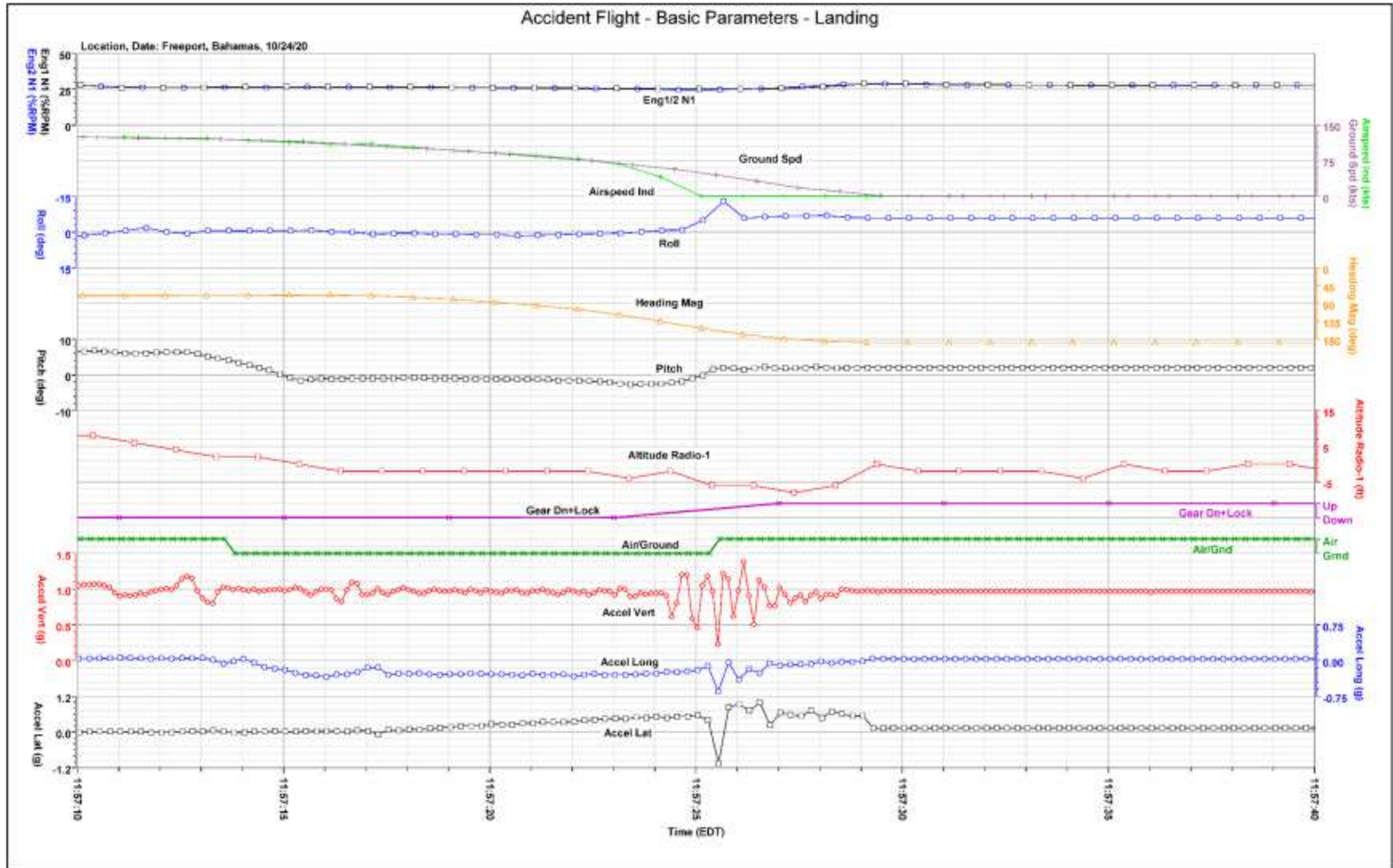
The FDR recording contained approximately 27 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The accident flight was the last flight of the recording and its duration was approximately 24 minutes.



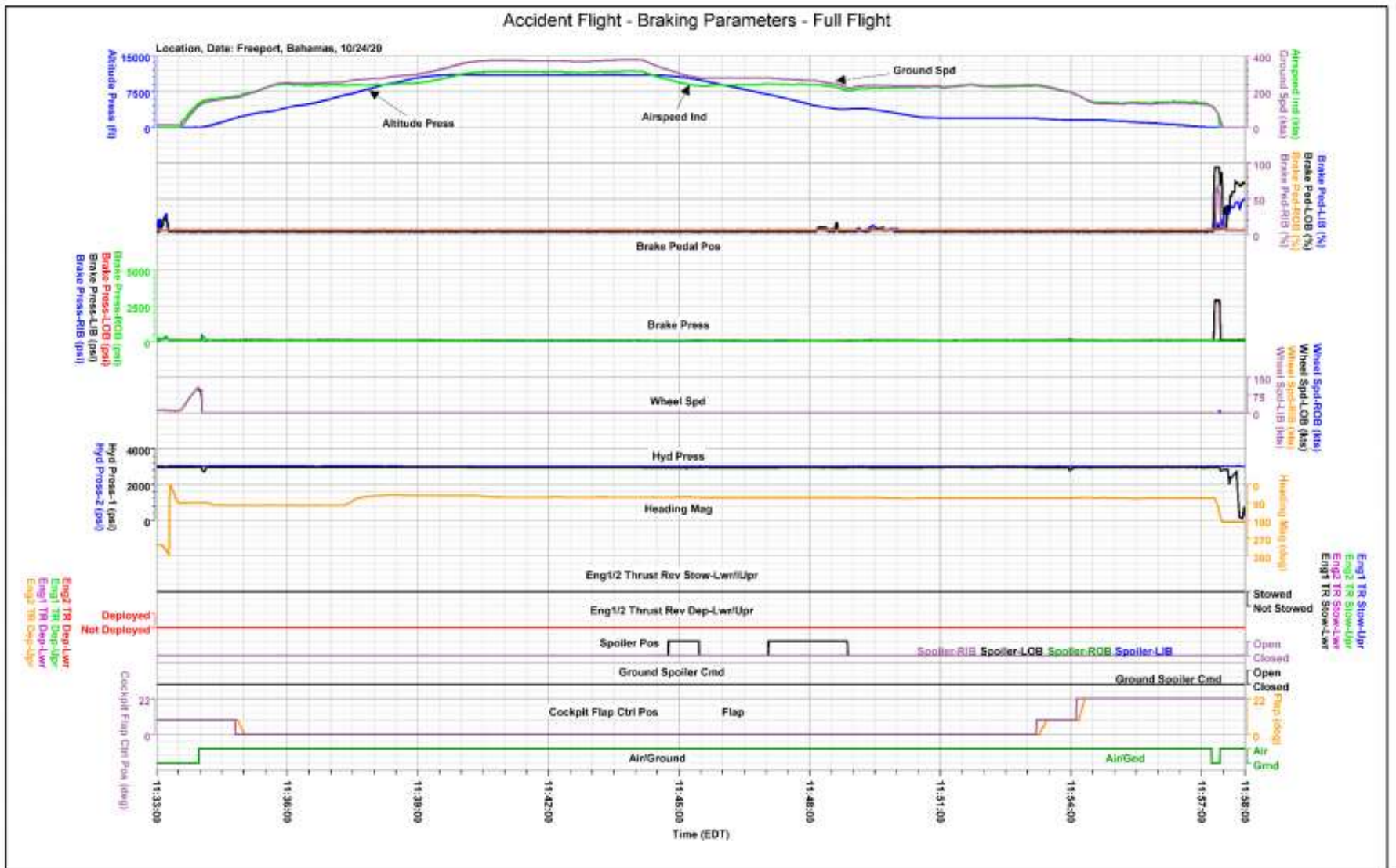
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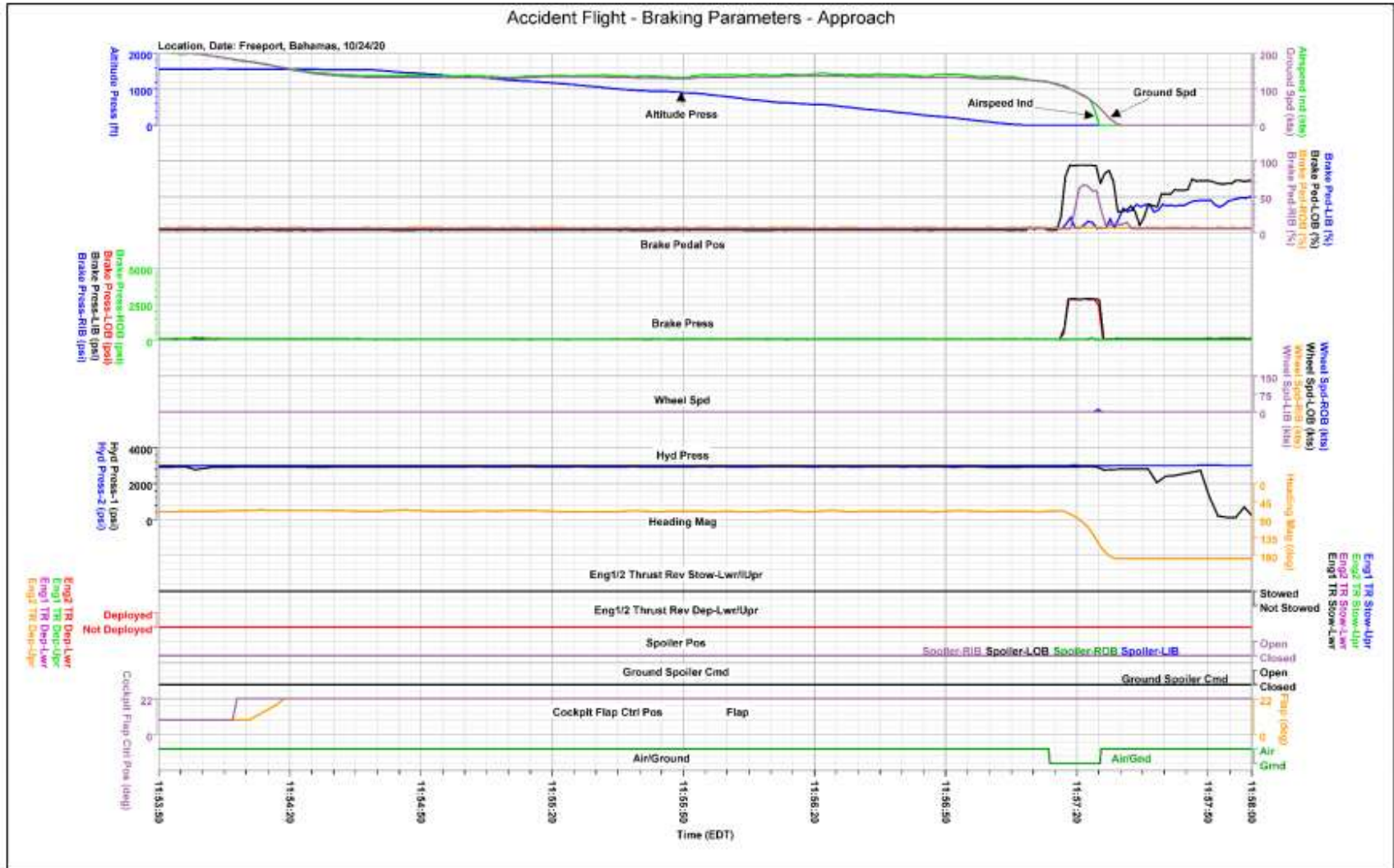
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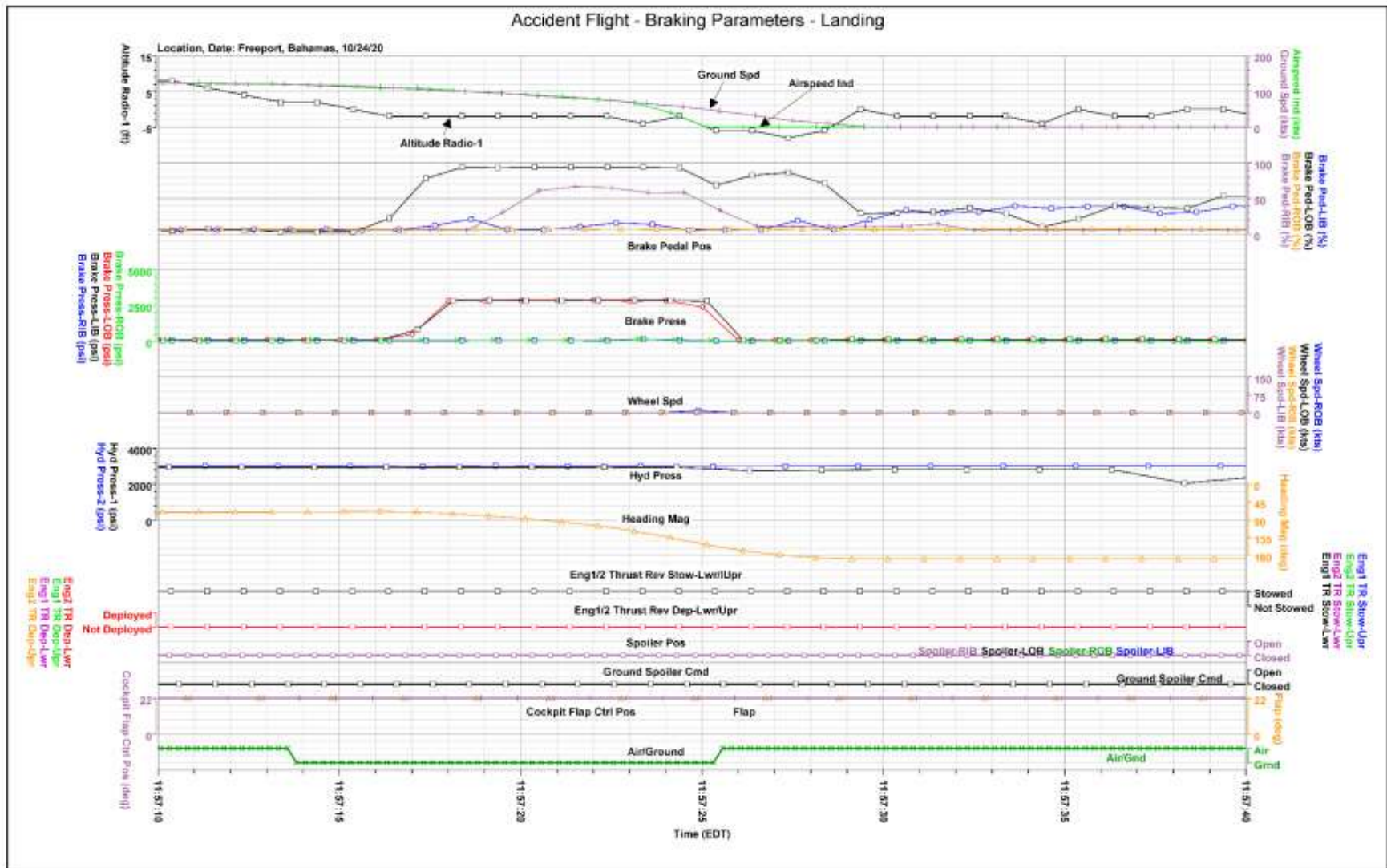
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APPENDIX B – COCKPIT VOICE RECORDER SUMMARY

In agreement with the Investigator-In-Charge and the Accredited Representative, a CVR group did not convene. A summary of events from the CVR follows. The first approximately 19 minutes of the recording captured the previous flight's approach, landing, and taxi-in to MIA. The captured events of the previous flight were uneventful. Recording for the accident flight began at 1415:24. At this time, the captain was aboard completing various preflight tasks and checklists.

At 1427:12, the first officer arrived and assisted the captain in performing various preflight tasks and checklists.

At 1453:45, the before-start checklist was performed.

At 1501:54, the engine start checklist was performed.

At 1503:16, the aircraft was cleared to pushback. The pushback began shortly thereafter, and the crew reported brakes set and clear to disconnect at 1505:49.

At 1508:25, the after-start checklist was performed.

At 1509:06, the crew called ground and reported they were ready to taxi. They received their taxi clearance to runway 8R shortly thereafter and began to taxi.

At 1528:13, the taxi checklist was performed.

At 1530:47, the before-takeoff checklist was performed.

At 1532:27, the flight was instructed by the tower to line up and wait on runway 8R.

At 1533:08, the flight was cleared for takeoff to an initial heading of 105 degrees. The takeoff roll began shortly thereafter and proceeded uneventfully. Gear up was called at 1534:02 and no unexpected sounds were noted.

At 1535:00, the after-takeoff checklist was performed.

At 1536:14, the flight was cleared to climb to 8,000 feet (ft).

At 1537:03, the flight was cleared direct to JANUS at 11,000 ft.

At 1540:08, the flight was cleared direct to PADUS.

Beginning at 1542:37, the crew discussed various arrival planning items including radio frequencies, landing distance, weather, and parking.

At 1543:52, the flight was instructed to cross PADUS at 4,000 ft.

At 1544:58, the descent checklist was performed.

At 1547:03, the crew contacted Freeport approach and were instructed to fly along the BR66V route to PADUS, then direct to Freeport via the RNAV runway 6. Freeport weather was given as an altimeter reading of 29.95 inches of mercury, temperature 29 degrees Celsius, dewpoint 24 degrees Celsius, winds from 100 degrees at 12 knots, and scattered clouds at 1,800 ft.

At 1548:01, the flight was instructed to cross PADUS, then descend and maintain 2,000 ft.

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At 1548:45, the crew were cleared to CURIX, cleared for the RNAV runway 6, and instructed to contact the tower.

At 1551:33, the captain noted that he could see the runway.

At 1553:48, the crew reported passing CURIX.

At 1553:55, the flight was cleared to land on runway 6 and winds were reported coming from 90 degrees at 8 knots. At this time, an increase in ambient noise, consistent with landing gear deployment, was heard.

At 1554:17, the before landing checklist was performed, which included the items gear down, three green and speed brake closed.

At 1556:29, an automated Enhanced Ground Proximity Warning System (EGPWS) 500 ft callout was heard.

At 1556:52, an automated minimums callout was heard, and the captain decided to continue the approach.

At 1557:00, an automated EGPWS 100 ft callout was heard.

At 1557:13, sounds consistent with touchdown were heard, followed shortly thereafter by a significant increase in ambient noise.

At 1557:22, sounds similar to tire squealing were noted.

At 1557:24, multiple rattling sounds were heard, consistent with the aircraft departing the paved surface.

At 1557:26, a triple chime followed by landing gear annunciation was heard. These alerts repeated consistently for the remainder of the recording.

At 1557:33, the flight attendant could be heard shouting "stay seated" repeatedly.

At 1557:37, the captain called for the engines to be shut off and to run the evacuation checklist.

At 1557:45, a sound similar to a call chime was heard.

At 1557:48, the captain called the tower requesting emergency vehicles be dispatched.

At 1557:59, the first officer began the evacuation checklist with the captain responding to prompts.

At 1558:58, the captain told the flight attendant to wait to evacuate until they could shut down the engines. The flight attendant responded that the passengers opened the doors themselves without her instructions.

At 1559:23, the crew discussed what happened, including recalling they had gear down three green. The captain commented that something must have locked up, and the first officer commented that there were no warnings.

At 1600:13, the captain asked the first officer to go outside and ensure the passengers remained clear of the engines.

At 1600:47 the captain reran the evacuation checklist.

The recording ended shortly thereafter at 1601:26.

APPENDIX C – BRAKE CONTROL UNIT TEST SUMMARY

```
*****
*                               TEST SUMMARY                               *
*****
Filename: A:\FUNC_12020915.DAT
Test Completed: Wednesday, December 02 2020 09:37:50 AM
Embraer FDR Functional Test Software
software p/n: 299-047120-06.00
*****

    UUT P/N: 142-093
    UUT S/N: 370
Tester P/N: 299-047
Tester S/N: 112

Work Order: AAIA

Test Operator:
    ID:


*****
    0 FAILURES FOUND
*****

Total Test Time : 00:22:23


*****
* PASSED *
*****
```

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APPENDIX D – EMERGENCY PARKING BRAKE VALVE TEST REPORT

| | | | | | | | |
|-----------------------------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------|----------------------------------|
|  | | <h2 style="margin: 0;">TEST REPORT</h2> | | | | | SHEET 1 of 2 ATP 9067-2 REV B |
| TEST STAND NO.: TFC 56 | | ACCEPTANCE TEST PROCEDURE FOR EMERGENCY PARKING BRAKE VALVE 9067-40-3, 9067-40-4 | | | DATE: 01/12/2021 | | |
| | | | | | SHOP ORD.: FAA INVESTIGATION | | |
| FLUID TEMP.: 92° F | | | | | CUST. ORD.: | | |
| CLEANLINESS: NAS - 0 | | | | | AMB. TEMP.: 72° F | | |
| | | | | | TEST FLUID: SKYDROL 500B-4 | | |
| | PARA. 2 | PARA. 3 | PARA. 4.1 | PARA. 4.1 | PARA. 4.2 | PARA. 4.2 | |
| S/N | EXAMINATION OF PRODUCT | PROOF PRESSURE AND EXTERNAL LEAKAGE | OPERATION | OPERATION | OPERATION | OPERATION | |
| | PER DRAWING 9067-40-3 9067-40-4 (ACC./REJECT) | EXTERNAL LEAKAGE, ZERO PERMANENT DEFORMATION, NONE | BRAKE PRESSURE 2850±150 PSIG | LEVER FORCE 33.1 LBS MAX 1.1 LBS MIN | BRAKE PRESSURE WITHIN THE LIMITS OF FIGURE 5 (ACC./REJECT) | CABLE FORCE WITHIN LIMITS OF FIGURE 6 (ACC./REJECT) | |
| 0646 | ACCEPT | NONE | 2985 | 29 | REJECT | ACCEPT | |
| | | | | | | | |
| | | | | | | | |

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| | | | | | | | |
|-----------------------------------------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|--|----------------------------------|--|
|  | | <h1>TEST REPORT</h1> | | | | SHEET 2 of 2 ATP 9067-2 REV B | |
| TEST STAND NO: TFC 56 | | ACCEPTANCE TEST PROCEDURE FOR EMERGENCY PARKING BRAKE VALVE 9067-40-3, 9067-40-4 | | | | DATE: 01/12/2021 | |
| | | | | | | SHOP ORD.: FAA INVESTIGATION | |
| FLUID TEMP.: SEE SHEET 1 | | | | | | CUST. ORD.: SEE SHEET 1 | |
| CLEANLINESS: SEE SHEET 1 | | | | | | AMB. TEMP.: SEE SHEET 1 | |
| | | | | | | TEST FLUID: SKYDROL 500B-4 | |
| | PARA. 4.3 | PARA. 5 | PARA. 6.1 | PARA. 6.2 | | | |
| S/N | OPERATION | PRESSURE DROP (MIN. FLOW) | INTERNAL LEAKAGE "OFF" POSITION | INTERNAL LEAKAGE 90° "ON" ROTATION | | | |
| | FLOW FROM P TO C IS 2.25 ± .75 GPM | MINIMUM FLOW OF 0.48 GPM @ 20 PSID | LEAKAGE SHALL NOT EXCEED 1 DROP IN FIVE MINUTES | LEAKAGE SHALL NOT EXCEED 1 DROP IN FIVE MINUTES | | | |
| 0646 | 1.59 | 0.67 | 4 | 0 | | | |
| | | | | | | | |
| | | | | | | | |