SERIOUS INCIDENT

Aircraft Type and Registration:	ERJ 170-100 LR, G-CIXW
No & Type of Engines:	2 General Electric Co CF34-8E5A1 turbofan engines
Year of Manufacture:	2008 (Serial no: 17000230)
Date & Time (UTC):	7 June 2021 at 1150 hrs
Location:	Descent to Birmingham Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 18
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	4,050 hours (of which 83 were on type) Last 90 days - 20 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and information provided by the operator

Synopsis

The pilots were alerted to a pitch trim failure and associated autopilot failure which resulted in greater nose-down control forces in pitch, requiring the pilot to use more force to control the aircraft than was normal for an approach. With both hands on the yoke, the PF flew a stable approach and made a safe landing. On landing, the pilots were alerted to a fault in the steering system. No injuries or damage were reported.

The pitch trim fault was probably caused by the jamming of the actuator ball nut due to the freezing of water that had entered the component, itself probably the result of condensation. The steering system fault was due to a sensor failure unrelated to the pitch trim fault.

History of the flight

G-CIXW was flying from Gibraltar to Birmingham Airport. The pilots began the descent into Birmingham from FL380 and during the descent, about 90 nm from landing, an amber PITCH TRIM FAIL caution illuminated on the Engine Indication and Crew Alerting System (EICAS). On seeing the message, the PF disconnected the autopilot (AP) to counter the potential threat from a pitch trim runaway. Shortly thereafter, the AP FAIL caution illuminated, indicating the loss of the AP.

The pilots continued the descent into Birmingham and actioned the checklist in the quick reference handbook (QRH) for PITCH TRIM FAIL. They determined, both from the forces

required to maintain the flight path and the trim indication, that neither the primary nor secondary trim systems were functioning and, as a consequence, nor was the AP.

The pilots did not declare an emergency and continued the descent as ATC vectored the aircraft for the ILS approach to Runway 15 at Birmingham. On the final approach, the PF found that he required more effort than usual to control the pitch of the aircraft. To counter this, the pilots decided that the PF would have both hands on the yoke to maintain control of the aircraft's flight path, while the PM would guard the throttle (since autothrottle remained engaged).

On landing, a STEER FAIL caution illuminated, together with a FLT CTRL NO DISPATCH caution. The commander, who had been operating as PM and occupied the left seat, took control and stopped the aircraft on the runway. The pilots then completed the STEER FAIL checklist in the QRH. The commander taxied the aircraft off the runway and onto the stand using differential braking and asymmetric power in accordance with the relevant abnormal checklist. On shutdown the commander advised the operator's maintenance control that the failures resulted in control issues both in the air and on the ground and made relevant entries into the aircraft technical log.

Aircraft examination

The operator carried out a maintenance inspection and the faults were rectified. This involved the replacement of the horizontal stabiliser actuator control electronics unit (HS-ACE), followed by an operational test on the horizontal stabiliser (HSTAB).

A sensor on the nosewheel steering system was found to be defective and replaced.

Recorded information

The event was notified nine days after it happened and consequently no CVR recording was available to the investigation. Relevant flight data is shown in Figure 1.

Prior to the descent from FL380 the AP was engaged, the pitch trim was recorded at -2.4° (nose up) and control column inputs were small. The descent was initiated with the AP in vertical path mode. Increasing amounts of control column pitch down input were recorded with no change in pitch trim until a jump in the recorded value passing through FL307 from -2.4° to 0°. Approximately 23 seconds later, the master caution was triggered. Approximately 24 seconds after that the AP was disengaged and remained disengaged for the rest of the flight. AP system failure was recorded about 15 seconds after it was disengaged, briefly at first and then continuously except for two short periods of 5 to 10 seconds. These two periods were when the recorded pitch trim position values switched from 0° to -2.4°, the AP system failure parameter became inactive, and co-pilot trim commands were recorded. After this the pitch trim position returned to 0°, the AP system failure parameter re-activated, and a master caution was triggered.

Pitch trim positions recorded during other flights were between approximately -4.7° and -7.4° during the final approach and landing phases. This would give more pitch up trim than the last reasonable value recorded on the incident flight of -2.4° of pitch trim. It is likely

that this -2.4° of pitch trim reflected the actual pitch trim of the HSTAB during the approach and landing as this was the last value recorded before the parameter switched to reading an unreasonable value of 0° and there was no recorded trim activity after that. Less than normal pitch up trim is also indicated by greater than the normal pitch up control inputs required by the pilot.

Flight data monitoring programme (FDM) data indicated that the aircraft was speed stable and remained within 0.6 dots of the glideslope on the final approach for the ILS.

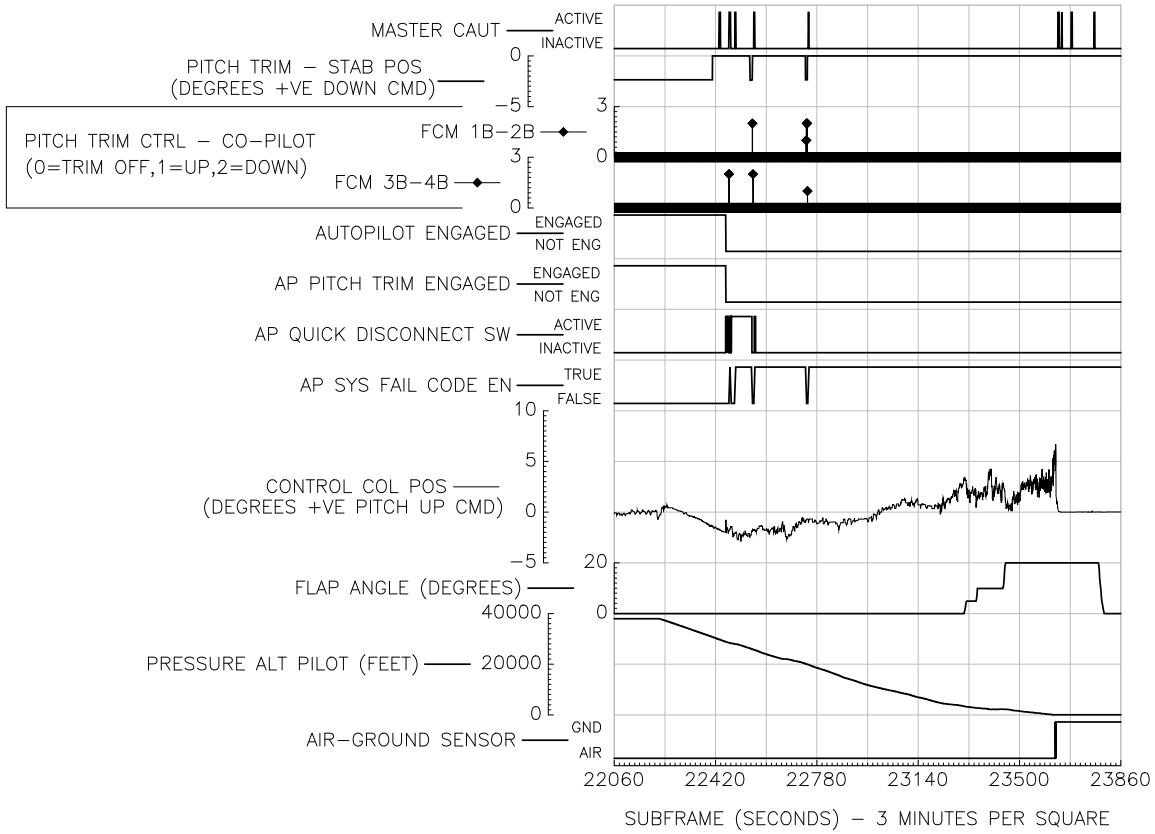


Figure 1

Pertinent extracts from the flight data recording

Aircraft information

Pitch control system

The aircraft has an electronic fly-by-wire system designed to operate the conventional control Surfaces. The horizontal tail surface consists of the HSTAB and the elevators. Pitch control is achieved by means of electro-hydraulically commanded elevators and an electro-mechanical HSTAB. Control is by autotrim, using the AP through the flight control module, or through manual trim, by either the captain's or first officer's main trim switches or the back-up trim switches, to the HS-ACE. If the AP trim function becomes inoperative, the AP will disengage and cannot be re-engaged without maintenance action.

The HS-ACE is a dual-channel active-standby redundant system, with each channel on receiving a signal, directly controlling its respective HS trim actuator (HSTA) servomotor to move a ball nut assembly linked to the HSTAB surface; this signal is also used for monitoring and EICAS indication.

In the event the active channel fails, the standby channel becomes active and both automatic and manual trim remain available. Following the failure of a single HS-ACE channel, the FLT CTRL NO DISPATCH caution will illuminate on landing. Following a failure condition that affects both HS-ACE channels, a PITCH TRIM FAIL caution will illuminate.

Nosewheel steering system

The aircraft nose landing gear has a steer-by-wire control powered by the No 2 hydraulic system and electronically controlled by the Nosewheel Steering Control Module.

The nosewheel steering has three modes of operation: handwheel steering mode, rudder pedal steering mode, and freewheel steering mode. The freewheel steering mode is mostly used for towing or when the normal steering system fails. In free wheel mode, steering can be accomplished using rudder, differential brake and/or asymmetrical thrust. The free wheel mode is automatically selected when:

- failure of the Air/Ground signal occurs, or
- nosewheel angle is greater than 76°, or
- nosewheel steering system failure is detected.

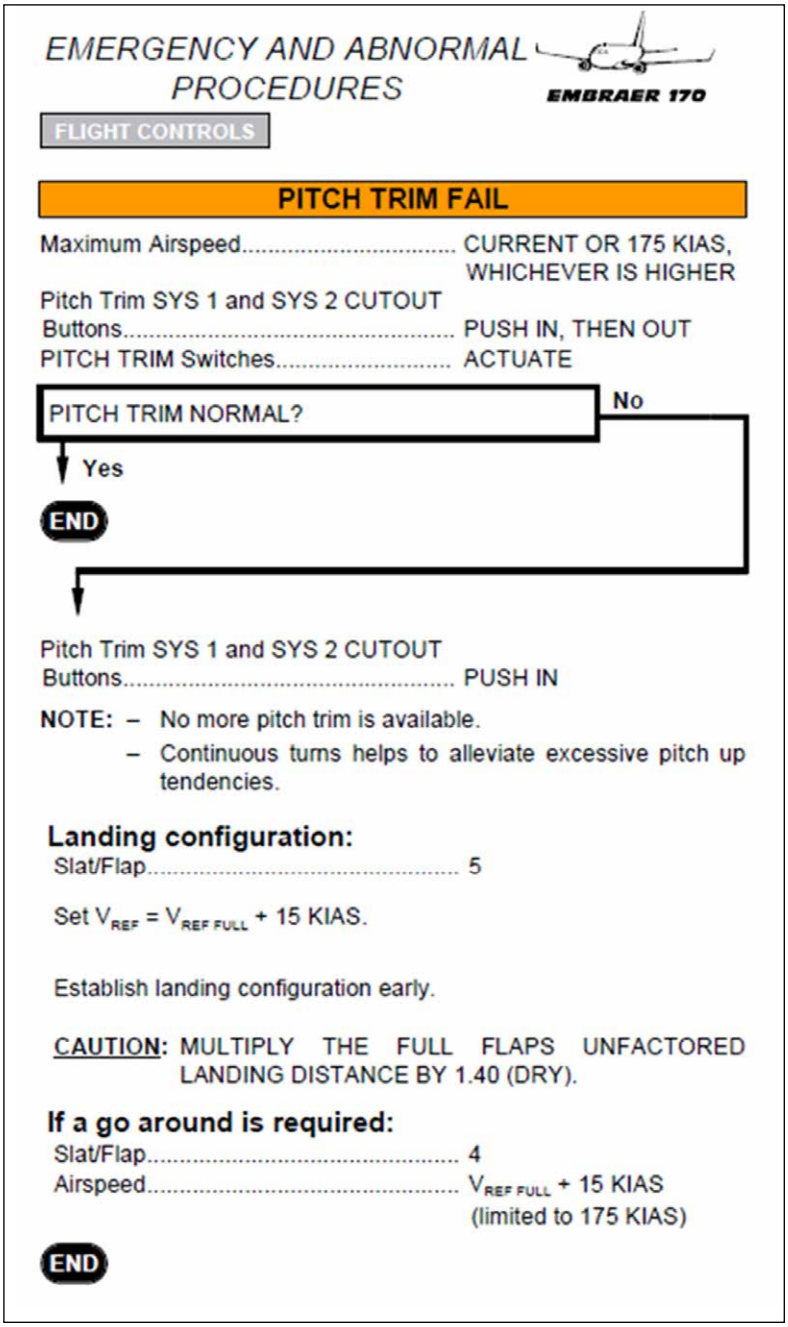
Crew Alerting System

The Crew Alerting System (CAS) is part of the EICAS and provides pilots awareness of the degradation or failure of aircraft systems by either a warning, caution, advisory or status message. Each CAS message has an associated emergency or abnormal procedure to manage the threats that arise from the system degradation or failure. The following messages, with their associated QRH procedures relevant to the incident were displayed:

- PITCH TRIM FAIL caution (Figure 2)
- STEER FAIL caution (Figure 3)

The FLT CTRL NO DISPATCH caution does not have an associated QRH procedure but is identified as a “Crew Awareness” caution. If a “Crew Awareness” message is displayed on the EICAS, takeoff is prohibited unless at least one of the following conditions is met:

- The message is an expected result of an intentional operation.
- Flight crew action is taken to clear the message.
- Maintenance personnel take action to clear the message.
- The aircraft is dispatched in accordance with all approved company minimum equipment list provisions.



EMERGENCY AND ABNORMAL PROCEDURES

EMBRAER 170

FLIGHT CONTROLS

PITCH TRIM FAIL

Maximum Airspeed..... CURRENT OR 175 KIAS, WHICHEVER IS HIGHER

Pitch Trim SYS 1 and SYS 2 CUTOUT Buttons..... PUSH IN, THEN OUT

PITCH TRIM Switches..... ACTUATE

PITCH TRIM NORMAL? — No

Yes

END

Pitch Trim SYS 1 and SYS 2 CUTOUT Buttons..... PUSH IN

NOTE: – No more pitch trim is available.
– Continuous turns helps to alleviate excessive pitch up tendencies.

Landing configuration:

Slat/Flap..... 5

Set V_{REF} = $V_{REF\ FULL}$ + 15 KIAS.

Establish landing configuration early.

CAUTION: MULTIPLY THE FULL FLAPS UNFACTORED LANDING DISTANCE BY 1.40 (DRY).

If a go around is required:

Slat/Flap..... 4

Airspeed..... $V_{REF\ FULL}$ + 15 KIAS (limited to 175 KIAS)

END

Figure 2

QRH Drill EAP8-6 – PITCH TRIM FAIL caution

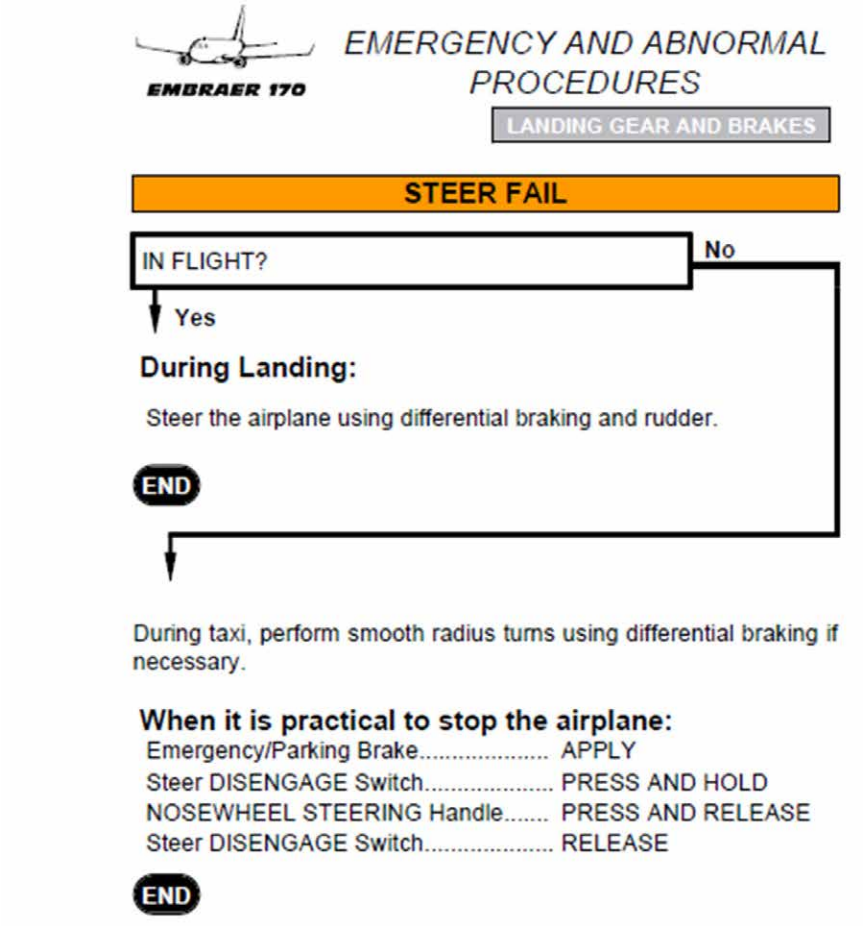


Figure 3

QRH Drill EAP 13-5 – STEER FAIL caution

Tests and research

Manufacturer analysis

The fault history database (FHDB) was recovered from the aircraft and supplied to the aircraft manufacture for decode and review. In its response it stated:

> *'Analysis of the recorded flight data showed that the "PITCH TRIM FAIL" occurred in the early stage of the descent, and the FHDB data suggests that this symptom is possibly related to a degraded performance of the horizontal stabilizer mechanism.'*

And:

> *'The presence of pitch trim fail displayed in flight is caused by a failure condition, affecting both HS-ACE channels …described by the Service Newsletter (SNL) 170-27-0067 issued on Aug/2018, where the HSTA jam condition was found as a root cause for the field events of pitch trim fail. …water ingression in the*

> *ball nut due to condensation phenomena was considered most likely to be the root cause for jamming in cold temperatures and long flights. In this case fully greasing the ball nut assembly reduces the amount of water that could ingress minimizing the probability of jamming and the message pitch trim fail.'*

In response to similar occurrences, in June 2009, the manufacturer had previously reduced the interval between horizontal stabiliser actuator lubrications from 1,500 to 1,000 flight hours. It demonstrated that this had significantly reduced the number of such cases, with no pitch trim fail events related to HSTA jams in the previous 12 months as of August 2020.

The manufacturer also commented that:

> *'During troubleshooting on ground, the effects of the low temperature disappear, which may induce operators to misdiagnose the root cause and replace the HS-ACE.'*

The manufacturer observed that *'due to Covid pandemic, this aircraft has been parked for some time recently' and stated that 'the effectiveness of lubrication may also be affected by a prolonged parking period';* consequently*, 'lubrication of the HSTAB is part of the return-to-service activities for prolonged parking.'*

The aircraft manufacturer recommended removal of the HSTA for further testing.

Operator investigation

The operator conducted its own investigation into the incident reviewing FDM data for the flight and speaking with the crew. It deduced that the two short periods when the recorded pitch trim stab position values switched from 0° to -2.4° and the AP system failure parameter became inactive, were a result of actuation of the pitch trim switches by the crew when they carried out the PITCH TRIM FAIL QRH procedure.

The PF stated to the operator that the aircraft had a slight nose-down tendency which required larger than normal input to achieve the desired nose attitude for the approach, and which was described as 'fairly benign'.

From a review of FDM data the operator identified no FDM events for stabilisation criteria. It further assessed that the data did not show any significant control difficulties or significant differences in lateral G for comparable flights during the approach and on landing. The operator concluded that the event was well-managed by the crew. It made no recommendations for crew actions or performance.

The technical element of the investigation reported that:

> *'The* [HS-ACE] *unit had been inspected on a recent input at our chosen MRO* [maintenance provider]. *No defects had been noted during the inspection.'*

The strip report of the unit, following the event, identified a failure of the No 1 channel.

The operator established that the HSTA had been lubricated 313 flight hours before the event. The aircraft maintenance manual defines a period of prolonged parking as '*Short out of operation time 8-60 days*.' A review of the aircraft's flight utilisation over the 5 months prior to the event established that there were only two occasions (both in March), where it was not utilised for extended periods beyond 8 days (10 and 11 days respectively). On average the aircraft was out of operation for 3.5 consecutive days in the same period, with average utilisation of 2.25 consecutive days. The operator confirmed that the aircraft maintenance manual did not require lubrication of the HSTAB in those circumstances.

Having identified the HS-ACE as the faulty unit, and replaced it, the operator did not remove and inspect the HSTA following the incident.

Since the event, the operator has reported no repeat of the defect. It concluded the pitch trim fail was the result of failure of HS-ACE, while the STEER FAIL caution was unrelated and the result of a sensor failure. The AP failure was a direct consequence of the pitch trim failure.

Analysis

The fixed position of the horizontal stabiliser was probably caused by the jamming of the ball nut due to the freezing of water ingress, itself probably the result of condensation. Although examination of the HS-ACE only identified a single channel failure, this condition alone should not prevent the surface movement as the channels are automatically switched after the failure of one channel. (The system is designed so that only one HS-ACE channel is active at a time and is able to command the system). Since the HSTAB was fixed, the active channel was not able to command any movement. After switching, the standby channel became active but could not command movement as well for the same reason. This condition resulted in the loss of pitch trim functionality and illumination of the PITCH TRIM FAIL caution.

The disengagement of the AP by the PF, even though this is not required by the relevant procedure, addressed the hazard of a more potentially serious trim condition of a pitch trim runaway. AP trim functionality, indicated by the illumination of the AP FAIL caution, would not have been available owing to the pitch trim failure.

Failure probably resulted in the HSTAB being stuck at -2.4°, (and that the two occasions, where -2.4° was recorded, were the result of the crew completing the actions which required the de-selection and re-selection of the pitch trim cut-out switches as part of the pitch trim failure procedure.) The consequence of the stabiliser being stuck was that the PF experienced heavier nose-down forces in pitch than would be normal, requiring stronger than normal pilot inputs to maintain the correct pitch attitude for the approach. The decision by the pilots that the PM would monitor the throttles, which were in autothrottle, to enable the PF to place both hands on the yoke to control pitch attitude, gave the PF the control to make the required pitch changes. The approach subsequently flown was stable and resulted in a safe landing.

The investigation found that the operator had lubricated the HSTAB in accordance with the recommended intervals, which were intended to prevent such an occurrence, as specified by the manufacturer.

The STEER FAIL caution was triggered by a sensor failure. This resulted in the loss of steering through the pedals (and the handwheel) which required the PF to steer the aircraft in free wheel mode using differential braking.

The PITCH TRIM FAIL and STEER FAIL cautions were unrelated. The nature of the failures, affecting control both in the air and the ground, together with the FLT CTRL NO DISPATCH CAS message required further action by the operator before the aircraft could be declared serviceable, necessitating an entry in the aircraft technical log by the commander.

Conclusion

The failure of the pitch trim system probably occurred because of jamming of the horizontal stabiliser as a result of freezing of water ingression in the ball nut due to condensation. The investigation found that the operator had lubricated the horizontal stabiliser at the intervals specified by the manufacturer to prevent such an occurrence.

Jamming of the horizontal stabiliser resulted in the loss of the pitch trim functionality. Consequently, the PF experienced greater than normal nose-down pitch forces on the approach. The PF delegated the monitoring of the throttles, which were still in autothrottle, to the PM to allow him to use both hands on the yoke. The PF flew a stable approach and made a safe landing. However, on landing, the STEER FAIL caution illuminated, as a result of an unrelated sensor failure. The commander took control and brought the aircraft to a safe stop and taxied the aircraft to stand using differential braking.