**NATIONAL TRANSPORTATION SAFETY BOARD**
Office of Aviation Safety
Washington, D.C. 20594

April 1, 2015

## Group Chairman's Factual Report

# OPERATIONAL FACTORS

## DCA14FA058

# Contents



## A. ACCIDENT

| | |
|---|---|
| Operator: | Trans States Airlines |
| Location: | Memphis International Airport, Memphis, TN |
| Date: | February 5, 2014 |
| Time: | 0022 Central Standard Time[1] |
| Aircraft: | Embraer EMB145EP airplane, Serial # 145066, Registration # N802HK |

[1] All times are Central Standard Time (CST) based on a 24-hour clock, unless otherwise noted.

## B. OPERATIONAL FACTORS GROUP

| | |
|---|---|
| Mr. Albert Nixon - Chairman<br>Air Safety Investigator<br>National Transportation Safety Board (NTSB)<br>490 L'Enfant Plaza East, SW<br>Washington, DC 20594-2000 | Capt. Normand Bissonnette– Member<br>Aircraft Evaluation Group<br>Federal Aviation Administration (FAA)<br>1601 Lind Avenue SW<br>Renton, WA 98057-3356 |
| Capt. Stuart Scott – Member<br>Manager of Flight Standards<br>Trans States Airlines<br>11495 Navaid Road, Suite 340<br>Bridgeton, MO 63044 | Capt. Mike Woodbury – Member<br>Chairman Air Safety Committee<br>Air Line Pilots Association (ALPA)<br>11495 Navaid Road, Suite 340<br>Bridgeton, MO 63044 |
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## C. SUMMARY

On February 5, 2014, about 0022 central standard time, N802HK, an EMB145EP operated by Trans States Airlines LLC as a Title 14 CFR Part 121 scheduled domestic passenger flight to Memphis International Airport (KMEM), Memphis, Tennessee, landed hard on runway 36R. Instrument meteorological conditions prevailed at the time of the accident. The airplane incurred substantial damage and there were no injuries to the 3 flight crew members or 41 passengers aboard. The flight originated in George Bush Intercontinental/Houston Airport (KIAH), Houston, Texas, on February 4, 2014, about 2022.

## D. DETAILS OF THE INVESTIGATION

The Operations Group conducted telephone interviews on March 5, 2014 - with the accident Captain and First Officer (FO).

On May 21 and May 22, 2014, the Operations Group interviewed a Trans States Airlines Check Airman, the Tran States Airlines, Manager of Flight Standards, Manager of Training, Director of Safety, Chief Pilot and the FAA Principle Operations Inspector (POI) for Trans States Airlines, at their facilities in St. Louis, Missouri. On May 21, 2014, the Operations Group chairman examined and documented an exemplar EMB145 on the ramp at Lambert/St. Louis International Airport

(KSTL), St. Louis, Missouri, and on May 23, 2014, the Operations Group conducted EMB145 simulator work at the Flight Safety facility in KSTL.

## E. FACTUAL INFORMATION

### 1.0 History of Flight

On February 4, 2014, a Trans States Airlines Inc. EMB145EP, N802HK, was operated as flight 3395 from KIAH to KMEM.

The flight pushed back from the gate at KIAH about 2228. This was the crew's first flight in the accident airplane that day and both pilots stated they were not fatigued for the flight. The first officer was the pilot flying (PF) and the captain was the pilot monitoring (PM). According to the flight crew, the preflight was routine and the anti-ice system was not tested since it was only a first flight of the day required check[2]. About 2242, the flight departed KIAH and climbed to a cruising altitude of 31,000 feet mean sea level (msl). Both pilots stated that the weather along the route was good and the enroute portion of the flight was flown in Visual Meteorological Conditions (VMC) conditions. About 2324, the initial descent into the Memphis International Airport (KMEM) was initiated. During the descent, the flight entered a cloud layer about 3,500 feet msl. The crew stated the flight to KMEM was routine until they were being vectored by Air Traffic Control (ATC) to a final approach for an Instrument Landing System (ILS) to runway 36L.

Prior to the Final Approach Fix (FAF) for the ILS to runway 36L, the crew stated that they received intermittent localizer indications on both Primary Flight Displays (PFDs) during the hand flown approach. The crew did not recall visually observing any icing during the approach, and the captain said he noticed no Engine Indicating and Crew Alerting System (EICAS) messages for ice.

Inside the FAF, about 2339, the crew stated the localizer course was intermittent again and they elected to execute a missed approach and climbed to 3000 feet msl.

The crew notified Air Traffic Control (ATC) of the localizer course difficulty they experienced on the approach and the captain requested vectors to the ILS approach to runway 36C. Shortly thereafter, ATC cleared them for the ILS approach to 36R. While level at 2,000 feet, on base leg to runway 36R, the crew said they entered Instrument Meteorological Conditions (IMC).

On the ILS approach to runway 36R, the crew stated that the localizer course was initially swaying to each side; similar to what they experienced on the first approach, but the localizer course would stay centered longer. The captain stated that when he advised ATC of their localizer course issue, ATC was unaware of any issues with the localizer approach.

Near the FAF for the ILS 36R, the crew noticed a moisture build up on the windshield wiper and unheated portion of the windshield. The crew stated that the airplane's ice protection system was selected in automatic and did not activate during this time. The crew did not select the manual

[2] FDR data indicated that the airplane's anti-ice was checked on the first flight of the day.

use of the ice protection system.

At the FAF, the localizer course was uninterrupted and the airplane's autopilot captured the course. The crew said the airplane was configured with gear down, 45 degrees of flaps, and was on a stabilized approach. The crew continued the ILS approach, and near the approach minimums at about 400 feet above ground level, broke out of the weather, and observed the landing runway in sight. According to the captain, as the first officer announced "landing," she disconnected the autopilot using the control yoke switch. The autopilot was disengaged about 234 feet above ground level (agl)[3].

Immediately after the autopilot disengagement, the captain verbalized a speed warning, by calling out "to watch speed" to the first officer. He stated, the first officer "got a little slow" (between 5 to 6 knots) during this time, which he estimated the airplane to be about 100 to 150 feet agl.

According to the crew, about 20-40 feet agl, a rapid roll to the right occurred, just as the first officer was inputting crosswind controls. The captain estimated the airplane's right bank over the runway to be about 25-30 degrees. The airplane's wing struck the runway, and the airplane landed hard on the right side of the runway. The crew's post flight inspection revealed damage to the right wing and an accumulation of ice on the airframe.

## 2.0 Flight Crew Information

The Trans States Airlines accident crew consisted of a Captain, First Officer and Flight Attendant. All crewmembers were current and qualified under Trans States Airlines and FAA requirements.

## 2.1 Captain EMB145

Captain was 38 years old.
His date of hire with Trans States Airlines was August, 2005.
A review of the Captain's FAA records found no prior accident, incident or enforcement actions.
A review of the Captain's driving records showed no revocation or suspensions.

### 2.1.1 Captain's Certificates and Ratings Held at Time of the Accident

AIRLINE TRANSPORT PILOT (issued November 17, 2007)
AIRPLANE MULTIENGINE LAND
EMB145
COMMERCIAL PRIVILEGES AIRPLANE SINGLE-ENGINE LAND
EMB145 CIRCLING APPROACH VMC ONLY
ENGLISH PROFICIENT
MEDICAL CERTIFICATE FIRST CLASS (issued April 17, 2013)
Limitations: MUST WEAR CORRECTIVE LENSES.

[3] All airplane flight parameters obtained from the Flight Data Record (FDR).

The captain advised NTSB investigators that he was wearing his corrective lenses at the time of the accident.

### 2.1.2 Captain's Certification Record

FAA records of the Captain indicated that:

Private Pilot - Airplane Single Engine Land - certificate originally issued on May 11, 2002. Instrument Airplane privileges were added on November 4, 2002.

A Notice of Disapproval was issued on March 27, 2003 when he failed the practical examination for a Commercial Pilot certificate. He was retested and issued the certificate on April 07, 2003.

Commercial Pilot – Airplane Single Engine Land certificate with Instrument privileges originally issued on January 26, 2003. Multiengine Land privileges and an EMB145 (SIC) rating were added on December 29, 2005.

Airline Transport Pilot - Airplane certificate with EMB145 type rating and Commercial Pilot, Airplane Single Engine Land privileges was originally issued on November 17, 2007.

### 2.1.3 Captain's Training and Proficiency Checks

Date of initial upgrade to Captain at Trans States Airlines: December 6, 2007.
Date of upgrade to EMB145: December 6, 2007.
Initial Type Rating EMB145: November 17, 2007.
Last recurrent ground training: December 14, 2013.
Last Proficiency Check in EMB145: December 16, 2013.
Last PIC Line Check: September 10, 2013.

A review of Trans States Airline training records indicated that the Captain had failed an oral exam during company training for first officer (Captain downgrade) in January 2009.

### 2.1.4 Captain's Flight Times

| | |
|---|---|
| Total pilot flying time | 6,400 hours |
| Total PIC Time | 1,700 hours |
| Total EMB145 flying time | 5,600 hours |
| Total EMB145 PIC time | 1,100 hours |
| Total flying time last 24 hours | 3 hours |
| Total flying time last 30 days | 49 hours |
| Total flying time last 90 days | 176 hours |
| Total flying time last 12 months | 505 hours |

### 2.1.5 Captain's Reported Activities

For the captain and first officer, the second flight of their pairing started that evening at KIAH. The captain was based in KSTL and he was on the first day of a 5 day reserve period. For the captain, the accident flight occurred on his forth leg of the day. His first leg was a deadhead from KSTL to Chicago O'Hare International Airport (KORD), Chicago, IL. His second leg was a return flight from KORD to KSTL, with the accident first officer. His third leg was a deadhead to KIAH.

On the day of the accident, Tuesday, February 4, 2014, he does not recall what time he awoke but stated he got normal sleep and felt rested for his trip. He departed his home in St Louis, Missouri, about 1115. He checked in for duty about 1300 for a scheduled departure of 1345.The accident occurred on the forth leg, on the first day of a five day reserve period.

The day before the accident, on Monday, February 3, 2014, he was at his residence. He does not recall what time he awoke or any specific major activity; just a day at home. He did not recall what time he went to bed but he slept "well."

Two days before the accident on Sunday, February 2, 2014, he returned from vacation about 1100 and said he got normal sleep that night.

### 2.1.6 Captain's Toxicology tests:

Post-accident toxicology test results were negative for Amphetamines (Amphetamine, Methamphetamine, Ecstacy), Cocaine, Marijuana, Phencyclidine, and Opiates (Codeine, Morphine, 6-MAM).

## 2.2 First Officer (FO) EMB145

FO was 29 years old.
Her date of hire at Trans States Airlines was September 10, 2012.
A review of FAA records found no prior accident, incident or enforcement actions.
A review of the FO's driving records showed no revocations or suspensions.

### 2.2.1 FO's Pilot Certificates and Ratings Held at Time of the Accident

<u>FLIGHT INSTRUCTOR (issued April 3, 2012)</u>
AIRPLANE SINGLE AND MULTIENGINE
INSTRUMENT AIRPLANE

<u>COMMERCIAL PILOT (issued February 13, 2010)</u>
AIRPLANE SINGLE AND MULTIENGINE LAND
EMB145 (issued October 23, 2012)
INSTRUMENT AIRPLANE
[LIMITATIONS]: ENGLISH PROFICIENT; EMB145 SIC PRIVILEGES ONLY

AIRLINE TRANSPORT PILOT (issued July 17, 2013)
AIRPLANE MULTIENGINE LAND
EMB145 (issued October 23, 2012)
COMMERCIAL PRIVILEGES AIRPLANE SINGLE-ENGINE LAND
EMB145 CIRCLING APPROACH VMC ONLY
ENGLISH PROFICIENT

MEDICAL CERTIFICATE FIRST CLASS (issued April 3, 2013)
Limitations: None

### 2.2.2 FO's Certification Record

FAA Records of the FO indicated:

Private Pilot - Airplane Single Engine Land certificate issued on September 18, 2008. Instrument Airplane privileges were added on November 19, 2008.

Commercial Pilot – Airplane Single Engine Land certificate with Instrument privileges issued on February 13, 2010. Multiengine Land privileges and an EMB145 SIC type rating were added on October 23, 2012.

Airline Transport Pilot Airplane certificate with Airplane Multiengine Land, EMB145 type rating, and Airplane Single Engine Land privileges issued on July 17, 2013.

A review of the FOs FAA records found no prior accident, incident or enforcement actions.
A review of the FO's driving records showed no revocation or suspensions.

### 2.2.3 FO's Training and Proficiency Checks

Date of initial FO qualification on the EMB145: December 7, 2012.
Last recurrent ground training: July 15, 2013.
Last Proficiency Check in EMB145: July 17, 2013.
Type rated on EMB145 [SIC type rating]: October 23, 2013.
Last SIC Line Check: December 7, 2012.

A review of Trans States Airlines training records indicated that the FO had no record of failures during company training.

### 2.2.4 FO's Flight Times[4]

| | |
|---|---|
| Total pilot flying time | 2,100 hours |
| Total EMB145 flying time –all SIC | 930 hours |
| Total flying time last 24 hours | 7 hours |
| Total flying time last 30 days | 55 hours |

[4] Approximate hours based on interviews and TSA employment records.

| | |
|---|---|
| Total flying time last 90 days | 160 hours |
| Total flying time last 12 months | 695 hours |

### 2.2.5 FO's Reported Activities

The first officer, who was also based in KSTL, began her sequence of trips on February 2, 2014. The accident flight was her third leg of the day. Her first leg was from KORD to KSTL, with the accident captain. The second leg was a flight from KSTL to KIAH.

On the day of the accident, Tuesday, February 4, 2014, she awoke about 0900 and had breakfast. She said she had slept "well." She had lunch in her room and went to the gym and departed the hotel about 1500.

The day before the accident, Monday, February 3, 2014, she woke up at 0530 and sleep "well." She departed the hotel to make a 0630 showtime. She flew from Memphis to Chicago, Chicago to Moline, and Moline to Chicago. She checked into the hotel for a 27 hour layover and went to bed about 2200.

Two days before the accident, Sunday, February 2, 2014, she commuted in the night prior. She awoke about 0400 and sleep "good." She had a showtime of 0515 and flew two flight legs. Her duty day ended at 1100 and she was in bed about 2000.

### 2.2.6 FO's Toxicology tests:

Post-accident toxicology test results were negative for Amphetamines (Amphetamine, Methamphetamine, Ecstasy), Cocaine, Marijuana, Phencyclidine, and Opiates (Codeine, Morphine, 6-MAM).

## 3.0 Aircraft Information

According to information supplied by Trans States Airlines, the airplane, owned by CIT Leasing Corporation, was an EMB145ER, serial number 145066, and registration N802HK. The airplane was certificated in the Transport category, and had a retractable, tricycle gear configuration. The airplane was configured with seating for two pilots, one cockpit observer jumpseat, one retractable flight attendant seat, and 50 passenger seats. The airplane was powered by two Rolls Royce AE3007A1 turbofan engines, rated at 7,426 pounds of thrust. At the time of the accident, the souls on board were comprised of two flight crewmembers, one flight attendant, and 41 passengers.

## 3.1 Weight and Balance Information[5]

- Basic operating Weight: 27,669
- Passenger Weight: 7,452
- Baggage/ Cargo Weight: 1,514

[5] According to information provided by TSA and the flight's dispatch release. (values listed are in pounds).

- Zero Fuel Weight: 36,635
- Max Zero Fuel Weight: 38,250
- Fuel Weight: 7,500
- Ramp Weight: 44,135
- Max Ramp Weight: 47,892
- Taxi Fuel Burn: 200
- Actual Takeoff Weight: 43,935
- Max Takeoff Weight[6] 44,050
- CG (MAC)[7]: 25.2%
- CG Limits: 13.8% to 36.0%
- Estimated Fuel Burn to Accident: 2,824
- Estimated Landing Weight: 41,111
- Max Landing Weight: 41,226
- Landing Speeds: $V_{ref}$ - 127 knots
- Landing Flap Setting: 45 degrees
- Min Required Landing Length: 4,514 feet

At the time of the accident, the dispatch paperwork referred to one open Minimum Equipment List (MEL) item on the airplane; MEL CDL54-50-2, BLEED VALVE ACCESS DOOR RH.

## 4.0 Performance

See Aircraft Performance Group Chairman's Factual Report.

## 5.0 Meteorological Information

At 2354, weather reported at time of arrival at KMEM was overcast clouds at 400 feet, winds were 290 degrees at 7 knots, temperature 1 degree Celsius, Dew point -1 degree Celsius, altimeter was 29.92 in/hg, and visibility was 1 statute mile.

At the time of dispatch, there were no National Weather Service advisories for any icing conditions over the route of the flight. See Weather Group Chairman's Factual Report for additional information.

## 6.0 Aid to Navigation

The FAA flight inspection of KMEM runway 36L localizer and glideslope was accomplished on October 29, 2014, and the inspection of runway 36R localizer and glideslope was accomplished on May 6, 2014. The periodic requirements were met during these inspections.

The flight crew said that KMEM tower was unaware of any issues with the localizer on the night of the accident. The first officer stated that she was not aware of any other airplanes experiencing

[6] Max takeoff weight was limited by the maximum landing weight at the destination.
[7] CG (MAC) setting is for takeoff.

the same localizer issue. The captain did not make a maintenance write-up on the airplane's localizer course function after the accident.

## 7.0 Communications

There were no known communication difficulties.

## 8.0 Airport and Runway 36R Information

According to FAA information, KMEM was located 3 miles South of Memphis, Tennessee. The airport elevation was 341 feet. The ATC control tower was continuous in operation and the airport had four runways – 18L/36R, 18C/36C, 18R/36L, and 9/27.

Runway 36R was the assigned landing runway for the accident flight.

Runway 36R:

- Dimensions: 9,000 feet long and 150 feet wide.
- Elevation 334.7 feet.
- Surface: concrete / grooved reported in good condition.
- Lighting: high intensity runway edge lights, centerline lights, touchdown zone lighted, 2,400 foot High Intensity Approach Lighting System (ALSF2) with centerline sequenced flashers (Category II or III).
- Precision Markings reported in good condition.
- Instrument Landing System (ILS) with distance measuring equipment (DME).
- 4-light Precision Approach Path Indicator (PAPI) located on the right side of the runway. The PAPI had a 3.00 degrees glide path.

## 9.0 Company Overview and Management Information

According to the company and their website, Trans States Airlines, Inc. had a total of 858 employees which included 390 pilots. The company had 29 of the Embraer 145ER airplanes. The company had crew bases in St Louis, Missouri, and Dulles, Washington D.C.

Trans States Holding Corp., an airline holding company with 124 employees was the parent company of Trans States Airlines Inc., Compass, Inc., and Go Jet Inc. Trans States Airlines Inc. corporate offices are located in St. Louis, Missouri. Trans States Airlines, Inc. flew for United Express and US Airways Express, operating EMB145 regional jet airplanes. Trans States Airlines Inc. operated 150 daily flights in the United States.

## 9.1 Federal Aviation Administration Oversight

The St. Louis, Missouri FAA Flight Standards District Office (FSDO) had responsibility for primary oversight of the Trans States Airlines certificate. The POI had an APM, and an Assistant POI assigned to provide operational oversight of the program. The POI was type rated in the EMB145 but was not current.

The POI stated that he was usually at Trans States Airlines at least once a week and routinely

attended appropriate meetings with the airline. He most recently attended the annual EMB145 Check Airman meeting. He said he divided his time evenly between working on surveillance and enforcement. His duties included reviewing EMB145 manuals and recommending changes. He currently was reviewing the TSA EMB Airplane Quick Reference Handbook (QRH) revision that corrected some differences with the AFM.

Trans States Airlines was moving towards an Advance Qualification Program (AQP) but at the time of the accident was in Phase 3 trials. Small group trials on instructors and the instructor evaluation course were currently being implemented.

The POI worked with Trans States Airlines to implement proactive changes to the TSA operations bulletin (#1-2014) that pertained to this accident. The operations bulletin listed an interim crew procedure to follow when operating in potential icing condition above 1,500 feet agl. The POI stated his concern about the EMB145 airplane's anti-ice system being unreliable and said he shared his concern with the airplane's manufacturer. This concern was why he pushed for proactive changes to the operations bulletin.

He stated that stabilized approaches, dealing with airspeed and late flap extension had been an issue identified by Flight Operational Quality Assurance (FOQA) but they have been trending better lately.

When the autopilot disconnect audio that occurred on the accident flight was discussed, he said, he had been aware of an autopilot disconnect issue on the EMB145, when the crewmember does not hold the disconnect button down adequately and the audio was heard until landing; He said that it occasionally occurred on past check rides. The POI stated that an intermittent localizer on the accident flight was the first time he was aware of its occurrence. No anomalies were observed in the airplane's localizer navigation system. Reference the Systems Group Chairman's Report for additional information.

## 10.0 Relevant Systems

### 10.1 Ice Detection System

The following information was obtained from TSA EMB145 Airplane Operations Manual (AOM), Volume 2, Section 2-15.

> *Ice detectors 1 and 2 are respectively installed at the airplane's left and right nose section, to provide icing condition detection. The ice detector was designed to pick up ice quickly. Therefore, in most cases, ice would be detected before it would be noticed by the crew.*
>
> *NOTE: Notwithstanding ice detector monitoring, the crew remains responsible for monitoring icing conditions and for manual activation of the ice protection system if icing conditions are present and the ice detection system is not activating the ice protection system.*

According to the TSA EMB145 AOM, Volume 2, Ice and Rain Protection, Ice Detection System section, any accumulation of ice thickness of 0.5 mm (0.020 inch) on either ice detector probe

caused the activation of the anti-icing system when operated in automatic mode. Simultaneously, an internal ice detector heat was activated to de-ice the probe until the probe's normal frequency was recovered. After a few seconds of cooling, the detector was ready to monitor for ice again. An EICAS advisory message (ice condition) would also be present to advise the crew.

The system's normal operation should be checked through the TEST knob on the Ice Protection panel.

The system was monitored by EICAS and the following messages were available to the crew:

***Ice detection system EICAS MESSAGES:***

| TYPE | MESSAGE | MEANING |
|---|---|---|
| CAUTION | ICE DETECTORS FAIL | Both ice detectors have failed. |
| | ICE DET 1 (2) FAIL | Associated ice detector has failed. |
| ADVISORY | ICE CONDITION | Airplane is flying under icing conditions. |

## 10.2 Ice and Rain Protection System

According to the TSA EMB145 AOM, Volume 2, Ice and Rain Protection, the airplane's ice protection system was provided by heating critical ice accumulation areas through use of either hot bleed air or electrical power. The system was fully automatic and under icing conditions, activated the entire anti-ice system, with the exception of the windshield heating system. Adequate ice protection for the wings and horizontal stabilizer leading edges and engine inlet lips was ensured by heating these surfaces with bleed air from the engines.

The electrically heated areas were: the windshields (must be manually activated), Pitot-Static tube, Angle of Attack (AOA) sensors, True Air Temperature (TAT) probes, Analog to Digital Computers (ADCs), pressurization static ports, lavatory water drains and water service drains. The ice and rain protection system provided signals to the EICAS that displayed appropriate system malfunctions.

In the automatic mode, the system was turned on through activation of the ice detector. The crew could manually activate the system through the OVERRIDE knob on the Ice Detection panel. Setting the OVERRIDE knob to the ALL position activated the system.

The following diagram was obtained from TSA EMB145 Airplane Operating Manual, Volume 2, Ice and Rain Protection, page 3, and depicts the airplane's ice and rain protection:

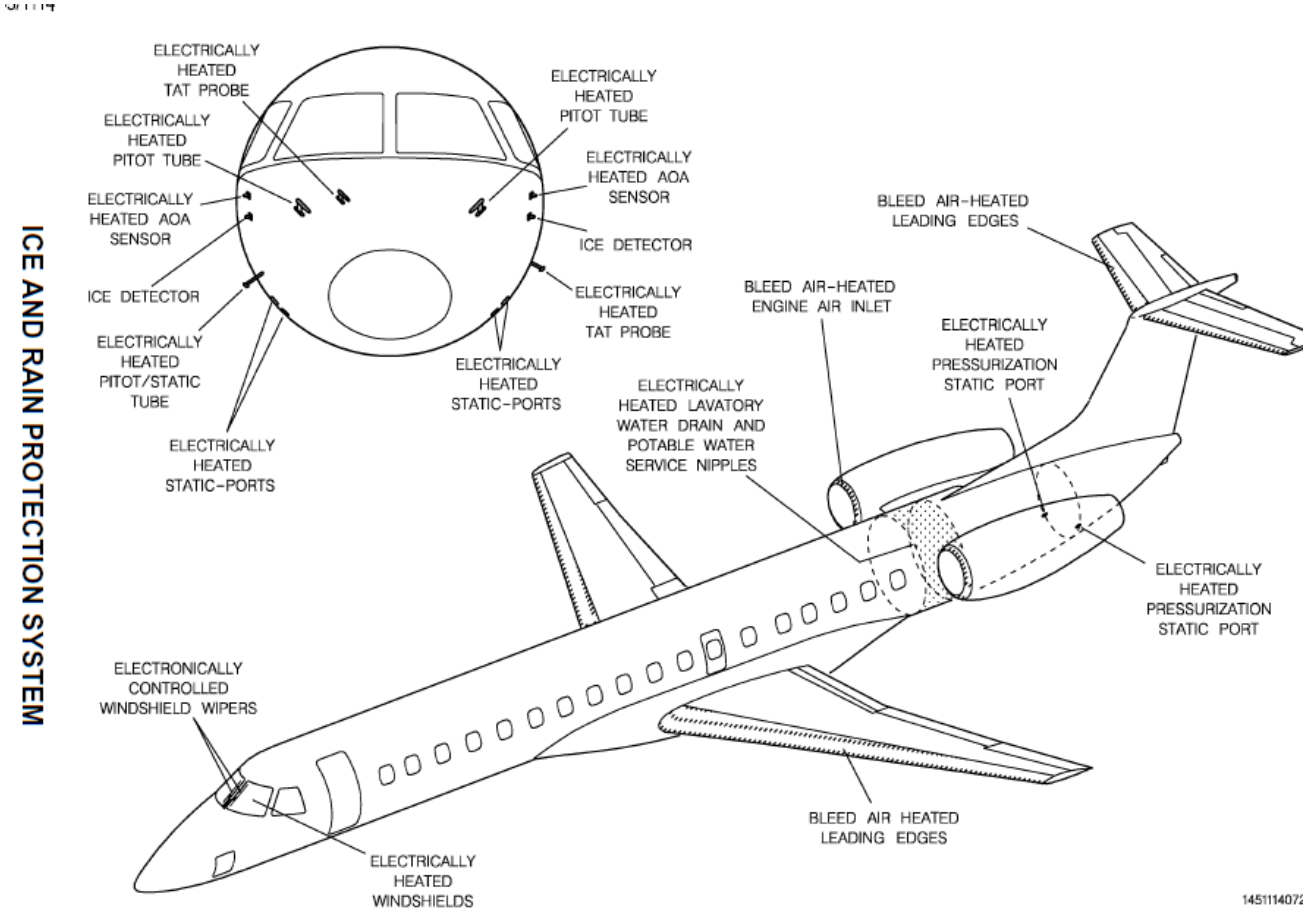


**Figure 1.** Diagram of the airplane depicting the ice and rain protection system.

The following diagram was obtained from TSA EMB145 Airplane Operating Manual, Volume 2, Ice and Rain Protection, pages 15-18, and depicts the ice protection controls and indicators available to the crew:

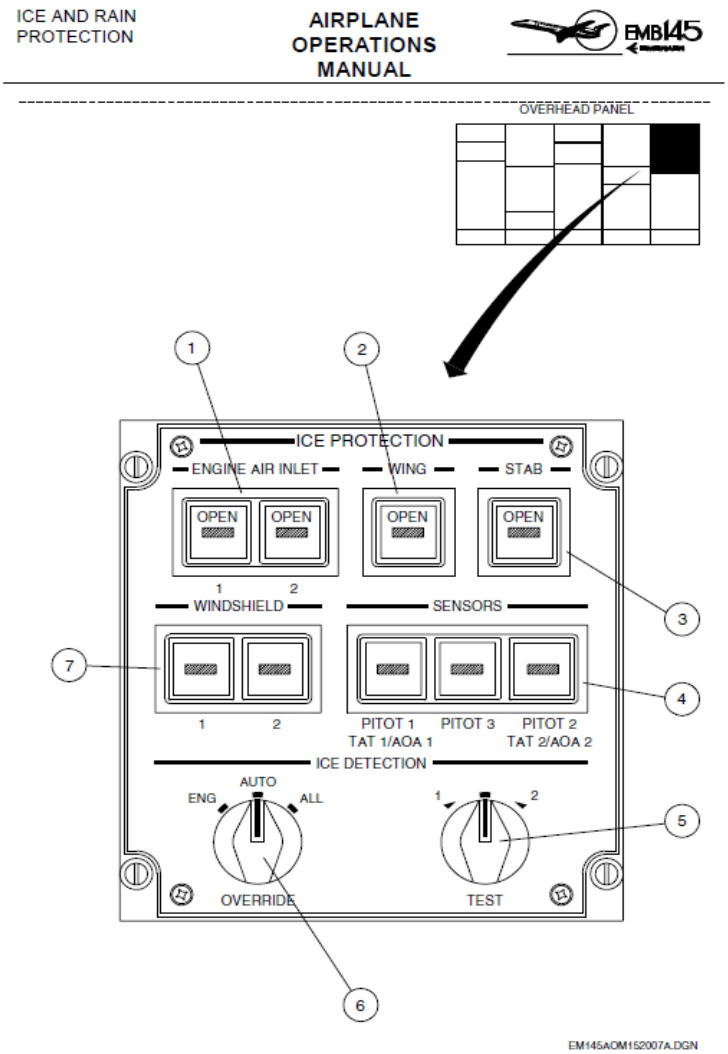


**Figure 2.** Ice Protection Control Panel.

### 10.3 Ice Protection Control Panel

The ice protection control panel was located in on the right rearward corner of the cockpit overhead instrument panel. The following switches and indicators are available to the flight crew (TSA EMB145 AOM, Volume 2, Ice and Rain Protection, pages, 18-20):

***1 - Engine Air Inlet Anti-Icing Buttons***

*− Turns off (released) or permits (pressed) the automatic activation of the associated engine air inlet anti-icing subsystem.*
*− A striped bar illuminates inside the button to indicate that it is released.*
*− An OPEN inscription illuminates inside the button to indicate that the associated engine air inlet anti-icing valve is open.*

***2 - Wing Anti-Icing Button***

*− Turns off (released) or selects the automatic mode (pressed) of the half-wing anti-icing subsystems.*
*− A striped bar illuminates inside the button to indicate that it is released.*
*− An OPEN inscription illuminates inside the button to indicate the following conditions:*
*− Both valves are open with the system commanded to open.*
*− At least one valve is open with the system not commanded to open.*

***3 - Horizontal Stabilizer Anti-Icing Button***

*− Turns off (released) or permits (pressed) the automatic activation of the horizontal stabilizer anti-icing subsystem.*
*− A striped bar illuminates inside the button to indicate that it is released.*
*− An OPEN inscription illuminates inside the button to indicate that the horizontal stabilizer anti-icing valve is open.*

***4 - Sensor Heating Buttons***

*− The left button controls Pitot tube 1, AOA 1 vane, TAT 1 probe, ADC Static Ports 1 and 3, and pressurization static port 1.*
*− The central button controls Pitot/Static tube 3 and pressurization static port 2.*
*− The right button controls the Pitot tube 2, AOA 2 vane, TAT 2 probe and ADC static ports 2 and 4.*
*− When pressed, the associated sensor heating system operates in the automatic mode according to its functional logic. When released, the associated sensor heating system is turned off.*
*− A striped bar illuminates inside the button to indicate that it is released.*

***5 - Ice Detection Test Knob***

*Permits the half-wing, horizontal stabilizer and engine air inlet anti-icing subsystems to operate for test purposes, by simulating an icing condition on ice detectors 1 and 2. The adequate system operation is confirmed by the illumination of the OPEN inscriptions in the anti-icing buttons, which indicate the current valve position.*

***6 - Ice Detection Override Knob***

*ENG - Turns on the engine air inlet anti-icing subsystems for ground speeds below 25 knots. Above 25 knots the wing and horizontal stabilizer anti-icing subsystems are also turned on if icing condition is detected.*
*AUTO - Allows the automatic operation of the bleed air anti-icing system.*

***Note:*** *If ground speed is equal or above 25 knots and an icing condition is detected, wing and horizontal stabilizer anti-icing subsystems are turned on. The engine anti-icing subsystem is turned on as soon as an icing condition is detected.*
*ALL - Turns on the complete bleed air anti-icing system provided airplane is on ground at speed equal or above 25 knots or in flight.*
***Note:*** *On ground, below 25 knots, only engine anti-icing is turned on.*

***7 - Windshield Heating Button***
*− Turns on (pressed) or turns off (released) the windshield heating system.*
*− A striped bar illuminates inside the button to indicate that it is released.*

## 10.4 Wing Inspection Lights

The TSA EMB145 AOM, Volume 2, External Lighting, page 2, described the wing inspection lights:

> *Two inspection lights, one on each side of the fuselage, provide lighting of the wing leading edge to allow the crew to verify ice formation. The inspection lights are controlled by a switch located on the overhead panel.*

During an interview with a TSA EMB145 Aircrew Program Designee (APD), he stated that it was hard to see the EMB145 wings from the cockpit in all conditions. Another TSA EMB145 Check Airman made a similar observation.

An evaluation of an exemplar EMB145 airplane during hours of darkness by the Operations Group revealed that only about the last three feet of leading edge of the wing could be observed from the cockpit from each respective side.

## 10.5 Ice Protection System Training

The EMB145 ice protection system was covered in a TSA ground training module in initial and recurrent training. The training covered the automated detection and activation of the anti-ice system. There were no training references that presented the crew as being responsible to monitor and potentially activate the system, when no warnings or cautions were received from EICAS. Manual ice detection methods for flight crews to use when flying in potential icing conditions were not referenced during training.

During the interview, the accident first officer stated that her training on the anti-icing system was that the system was supposed to let the pilots know when it failed to operate correctly. She said that they were not trained to turn on the system manually, but just follow what the QRH tells them to do. She stated that since they did not know the anti-ice system failed to activate on the accident flight, they did not follow the QRH. The first officer said that she was not aware of any procedure to override the anti-ice system.

While on the ground, the crew was responsible to manually activate the airplane's anti-icing system during potential icing conditions. A caution, advised the crew to manually activate the anti-ice system to "ENG" if they experienced potential icing conditions while on the ground. The adverse weather ground school training module had several slides that presented potential icing conditions on the ground and the associated crew procedures.

A note in the EMB145 AOM, Volume 1, Ice and Rain Protection, pages 1, states the potential for inflight icing conditions:

> *Icing conditions may exist whenever the Static Air Temperature (SAT) on the ground or for takeoff, or Total Air Temperature (TAT) inflight, is 10°C or below and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet, and ice crystals).*

According the TSA EMB Airplane QRH, Section 9, Page 6, a temperature of 10 degrees Celsius or less combined with visible moisture would indicate flying in potential icing conditions.

## 10.6 Ice Identification Training

Wing inspection lights: TSA provided their EMB145 AOM, Volume 2, as a reference, when the wing inspection lights were discussed in training.

A TSA APD stated it was easy to tell if you had ice by looking at the pattern on the unheated portion versus the heated portion of the windshield. A TSA Check Airman said that the windshield wiper and windshield were used to identify icing. The TSA Chief Pilot said he identified icing by looking at the unheated portion of the windshield and the windshield wiper.

Referencing the Ice Detector 1 or 2 Fail or Ice Detectors Fail checklist in the TSA EMB Airplane QRH, The first step called for the use of visual cues (ice accretion on windshield and windshield wipers) and temperature criteria to determine whether icing conditions existed. According to the accident crew, they did not receive any malfunction or failure messages of the ice protection system during the accident flight, and as a result; did not reference this checklist. The first officer said she did not recall the Total Air Temperature (TAT) gauge reading during the final approach flown during the accident.

## 10.7 Auto-Pilot System Disconnect Training

According to the TSA EMB145 AOM, Volume 2, Autopilot section, page 16:
The autopilot was normally disengaged through the autopilot engage/disengage button or through the quick disconnect button on the control wheel. A voice message "Autopilot" was generated when the autopilot was disengaged.

Interviews with a TSA EMB145 APD and Check Airman revealed that the autopilot disconnect issue where the audio remained on for an extended period of time was a problem associated with new hires and usually was corrected by the time they completed training. One APD said that new pilots "tap" the disconnect switch too quick, without delay, rather than press and hold the switch between activations.

## 11.0 Relevant Procedures

### 11.1 Stabilized Approach Criteria

The Trans States Airlines EMB145 Standard Operating Procedures (SOP) manual, Section 1, Maneuvers and Procedures Guide, page 40, referenced an airspeed of 127 knots, for a landing weight of 41,000 pounds and 45 degrees of flaps.

According to the Trans States Airline EMB145 SOP, Section 1, Maneuvers and Procedures Guide, Section 1, page 39:

> *"Stabilized Approach" the approach must be stabilized by 1,000 feet above field elevation when conducting visual and straight in instrument approaches in both IMC and VMC weather conditions. During the final approach phase, when operating below stabilized approach height, in both VMC and IMC, on instrument and visual approaches, the following operational parameters must be maintained to be consider the approach stabilized. Sustained deviation from these parameters means the approach has become unstabilized and an immediate missed approach should be initiated. Either pilot may initiate the missed approach utilizing the callout "Go Around."*

- *In-Range and Before Landing checklists complete.*
- *Airplane properly configured; Final flap setting on circling approaches may be delayed as per EMB SOP Sec 1.5.9.*
- *Airspeed in the range Vref -5 knots to Vref +10 knots.*
    - *VOR/LOC/FMS course deviation does not exceed one dot deflection.*
    - *Glideslope deviation does not exceed one dot deflection.*
    - *Descent rate does not deviate +/- 300 feet per minute (fpm) from planned descent rate and is no greater than 1000 fpm, unless specifically briefed.*
    - *The airplane is descending along the proper descent path or is able to maintain obstacle clearance.*

### 11.2 Trans States Airlines Unstable Approach Data – General

The Trans States Airlines Director of Safety told the NTSB that there was no data from their Aviation Safety Action Program (ASAP) or with FOQA - pointing to problems with stabilized

approaches. He said their department looked at stabilized approaches, and the trend has been lower this past year. He stated that Trans States Airline's pilots could go around and not fear that they would get a call from the chief pilot's office, under their company's no-fault go around policy[8].

The Trans States Airlines Director of Safety said the number of unstable approaches below 1,000 feet was "very low."

TSA EMB145 SOP manual, Section 1, page 38, stated:

> *The pilot monitoring (PM) will callout aircraft deviations from the proper approach course and descent profile during any portion of a visual or instrument approach in plain language:*
>
> *Airspeed deviations – the PM will callout sustained deviation +/- 5 knots from the target Vapp speed. The PM will callout airspeed deviations using the call "speed". At approximately 100 feet above touchdown and after the landing is assured, the PM, will call any speed deviation from VREF is the same manner as above.*
>
> *Lateral Course Deviations – The PM will call out LOC deviations of +/- ½ DOT. The word "course" will be called.*

The Chief Pilot and Director of Safety were not aware of any earlier reports or incidents where the localizer course was intermittent on final approach at any airport.

### 11.3 Icing

According to the TSA EMB145 SOP, Expanded Flows/Checklist, Section 2, page 67:

> *After takeoff, the Ice Detection Knob should be set to the AUTO position. The crew was to monitor the weather during the flight.*
>
> *Closely monitor the static air temperature indication so that when moisture is present, a look at the windshield, windshield wiper, engine air inlets, and wing will indicate if ice is accumulating. Notwithstanding installation of the ice detector, the crew remains responsible for monitoring icing conditions and for manual activation of the ice protection system whenever necessary.*

The TSA EMB145 AOM, Volume 1, Ice and Rain Protection, pages 1, Note:

> *Icing conditions may exist whenever the Static Air Temperature (SAT) on the ground or for takeoff, or Total Air Temperature (TAT) inflight, is 10°C or below and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet, and ice crystals).*

[8] TSA Flight Crew Operations Manual, Section 3.5.4.1 No Fault Go Around Philosophy.

## 11.4 Auto-Pilot Disconnect

The TSA EMB145 SOP manual, Section 1, page 80, stated:

> *Upon reaching the Decision Altitude (DA) and having the runway environment in sight, the autopilot will be disconnected and the landing made.*

The TSA EMB145 AOM, Volume 2, page 16, stated the following about auto-pilot disconnect/disengagement:

> *AUTOPILOT DISENGAGEMENT*
>
> *The autopilot is normally disengaged through the Autopilot Engage/Disengage button or through the quick disconnect button on the control wheel.*
>
> *A voice message AUTOPILOT is generated when the autopilot is disengaged.*
>
> *The voice message occurs at any altitude in case of intentional disengagement or due to an autopilot failure and may be canceled according to the following associated conditions:*

| ***Associated Conditions*** | ***Cancellation*** |
|---|---|
| *Above 2500 ft radio altitude with a valid Radio Altimeter signal.* | *Self canceled.* |
| *Below 2500 ft radio altitude with a valid Radio Altimeter signal.* | *Pressing the Autopilot Quick Disconnect Button twice.* |
| *Invalid Radio Altimeter signal.* | *Pressing the Autopilot Quick Disconnect Button twice.'* |

According to the crew, during the accident flight, the autopilot audio, announcing the auto-pilot was disconnected, remained on for several seconds. The captain said this audio annoyed the first officer and he held down the autopilot quick disconnect button, in order to silence it. The captain further stated that the first officer apparently did not hold down the auto-pilot disconnect button long enough to get the aural warning to stop. The first officer said she could not get the autopilot audio to silence when she used the yoke switch to disconnect it and asked the captain to turn it off.

The following diagram was obtained from TSA EMB145 AOM, Volume 2, Autopilot, Controls and Indicators, page 8, and depicts the control wheel and associated switches available to the crew:

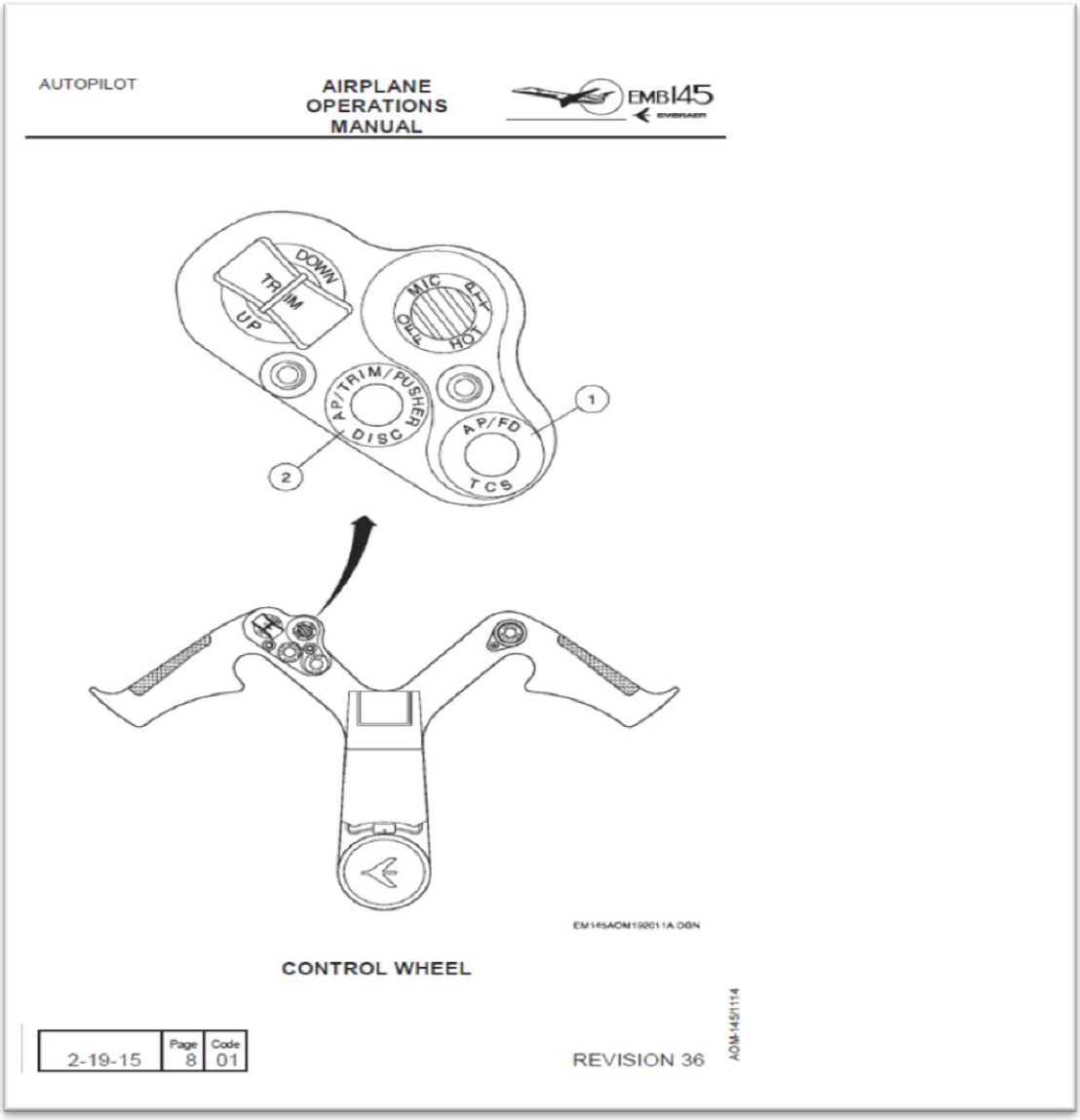


**Figure 3.** Airplane Control Wheel**.**

*2 - QUICK DISCONNECT BUTTON*

- *Provides the means to disengage autopilot and yaw damper.*
- *The pilot's and copilot's buttons are interconnected to allow autopilot cancellation from either seat.*
- *For Post-Mod. SB 145-22-0001 airplanes or airframes S/N*

*145001 through 145003, 145041*[9] *and on, if the autopilot is disengaged and the button is pressed, the voice message AUTOPILOT will be canceled in 2 seconds.*[7]

## 11.5 Ice Protection Check

According to the TSA EMB145 SOP Manual, Section 2; the ice protection test was a first flight of the day only check.

On the accident flight, the Flight Data Recorder (FDR) data of the first flight of the day of the accident airplane on February 4, 2014 was consistent with the ice protection test being accomplished.

***+Ice Test (Ice Protection Test)***

*Engine Bleeds.....OPEN*

*APU Bleed.....CLOSED*

*Air Conditioning Packs.....ON*

*Ice Detection Override Knob .....ALL*

*Thrust Levers.....83% N2*

*Ice Detection Test Knob.....1, then 2 Test Knob must not be held in TEST position for more than 15 seconds*

*For each side, separately check that the following messages are displayed:*

- *OPEN inscription in the ENG, WING and STAB push buttons*
- *ICE CONDITION EICAS advisory*
- *CROSS BLD OPEN EICAS advisory (may be displayed)*
- *ICE DET 1 (2) FAIL EICAS caution*
- *BLD 1 (2) LOW TEMP EICAS caution*

*Note: Aircraft with PRSOV will not see "CROSS BLD OPEN" EICAS message.*

*Thrust Levers ..... IDLE*

*Ice Detection Override Knob .....AUTO or ENG, as required*

*Engine & APU Bleeds.....AS REQ'D*

*CAUTION: Ice detection override knob must not be set to ALL on the ground, except during test.*

***Note:*** *Never reset/alternate a FADEC after this anti-ice system test.*

[9] Note: The accident airplane was S/N 145066.

## 11.6 Airplane Icing Limitations

Trans States Airlines EMB145 SOP Manual, Section 2, page 67:

> *After Takeoff:*
>
> *The Ice Detection Override Knob should be set to the AUTO position. Monitor weather conditions for an encounter of ice for the remainder of the flight. Closely monitor the static air temperature indication so that when moisture is present, a look at the windshield, windshield wiper, engine air inlets, and wing will indicate if ice is accumulating. Notwithstanding installation of the ice detector, the crew remains responsible for monitoring icing conditions and for manual activation of the ice protection system whenever necessary.*

The Trans States Airlines EMB145 SOP Manual, Section 2, page 70, stated the following:

> *General Remarks when Flying in Icing Conditions: (temp range) AOM*
>
> *- Continuously monitor engine parameters, airplane pitch attitude and airspeed. Be careful for any mis-trim condition that may be masked by the autopilot. Keep the airplane trimmed all the time.*
>
> *- Monitor the anti-ice systems for proper operation. Apply the associated abnormal procedure in case of a system failure. If the failure persists, exit and avoid icing conditions. Advise ATC that you are requesting the change due to icing conditions.*
>
> *- Do not hesitate to leave severe icing conditions, even with anti-ice system operating properly.*

The TSA EMB Airplane QRH procedure for Wing Anti-Icing Failure called for the Ice Detection Override knob to be selected to the "ALL" position. It also states that if in icing conditions or if there is any uncertainty as to whether the wing surfaces are clear of ice prior to the approach and landing, to proceed to a flaps 22 degrees landing configuration and increase vref for 45 degrees of flaps airspeed by 30 knots.

The TSA EMB Airplane QRH, Section 9, page 2, checklist for wing anti-icing failure:

> ***EMB EMERGENCY /ABNORMAL PROCEDURES***
>
> ***WING ANTI-ICING FAILURE***
>
> *EICAS WARNING: ICE COND-A/I INOP*
>
> *EICAS CAUTION: WG 1 (2) A/ICE FAIL or WG A/ICE FAIL*

*Ice Detection Override Knob.....ALL*
*Thrust Levers.....ADVANCE*
*If failure persists:*
*Wing Anti-Icing Button ..... ....CYCLE*
*If failure persists:*
*Wing Anti-Icing Button ..... OFF*
*Avoid or exit icing conditions. After exiting icing conditions:*
*Ice Detection Override Knob.....AUTO*
*Maximum Bank Angle .....30°*
*Minimum Airspeed for Flaps up or 9° .....190 KIAS*

*If in icing conditions or if there is any uncertainty as to whether the wing surfaces are clear of ice prior to approach and landing, proceed:*
*Landing configuration:*
*Flaps.....22°*
*Airspeed.....$V_{REF\ 45}$ + 30 KIAS*

***CAUTION:*** *TO DETERMINE THE MINIMUM SUITABLE LANDING DISTANCE, MULTIPLY THE UNFACTORED LANDING DISTANCE FOR FLAPS 45° BY 1.48."*

TSA EMB Airplane QRH, Section 9, page 6, checklist for Ice Detector failure:

***ICE DETECTOR FAIL***

*EICAS CAUTION: ICE DET 1 (2) FAIL or ICE DETECTORS FAIL Use visual cues (ice accretion on windshield and windshield wipers) and temperatures criteria to determine whether icing conditions exist.*

*When flying in icing conditions:*
*Ice Detection Override Knob .....ALL*
*After positively exiting icing conditions:*
*Ice Detection Override Knob .....AUTO*

***NOTE:*** *- Icing conditions may exist in-flight when Total Air Temperature (TAT) is 10°C or below and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet, and ice crystals).*

*- Ice Detection Override Knob must be kept at ALL for least 2 minutes after exiting icing conditions or after ICE CONDITION advisory message has disappeared. In such condition, caution message NO ICE-A/ICE may be presented, and must be disregarded.*

TSA EMB Airplane QRH, Section 9, page 1, checklist for Anti-icing Inoperative in Icing Conditions stated the following:

During inflight, the checklist directs the flight crew to manually operate the anti-ice system by selecting the Ice Detection Override Knob to "ALL."

***EMB EMERGENY / ABNORMAL PROCEDURES***

*EICAS WARNING: ICE COND-A/I INOP with any or all Anti- icing System EICAS CAUTION*

*Below V1:*
*TAKEOFF ..... REJECT*

*On the ground, whenever the message is displayed, do not takeoff and perform the test below:*

*ThrustLevers.....IDLE*

*Ice Detection Override Knob .....AUTO*

*Ice Detection Test Knob…….....1, THEN 2*

*Test knob must be held for 5 seconds in each test position.*

*For each side separately, check that OPEN inscriptions in the anti-icing buttons flash alternately and that ICE DET 1 (or 2) FAIL caution message and ICE CONDITION advisory message are displayed on the EICAS.*

*If an OPEN inscription does not flash do not takeoff. Report to the maintenance personnel.*

*If the message ICE COND-A/I INOP persists do not takeoff. Report to the maintenance personnel.*

*If the message ICE COND-A/I INOP disappears within 60 seconds:*

*TAKEOFF……..ACCOMPLISH*

*In flight:*

*Ice Detection Override Knob .....ALL*

*If necessary, refer to the specific anti-icing system failure. If the message persists, exit and avoid icing conditions.*

## 12.0 Aviation Safety Reporting System (ASRS) Reports

A search for "EMB145 ER/LR" found 1601 voluntary reports. Only two involved a similar icing issue[10].

The first report, detailed an icing encounter at a cruise altitude of 37,000 feet msl, where the crew observed condensation on the front windshield but the airplane's ice detectors did not detect ice. The crew manually selected the anti-ice system override switch to "ALL."

In the second report, the airplane experienced icing on the windshield wipers and nose during climb out. According to the crew, the anti-ice system did not activate at that time and the crew was in the process of manually activating the system when the anti-ice system turned on automatically.

## 13.0 Trans States Airlines Post-Accident Changes

Trans States Airlines made several changes to their operation following the accident:

Trans States Airlines issued an Urgent Safety Bulletin[11] on February 7, 2014, titled "Automatic Anti-Ice Monitoring. The bulletin was effective immediately. The bulletin discussed an incident under investigation where a TSA EMB145 landed with ice on its leading edge of the wings, empennage, and engine inlets. The bulletin also advised flight crews to be vigilant about monitoring deicing/anti-icing equipment when operating in icing conditions. The bulletin also "strongly encouraged" flight crews to reference MEL 30-80-00 (Ice Detectors Inoperative) when operating in icing conditions and the crew does not observe the appropriate "open" indications on the push buttons (deice/anti-ice equipment is active).

Trans States Airlines issued an Operations bulletin #01-2014[12] on February 19, 2014, that superseded the Urgent Safety Bulletin issued on February 7, 2014. The bulletin states that one of their airplanes recently landed with ice on the leading edges of the wings, empennage and engine inlets. The bulletin issued interim procedures for flight crewmembers to follow when operating in icing conditions above 1,500 feet, above ground level. The bulletin calls for active monitoring of the deicing/anti-icing equipment, and in the event it does not activate, to accomplish the QRH, Ice detectors Fail procedures.

[10] ASRS report numbers ACN 1090636 and ACN 10161586
[11] See attachment 2 – Urgent Safety Memo, dated Feb 7, 2014
[12] See attachment 3 – Operations Bulletin, #01-2014

## F. LIST OF ATTACHMENTS

Attachment 1 – Interview Summaries
Attachment 2 – Urgent Safety Memo, dated Feb 7, 2014
Attachment 3 – Operations Bulletin #01-2014
Attachment 4 - Simulator Session Notes
Attachment 5 – Dispatch Release
Attachment 6 – KMEM ILS/LOC 36R Approach
Attachment 7- Crew Currencies

Submitted by:

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Albert Nixon
Air Safety Investigator - Operations
April 1, 2015