



National Transportation Safety Board Aviation Accident Final Report

Location:	Eden Prairie, MN	Accident Number:	CEN13LA462
Date & Time:	08/05/2013, 0848 CDT	Registration:	N327FL
Aircraft:	EMBRAER S A EMB-505	Aircraft Damage:	Substantial
Defining Event:	Runway excursion	Injuries:	2 None
Flight Conducted Under:	Part 91: General Aviation - Positioning		

Analysis

The flight crew of the light jet was conducting a landing to a wet 5,000-ft-long runway. Their preflight calculations indicated an approach speed of 110 knots given the airplane's estimated landing weight. Data obtained from the flight recorder showed that, as the airplane descended through about 500 ft above ground level on final approach, its speed was 186 knots and its rate of descent was over 3,000 ft per minute. The airplane crossed the runway threshold about 158 knots, and touched down about 1,000 feet down the runway about 145 knots. The airplane subsequently departed the end of the runway, impacted obstructions, and came to rest upright on a four-lane highway about 1,000 ft beyond the runway surface. A postaccident examination of the engines, airframe, and braking system revealed no evidence of mechanical malfunctions or failures that would have precluded normal operation.

The operator's procedures stated that all approaches to land must be stabilized at 500 feet above airport elevation, and any approach that became unstabilized required an immediate go-around. Among the company's criteria for determining a stable approach was: airspeed no more than 20 knots over target, and descent rate no greater than 1,000 ft per minute. During the approach, the airspeed was 76 knots over the target approach speed and the descent rate of 3,000 ft per minute greatly exceeded the criteria for a stabilized approach.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The flight crew's failure to execute a go-around during a non-stabilized approach, which resulted in a runway overrun.

Findings

Aircraft

Surface speed/braking - Attain/maintain not possible (Cause)

Personnel issues

Incorrect action performance - Flight crew (Cause)

Lack of action - Flight crew (Cause)

Factual Information

On August 5, 2013, at 0848 central daylight time, N327FL, an Embraer S.A. EMB-505, multi-engine turboprop airplane, was substantially damaged during landing at Flying Cloud Airport (FCM), Eden Prairie, Minnesota. The two pilots were not injured. The airplane was registered to and operated by Flight Options, LLC; Cleveland, Ohio. Day visual meteorological conditions (VMC) prevailed at the time of the accident and an instrument flight rules flight plan had been filed for the 14 Code of Federal Regulations Part 91 positioning flight. The airplane had departed Pittsburgh International Airport (PIT), Pittsburgh, Pennsylvania, at 0731 eastern daylight time and was destined for FCM.

Both pilots reported that the airplane had been on a fast and steep visual approach when it then landed on runway 10R at FCM. They also reported that the indicated airspeed was about 150 to 160 knots when the airplane touched down on the runway at some point after the 1,000 foot marker. The airplane departed the end of the 5,000 foot long runway and impacted an airport boundary fence and other obstructions before coming to rest upright on a four-lane highway about 1,000 feet from the runway surface. The impact resulted in substantial damage to both wings and the fuselage.

A hand written takeoff and landing data card prepared by the flight crew before their arrival at FCM showed their expected landing weight was 14,000 pounds, their calculated Vref speed was 106 knots, and the Vap speed was 110 knots, with the flaps set at position 3. The airport elevation was noted as 906 feet. The space on the card for runway required was blank and did not have an entry.

Data on page PD35-3 in the Quick Reference Handbook (QRH) showed landing performance for an EMB-505 airplane landing at an airport at an altitude of 1,000 feet at a landing weight of 14,000 pounds, with the flaps set at position 3. When the airplane was flown at a Vref speed of 107 knots and a Vap speed of 110 knots, the expected dry runway unfactored landing distance was 2,378 feet, the expected wet unfactored landing distance was 3,000 feet, and the expected wet factored landing distance was 4,600 feet.

A combination voice and flight data recorder (CVDR) was removed from the wreckage and examined at the NTSB Vehicle Recorder Laboratory, in Washington, D.C. The cockpit voice recorder portion of the CVDR contained 2 hours and 4 minutes of excellent quality voice recordings. A cockpit voice recorder group was convened and a partial transcript was prepared for the last 32 minutes of the flight.

Data from the flight data recorder (FDR) portion of the CVDR recording contained about 107 hours of data. The accident flight was the last flight of the FDR recording and its duration was about 2 hours and 56 minutes, which included the portion of time during the preflight checks before departure from PIT.

An examination of the FDR data showed the following:

At 0846:40 the airplane was on final approach at an altitude of 2,510 feet mean sea level (msl), at an indicated airspeed of 177 knots, and was descending at 3,986 feet per minute. The airplane was then configured with the landing gear extended, the speed brake extended, and the flaps at position 1.

At 0846:40 the recorder values for both engines were about 30 percent N1, and they remained

at this level until engine shutdown after the airplane came to rest.

Between 0846:40 and 0847:17 thirteen different aural warning unit (AWU) sounds were announced including multiple calls of: "whoop whoop pull up", "high speed", and "too low terrain".

At 0847:02 the airplane was on final approach at an indicated airspeed of 186 knots, at an altitude of 1,329 feet msl, or about 423 feet above the airport, and was descending at 3,077 feet per minute.

At 0847:14 the AWU announced "two hundred".

At 0847:16 the flap lever was selected to position 2.

At 0847:18 the AWU announced "one hundred".

At 0847:18 the indicated airspeed was 168 knots and the flap lever was selected to position 3.

At 0847:24 the airplane crossed the runway threshold at an indicated airspeed of 158 knots.

At 0847:28 the airplane touched down on the runway. Indicated airspeed near the point of touchdown was between 145 and 148 knots and groundspeed was between 150 and 153 knots.

At 0847:29 brake pressures for both left and right braking systems began increasing to an initial local maxima of around 630 psi between about five and six seconds after the maximum wheel spin value was recorded. Left and right brake pressure values varied between about 140 and 740 psi until 0847:47.

At 0847:47 there was a recorded brake pedal displacement of about 35 mm of stroke for the right brake pedal and the FDR discrete for brake fail parameter changed to true. Brake pressures then dropped to a value of about 50 psi and remained near that value for the remainder of the recording.

At 0847:50 indicated airspeed was 68 knots when the airplane exited the runway surface.

At 08:48:07 indicated airspeed and groundspeed had become approximately zero knots.

FDR data for the emergency / parking brake lever discrete showed the brake to be on at the start of the flight and was then moved to the release position for taxiing during the airplane's departure from PIT. The emergency / parking brake lever remained off for the remainder of the flight and was not activated during the landing at FCM.

Instructions in the QRH for a loss of normal braking on page EAP12-5 showed that when the yellow BRK FAIL message is illuminated the emergency / parking brake lever should be gently applied.

Embraer reported that the brake-by-wire system is designed such that if a failure occurs in either pedal transducer, then the system will declare a brake failure and close the main brake system shut-off valve. The brakes could then be controlled by the emergency brake system using the emergency / park brake handle. There is no anti-skid function when using this emergency brake system.

Recorded data from the brake control unit (BCU) and the FDR indicated that the brakes initially operated normally during the landing roll with the anti-skid operating. During landing, the pedal displacement gradually increased over 17 seconds until the BRK FAIL message illuminated and failure of the normal brake system occurred. The displacement of the right

pedal suggests that this failure occurred as a result of over travel of the pedal beyond the mechanical stop.

The recorded data also showed that during the accident landing the emergency / parking brake handle was not actuated and remained at the off position.

Wreckage examination:

A postaccident examination of the engines and the airframe revealed no evidence of mechanical malfunctions or failures that would have precluded normal operation.

The BCU was examined at the manufacturer's facility. The BCU passed a full functional test and it was returned to service.

Airport Information:

The FAA Airport/ Facility Directory, North Central U. S., indicated that FCM was a towered airport with a field elevation of 906 feet mean sea level (msl). The longest runway was 10R-28L, which was an asphalt runway 5,000 feet long by 100 feet wide. Runway 10R was oriented to 098.8 degrees true and 99.9 degrees magnetic. Records show that the asphalt surface was not grooved and did not have a porous friction course overlay.

Meteorological Information:

At 0838 the recorded weather data from FCM revealed that the wind was from 150 degrees at 4 knots, 6 miles visibility in mist, few clouds at 200 feet above ground level (agl), an overcast ceiling at 7,000 feet agl, temperature 18 degrees C, dew point temperature 17 degrees C, with an altimeter setting of 29.89 inches of mercury. Remarks indicated that rain ended at 0819 with a one hour precipitation of 0.01 inches. At 0737 FCM reported that there had been a one hour total of 0.14 inches of rain. At 0653 FCM reported that the daily total rainfall had been 0.81 inches.

At 0847:43 a security camera video frame capture photo showed the aircraft parking ramp adjacent to the runway was wet and there were pools of standing water. Photos of the roadway surface taken between 0857 and 0901 showed the pavement was wet. At 1035 a photo of the runway surface showed the pavement was wet and had several areas of standing water.

Additional Information:

FAA AC 120-108 states "A stabilized approach is a key feature to a safe approach and landing (and is) characterized by maintaining a stable approach speed, descent rate, vertical flight path, and configuration to the landing touchdown point ... at a rate of descent no greater than 1,000 feet per minute (fpm)"

FAA Safety Alert for Operators - SAFO 15009 Date: 8/11/15

Subject: Turbojet Braking Performance on Wet Runways

"Several recent runway landing incidents/accidents have raised concerns with wet runway stopping performance assumptions. Analysis of the stopping data from these incidents/accidents indicates the braking coefficient of friction in each case was significantly lower than expected for a wet runway as defined by the Federal Aviation Administration (FAA) in Federal Air Regulation (FAR) 25.109 and Advisory Circular (AC) 25-7C methods. These incidents/accidents occurred on both grooved and un-grooved or non-Porous Friction Course overlay (PFC) runways. The data indicates that applying a 15 percent safety margin to wet

runway time-of-arrival advisory data as, recommended by SAFO 06012, may be inadequate in certain wet runway conditions."

FAA Advisory Circular AC No: 91-79A - Date: 9/17/14

Subject: Mitigating the Risks of a Runway Overrun Upon Landing

Paragraph 6, c, (1): "A 10 percent increase in final approach speed results in a 20 percent increase in landing distance."

...

Paragraph 6, j.: "Landing distances in the manufacturer-supplied AFM provide performance in a flight test environment that is not necessarily representative of normal flight operations. For those operators conducting operations in accordance with specific FAA performance regulations, the operating regulations require the AFM landing distances to be factored to ensure compliance with the pre-departure landing distance regulations. These factors should account for pilot technique, wind and runway conditions, and other items stated above. Pilots and operators should also account for runway conditions at the time of arrival (TOA) to ensure the safety of the landing. Though the intended audience of SAFO 06012 is turbojet airplanes, it is highly recommended that pilots of non-turbojet airplanes also follow the recommendations in SAFO 06012."

(1) The SAFO urgently recommends that operators develop a procedure for flightcrews to assess landing performance based on conditions actually existing at the TOA, as distinct from conditions presumed at time of dispatch. Those conditions include weather, runway conditions, the airplane's landing weight, landing configuration, approach speed, and the flightcrew deploys deceleration devices in a timely manner.

(2) Once the actual landing distance is determined, an additional safety margin of at least 15 percent should be added to that distance. Except under emergency conditions, flightcrews should not attempt to land on runways that do not meet the assessment criteria and safety margins as specified in SAFO 06012.

(3) A safety margin of 15 percent should be added, and the resulting distance should be within the runway length available. The FAA considers a 15 percent margin to be the minimum acceptable safety margin.

...

Appendix 1; Paragraph 2: Definitions:

j. Unfactored or Certified Landing Distance. The landing distance determined during certification as required by 14 CFR part 23, § 23.75 and 14 CFR part 25, § 25.125. The unfactored landing distance is not adjusted for any safety margin additives. The unfactored certified landing distance may be different from the actual landing distance because not all factors affecting landing distance are required to be accounted for by certification regulations.

k. Factored Landing Distance. For applicable operations, the dispatch landing distance allows the airplane to land and stop within 60 percent of the available runway when the runway is dry. The factored landing distance is the certified landing distance multiplied by 1.67, which can then be compared directly to the available landing distance. When the runway is wet, the certified distance is multiplied by 1.97 to account for the 15 percent additional runway requirement.

FAA Safety Alert for Operators SAFO 10005 - Date: 3/1/10

Subject: Go-Around Callout and Immediate Response

"It is critical to flight safety that both the pilot flying and the pilot monitoring should be able to call for a go-around if either pilot believes an unsafe condition exists. Also, although CRM principles prescribe that some cockpit decisions can be made by crew consensus, others, including the go-around callout, require immediate action, without question, because of the immediacy of the situation."

Flight Options – Flight Operations Manual

Page 4-19 – Date June 1, 2012

Subject: Go around

"Any time a "Go Around" is called, the PF will immediately execute the briefed maneuver. Any crewmember can call a "Go Around." "

Flight Options – Flight Operations Manual

Page 4-98 – Date June 1, 2012

Subject: Stabilized Approach Criteria

"All flights must be stabilized at 500' above MDA/DH when IMC or 500' above airport elevation when in VMC conditions. A go-around must be initiated if the aircraft does not meet the stabilized approach criteria ... An approach is stabilized when it meets the following criteria: 1. All briefings have been conducted

2. Aircraft is fully configured ... for landing

3. IAS airspeed is no more than VREF + 20 KTS and no less than VREF

4. IVSI is no more than 1000' per minute

...

An approach that becomes unstabilized requires an immediate go-around".

Flight Options – Part 135 / 91K Aircrew Training Manual

Page A6-11 – Date April 15, 2013

Subject: Visual Approach and Landing

The training manual pictorial shows that on base leg for a visual approach and landing the landing gear should be down, the before landing checklist should have been completed, the flaps should be at Flaps 3, the bank should not exceed 30 degrees, and the airspeed should be 120 knots. The pictorial also shows that when the airplane is crossing the runway threshold the airspeed should be at Vref.

Flight Options – Phenom 300 Aircraft Specific Standard Operating Procedures (SOP)

Page 9 – Date July 13, 2012

Subject: Visual Traffic Patterns

The SOP shows that when the airplane is at 500 feet above the airport surface on a visual approach the pilot monitoring (PM) should call out "500 FT, Stabilized" and the pilot flying

(PF) should then respond with "Stabilized". If the PM calls out "500 FT, Go Around", the PF should then respond with "Go Around"

Postaccident Changes to the BCU

On September 9, 2014, Embraer issued Service Bulletin (SB) 505-32-0015, which decreases the possibility of occurrence of the loss of main brakes if a brake pedal overtravels during an emergency situation. The overtravel monitoring remains active on the airplane in case of an actual transducer failure.

The changes implemented by the SB on BCU p/n DAP00100-09 include the following:

The "ANTISKID FAIL" message will appear on CAS when one of the pedals moves above 95.8 percent. The CAS message "ANTISKID FAIL" will be triggered on ground when the aircraft is stationary for 5 seconds, in order to indicate that the brake pedal adjustment is required before next flight – no loss of anti-skid function.

The "BRK FAIL" message will appear on CAS when one pedal achieves 100 percent and the other pedal is below 60 percent (resulting in loss of main brake).

The "BRK FAIL" message will NOT appear on CAS when one pedal is at 100 percent and the other pedal is above 60 percent (no brake loss).

History of Flight

Approach-VFR pattern final	Miscellaneous/other
Landing-flare/touchdown	Abnormal runway contact
Landing-landing roll	Miscellaneous/other Runway excursion (Defining event) Collision with terr/obj (non-CFIT)

Pilot Information

Certificate:	Airline Transport	Age:	48, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 With Waivers/Limitations	Last Medical Exam:	05/14/2013
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	06/07/2013
Flight Time:	(Estimated) 8158 hours (Total, all aircraft), 1081 hours (Total, this make and model), 4610 hours (Pilot In Command, all aircraft), 153 hours (Last 90 days, all aircraft), 74 hours (Last 30 days, all aircraft), 7 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport	Age:	50, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Right
Other Aircraft Rating(s):	None	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 With Waivers/Limitations	Last Medical Exam:	02/02/2013
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	03/08/2013
Flight Time:	(Estimated) 12348 hours (Total, all aircraft), 150 hours (Total, this make and model), 5128 hours (Pilot In Command, all aircraft), 101 hours (Last 90 days, all aircraft), 48 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	EMBRAER S A	Registration:	N327FL
Model/Series:	EMB-505	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	No
Airworthiness Certificate:	Commuter	Serial Number:	50500094
Landing Gear Type:	Retractable - Tricycle	Seats:	9
Date/Type of Last Inspection:	11/01/2012, Conditional	Certified Max Gross Wt.:	17968 lbs
Time Since Last Inspection:		Engines:	2 Turbo Fan
Airframe Total Time:	581 Hours	Engine Manufacturer:	P&W CANADA
ELT:	C126 installed, not activated	Engine Model/Series:	PW535E
Registered Owner:	FLIGHT OPTIONS LLC	Rated Power:	3360 lbs
Operator:	FLIGHT OPTIONS LLC	Air Carrier Operating Certificate:	Fractional Ownership; On-demand Air Taxi (135)
Operator Does Business As:	FLIGHT OPTIONS LLC	Operator Designator Code:	DJFA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	Condition of Light:	Day
Observation Facility, Elevation:	FCM, 906 ft msl	Observation Time:	1338 UTC
Distance from Accident Site:	1 Nautical Miles	Direction from Accident Site:	270°
Lowest Cloud Condition:	Few / 200 ft agl	Temperature/Dew Point:	18° C / 17° C
Lowest Ceiling:	Overcast / 7000 ft agl	Visibility	6 Miles
Wind Speed/Gusts, Direction:	4 knots, 150°	Visibility (RVR):	
Altimeter Setting:	29.89 inches Hg	Visibility (RVV):	
Precipitation and Obscuration:	Moderate - Mist; In the Vicinity - Rain		
Departure Point:	Pittsburgh, PA (PIT)	Type of Flight Plan Filed:	IFR
Destination:	Eden Prairie, MN (FCM)	Type of Clearance:	IFR
Departure Time:	0731 EDT	Type of Airspace:	Class D

Airport Information

Airport:	Flying Cloud Airport (FCM)	Runway Surface Type:	Asphalt
Airport Elevation:	906 ft	Runway Surface Condition:	Wet
Runway Used:	10R	IFR Approach:	Visual
Runway Length/Width:	5000 ft / 100 ft	VFR Approach/Landing:	Full Stop; Traffic Pattern

Wreckage and Impact Information

Crew Injuries:	2 None	Aircraft Damage:	Substantial
Passenger Injuries:	N/A	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	2 None	Latitude, Longitude:	44.826667, -93.447500 (est)

Administrative Information

Investigator In Charge (IIC): Thomas Latson **Adopted Date:** 09/12/2016

Additional Participating Persons: David R Nelson; FAA Minneapolis St Paul FSDO; Minneapolis, MN
Kevin Morris; FAA Minneapolis St Paul FSDO; Minneapolis, MN
Todd Anguish; Flight Options LLC; Cleveland, OH
Russ Leighton; International Brotherhood of Teamsters (IBT); Washington, DC
Mike Minellono; International Brotherhood of Teamsters (IBT); Cleveland, OH
Dan Ramirez; Embraer S. A.; São José dos Campos, FN
Cesar de Medeiros; CENIPA - Brazil; Brasilia, D F, FN
Brian McDermid; UK Air Accidents Investigation Branch (AAIB); Aldershot, Hampshire, FN

Publish Date: 09/12/2016

Note: The NTSB traveled to the scene of this accident.

Investigation Docket: <http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=87694>

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report.