

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

March 7, 2016

SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT

DCA14FA058

A. ACCIDENT:

Operator: Trans States Airlines
Location: Memphis, TN
Date: February 5, 2014
Time: 0015 CST
Airplane: EMB 145 EP, N802HK

B. SYSTEMS GROUP:

Chairman: Adam Huray
National Transportation Safety Board
Washington, DC

Member: Eric West
FAA
Washington, DC

Member: Daniel Marimoto
Embraer
Ft Lauderdale, FL

Member: Matt Conrad
Trans States Airlines
Bridgeton, MO

Member: Quinn Moynihan
UTC Aerospace Systems
Burnsville, MN

Member: Mike Woodbury
Air Line Pilots Association, INT'L
St Louis, MO

C. ACCIDENT SUMMARY:

On February 5, 2014, about 0015 Central Standard Time (CST), N802HK, an Embraer S.A. EMB-145EP, operated by Trans States Airlines LLC as a Title 14 CFR Part 121 scheduled domestic passenger flight to Memphis International Airport (MEM), Memphis, Tennessee, landed hard on runway 36R. Instrument meteorological conditions prevailed at the time of the accident and an instrument flight rules flight plan was filed. The right wing struck the ground and the airplane incurred substantial damage. There were no injuries to the three flight crew members or the 50 passengers aboard. The flight originated from Houston, Texas, the previous day about 2022 CST.

The NTSB did not travel to the accident scene and did not witness the aircraft level functional tests detailed in section E.2. The NTSB did witness the ice detector component level testing as detailed in section E.3.

Following the accident the crew observed ice build-up on the wings, horizontal stabilizer, and both engine inlets. See Figure 1 for a picture of the ice-build up taken approximately 40 minutes after the aircraft arrived at the gate. Review of the Flight Data Recorder (FDR) revealed that the ice condition parameter indicated “no ice” and the ice detection fail parameter indicated “normal” (not failed) for the entire flight. Therefore, the systems examination focused on the airworthiness of the ice detection system.



Figure 1: Picture Taken Approximately 40 Minutes After Gate Arrival of Ice Build-Up Discovered On Wing

D. ICE DETECTION SYSTEM DESCRIPTION:

The ice detection system is used to detect and alert the formation of ice. It is the primary source to automatically activate the aircraft anti-icing systems for the wings and engines. The ice detection system is comprised of two identical ice detection circuits that operate independently during all phases of the flight. The following components make up each ice detection system circuit:

- Ice Detector (see figure 2)
- Ice Detector Relay
- Ice Protection Overhead Panel (see figures 3 and 4)
- Circuit Breakers
- Data Acquisition Unit

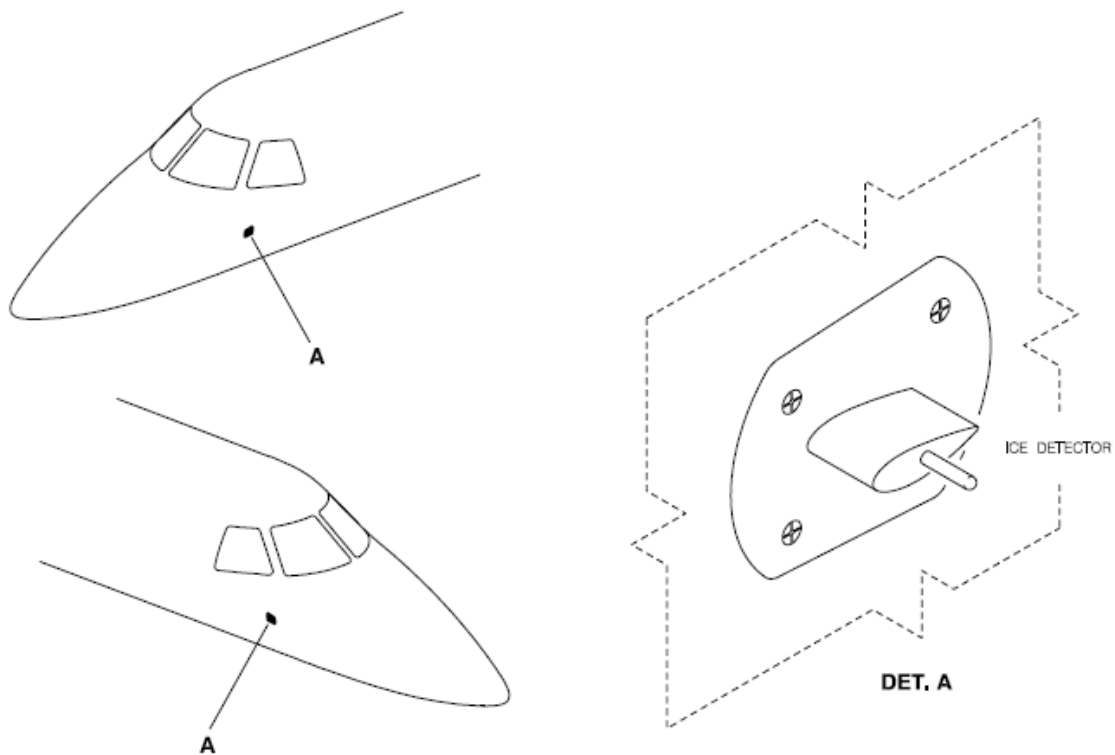


Figure 2: Ice Detector and Locations

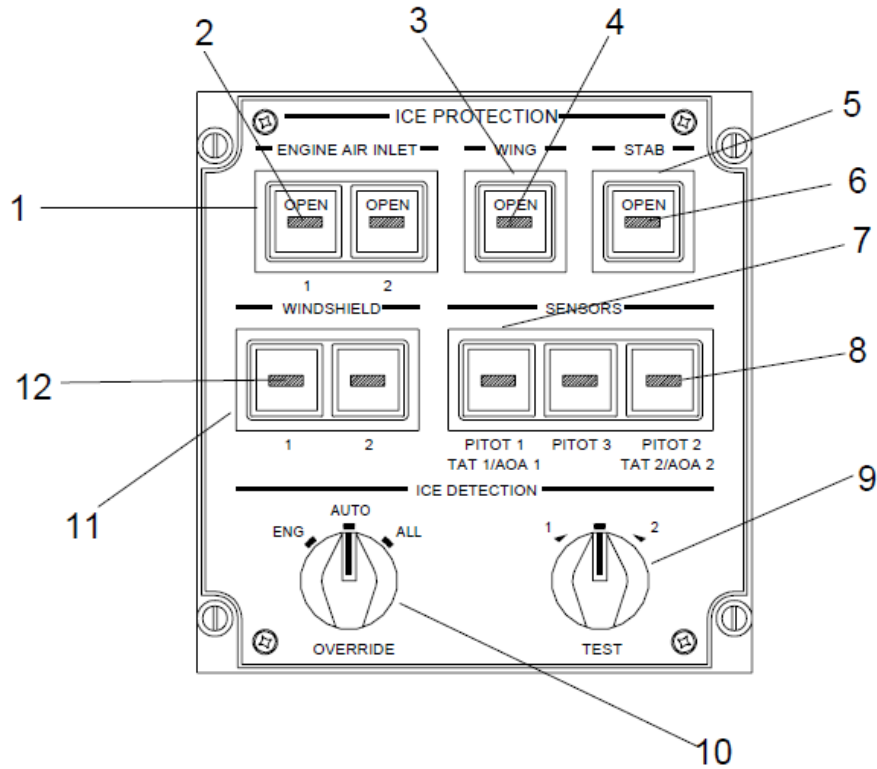


Figure 3: Ice Protection Overhead Panel

Ref	Switch Name	Function
1	Engine Anti-Ice Valve	Turns on/off the automatic engine anti-ice system. Closes valve independent of the ice detection system.
3	Wing Anti-Ice Valve	Turns on/off the automatic wing anti-ice system. Closes valve independent of the ice detection system.
5	Stabilizer Anti-Ice Valve	Turns on/off the automatic stabilizer anti-ice system. Closes valve independent of the ice detection system.
7	Sensor	Enables the automatic system to operate the sensors' anti-ice systems according to system logic
9	Ice Detection Test	Toggle switch is spring loaded to center (normal - test not activated) position. Movement to the left enables test of the left ice detector system. Movement to the right enables test of the right ice detector system.
10	Ice Detection Override	In ENG position, turns on only the engine air inlet protection independently of the ice detection system. In the AUTO position, enables the system operation according to the system logic when ice is detected. In the ALL position, turns on all the bleed air anti-ice systems independently of the ice detection system.
11	Windshield Anti-Ice	Enables the windshield anti-ice system according to system logic.

Figure 4: Ice Protection Overhead Panel Switch Functions

The ice detector is a one-piece unit including the sensor and processing electronics that detects the presence of ice. The sensing probe is an iron-nickel alloy tube mounted on the ice detector strut, with one inch of the sensing element exposed to the airstream. Under the influence of a modulated magnetic field, the probe oscillates at approximately 40 KHz. As ice accumulates on the probe, the added mass of the ice causes the frequency of the sensing probe to change. The frequency change is then monitored by the detector. The alert threshold corresponds to an ice thickness of approximately 0.020 inch that accumulates anywhere on the sensing probe. Ice detector 1 is powered by DC Bus 1 and ice detector 2 by DC Bus 2.

When ice is detected by either of the ice detection circuits, an advisory message “ICE CONDITION” is shown on the EICAS display, a signal is sent to the anti-ice valves to control them to open, and a signal is sent to the FADEC to activate the automated engine icing thrust setting logic to limit the thrust to a minimum acceptable level. The icing signal stays active for 60 seconds. At the same time the icing signal is activated the ice detector heaters are turned on to deice the detector strut and probe. When the sensing probe is deiced, it is ready to sense ice again. If the icing condition continues, and the ice thickness switching level is reached before 60 seconds have passed, the icing signal is continuous. All anti-ice functions operate regardless of if one or if both detectors detect ice.

The ice detectors are self-monitored through built in test (BIT) circuits. Their internal software makes a continuous test of:

- Valid input voltage
- Valid regulated 5 V DC voltage
- Correct micro controller operation
- Correct Magnetostrictive Oscillator frequency
- Correct heater state
- Correct output state

A detected failure in either detector will cause a change to the status output signal. This will activate a caution message “ICE DET 1 FAIL” or “ICE DET 2 FAIL” on the engine indication and crew alerting system (EICAS) display. The failed unit will not detect ice after an internal failure detection. If a dual ice detector failure condition is present, a CAUTION message “ICE DETECTORS FAIL” is shown on the EICAS display. If ice detector #1 fails, or if both detectors fail simultaneously, the “Ice Detection Fail” parameter on the FDR will also switch to the failed state.

A rotary switch on the Ice Protection overhead panel allows for a manual test of the ice detectors. When the test switch is moved to the left or right the completed contact will test the corresponding ice detection system. When the rotary switch is in the normal position neither contact is completed and therefore neither system is tested. During the test, the advisory message “ICE CONDITION” is shown on the EICAS display and the caution message “ICE DET 1 FAIL” or “ICE DET 2 FAIL” is shown on the EICAS display. During a manual test of ice detection system #1, the status of the ice condition output and ice detector fail output is recorded on the FDR. These parameters are not recorded on the FDR during a manual test of ice detection system #2.

The ice detection system is monitored by the following ice detection messages on the EICAS display:

ICE CONDITION

Status: ADVISORY.

Condition: During ice detector ground test or in-flight detected icing condition

NO ICE-A/ICE ON

Status: CAUTION.

Condition: Any bleed air valve is activated when no icing condition is detected. This message is inhibited on the ground. This message will occur if the ice detection override switch is not in the “AUTO” position and ice is not detected during flight.

ICE DET 1 (2) FAIL

Status: CAUTION.

Condition: Failure of any single ice detector

ICE DETECTORS FAIL

Status: CAUTION.

Condition: Failure of both ice detectors.

There are two circuit breakers related to the ice detection system. “Ice Detector 1” and “Ice Detector 2” are each located on their respective electrical power control distribution boxes. When either the Ice Detector 1 or Ice Detector 2 circuit breakers are open, power will be lost to the associated ice detection system and a caution message “ICE DET 1 FAIL” or “ICE DET 2 FAIL” will alert on EICAS. In the case that both the Ice Detector 1 and Ice Detector 2 circuit breakers are open, the caution messages “ICE DETECTORS FAIL”, “ICE DET 1 FAIL”, and “ICE DET 2 FAIL” will be displayed. If power is lost to ice detector #1, or if power is lost to both detectors simultaneously, the “Ice Detection Fail” parameter on the FDR will also switch to the failed state.

E. DETAILS OF THE INVESTIGATION:

E.1 Central Maintenance Computer Download:

The Central Maintenance Computer was downloaded following the accident. Select messages from the download are listed below. The first seven entries include all messages that were time stamped from the accident flight. The last entry is labeled “WING2 A/ICE LOW PRESS” and was the only message in memory related to the anti-ice system.

Message	1st Date	Time	Occ	Last Date	Time (UTC)
ENG2 SCHED MAINT REPAIR	31.01.14	15:36:24	2	05.02.14	04:31:58
LG RIGHT WOW PROX SW FAIL	29.01.14	16:39:38	27	05.02.14	04:41:58
DUCT OVERTEMP 2	30.01.14	01:05:31	4	05.02.14	05:40:30
PACK OVERPRESS 2	30.01.14	01:05:31	5	05.02.14	05:40:30
LG RIGHT UP PROX SW FAIL	29.01.14	16:39:42	28	05.02.14	05:53:08
LG NOSE UP PROX SW FAIL	29.01.14	16:39:43	28	05.02.14	05:53:09
LG UP/DN PROX SW/LGEU FAIL	29.01.14	16:39:47	28	05.02.14	05:53:13
WING2 A/ICE LOW PRESS	01.02.14	19:45:10	3	01.02.14	19:53:35

The “ENG2 SCHED MAINT REPAIR” message is logged when the FADEC finds a no loss of thrust control fault.¹ The “LG RIGHT WOW PROX SW FAIL” message is logged when there is a disagreement between the right landing gear WOW proximity switches. The “DUCT OVERTEMP 2” message is logged when the temperature in the right side pack outlet duct is above 93°C ± 6°C (200°F ± 10°F). The “PACK OVERPRESS 2” message is logged when the right side pack inlet pressure is above 55 ± 1.5 psig. The “LG RIGHT UP PROX SW FAIL” message is logged when the landing gear electronic unit (LGEU) or the right landing gear up proximity switch is faulty. The “LG NOSE UP PROX SW FAIL” message is logged when the LGEU or the nose landing gear up proximity switch is faulty. The “LG UP/DN PROX SW/LGEU FAIL” message is logged when the landing gear UP/DOWN proximity switches or LGEU are faulty. The “WING2 A/ICE LOW PRESS” message is logged when the pressure downstream of the right wing anti-icing valve is below the limit when the anti-icing system is in operation.

E.2 Aircraft Level Testing:

Below is a list of task cards that were performed by Trans States Airlines maintenance personnel following the accident. Adjustment procedures included in the task cards were not performed unless necessary. Some tasks were performed in Memphis prior to relocating the airplane to St. Louis and performing additional testing. Maintenance records show that the FDR, CVR, and the

¹ A “no loss of thrust control” level fault is a fault that has been determined as unable to cause a loss of thrust control event, and is therefore permitted the longest period of time for the operator to remedy (120 calendar days).

#2 Navigation Unit were removed and replaced while the aircraft was in Memphis and prior to the ferry flight. Some structural repairs were also made prior to the ferry flight. Both ice detectors were removed after the ferry flight, but prior to the commencement of aircraft testing in St. Louis.

The right wing tip and associated flux detector valve was damaged from impact with the runway. Aircraft level testing discovered that the rudder auto-pilot servo cable and aileron cable tensions were lower than required per the AMM, section 27-21-01. The tension in the rudder auto-pilot servo cable was found to be 0 lbs (50 +/- 5 lbs required), and the tension in the aileron cables was found to be 23 lbs (35 +/- 5 lbs required). Slight kinking of the rudder auto-pilot servo cable was also observed. The left rudder stop was found to be out of adjustment. Testing also found that the rudder, aileron, and elevator rotary variable differential transformers (RVDT) that transmit position data to the FDR were not functioning correctly and appeared corroded. In addition, the cockpit area mic was found to be weak and was replaced. The aircraft passed all performed tests listed below with no additional anomalies identified.

The following tasks were performed in Memphis prior to relocating the aircraft via a ferry flight:

- 27-21-00 (Rudder System Operational Check)
- 27-10-00 (Aileron Freedom of Movement Check)
- 27-10-00 (Aileron Operational Check)
- 30-00-700-802-A (Anti-Ice System Operational Check)

The following tasks were performed after the ferry flight:

- 30-00-00-700-801A (Anti-Ice System Message Operational Check)
- 30-00-00-700-803A (Anti-Ice Valves Operational Check)
- 30-00-00-700-804A (Anti-Ice Functional Check)
- 30-00-00-810-803A (Absence of Ice Condition Message)
- 30-00-00-810-804A (Absence of Ice Detect 1 / 2 Fail Message)
- MPP1124-30-80-00-5 (Ice Detection System Operational Test)
- 27-22-00-810-804A (Rudder 1 / 2 Inop Fail Message)
- 27-22-03-5 (Check of the Rudder Power Control Unit for Leakage)
- MPP1124-27-20-00-5 (Rudder Adjustment/Test) *tests only-no adjustments
- TASK 27-25-02-700-801A (Rudder Position Microswitches - Adjustment/Test) *test only-no adjustments
- TASK 27-25-00-700-801A (Rudder Pedals Auto-shutoff and Rudder Manual Shutoff Functions - Operational Check)
- TASK 27-22-02-200-801A (Rudder Actuators - General Visual Inspection)
- TASK 27-22-02-700-802A (Check of the Rudder Actuators for Leakage)
- 31-31-06-820-803A (RVDT Test) * performed for all RVDTs
- TASK 23-71-00-700-801-A (Voice Recording - Operational Check)
- TASK 23-71-00-700-802-A (Voice Recording System - Operational Test)
- 31-42-00-700-801A (Integrated Computers – Operational Test)
- 34-32-00-700-801A (VOR/ILS System Operational Test)

- 20-13-21 (Electrical Bonding Test of VOR/LOC Antennas)
- 34-32-03 (VOR/LOC Antenna – Inspection)
- 23-60-00 (Check of Static Dischargers)
- Perform visual inspection of elevator actuator and cable tension
- Perform visual inspection of aileron actuator and cable tension
- Perform visual inspection of rudder actuator and cable tension
- Check for 15VDC at the AUTOPILOT CONT (PC-400) connector "15 VDC EXCITATION" pin.
- Check for 28 ± 0.5 VDC from the AUTOPILOT CONT (PC-400) connector "28 VDC PWR" pin to the "GROUND" pin
- Check for continuity:
 - From the AUTOPILOT CONT (PC-400) connector "15VDC EXCITATION +" pin to the integrated computer (IC-600) "15VDC EXCITATION +" pin
 - From the AUTOPILOT CONT (PC-400) connector "PITCH WHEEL" pin to the integrated computer (IC-600) "PITCH WHEEL" pin
 - From the AUTOPILOT CONT (PC-400) connector "TURN KNOB OUT OF DETENT" pin to the integrated computer (IC-600) "TURN KNOB OUT OF DETENT" pin
 - From the AUTOPILOT CONT (PC-400) connector "TURN KNOB WIPER" pin to the integrated computer (IC-600) "TURN KNOB WIPER" pin
- Check for ground:
 - At the AUTOPILOT CONT (PC-400) connector "GROUND" pin
 - At the AUTOPILOT CONT (PC-400) connector "CHASSIS GND" pin

E.3 Component Level Ice Detector Testing:

The left and right ice detectors were removed from the aircraft and tested at UTC Aerospace Systems in Burnsville, MN, on April 30, 2014. The testing was witnessed by the NTSB, the Federal Aviation Administration, UTC Aerospace Systems, Embraer, Trans States Airlines, and the Air Line Pilots Association.

Each ice detector contains non-volatile memory (NVM). When the NVM is downloaded, the resulting fault log is broken up into three separate registers. The first register is labeled “Last Errors” and consists of all faults recorded during the last fault event. The second register is labeled “2nd Last Errors” and consists of all faults recorded during the second to last fault event. The third register is labeled “Permanent Errors” and consists of all faults that have been logged in memory except for faults recorded in the “Last Errors” and “2nd Last Errors” registers. If multiple faults are recorded in a register (excluding the “Permanent Errors” register), then those faults were recorded during a single event. The log also contains a “Total Fail Count”, which is the total count for faults including multiple faults of the same type. Finally, the log contains a list of “Current Errors”, which are faults that were currently active at the time of the NVM download. Faults do not contain a time stamp.

E.3.1 Left Ice Detector:

The left ice detector was labeled as follows:

Model: 0871HT3-1A

S/N: 00398

MFD: 11/97

Mods: None

Functional Test Stamp: Nov 16 06

A visual inspection of the ice detector was performed. The connector pins were observed to be clean and straight. There was erosion found on the leading edge of the strut. The surface of the trailing edge of the probe had a rough texture and contained traces of a red residue. No other anomalies were noted with the unit's physical condition. The bonding resistance from the connector shell to the face plate flange was measured to be approximately 17 milliohms. There is no requirement for this model, but a typical bonding resistance for ice detectors is 20 milliohms or less.

The cover was then removed and the non-volatile memory was downloaded. There were no current errors at the time of test. The "Last Errors" were "Voltage Sensing Circuit Fail", "Status Signal Always Ground", and "Ice 1 Signal Always Ground". There was one "2nd Last Error" labeled "De-Icing Fail Input Voltage > 25V". There were two "Permanent Errors" labeled "MSO Frequency Fail" and "Status Signal Always Ground". The total fail count was 6.

The "Voltage Sensing Circuit Fail" fault occurs when the BIT detects that the power loss circuit is not detecting power loss correctly. This fault results in an "ICE DET 1 (2) FAIL" caution message displayed on the EICAS. The "Status Signal Always Ground" fault occurs when the status signal output is ground for longer than expected when not commanded during BIT. The ground state results in an output signal of "no faults". If another failure occurs following this error, then the ice signal output becomes active and the "ICE CONDITION" advisory message appears on the EICAS. This error without another error will not be alerted to crew. The "Ice 1 Signal Always Ground" fault occurs when the Ice 1 signal output is ground for longer than expected when not commanded. The ground state results in an "ice detected" output and, depending on the exact failure mode, the crew is alerted via either an "ICE DET 1 (2) FAIL" caution message or both an "ICE DET 1 (2) FAIL" and "ICE CONDITION" message on the EICAS. The "De-Icing Fail Input Voltage > 25V" fault occurs when the frequency does not recover above 39965 Hz within 25 seconds of heater activation. The crew is alerted via an "ICE DET 1 (2) FAIL" caution message displayed on the EICAS. The "MSO Frequency Fail" fault occurs when the measured frequency is less than 36000Hz or greater than 40150 Hz. The crew is alerted via an "ICE DET 1 (2) FAIL" caution message displayed on the EICAS. All errors reported to crew as "ICE DET 1 (2) FAIL" on the EICAS are latched until power is cycled or a pilot initiated BIT is performed.

The unit was then functionally tested per CMM 30-81-24 (dated Jan 15/13). The unit passed all tests except for 2.B (3). The sensing mode frequency was 39968 Hz but the requirement was 40000 +/- 25 Hz. UTC Aerospace Systems stated that a lower than expected frequency reading

would cause the unit to sense ice sooner. For section 2.B (5) “Icing Condition Simulation Test”, both the ice spray and the touch methods were used to trigger the sensor.

UTC Aerospace Systems provided return history for serial number 398. The unit was returned on April 9, 2003 due to an ice detector fail message on EICAS. The unit was tested with no fault found. The unit was cleaned and returned to service. The unit was again returned on October 30, 2003 due to an ice detector fail message on EICAS. The strut and probe assembly were replaced and the unit was returned to service. The unit was also returned on October 16, 2006 for upgrade to a -1A.

E.3.2 Right Ice Detector:

The right ice detector was labeled as follows:

Model: 0871HT3-1A
S/N: 02401
MFD: 11/04
Mods: None
Functional Test Stamp: Jul 08 ?? (? = unreadable)

A visual inspection of the ice detector was performed. The pins were clean and straight. The leading edges of the strut and the probe were in good condition. No anomalies were noted with the unit’s physical condition. The bonding resistance from the connector shell to the face plate flange was measured to be approximately 0.63 milliohms. There is no requirement for this model, but a typical bonding resistance for ice detectors is 20 milliohms or less.

The cover was then removed and the non-volatile memory was downloaded. There were no current errors at the time of test. There was one “Last Error” labeled “MSO Frequency Fail”. There were no “2nd Last Errors” or “Permanent Errors” recorded. The total fail count was 2.

The “MSO Frequency Fail” fault occurs when the measured frequency is less than 36000Hz or greater than 40150 Hz. The crew is alerted via an “ICE DET 1 (2) FAIL” message displayed on the EICAS and is latched until power is cycled or a pilot initiated BIT is performed.

The unit was then functionally tested per CMM 30-81-24 (dated Jan 15/13). The unit passed all tests except for 2.B (3). The sensing mode frequency was 39974 Hz but the requirement was 40000 +/- 25 Hz. UTC Aerospace Systems stated that a lower than expected frequency reading would cause the unit to sense ice sooner. For section 2.B (5) “Icing Condition Simulation Test”, both the ice spray and the touch methods were used to trigger the sensor.

UTC Aerospace Systems provided return history for serial number 2401. The unit was returned on June 22, 2010 for repair. The strut and probe assemblies were replaced and the unit was upgraded to -1A.

E.3.3 Wind Tunnel Testing:

Both ice detectors were subjected to wind tunnel testing per the requirements of SAE AS5498, section 5.2.1.1.1. The testing was accomplished at the UTC Aerospace Systems facility in

Burnsville, MN, on June 9-10, 2015. The testing was witnessed by the NTSB, the Federal Aviation Administration, UTC Aerospace Systems, Embraer, and Trans States Airlines. Both ice detectors functioned within the requirements of the three conditions specified in section 5.2.1.1.1 of the standard.

E.4 Critical Temperature Analysis:

Embraer analysis demonstrated that for an altitude of 1928 ft, calibrated airspeed of 172 kts, angle of attack of 3.5°, and a flap setting of 9°, the critical temperature at the ice detector was higher than the critical temperature at the wing. The critical temperature is defined as the temperature above which ice cannot form.

F. MAINTENANCE RECORDS:

Trans States Airlines reported that there were no items deferred on the Minimum Equipment List for the accident flight. The right side bleed valve access door was deferred per CDL 54-50-2 for the accident flight.

A review of Trans States Airlines digital maintenance log book entries for 802HK was performed. All ATA codes for the month prior to the incident were reviewed, with emphasis on ice detection and navigation discrepancies. In addition, records for ATA 30 (Ice and Rain Protection) were reviewed for the 6 months prior to the incident. The following relevant records were identified:

- 2/3/2014 – discrepancy: RH bleed valve access panel nut plate damaged, corrective action: deferred RH fan air valve access panel [bleed valve access door] on CDL 54-50-2
- Multiple reports of bleed air system 2 leaks from 1/10/2014 to 2/1/2014.
- 1/24/2014 – discrepancy: both NAV radios not receiving glide slope/VOR, corrective action: performed VOR/ILS/GS/MB adjustment test
- 1/19/2014 – L/H VOR antenna erosion tape is missing, corrective action: installed E-tape on LH VOR antenna
- 1/10/2014 – discrepancy: ice condition anti-ice inop EICAS message during descent in ice condition, corrective action: performed ops check
- 9/12/2013 – discrepancy: wing anti ice fail during ice open test, corrective action: remove and replace switch
- The left ice detector was serial number 398 and installed on the aircraft on 12/9/2006
- The right ice detector was serial number 2401 and installed on 3/30/2013

G. FLIGHT DATA RECORDER REVIEW:

For the accident flight, the ice detection fail parameter remained in the normal state for the entire flight. The ice condition parameter remained in the no-ice detected state for the entire flight. The FDR records these parameters from the #1 ice detection system only. A review of the FDR from the flight prior to the accident flight revealed that before departure the ice detection fail parameter switched to fail, the ice condition parameter switched from no ice to ice, and the stab anti-ice command and wing anti-ice command switched to on. These parameter changes were

consistent with a manual test of the #1 ice detection system. During the same flight, shortly after takeoff, the ice detection fail parameter remained in a normal status, the ice condition parameter switched from no ice to ice, and the stab, wing, engine 1, and engine 2 anti-ice commands switched from off to on. These parameter changes are expected for a properly functioning #1 ice detection system that has detected icing conditions.

The static air temperature parameter recorded on the FDR is the temperature of the ambient air, also called the outside air temperature. The static air temperature is found by adding a conversion to the total air temperature reading. UTAS stated that the Total Air Temperature Probe accuracy is +/- 1° C in non-icing conditions, but the accuracy of the probe may degrade slightly in icing conditions. The Air Data Computer, which applies the conversion, also has an accuracy of +/- 1° C.

H. CAUTION ALERT INFORMATION:

H.1 “RUDDER SYS 1-2 INOP” Caution:

The crew reported the presence of the “RUDDER SYS 1-2 INOP” caution alert on the EICAS during the landing roll. The rudder electrical circuit provides a rudder hardover protection function which is effective in the case of a system runaway event. The protection is designed to engage if both engines are running with N2 greater than 56%, the pilot or copilot apply 130 lbf or more on a rudder pedal in one direction (left or right) and, simultaneously, the rudder is deflected more than 5° +/- 1° to the opposite side. The protection will automatically shut off the rudder system which then reverts to a mechanical operation mode. A "RUDDER SYS 1-2 INOP" caution will alert on EICAS following a 3 second confirmation time. The master caution parameter is recorded on the FDR every second.

The hardover protection system is a latch function so that the rudder system is kept shut off even after the pilot releases the pedals. The system can be reset by commanding both rudder shutoff switches on the overhead panel to the OFF and then to the ON position again.

H.2 “ENGINE NO TO DATA” Caution:

The “Engine No Takeoff Data” caution message, displayed on EICAS as “ENGINE NO TO DATA”, is designed to inform the crew that the takeoff data has not been successfully entered. The caution is displayed when the following conditions are met: weight on wheels determination is on ground, both engines are running with N2 greater than 53%, and both power thrust lever angles are greater than 45 degrees. These conditions are typically met during landing as well as takeoff, and therefore the caution is a common occurrence during a landing roll out. There is a 35 second delay before the EICAS message is displayed.

Adam Huray
Mechanical Engineer