NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 13, 2020

Specialist's Report

OPERATIONAL FACTORS

DCA20LA013

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A. ACCIDENT

Operator:	Envoy Airlines
Location:	Chicago, Illinois
Date:	November 11, 2019
Time:	0743 Central Standard Time (CST)[1]
Airplane:	Embraer EMB-145; N619AE
Flight No.:	4125

B. AIR SAFETY INVESTIGATOR

Shawn Etcher – Investigator
Operational Factors Division (AS-30)
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, DC 20594-2000

C. SUMMARY

On November 11, 2019, at about 0742 CST, Envoy EMB145LR, N619AE, right main landing gear collapsed after the aircraft departed runway 10L after landing at Chicago O'Hare International Airport (ORD), Chicago, Illinois. The aircraft experienced substantial damage due to the gear collapse. There was blowing snow at the time of the accident. There were 3 crew and 38 passengers on board who were deplaned after the event. No injuries were reported. The flight was operating as a 14 *Code of Federal Regulations (CFR)* part 121 as domestic passenger flight. The flight originated at the Piedmont Triad International Airport (GSO), Greensboro, North Carolina at 0622 Eastern Standard Time (0522 CST)

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board (NTSB) Operational Factors investigator was assigned to the accident on December 3, 2019 and did not travel for this accident investigation. The operational factors investigator was briefed by the Investigator in Charge (IIC) on the events surrounding the accident.

The Operational Factors investigator requested manuals, statements, training records, and other various items for the investigation from the airline. Pilot certification information was obtained from the operator and the Federal Aviation Administration (FAA).

[1] All times in the report will be Central Standard Time except as otherwise noted. At the time of the accident Greenwich Mean Time, also known as Zulu (Z) time, was 6 hours ahead of CST.

E. FACTUAL INFORMATION

1.0 History of Flight[2]

Envoy flight 4125 had departed GSO at 0622 EST (0522 CST). The flight's planned arrival time was 0738 CST. The captain was the pilot flying, (PF) and the First Officer (FO) was the pilot monitoring (PM).

According to the captain, the weather was reviewed for ORD while at the gate in GSO. While enroute the crew monitored the weather at ORD and the reported visibility was between ¾ and 1 mile. On initial contact with Chicago approach control, the flight was assigned to runway 9L. While on the downwind leg for the runway, air traffic control (ATC) changed the runway to 10L as runway 9L became closed.

During the approach to runway 10L, while on "short final," ATC issued a go-around to the accident flight. The ATC controller informed the crew that a preceding aircraft reported that the runway needed to be cleared.

After the go-around, the crew contacted the flight's dispatcher and discussed various options including diverting to their alternate airport or changing the alternate airport to a closer airport. After conferring with the dispatcher, the crew elected to try another approach to ORD. The captain reported that the determination was made based on that they had plenty of fuel and the braking action was being reported as "5 5 5[3]."

The flight was vectored by Chicago approach control for another approach to runway 10L. The flight intercepted the localizer and glideslope to runway 10L. The crew reported that the approach was stable, and they broke out of the clouds around 500 ft above ground level. The autopilot was disengaged, the wind was from 350° at 15 kts with gust to 20 kts, and they observed there was snow on the runway. The landing was "normal," the captain reported he applied brakes, and as the airplane approach 80 kts it began "swerving" to the right. The FO called "centerline" and the captain applied corrections, including maximum reverse thrust and brakes. The airplane returned to the centerline, and then veered to the left. The captain again applied corrections and as the airplane began to correct back towards the centerline but it then "swerved more to the left." The aircraft was decelerating through 50 kts when it experienced "an uncommanded swerve toward the taxi turn off N1" and departed the runway. The right main landing gear collapsed after the airplane departed the paved surface.

The FO reported that after the airplane came to rest, the ATC tower controller asked if they needed assistance to which he answered in the affirmative.

The captain reported that there was no fire so he determined that the passengers would remain on board until emergency services had arrived and transportation buses to take the passengers to the terminal. After the passengers deplaned via the main cabin door, the first officer reported that he noticed the taxiway was "very icy."

[2] Sources: Attachment 1 - "Crew Interview Summaries"

[3] Runway Condition Codes. Reference Section 6.1.1.1 and Section 7.2 of this report for more information on the FAA's Runway Condition Assessment Matrix

2.0 Flight Crew Information

The accident flightcrew consisted of 2 pilots and 1 cabin crew member. Radio transmissions and KNKT personnel knowledge of the FO determined that the captain was the pilot flying (PF) on the accident flight and the FO was the pilot monitoring (PM).

2.1 Captain

The captain was 33 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land and type rating on the EMB-145[4], limitations included English Proficient, ATP Circling Approach – VMC[5] only, and EMB-145 Circling Approach – VMC only. He held an FAA first-class medical certificate dated September 9, 2019, with no limitations listed. At the time of the accident, he was based at Dallas-Fort Worth International Airport (DFW), Dallas-Ft Worth, Texas.

According to information provided by Envoy Airlines, the captain had approximately 3,166 total hours of flight experience, of which 1,084 of those hours were in the EMB-145, and 56 of those hours were as pilot in command (PIC) in the EMB-145.

2.1.1 Captain's Training and Proficiency Checks Completed

A synopsis of the captain's recent training at Envoy Airlines was as follows[6]:

Date of Initial New Hire Training at Envoy Airlines	June 5, 2017
Initial Ground Training[7]	September 9, 2017
Completion of Initial IOE[8]	September 24, 2017
Upgrade to captain[9]	October 13, 2019
Most Recent FAA Observation	October 13, 2019
Most Recent Line Oriented Evaluation	September 19, 2019
Most Recent Maneuvers Validation	September 18, 2019
Most Recent Crosswind Landing Training[10]	September 19, 2019

2.1.2 Captain's Flight Times

The Captain's estimated flight times were based on Envoy Airlines provided documentation:

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[4] Embraer S.A. EMB-135ER, EMB-135LR, EMB-135KE, EMB-135KL, EMB-135BJ, EMB-145, EMB-145ER, EMB-145MR, EMB-145LR, EMB-145XR, EMB-145MP, EMB-145EP. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

[5] Visual Meteorological Conditions

[6] Source: Attachment 2 – "Flight Crew Training Records"

[7] Date ground training was completed.

[8] Initial Operating Experience. Training records indicated that IOE was accomplished in 50.4 flight hours. Additionally, training records indicated that during IOE the captain had operated several flights into or out of ORD.

[9] Upgrade training began with upgrade ground school which concluded September 19, 2019 and then training was completed with the completion of IOE and the FAA observation ride with Consolidation of Knowledge & Skills training as required under *CFR* Part 121.434.

[10] Part of the Line Oriented Evaluation training event associated with his upgrade training.

Total pilot flight time	3,166
Total EMB-145 flight time	1,084
Total EMB-145 PIC flight time	56
Total flight time preceding 24 hours	3
Total flight time preceding 30 days	63
Total flight time last 90 days	112

2.2 First Officer

The FO was 35 years old; held an ATP certificate with type rating on the EMB-145[11]. He held a commercial pilot certificate for airplane single-engine land; limitations included English Proficient, ATP Circling Approach – VMC only, and EMB-145 Circling Approach – VMC only. He also held an FAA first-class medical certificate dated July 8, 2019, with a limitation of "Must wear corrective lenses." At the time of the accident, he was based at ORD.

According to information provided by Envoy Airlines, the first officer had accumulated about 2,855 total hours of flight experience, of which 1,158 of those hours were in the EMB-145.

2.2.1 First Officer's Training and Proficiency Checks

A synopsis of the captain's recent training at Envoy Airlines was as follows[12]:

Date of Initial New Hire Training at Envoy Airlines	July 31, 2017
Initial Ground Training[13]	October 3, 2017
Completion of Initial IOE[14]	October 29, 2017
Most Recent Supervised Line Flying	February 27, 2018
Most Recent Line Oriented Evaluation[15]	May 12, 2019
Most Recent Maneuvers Validation	May 11, 2019
Most Recent Recurrent Ground Training[16]	May 10, 2019
Most Recent Crosswind Landing Training[17]	May 13, 2019

[11] Embraer S.A. EMB-135ER, EMB-135LR, EMB-135KE, EMB-135KL, EMB-135BJ, EMB-145, EMB-145ER, EMB-145MR, EMB-145LR, EMB-145XR, EMB-145MP, EMB-145EP. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019

[12] Source: Attachment 2 – "Flight Crew Training Records"

[13] Date ground training was completed.

[14] Initial Operating Experience. Training records indicated that IOE was accomplished in 28.2 flight hours. Additionally, training records indicated that during IOE the first officer had operated at least one flight into or out of ORD.

[15] Training records indicated that the recurrent training was complete following the completion of the Special Purpose Operational Training (SPOT) which occurred on May 13, 2019 with a simulator training event.

[16] Training records indicated that ground training was comprised of 2 days of training. The first officers training began on May 9, 2019 and concluded on May 10, 2019.

[17] Part of the Specific Purpose Operational Training.

2.2.2 First Officer's Flight Times

The FO's estimated flight times were based on Envoy Airlines' provided documentation:

Total pilot flight time	2,855 hours
Total EMB-145 flight time	1,158 hours
Total flight time preceding 24 hours	3 hours
Total flight time preceding 30 days	45 hours
Total flight time last 90 days	108 hours

3.0 Airplane Information

Photo 1: Accident Airplane, N619AE (Courtesy of flightradar24.com)

The accident airplane (Registration N619AE, Serial No.145101) was an Embraer EMB-145LR, powered by two Rolls-Royce Corporation AE3007A engines. The engines were rated at 7,426 pounds of takeoff thrust each. The airplane was built in 1998, registered to American Airlines, Inc., leased to Envoy Air Inc. on September 10, 2018, and held a transport category airworthiness certificate. The aircraft was certified for operation during day and night, VFR[18] and IFR[19], flight in icing conditions, and RVSM[20]. The airplane was configured with 2 pilot seats, a cockpit observer seat, a flight attendant seat, and 50 passenger seats.

According to the accident flight's dispatch release there were no maintenance deferral items at the time of departure.

3.1 Limitations

The Envoy Airlines EMB-140/145 Aircraft Operations Manual Volume 1, provided the following aircraft limitations as it pertained to this event:

[18] Visual Flight Rules
[19] Instrument Flight Rules
[20] Reduced Vertical Separation Minimum

Yaw Damper

Yaw Damper operation *is **not authorized** for:*

- Takeoff to 500 ft. AFL
- Landing

Thrust Reverser Use

- Thrust reversers are intended for use during rejected takeoff or landing only. After initiating reverse thrust, a full stop *MUST* be made.
- MAXIMUM reverse thrust *MUST* be used:
  - Whenever its use will prevent a runway excursion.
  - When landing on runways with "Medium" or "Poor" braking action, unless the appropriate landing distance penalty *[Flip Cards]* is applied.
- IDLE reverse *MAY* be used on:
  - Dry runways 9,000 ft. or shorter usable length (LDA)
  - Non-dry runways where braking action is "Good"
- Thrust reverser use is PROHIBITED for:
  - Power-back operations
  - Taxi operations
  - Thrust levers stabilized in any intermediate position between IDLE reverse and MAXIMUM reverse.

Circling Approach

Circling Approaches are not authorized when the weather is less than 1,000 ft. ceiling and three miles visibility.

Demonstrated Crosswind

Takeoff and Landing ..... 30 kts.

NOTE

Reference *Flight Manual – Part 1* for additional restrictions that may apply.

Tailwind

Maximum Takeoff and Landing Tailwind Component..... 10 kts.

3.2 Weight and Balance

The following weight and balance information was taken from the dispatch flight closeout form. Limitations are indicated in **bold** type[21]. All weights below are in pounds (lbs.).

Basic Operating Weight		28,530
Passenger Weight[22]	7,182	
Cargo Weight	980	
Total Payload		8,162
Zero Fuel Weight		36,692

[21] Source: Attachment 6 – Envoy Airlines Aircraft Operations Manual [Excerpts]

[22] Passenger weight included the 38 passengers 12 were seated in zone A, 11 were seated in zone B, and 15 were seated in zone C. The form indicated there were no children or additional crewmembers. Zones A, B, and C held a maximum of 17, 15, and 18 passengers respectively.

Maximum Zero Fuel Weight	**40,564**
Fuel on Board	10,880
Ramp Weight	47,572
Maximum Ramp Weight	**50,044**
Taxi Fuel	432
Takeoff Weight	47,140
Maximum Takeoff Weight	**49,823**
Planned Fuel Burn	5,356
Planned Landing Weight[23]	41,784
Maximum Landing Weight	**43,651**
Center of Gravity[24]	24

3.3 Landing Performance

Envoy Airlines flight crews utilized electronic flight bags for calculating aircraft performance. The following calculations were based on the aircrafts landing weight and the wind speed and direction provided by the ATC tower controller and what the flight crew reported they used based on the latest conditions:

Figure 1: Landing Performance with Wind from 350 Degrees at 13 kts Gusting to 20 kts

[23] Planned landing weight was a dispatch estimated weight based on an estimated takeoff weight.
[24] Takeoff Center of Gravity range for this aircraft was 18 to 38 inches.

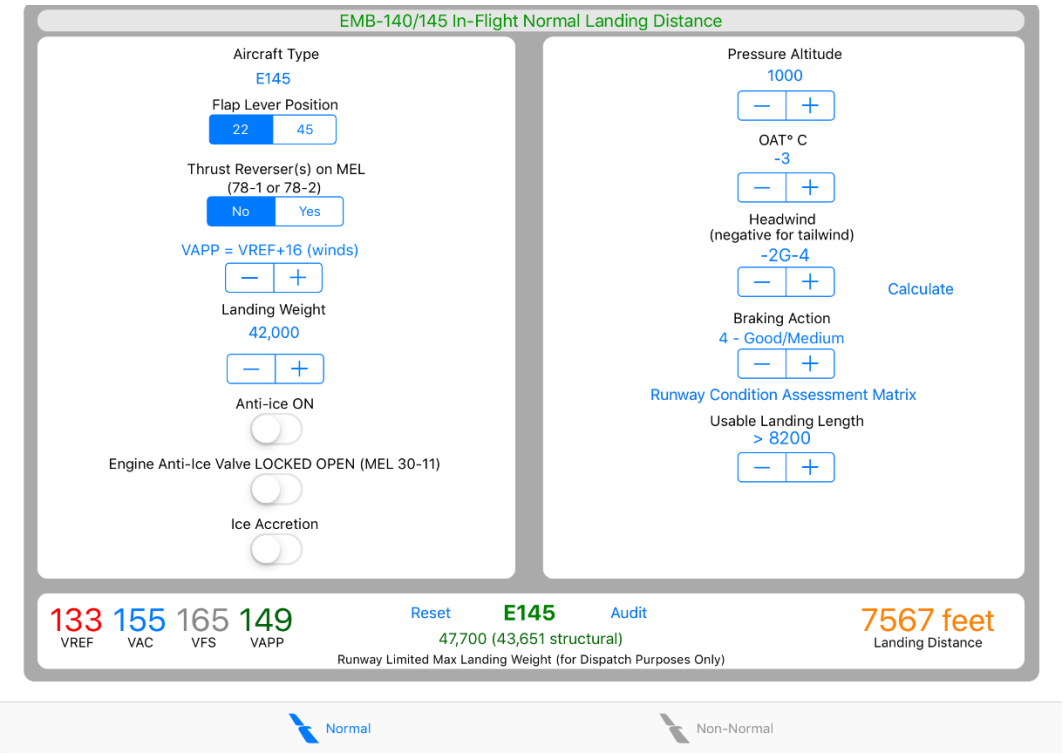

Figure 2: Landing Performance with Tower Provided Winds from 360 degrees at 17 kts Gusting to 24 kts

4.0 Airport Information

Chicago O'Hare International Airport was one of two commercial airports for the city of Chicago, Illinois, and was located about 13 miles northwest of downtown Chicago. It had eight paved landing surfaces for airplanes.

4.1 Airport Diagram and Notes

According to the FAA Chart Supplement, runway 10L was 13,000 feet in length and 150 feet in width. The surface was asphalt/concrete, grooved, in good condition. The runway was equipped with high intensity runway lights, centerline lights, and a 4-light precision approach path indicator (PAPI) installed on the left side of the runway. The landing distance available was 12,246 ft.

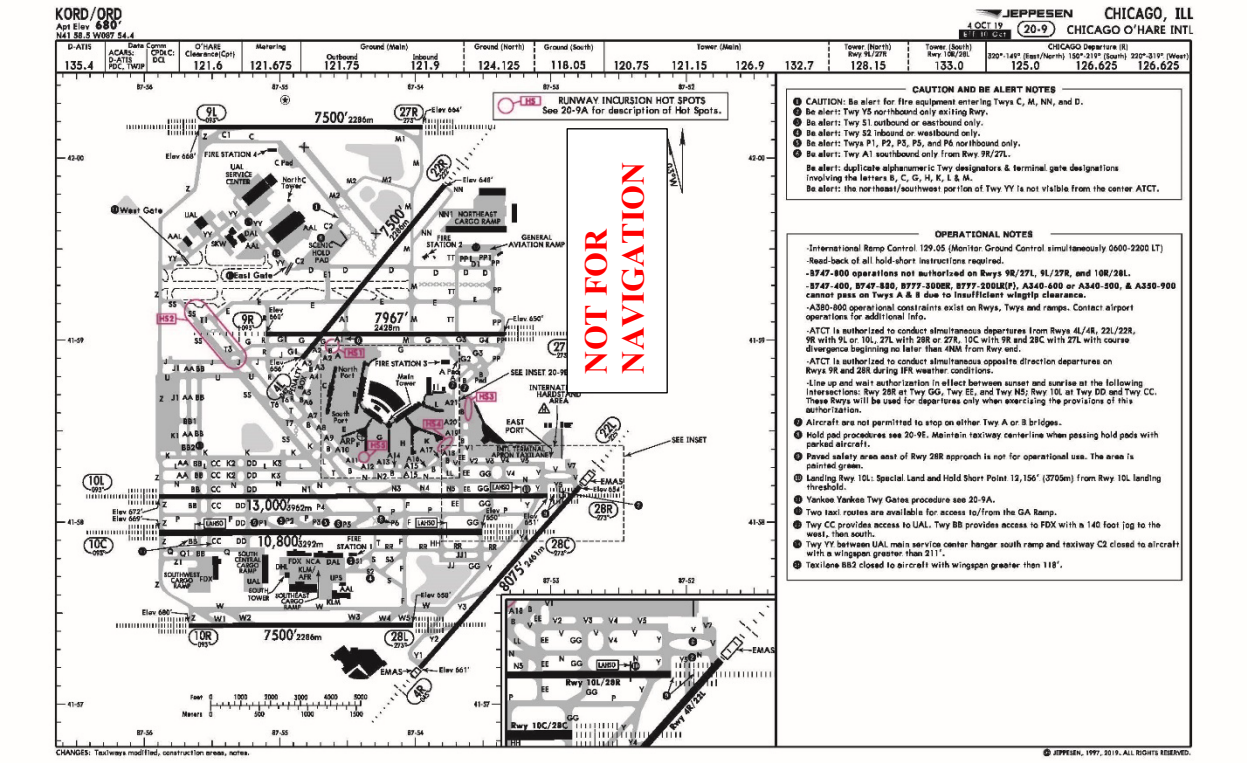

Figure 3: ORD Airport Diagram Page

5.0 Accident Flight Dispatch Release and Weather Packet

5.1 Dispatch Release

Envoy Airlines Dispatch Release for the accident flight was listed as "Plan 1 of 1" and was a 24-page document. The dispatch release contained information for the accident flight such as, fuel required, route of flight, departure, destination, and alternate airport weather, MEL/CDLs[25], planned departure and arrival weights, enroute winds and temperature summary, aircraft restriction, and a "remarks" section. The "Remarks" section of the release was the location that the dispatcher could provide the crew with any remarks they deemed necessary to draw the crew attention to, this section listed "*None"*

The fuel section of the release showed that the dispatcher had added an addition 821 lbs. of "*Ferry"* fuel, which equated to 27 additional minutes of fuel and 450 lbs. of "*Hold*" fuel which equated to 15 minutes of fuel; however, it did not list an altitude or speed that those times were based upon. Additionally, the release listed an alternate airport of Cincinnati/Northern Kentucky International Airport (CVG), Covington, Kentucky and required 2,245 lbs. of fuel to fly from ORD to CVG at FL230.

5.1.1 Pilot Reports

The following pilot reports were on the accident flight's dispatch release. The reports were in original coded format and in UTC time:

[25] Minimum Equipment List/Configuration Deviation List

UA /OV MCW170030/TM 0753/FL370/TP B738/TB CONT MOD

UA /OV 10 NE CVG/TM 0300/FLDURD/TP CRJ2/SK B053 BKN T058

The following are decoded reports in plain language with the time converted to local CST:

Routine pilot report (UA)/ Location - Over a point 30 miles south of Mason City VOR/DME, Mason City Iowa/ Time – 0153 CST/ Altitude FL370/ Aircraft – Boeing 737-800/ Turbulence – continuous moderate.

Routing pilot report (UA)/ Location - Over a point 10 miles northeast of the CVG VORTAC, Covington, Kentucky/ Time – 2100 CST [day prior]*/ Altitude – During descent/ Aircraft – Bombardier CRJ-200/ Sky conditions – broken cloud bases at 5,300 ft and cloud tops at 5,800 ft.*

5.1.2 ORD Weather

The dispatch release contained the following weather information both current at the time the dispatch release was generated and forecasted at ORD:

ORD
110951Z 35013KT 3/4SM R10L/4000V5000FT -SN BR OVC007
M02/M02 A3015 RMK AO2 SLP218 P0004 T10171022

ORD TAF/
TAF KORD 110655Z 1107/1213 02012KT 3SM -SN BKN008 OVC012
TEMPO 1107/1109 1SM -SN BR OVC006
FM110900 01012G18KT 1SM -SN BR OVC006
TEMPO 1109/1113 1/2SM SN FZFG VV004
FM111500 36015G25KT 1SM -SN BLSN BKN008 OVC012
FM111800 35015G25KT 2SM -SN BLSN BKN012 OVC020
FM112100 34017G25KT 5SM BLSN BKN020 OVC030
FM120000 33015G25KT P6SM SCT025 BKN040
FM120400 32014KT P6SM SCT040
FM120900 32013KT P6SM SKC

5.1.3 ORD Airport Conditions

The following airport conditions were provided to the flight crew prior to departure on the flight's dispatch release:

- KORD/ORD - CHICAGO OHARE INTL
----------/
--------- AIRPORT ---------
-ALL SFC WIP SN REMOVAL 11NOV19/0917 12NOV19/1200 KORD A1985/19
-ACFT REQUESTING NOISE ABATEMENT RWY REQUIRE 2HR PPR 773-686-2255
04NOV19/1754 17MAY20/1100 KORD A1546/19

-AD AP WDI FOR RWY 22L U/S 1911020630-1911161100 02NOV19/0630 16NOV19/1100 KORD 11/073
-AP ABN U/S GREEN ONLY 29OCT19/0759 13NOV19/0759 KORD A1022/19
--------- RUNWAY ---------
-RWY 10C/28C CLSD 11NOV19/1009 11NOV19/1200 KORD A1990/19
-RWY 09R/27L CLSD 11NOV19/0457 11NOV19/1200 KORD A1972/19
-RWY 04R/22L CLSD 11NOV19/0435 11NOV19/1200 KORD A1970/19
-RWY 04L/22R CLSD 11NOV19/0435 11NOV19/1200 KORD A1969/19
-RWY 10R/28L CLSD 11NOV19/0357 11NOV19/1200 KORD A1966/19
-RWY 09L/27R CLSD 11NOV19/0356 11NOV19/1200 KORD A1965/19
-RWY 10L FICON 3/2/2 50 PCT 1/8IN WET SN, 50 PCT 1/8IN WET SN, 100 PCT 1/8IN WET SN OBS AT 1911111046. 1911111046-1911121046 11NOV19/1046 12NOV19/1046 KORD 11/379
-RWY 10L 5/5/5 100 PCT WET OBS AT 1911110914. 11NOV19/0914 12NOV19/0914 KORD A1984/19
-RWY 27R LEAD OFF LGT U/S 01NOV19/0812 29NOV19/1200 KORD A1340/19
-RWY 09L LEAD OFF LGT U/S 01NOV19/0812 29NOV19/1200 KORD A1341/19
-RWY 10C/28C CL MARKINGS OBSC 1911010803-1911291100 01NOV19/0803 29NOV19/1100 KORD 11/025
-RWY 04L/22R SAFETY AREA IRREGULAR SFC NE END 31OCT19/1733 30APR20/1200 KORD A1242/19
-RWY 04L/22R SAFETY AREA IRREGULAR SFC SE SIDE BTN TWY M AND TWY NN 31OCT19/1731 30NOV19/1200 KORD A1241/19
-RWY 04L/22R SAFETY AREA IRREGULAR SFC NW SIDE BTN TWY D AND TWY M 31OCT19/1729 30APR20/1200 KORD A1240/19
-RWY 09R/27L CL MARKINGS OBSC 1910311413-1911301200 31OCT19/1413 30NOV19/1200 KORD 10/177
-RWY 09R/27L SAFETY AREA IRREGULAR SFC N SIDE BTN TWY TT AND TWY M 21OCT19/0631 21NOV19/1200 KORD A0436/19
-RWY 09R/27L SAFETY AREA IRREGULAR SFC N SIDE BTN TWY TT AND TWY PP 16OCT19/1503 31DEC19/2359 KORD A0190/19
-RWY 09L/27R CL MARKINGS OBSC 1910081437-1912091200 08OCT19/1437 09DEC19/1200 KORD 10/269

5.1.4 ORD Field Report

The following airport field report, issued about 90 minutes prior to departure, was provided on the flight's dispatch release:

** ORD FIELD REPORT **

DATE 11NOV19 TIME 0450 LOCAL

EXISTING TAA SEE NOTAMS

RWY STATUS CONDITIONS REMARKS
04L /22R CLOSED

04R /22L CLOSED
09L /27R CLOSED
09R /27L CLOSED WET
10L /28R OPEN WET RWYCC 10L 5/5/5
10C /28C CLOSED WET
10R /28L CLOSED WET
RAMP/TXWY SURFACE WET

5.2 Communication with Dispatch

The flight crew was able to communicate directly with dispatch via the ACARS[26] system. ACARS communication from the flight contained, in part, the following[27]:

> At 1322:35Z (0722:35 CST) the crew messaged dispatch that the flight had made a go around and that they would try one more approach. If they weren't able to get in, they would divert to their alternate airport.
>
> At 1324:30Z (724:30 CST) dispatch responded to the crew's message and informed them that if the crew wanted to attempt 2 approaches that dispatch would select a closer airport as an alternate if the crew wanted that.
>
> At 1328:26Z (0728:26 CST) the crew replied to dispatch that the numbers were good for a closer alternate, and they could do that.
>
> At 1331:44Z (0731:44 CST) dispatch informed the crew that there were already two aircraft heading to the closer alternate airport and that the flight, if it needed to divert, would go to the original alternate airport to get fuel and back to ORD would be faster.
>
> At 1333:48Z (0733:48 CST) the flight crew responded with "thanks."
>
> At 1343:17Z (0743:17 CST) ACARS sent a message that the flight was on the ground at ORD.
>
> At 1346:23Z (0745:23 CST) the flight crew sent a message to dispatch reporting "all ok."
>
> At 1349:52Z (0749:52 CST) the flight crew sent another message to dispatch reporting "just went off the runway."

6.0 Meteorological Conditions

The last recorded weather, prior to the accident, was the ORD METAR[28], which recorded the following ATIS[29] information:

[26] Aircraft Communications, Addressing and Reporting System
[27] Source: Operation Factors Attachment 5 – Accident Flight ACARS Communication [Excerpt]
[28] Meteorological Aerodrome Reports.
[29] Airport Terminal Information System

SPECI KORD 111302Z 35013G25KT 3/4SM R10L/4000V5500FT -SN BLSN VV010 M05/M06 A3019 RMK AO2 P0001 T10501061 $=

For detailed weather information see the Meteorology Group Chairman report located in the docket associated with this accident.

7.0 Envoy Airlines Guidance

7.1 Aircraft Operating Manual

The following information was provided to all flightcrews in the Envoy EMB-140/145 Aircraft Operating Manual Volume 1, Revision 12, effective on July 30, 2019.

7.1.1 Contaminated Runway

The Envoy Airlines EMB-140/145 Aircraft Operations Manual Volume 1 defined contaminated runway as the following:

A runway is considered "Contaminated" when more than 25% of the required field length, within the width being used, is covered by:
• More than 1/8th inch (3 mm) of:
— standing water,
— slush, or
— wet snow.
• More than 3/4 inch (19 mm) of dry snow.
• Compacted snow
• Ice
However, in certain other situations it may be appropriate to consider the runway contaminated. For example, if the section of the runway surface that is covered with standing water or slush is located where rotation and liftoff will occur, or during the high speed part of the takeoff roll, the retardation effect will be far more significant than if it were encountered early in the takeoff while at low speed. In this situation, the runway might better be considered contaminated.

7.1.1.1 FAA/Industry Braking Action Definitions

Envoy Airlines' EMB-140/145 Aircraft Operations Manual Volume 1 provided the following guidance based on FAA Advisory Circular AC 91-79A Appendix 1; further information is available in Section 7.2 *Landing Condition Reports* below in this report:

Airport Operator Assessment Criteria			Control/Braking Assessment Criteria		Landing Distance Column Used
Runway Condition Description	Mu	Code	Deceleration of Directional Control Observation	Pilot Reported Braking Action	
• Dry		6	-	-	Dry
• Frost • Wet (includes damp and less than 1/8 inch depth of water) **Less than 1/8 inch (3mm) depth of:** • Slush • Dry Snow • Wet Snow	40 or higher	5	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	Good	Good
-15°C and colder outside air temperature: • Compacted Snow	39-30	4	Braking deceleration OR directional control is between Good and Fair (Medium).	Good to Medium	Medium
• Slippery When Wet (wet runway) • Dry Snow or Wet Snow (any depth) over Compacted Snow **1/8 inch depth or greater of:** • Dry Snow • Wet Snow **Warmer than -15°C outside air temperature:** • Compacted Snow		3	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	Medium	
1/8 inch depth or greater of: • Water • Slush	29-21	2	Braking deceleration OR directional control is between Fair (Medium) and Poor.	Medium to Poor	Poor
• Ice		1	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	Poor	
• Wet Ice • Water on top of Compacted Snow • Dry Snow or Wet Snow over Ice	20 or lower	0	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	Nil	Landing not allowed

Figure 4: Runway Condition Assessment Matrix (RCAM) Guidance from the FAA

7.1.2 Winter Operations

The following winter operations guidance was provided, in part, in the Envoy Airlines Aircraft Operations Manual Volume 1, "General – Winter Operations" section:

> ***Landing***
> *When landing at temperatures below -40°C, ensure that the rate of descent before touchdown is less than 300 ft./min. The aircraft may not takeoff again without further maintenance inspection.*
>
> *• Falling or blowing snow can create optical illusions or depth perception problems during landing and taxi-in.*

• Check ATIS for latest runway braking action report. Obtain current runway condition reports for both destination and alternate. Request runway surface friction information from Approach control or Tower (refer to Flight Manual – Part I, Chapter 10 Approach and Landing and Flight Manual – Part II).

• If landing on a slippery runway, the recommended technique is:

— Land on speed.

— Touchdown at the planned point. A firm landing is better than a "grease job".

— Lower the nose wheel immediately to the runway as it will decrease lift and increase weight on the main landing gear.

— Keep nose wheel firmly on the runway with elevator.

— Immediately after touchdown, check the ground spoilers have deployed after the thrust levers are reduced to IDLE.

— Use reverse thrust as soon as possible after touchdown.

— When reversing, be alert for yaw from asymmetric thrust. If directional control is lost, bring engines out of reverse until control is regained.

— Do not come out of reverse quickly. Sudden transition of reversers before engines spool down will cause a forward acceleration.

— Do not use asymmetric reverse thrust on a slippery and icy runway.

— Apply brakes with moderate to firm pressure, smoothly and symmetrically, and let the anti-skid do its job.

— If no braking action is felt, hydroplaning is probably occurring. Do not apply the Emergency/Parking Brake, since anti-skid protection will not be available. Maintain runway centerline and keep braking until the aircraft is decelerated.

— Use as much of the runway for roll-out as needed to slow the aircraft to a safe taxi speed before turning off a slippery runway.

— If required, use maximum reverse thrust to prevent a runway excursion.

7.1.3 Reverse Thrust

The following reverse thrust guidance was provided in the EMB-140/145 Aircraft Operations Manual, Volume 1:

Reverse Thrust

Refer to Thrust Reverser Use [LIMITATIONS].

Thrust Reversers were not used during aircraft certification under Title 14 CFR Part 25. Landing performance data [Flip Cards] is therefore based upon brake energy only and no reverse thrust credit is taken for runways that are:

— Dry

— Not dry and braking action "Good."

Thrust Reversers provide an additional margin of safety and control during rejected takeoffs and landings, especially on contaminated runways when braking effectiveness can be diminished. Reverse thrust is most effective at high speeds, with the Nose Wheel on the ground.

NOTE1
MAXIMUM reverse should not be used below 80 knots, and IDLE reverse should not be used below 60 knots to avoid FOD ingestion.

NOTE2
MAXIMUM reverse though, can be maintained down to lower speeds whenever its use will prevent a runway excursion.

7.1.3.1 Thrust Revers Use Limitation

The following limitation was applicable to all Envoy EMB-140/145 aircraft and was located in the limitations section of the Envoy Airlines EMB-140/145 Aircraft Operations Manual Volume 1:

• Thrust reversers are intended for use during rejected takeoff or landing only. After initiating reverse thrust, a full stop MUST be made.
• MAXIMUM reverse thrust MUST be used:
— Whenever its use will prevent a runway excursion.
— When landing on runways with "Medium" or "Poor" braking action, unless the appropriate landing distance penalty [Flip Cards] is applied.
• IDLE reverse MAY be used on:
— Dry runways 9,000 ft. or shorter usable length (LDA)
— Non-dry runways where braking action is "Good"
• Thrust reverser use is PROHIBITED for:
— Power-back operations
— Taxi operations
— Thrust levers stabilized in any intermediate position between IDLE reverse and MAXIMUM reverse.

7.1.4 Landing Under Adverse Weather Conditions

The following guidance, in part, was provided to all flightcrews in the Envoy Airlines EMB-140/145 Aircraft Operations Manual Volume 1 "Environmental":

General

This section discusses those techniques that apply to varying degrees of adverse landing conditions, from the everyday crosswind landing to the more complex problems of tire hydroplaning and slippery runways.

Do not try to offset a poor runway braking condition by landing short. While it is important not to land long, landing short can have more serious consequences than overrunning the far end of the runway at low speed. The desired touchdown point is 1,000 ft. from the approach end of the runway.

Brakes

The braking force available from the tires is proportional to the area in contact with the runway, the force on the tires perpendicular to the runway, the brake coefficient and coefficient of friction between the tires and runway.

The contact area normally changes little during the braking cycle. The coefficient of friction depends on the tire condition and runway surface (concrete, asphalt, dry, wet or icy). The perpendicular force comes from aircraft weight and any downward aerodynamic force.

The following recommended procedure will give the optimum braking for all runway conditions:

- *Immediately after nose gear touchdown, smoothly apply a constant brake pedal pressure for the desired braking. For short or slippery runways, use full brake pedal application.*
- *DO NOT attempt to modulate, pump or improve by any other special techniques.*
- *Do not release the brake pedal pressure until the aircraft speed has been reduced to a safe taxi speed.*

Accomplish a firm touchdown to obtain wheel spin-up required for automatic spoiler extension. Upon touchdown, lower the nose, select reverse thrust as required and apply brakes firmly and symmetrically. Reverse thrust is most effective at high speeds.

The Anti-skid System will stop the aircraft for all runway conditions in a shorter distance than is possible with brake pedal modulation. The Anti-skid System adapts pilot-applied brake pressure to runway conditions by sensing an impending skid condition and adjusting the brake pressure to each individual wheel for maximum braking effort.

When brakes are applied in a slippery runway, several skid cycles will occur before the Anti-skid System establishes the right amount of brake pressure for the most effective braking. If the pilot modulates the brake pedals, the Anti-skid System is forced to re-adjust the brake pressure to re-establish optimum braking. During this readjustment time, braking efficiency is lost.

At high speeds on extremely slippery runways, braking effectiveness may be sharply reduced resulting in a much slower than anticipated deceleration. The pilot may misinterpret the lack of deceleration as an anti-skid failure and pump the brakes; this technique should be avoided.

FOD – Reversing at Low Speeds

Using reverse thrust at low speed on snow and ice covered runways can cause engine foreign object damage. It is a natural tendency to carry thrust reversing to a low speed and use less brakes when the braking action is expected to be poor.

However, runways which have been cleared with snow removal equipment usually have chunks of ice and snow remaining and/or sand applied. Under these conditions, the engines are especially susceptible to blade damage. To minimize ingestion damage potential, the procedures for reverse thrust operation should be strictly followed unless aircraft safety dictates otherwise.

Slippery Runway – No Crosswind

The braking action of the EMB Anti-skid System on a wet runway is significantly different than on a dry surface. Hydroplaning may occur if the brakes or nose wheel steering are used on a wet runway.

Harsh application of the brakes aggravate the condition more than a smoothly applied increase of pressure. Early recognition of a directional control problem and immediate action is essential. Aggressive use of the rudder may be required.

Braking on a slippery runway can range from fairly good to virtually nil. Snow covered runways are at least twice as slippery as a dry runway. Ice covered runways can be 4 to 16 times as slippery as dry runways, depending upon temperature. Ice near the melting point is the most slippery.

Standing water and slush on the runway can produce hydroplaning as well as low-speed slickness. Hydroplaning speed will frequently be less than the touchdown speed. The higher the speed, the greater the hydroplaning effect. Without reverse, hydroplaning can double or triple runway stopping distance.

On slippery runways, reversing is the best aid in stopping. Using high levels of symmetrical reverse early in the landing roll will produce the greatest degree of stopping force. When coming out of reverse do not rapidly go from full reverse to forward thrust and thereby increase forward thrust and the stopping problem. Directional control will be primarily through use of the rudder. At lower speeds Nose Wheel Steering and differential braking will, to a degree, provide directional steering.

Slippery Runway – Crosswind

A slippery runway and a crosswind obviously make a bad combination. After touchdown on a slippery runway with a crosswind, the aircraft may weathercock into the wind and drift toward the downwind side of the runway. One of the worst situations occur when there is a crosswind and sufficient water and speed to produce total tire hydroplaning.

The use of forward Control Column pressure through the landing roll will help maintain control.

The forces acting to move the aircraft downwind are proportional to the square of the crosswind velocity; thus a 10 kts. crosswind would quadruple the side force developed on the aircraft by a 5 kts. crosswind.

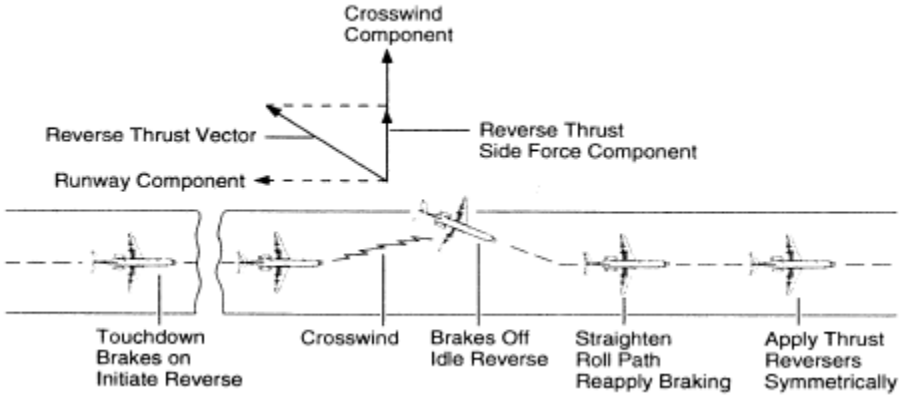

Figure 5: Reverse Thrust and Crosswind (Source: Envoy Airlines AOM)

NOTE

The application of reverse thrust increases the tendency of the aircraft to drift downwind since the side component of reverse thrust vector is acting in the same way as wind force.

If the aircraft should weathercock into the wind or move gradually to the downwind side of the runway, it may be necessary to release the brakes and possibly stop reversing to regain "cornering" control and re-establish alignment with the runway. Remember, forward thrust is capable of pulling the aircraft onto the desired runway track even though there is little or no traction. Use of forward thrust must obviously be tempered with consideration for existing runway margins. If hydroplaning is the problem, the tires can begin to take more of the side load as the aircraft slows below hydroplaning speed, thus improving directional control.

7.1.4.1 Limitations

The Envoy Airlines' EMB-140/145 Aircraft Operations Manual Volume 1, "Limitations" included, in part, the following limitations:

Demonstrated Crosswind
Takeoff and Landing ..... 30 kts.
NOTE
Reference Flight Manual – Part 1 for additional restrictions that may apply.
Tailwind
Maximum Takeoff and Landing Tailwind Component.....10 kts.

8.0 FAA Guidance

8.1 Braking Action Reports

The Aeronautical Information Manual (AIM), Section 4-3-8 *Braking Action Reports and Advisories* provided the following information in regard to braking action reports:

a. *When available, ATC furnishes pilots the quality of braking action received from pilots. The quality of braking action is described by the terms "good," "good to*

medium," "medium," "medium to poor," "poor," and "nil." When pilots report the quality of braking action by using the terms noted above, they should use descriptive terms that are easily understood, such as, "braking action poor the first/last half of the runway," together with the particular type of aircraft.

b. *FICON NOTAMs will provide contaminant measurements for paved runways; however, a FICON NOTAM for braking action will only be used for non-paved runway surfaces, taxiways, and aprons. These NOTAMs are classified according to the most critical term ("good to medium," "medium," "medium to poor," and "poor").*
    1. *FICON NOTAM reporting of a braking condition for paved runway surfaces is not permissible by Federally Obligated Airports or those airports certificated under 14 CFR Part 139.*
    2. *A "NIL" braking condition at these airports must be mitigated by closure of the affected surface. Do not include the type of vehicle in the FICON NOTAM.*
c. *When tower controllers receive runway braking action reports which include the terms medium, poor, or nil, or whenever weather conditions are conducive to deteriorating or rapidly changing runway braking conditions, the tower will include on the ATIS broadcast the statement, "BRAKING ACTION ADVISORIES ARE IN EFFECT."*
d. *During the time that braking action advisories are in effect, ATC will issue the most recent braking action report for the runway in use to each arriving and departing aircraft. Pilots should be prepared for deteriorating braking conditions and should request current runway condition information if not issued by controllers. Pilots should also be prepared to provide a descriptive runway condition report to controllers after landing.*

8.2 Runway Condition Reports

The AIM, Section 4-3-9 *Runway Condition Reports* provided the following information in regard to braking action reports:

a. *Aircraft braking coefficient is dependent upon the surface friction between the tires on the aircraft wheels and the pavement surface. Less friction means less aircraft braking coefficient and less aircraft braking response.*
b. *Runway condition code (RwyCC) values range from 1 (poor) to 6 (dry). For frozen contaminants on runway surfaces, a runway condition code reading of 4 indicates the level when braking deceleration or directional control is between good and medium.*

NOTE-
A RwyCC of "0" is used to delineate a braking action report of NIL and is prohibited from being reported in a FICON NOTAM.

c. *Airport management should conduct runway condition assessments on wet runways or runways covered with compacted snow and/or ice.*
    1. *Numerical readings may be obtained by using the Runway Condition Assessment Matrix (RCAM). The RCAM provides the airport operator with data to complete the report that includes the following:*

a) Runway(s) in use
b) Time of the assessment
c) Runway condition codes for each zone (touchdown, mid-point, roll-out)
d) Pilot-reported braking action report (if available)
e) The contaminant (for example, wet snow, dry snow, slush, ice, etc.)

2. Assessments for each zone (see 4-3-9c1(c)) will be issued in the direction of takeoff and landing on the runway, ranging from "1" to "6" to describe contaminated surfaces.

NOTE-
A RwyCC of "0" is used to delineate a braking action report of NIL and is prohibited from being reported in a FICON NOTAM.

3. When any 1 or more runway condition codes are reported as less than 6, airport management must notify ATC for dissemination to pilots.
4. Controllers will not issue runway condition codes when all 3 segments of a runway are reporting values of 6.

d. When runway condition code reports are provided by airport management, the ATC facility providing approach control or local airport advisory must provide the report to all pilots.
e. Pilots should use runway condition code information with other knowledge including aircraft performance characteristics, type, and weight, previous experience, wind conditions, and aircraft tire type (such as bias ply vs. radial constructed) to determine runway suitability.
f. The Runway Condition Assessment Matrix identifies the descriptive terms "good," "good to medium," "medium," "medium to poor," "poor," and "nil" used in braking action reports.

F. LIST OF ATTACHMENTS

Attachment 1: Flight Crew Written Statements
Attachment 2: Flight Crew Training Records
Attachment 3: Accident Flight Release
Attachment 4: Accident Flight Closeout Weight and Balance
Attachment 5: Accident Flight ACARS Communication [Excerpt]
Attachment 6: Envoy Airlines Aircraft Operations Manual [Excerpt]

Submitted by:

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