

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

August 9, 2022

SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT

DCA20IA014

A. INCIDENT:

Location:	Atlanta, GA
Date:	November 6, 2019
Time:	2115 EST
Aircraft:	Embraer ERJ 170-200LR, N117HQ
Operator:	Republic Airways, Inc.

B. SYSTEMS GROUP:

Chairman:	Adam Huray National Transportation Safety Board Washington, DC
Member:	Patrick Lusch FAA Washington, DC
Member:	Paulo Ribeiro Embraer Ft Lauderdale, FL
Member:	Lee Hayes Republic Airways, Inc. Indianapolis, IN

C. SUMMARY:

On November 6, 2019, about 2115 EST, Republic Airways flight 4439, an Embraer EMB-175LR, N117HQ, experienced a pitch trim anomaly shortly after takeoff from Hartsfield–Jackson Atlanta International Airport (ATL), Atlanta, Georgia. The flight crew declared an emergency and returned to ATL. None of the 9 passengers and crew onboard were injured and the airplane was not damaged. The airplane was operating under the provisions of Title 14 *Code of Federal Regulations* Part 121 as regularly scheduled passenger flight and was destined for LaGuardia Airport (LGA), New York, New York.

D. AIRCRAFT DESCRIPTION:

Operator:	Republic Airways, Inc.
Registration number:	N117HQ
Aircraft Serial Number:	17000184
Aircraft Manufacturer:	Embraer
Model:	ERJ 170-200LR (commonly referred to as EMB-175LR)
Aircraft Year:	2007
Total Time:	31263 hours
Total Cycles:	24416

E. PITCH TRIM SYSTEM DESCRIPTION:**E.1 Pitch Trim System Components**

The function of the horizontal stabilizer system is to operate the horizontal stabilizer control surface to provide the aircraft with stability and control for pitch trim adjustment. The control surface is moved by a single ballscrew-type with fail-safe internal tierod Horizontal Stabilizer Trim Actuator (HSTA) which is driven by two electric motors.

The horizontal stabilizer control system consists of a Horizontal Stabilizer Actuator Control Electronics (HS-ACE), HSTA motor assemblies, manual pitch trim control switches, cutout switches, and quick-disconnect switches. The HS-ACE is a computer that controls and monitors the position of the HSTA. It provides commands to the horizontal stabilizer actuator motor assemblies from the manual pitch trim control switches and from the automatic control functions. There are two horizontal stabilizer actuator electric motor assemblies that position the HSTA. There is a manual pitch trim control switch located on each control-yoke and a backup manual pitch trim control switch located on the center pedestal. These three switches are dual split switches that are spring loaded to neutral. There are two stabilizer cutout switches (one for each HS-ACE channel as described in section E.2) located on the center pedestal. If both cutout switches are pushed in the signal provided to the HSTA motors stops and the stabilizer actuator is frozen in place. If only one cutout switch is pushed then the pitch trim system, including all three manual pitch trim control switches, will continue to work as normal. There is also one autopilot/trim quick disconnect switch button on each control yoke. Pressing and holding either quick disconnect switch, while both cutout switches are in the normal (not pressed) position, disables both HSTA motor drives which prevents any active trim command (manual or auto) from moving the HSTA. Pressing either switch will also disengage the autopilot. Releasing the pressed quick disconnect button will re-enable the HSTA motor drives. If only one cutout switch is pushed, the associated quick disconnect switch (channel 1 cutout associated with the left quick disconnect switch, channel 2 cutout associated with the right quick disconnect switch) will not function for the HS-ACE. See figure 1 for select system component familiarization.

The HSTA provides position data to the HS-ACE. The HS-ACE provides position data and fault information to the Engine Indication and Crew Alerting System (EICAS) for display (see Figure 1). Position data is displayed on the EICAS by the pitch trim indicator. Caution messages are displayed in the EICAS message window. The EICAS displays the following messages to alert

the aircrew of problems in the horizontal stabilizer system:

- FLIGHT CONTROLS NO DISPATCH
- PITCH TRIM FAIL
- PITCH TRIM SW 1 FAIL
- PITCH TRIM SW 2 FAIL
- PITCH TRIM BKUP FAIL
- STAB LOCK FAULT
- FLT CTRL FAULT
- PITCH TRIM LO RATE

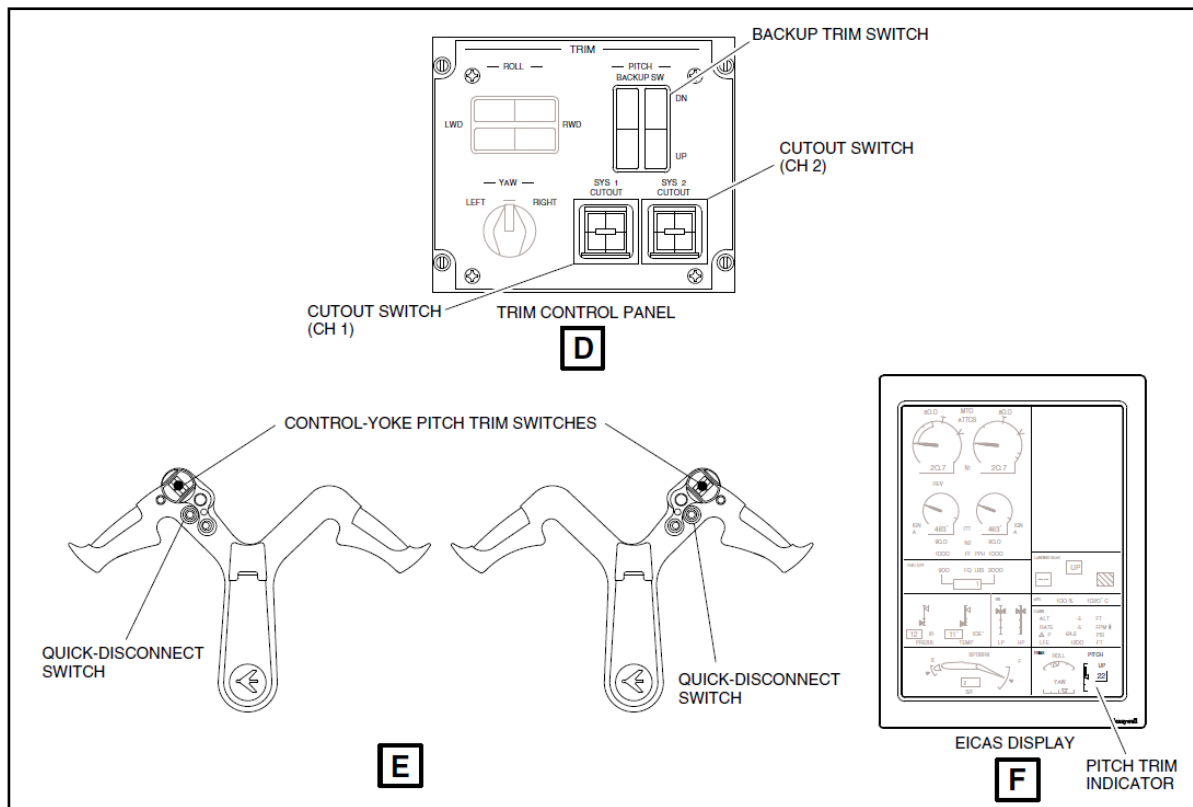


Figure 1: Select Horizontal Stabilizer System Flight Deck Component Locations
(Ref Embraer 170/175 Aircraft Maintenance Manual (AMM), Part I 1963, Revision 64)

E.2 Pitch Trim System Operation

The HSTA has two brushless motors, each with internal resolvers. During normal operation, one motor is active while the other motor remains in standby mode. The active motor positions the horizontal stabilizer control surface based on commands received from the HS-ACE. The HSTA deflects the horizontal stabilizer control surface ± 13 degrees at a rate of 0.15 to 0.735 degrees per second, determined by the airspeed gain schedule based on information provided by the Flight Control Modules (FCM). Two position resolvers on the HSTA report position information, through the HS-ACE, for display on the EICAS. The HS-ACE is a dual channel control system that works in an active-standby configuration. Each channel (HS-ACE channel 1

and HS-ACE channel 2) consists of a control monitor dual lane structure that controls one HSTA motor (HSTA-1 or HSTA-2). The HS-ACE alternates the active and standby channels based upon inputs received from the FCM. The channels are also able to reconfigure their current status in response to faults in the system.

The HS-ACE control and monitor lanes receive trim signals from either the FCM or the manual pitch trim control switches (pilot, copilot, or backup). The FCM trim signal is sent to the HS-ACE over the Controller Area Network data bus. This FCM signal combines the configuration trim, autopilot trim, and match trim functions into one command that the HS-ACE uses to control the HSTA trim rate. If a manual trim command is received from any of the cockpit pitch trim control switches, it will override the auto trim command from the FCM and will disconnect the autopilot. The HS-ACE will then use airspeed data to determine the HSTA trim rate. The HS-ACE responds to all trim commands with the following priority: 1) Backup Switch, 2) Captain Switch, 3) Co-pilot Switch, 4) FCM commands. See Figure 2 for a schematic of the horizontal stabilizer system.

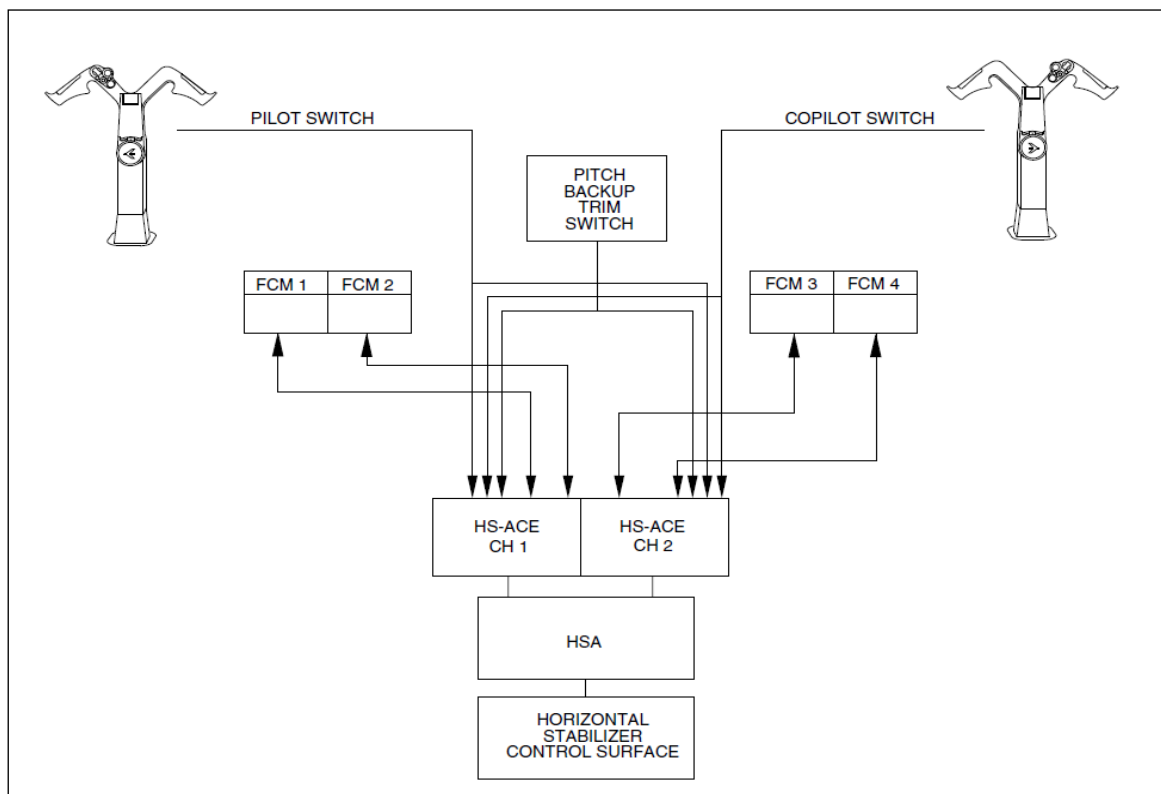


Figure 2: Horizontal Stabilizer System Schematic
(Ref Embraer 170/175 AMM, Part I 1963, Rev 64)

In the standby configuration, the HS-ACE standby channel will remain powered up and the monitoring lane will provide monitoring functions, but the controlling lane does not provide any control functions until a failure has been detected in the active HS-ACE channel.

In both the active and standby configurations, the monitor lane monitors numerous HS-ACE functions including: control lane performance, FCM Controller Area Network data bus

messages, actuator motor velocity, and internal power. Each HS-ACE channel is powered by 28 VDC (Volt Direct Current). HS-ACE channel 1 receives power through DC (Direct Current) Bus 1. HS-ACE channel 2 receives power through Essential DC Bus 2. Emergency power is provided by the Ram Air Turbine to channel 2 only, which is the channel supplied by an essential DC bus.

The backup pitch trim control switch and the control wheel pitch trim control switches are dual split switches. Pressing one half of a switch up or down applies a ground and completes a specific circuit. It is noted here that if a wire for a specific pitch trim control switch circuit is shorted to ground due to damage, the HS-ACE would interpret the signal as a command. The HS-ACE requires a matching signal from both switch halves before sending a command to the HSTA.

There is no movement of the HSTA when only one half of the switch is actuated. If only half the switch is kept actuated and this disagreement persists for more than 5 seconds, that switch is automatically deactivated and the applicable advisory PITCH TRIM SW FAIL message is displayed on the EICAS. Once a half-pressed switch condition persists for a total of 6 seconds, the aural warning "Trim" is annunciated as an additional indication to the crew of the disagreement. The switch remains deactivated until the next power up or pitch trim system cutout is actuated.

Activation of the quick disconnect button also completes the circuit by applying a ground. As with the pitch trim control switch circuits, if a short to ground occurs within the quick disconnect circuit the HS-ACE would interpret the signal as a command.

The HS-ACE limits manual pilot trim commands to 3 seconds. After the control wheel or backup pitch trim control switches have both halves simultaneously pressed in the same direction for more than 3 seconds, a timer within the HS-ACE stops the horizontal stabilizer control surface movement and if the switch remains pressed, the aural warning "TRIM" triggers. When the switch is released, the aural warning stops and the timer is reset. In case of stick shaker activation, the HS-ACE is prevented from responding to any pitch trim UP commands (except for pitch trim UP commands from the backup pitch trim control switch) by a stick shaker signal from the Automatic Flight Control System.

F. DETAILS OF THE POST-INCIDENT INVESTIGATION:

The NTSB did not travel to the aircraft following the incident. Immediately following the incident flight, Republic Airways commissioned a third party maintainer who was local to Atlanta to troubleshoot the airplane. The maintainer stated the following:

"The pilot's write up was "Flight control issue pitch up." The pilot verbally reported a pitch trim runaway shortly after takeoff resulting in a return to KATL. I found fault code 24430200 HS2 on the CMC. Per MCC instructions and FIM 27-43-00, I cycled the trim cutouts and messages cleared. Performed an ops [check] per AMM 27-40-00. All operations were normal with no sign of pitch trim runaway. Additional Tech [name omitted] was there to ensure the A/C was clear for the operations of flight control and to visually verify proper movement of the [Horizontal Stabilizer] as I

operated the trim from the flight deck. At no point did we remove, install or alter any parts or controls.”¹

The maintenance logbook page for this event stated in the corrective action section that the maintainer found fault coded 27430200HS2. The definition for this fault code is "HSACE2 (X CHANNEL PWR)/WRG FAULT" and means there is a loss of power to channel 1 of the HS-ACE. It will be logged when channel 2 detects that channel 1 has been cut out, which is consistent with the activation of the channel 1 pitch trim cutout switch during the event flight as reported by the flight crew.

A senior maintenance manager from Republic arrived on 11/7/2019 to secure the airplane and remove the FDR/CVR. Republic reported that no additional work was done to the aircraft until two additional Republic Airways mechanics arrived from their Headquarters on November 8. The maintenance crew stated that they confirmed the correct operation of all three switches per the AMM Part II 1963, Rev 80, Task 27-40-00-710-801-A (Horizontal Stabilizer System – Operational Check). They stated that the technician performing the procedure was very familiar with the horizontal stabilizer trim system, indication, and associated direction of movement. In addition, a technician was placed near the horizontal stabilizer, one at the pitch trim controls, and one in between, and verbal communication was used to verify that the stabilizer moved in the correct direction when operated. The maintenance crew stated that they did not observe any anomalies with the operation of the pitch trim system.

In preparation to ferry the aircraft to Indianapolis for detailed examination, the maintenance crew disconnected the captain's pitch trim control switch from the HS-ACE at the connector per Republic Airways Task 170EI-27-42-0004. The switch was not disturbed at the control column during this procedure. The captain's pitch trim control switch and/or wiring was suspected because the switch was deferred per the Minimum Equipment List for the incident flight. Also, the FDR revealed that the captain's switch was sending pitch up signals during the incident flight. The Engineering Instruction (EI) required that after the captain's pitch trim control switch was deactivated, the rest of the pitch trim system, including the co-pilot switch, backup switch, both cutout switches, and both quick disconnect switches, again pass the requirements of AMM Part II 1963, Rev 80, Task 27-40-00-710-801-A.

The ferry flight to Indianapolis occurred on 11/9/2021 with no anomalies noted. Once in Indianapolis, the Republic Airways maintenance crew performed wire inspections and identified damaged wiring at the base of the captain's control column. Six wires were identified as chaffed and damaged due to contact with an incorrectly tucked pigtail from the safety wire retaining the captain's control column forward mechanical stop bolt (part number: NAS428H4A12). See Figure 3. Subsequent laboratory testing revealed that the insulation for wires W251-00013-24 (Captain Quick Disconnect Switch), W251-00060-22 (Captain Trim Switch - Nose Up Trim A), and W251-00059-22 (Captain Trim Switch - Nose Up Trim B) were damaged such that continuity to the internal wire strands could be achieved. The Captain Quick Disconnect switch wire insulation was damaged completely around the wire strands and multiple exposed wire

¹ The referenced fault code is inconsistent with both the CMC data and the corrective action writeup in the maintenance log. The intended fault code was likely 27430200HS2.

strands were severed. The Captain Trim Switch – Nose Up Trim A wire insulation was chaffed exposing a small section of the conducting wire which showed signs of mechanical scraping. The Captain Trim Switch – Nose Up Trim B wire insulation was chaffed and damaged, but the conducting wire strands were not definitively visible. Continuity to the conducting wire could not be made with the multimeter leads alone; however, continuity was achieved by using both a cotton swab soaked in soapy water placed on the damage area, as well as by using a sample piece of cut safety wire pressed lightly on the damaged area. No definitive signs of arcing were identified on any wire. Wires W251-00061-22 (Captain Trim Switch - Nose Down Trim A), W251-00058-22 (Captain Trim Switch - Nose Down Trim B), and W251-00057-22 (Captain Trim Switch Ground) also demonstrated varying degrees of damage to the insulation; however, the damage was not severe enough to allow for continuity to the internal wire. According to Republic, there were no problems identified with the routing of these damaged wires.



Figure 3: Incorrectly Tucked Safety Wire Contacting Electrical Wires

A test flight was performed on 11/10/2019 after the damaged wires were repaired. The test flight was aborted during climb out due to a perceived trim anomaly by the crew. The aircraft returned to base and further troubleshooting was performed but no additional problems were identified. It was theorized that the perceived trim anomaly that occurred during the test flight was either caused by unintended physical activation, or that it was actually normal behavior of the auto-trim function that is active even when autopilot is not engaged. The HS-ACE was removed and replaced, and then two additional test flights were flown on 11/13/2019 using only the first officer's and backup pitch trim control switches. The captain's pitch trim control switch was then replaced, followed by a third test flight on 11/14/2019 in which the replaced captain's pitch trim control switch was operated. There were no anomalies identified in the final three test flights. Embraer specialists arrived on 11/13/2019, after the captain's pitch trim control switch had

already been replaced. Embraer inspection of the removed pitch trim control switch on 11/14/2019 revealed an imprint mark in the silicone area on the back of the switch (see Figure 4). According to Embraer, this mark is caused by contact against a spring and is consistent with the switch being installed inverted at some point in time. Embraer released Service Bulletin 170-27-0051, with an original release date of February 27, 2015, to alert the fleet of the possibility that the switch could be installed inverted and to recommend the installation of a support in the control yoke to prevent future incorrect installation of the pitch trim control switch. The compliance time of the bulletin was 7,500 hours or 36 months, whichever occurred first. SB 170-27-0051 had not been incorporated on the incident airplane at the time of the event.



Figure 4: Imprint on Back of Captain's Pitch Trim Control Switch

G. PREVIOUS MAINTENANCE ACTION (2 Flights Prior to Incident Flight):

Two flights prior to the incident flight the crew reported a “PITCH TRIM SW 1 FAIL” EICAS message. The lead mechanic at the arrival airport stated that he and another mechanic performed some basic troubleshooting and removed the captain’s pitch trim control switch to inspect for discrepancies and to clean the connectors. This did not clear the message, and the decision was made to replace the switch with a new switch. While waiting for parts, the process of removing the old switch was started; however, after about 15 minutes the maintenance crew was told to reassemble everything and defer the switch per the MEL. They updated the crew with the status of the switch. He reported that he spent approximately 1 hour on the airplane. Republic stated that a functional check of the switch following this work was not performed because the switch was deferred per the MEL.

The captain's pitch trim control switch was not used, and there were no recorded commands on the FDR originating from the captain's pitch trim control switch, for the flight that occurred between this maintenance action and the incident flight. The first officer was the pilot flying this flight leg.

H. MAINTENANCE RECORDS:

The incident aircraft had a history of "PITCH TRIM SW 1 FAIL" EICAS messages dating back to August 4, 2019, resulting in five captain's pitch trim control switch replacements and two HS-ACE replacements. This EICAS message occurs when there is a disagreement between both trim switch halves for more than 5 seconds. A maintenance records search performed by Republic was unable to determine the last time the captain's column adjustment bolt was adjusted. The captain's control column dust cover was replaced on 03/20/2019 for wear. The last heavy maintenance was a C check on 4/26/2018.

The following is a list of the recent maintenance history related to the pitch trim system:

- 10/30/2019 – "PITCH TRIM SW 1 FAIL" EICAS message reported, captain's pitch trim control switch was deferred per MEL
- 10/30/2019 – 11/01/2019 – 11 or 13 flights occurred while the captain's pitch trim control switch was deferred, no pitch trim discrepancies reported²
- 11/02/2019 – The captain's pitch trim control switch was replaced, MEL item cleared
- 11/02/2019 – 4 flights occurred with no discrepancies reported
- 11/02/2019 – "PITCH TRIM SW 1 FAIL" EICAS message reported– captain's pitch trim control switch deferred per MEL
- 11/02/2109 – OMA-CLT – Captain's pitch trim control switch was deferred for this flight, no discrepancies reported.
- 11/03/2109 – CLT-IND – Captain's pitch trim control switch was deferred for this flight, no discrepancies reported.
- 11/03/2019 – IND - HS-ACE was replaced, MEL item cleared
- 11/03/2019 – 11/05/2019 – 16 flights occurred, no pitch trim discrepancies reported
- 11/06/2019 – CMH-CLT – No discrepancies reported
- 11/06/2019 – CLT-XNA – No discrepancies reported
- 11/06/2019 – XNA-LGA – No discrepancies reported
- 11/06/2019 – LGA-DTW – No discrepancies reported
- 11/06/2019 – DTW-LGA – "PITCH TRIM SW 1 FAIL" EICAS message – switch was removed, contacts were cleaned, same switch was re-installed. The switch was deferred per MEL 27-43-02-1.
- 11/06/2019 – LGA-ATL – F/O was pilot flying. Captain's pitch trim control switch was not used and no discrepancies were reported
- 11/06/2019 – ATL-LGA – Incident flight. The switch remained deferred per MEL 27-43-02-01.

² There were two flights to CLT on the same logbook page. The log did not identify which flight the discrepancy was entered.

I. AIRCRAFT MAINTENANCE MANUAL PROCEDURES:

The Embraer 170/175 AMM Part II 1963, Rev 80, Task 27-40-00-710-801-A Horizontal Stabilizer System – Operational Check, provides the instructions for checking the stabilizer trim operation. While the instructions are technically correct, the investigation notes that successful completion of the task requires particular attention to appropriate reference points. For example, step 1.F.(2)(b) states “Push the pilot-control-yoke pitch-trim switch (5) to the DN position (according to the placard (9) direction) until the leading edge of the horizontal stabilizer moves to the full up position.” It is important for the maintainer to reference the placard on the control column because to move the stabilizer to the DN (down) position according to the placard requires the pitch trim control switch to be moved in the up direction. The placard refers to the aircraft attitude. In addition, any communication between maintainers regarding the position of the stabilizer would need to clearly define the reference point (stabilizer leading edge or trailing edge). The next step, step 1.F.(2)(b)1 states “The PITCH trim indication (8) on the EICAS display moves to the full down position.” It is again important for the maintainer to understand that the indicated position is a reference to the aircraft trim position, and not to the “leading edge of the horizontal stabilizer” as provided as the reference in the previous step. The stabilizer leading edge will move in a direction opposite the aircraft trim direction.

The procedure for adjusting the control column stop bolts can be found in the Embraer 170/175 AMM Part II 1963, Rev 80, Task 27-31-01-820-801-A “Control Column Mechanical Stops – Adjustment”. The complete instructions related to the safety wire state:

(22) Safety the applicable nut (7) or (9) with lockwire (5) or (11).

NOTE: Make sure that the lockwire is not on the top of the bolt, this can cause a measurement error.

The task did not call out AMM Task 20-10-02-910-801-A “Typical Safetying Methods - Maintenance Practices”. This task states that a typical safetying method when using safety wire is to “Bend the wire end to the part to prevent injury to the hands and not to permit the wire to catch on moving parts.” Although this bending technique is common practice, Embraer added this reference to Task 27-31-01-820-801-A in October of 2020 for additional emphasis regarding this maintenance action.³

J. RECORDED DATA REVIEW:

The cockpit voice recorder (CVR) did not capture the event. The circuit breaker was not pulled prior to initial maintenance activity (prior to the initiation of the investigation) which overwrote the event.

³ FAA Advisory Circular 43.13-1B, dated 9/8/98, titled “Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair”, section 7-123, step f, states “Safety-wire ends must be bent under and inward toward the part to avoid sharp or projecting ends, which might present a safety hazard.”

J.1. Incident Flight

Review of the FDR revealed that during the incident flight there were multiple pitch trim up commands and there were no pitch trim down commands originating from the captain's pitch trim control switch. There were multiple pitch trim up and pitch trim down commands originating from the first officer's pitch trim control switch. The FDR did not record any commands as "Trim Fail", which would have been recorded if the HS-ACE received differing signals from the two halves of a manual pitch trim control switch for more than 5 seconds. Therefore, all recorded pitch trim commands for the incident flight were initiated by a simultaneous command signal from both system halves of the relevant switch. All recorded pitch trim commands from both captain's and first officer's pitch trim control switches resulted in a properly corresponding stabilizer movement until time 21:10:36. At this time the stabilizer position parameter on the FDR goes to 0 for the remainder of the flight. Embraer stated that if a single, or both, pitch trim cutout switch is pressed, the recorded indication for the stabilizer position on the FDR will go to 0; however, the stabilizer will continue to perform normally. In addition, Embraer stated that with one cutout switch pressed, positions for all three pitch trim control switches would still be recorded on the FDR.

The FDR has a single parameter which records the operation of the two autopilot/trim quick disconnect switches. It cannot be determined from the parameter which disconnect switch was operated, only that one of the two disconnect switches was activated. Review of the FDR data revealed that each time a quick disconnect switch was engaged, there was no movement of the horizontal stabilizer surface. In addition, at no time was a quick disconnect signal and a captain's pitch trim control switch command signal recorded at the same time. It is noted here that due to the proximity of the autopilot/trim disconnect switch to the pitch trim control switch, the same thumb is typically used for the operation of both these switches by the pilot-in-command.

Review of the FDR data revealed that the captain's trim commands occurred only during times when the captain appeared to be in command. These times were identified by an increase in force recorded on the FDR for the captain's control column force parameter. The following observations were made from the FDR data:

The FDR shows that the backup switch was used one time to trim down at approximately 21:11:00.⁴

21:05:50 - 21:07:50 = multiple trim up commands from the captains switch only^{5,6}
 21:10:40 - 21:13:30 = multiple trim down commands from the first officer switch only
 (except backup switch usage noted above at time 21:11:00)

⁴ The captain was asked by email: "After the SYS 1 system was turned off and controls were transferred over to the first officer, was there any point where you used your trim switch?" The captain replied by email: "I think I used the backup trim to test if the pressure was relieved after cutting out system one not 100% sure though".

⁵ There was one trim down command from the first officer switch recorded during this time.

⁶ According to FDR data, the captain's control column force parameter showed a variable increase in the force applied to the captain's control column from time 21:05:50 to 21:11:40. Just after these times the force applied to the captain's control column was essentially 0 lbs.

21:14:30 - 21:16:40 = multiple trim up commands from the captain's switch only^{7,8}
 21:16:40 - 21:18:10 = multiple trim down commands from the first officer switch only
 21:18:10 - end of flight = multiple trim up and trim down commands from the first officer switch only

According to the Central Maintenance Computer (CMC) data, at about time 2:05:33, during the take-off roll, a PITCH TRIM SW 1 FAIL EICAS message is reinstated and then three seconds later is inhibited.⁹ According to Embraer, by design, following a pitch trim control switch failure, a power cycle of the HS-ACE will clear both the fault indication and the switch lockout protection, but the CMC message will remain latched until the applicable maintenance action is performed on the flight control system. This CMC message remained latched from the DTW-LGA flight that occurred two flights prior to the incident flight.

At 21:06:06 the FDR shows that the autopilot engaged and immediately disengaged. The CMC data shows that three seconds later a "PITCH CTRL OVERFORCE FAULT" maintenance message posted. This is recorded when the autopilot disengages due to either excessive resistance when trying to move the elevator mechanism or there is an unexpected application of counterforce on the control column from the crew. At time 2:10:41, a HSACE2 (X CHANNEL PWR)/WRG FAULT maintenance message posted on the CMC due to the channel 1 cutout switch being pressed.

J.2 Previous Flights

During the flight from LGA to ATL (one flight prior to the incident flight) the first officer was the pilot flying. The FDR did not record any indications of the captain's pitch trim control switch sending a command signal. The first officer's pitch trim control switch appeared to operate normally. According to the CMC data, at about time 23:20:40, during the take-off roll, a PITCH TRIM SW 1 FAIL EICAS message is reinstated and then one second later is inhibited. According to Embraer, by design, following a pitch trim control switch failure, a power cycle of the HS-ACE will clear both the fault indication and the switch lockout protection, but the CMC message will remain latched until the applicable maintenance action is performed on the flight control system. This CMC message remained latched from the DTW-LGA flight that occurred two flights prior to the incident flight.

During the flight from DTW to LGA (two flights prior to the incident flight) the first officer was the pilot flying and the autopilot was engaged. The CMC showed that during the initial climb a PITCH TRIM SW 1 FAIL message was posted and the captain's switch was deactivated by the failure logic. For the remainder of the flight, the FDR revealed multiple instances where the captain's pitch trim control switch was recorded as being in a TRIM FAIL condition for short

⁷ According to FDR data, the captain's control column force parameter showed a large increase in the force applied to the captain's control column from time 21:14:30 to 21:16:50. Just prior to and after these times the force applied to the captain's control column was essentially 0 lbs.

⁸ The captain was asked by email: "After the SYS 1 system was turned off and controls were transferred over to the first officer, were controls ever transferred back over to you, (the captain) at any point before landing?" The captain replied by email: "The controls were transferred to [me] briefly but... so the FO shot the approach and landed."

⁹ CMC data is recorded in Greenwich Mean Time (GMT).

time intervals. A pitch trim control switch is labelled as failed when the signal from one switch half disagrees with the signal from the other switch half for 5 seconds. At this time the switch is disabled and will not be able to command stabilizer movement until power is cycled to the HS-ACE. According to Embraer, the FDR will record the TRIM FAIL discrete for a disabled pitch trim control switch every time there is a pitch trim input from any operational source (another pitch trim control switch or autopilot trim input). If the operational source is another pitch trim control switch, the location of the commanding switch and the command direction will be recorded in addition to the failed switch's TRIM FAIL label. If the operational source is an autopilot command then no other pitch trim control switch commands will be recorded. Therefore, a TRIM FAIL indication for a pitch trim control switch recorded on the FDR does not mean that the failed switch was providing a command, but rather that it was in a failed state when the HS-ACE received a pitch trim command from an operational source.

Prior to the flight from DTW to LGA (two flights prior to the incident), the most recent flight where the FDR recorded any signal from the captain's pitch trim control switch was the flight from CMH to CLT (six flights prior to the incident flight). In this flight the data showed that the captain trimmed the aircraft both on ground and in flight and there were no failures recorded on the FDR related to the trim system.

Adam Huray
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