INCIDENT

Aircraft Type and Registration:	Airbus A320-214, G-EZWX
No & Type of Engines:	2 CFM56-5B4/3 turbofan engines
Year of Manufacture:	2014 (Serial no: 6192)
Date & Time (UTC):	27 July 2016 at 0729 hrs
Location:	In-flight from Heraklion, Greece, to London Gatwick
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 177
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to trimmable horizontal stabiliser (THS) mini reduction gear
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	17,000 hours (of which 6,000 were on type) Last 90 days - 217 hours Last 28 days - 82 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

During cruise at FL340 an Electronic Centralised Aircraft Monitor (ECAM) message STAB JAM appeared, there was a pitch excursion, the autopilot disengaged and the control law degraded to Alternate Law. The flight crew carried out the ECAM actions and the aircraft continued to its destination without further incident. The failure was probably due to water ingress into the trimmable horizontal stabiliser (THS) command transducer which migrated into the mini reduction gear, froze and damaged the gear.

History of the flight

Whilst the aircraft was in cruise, there was an oscillation in pitch and in normal acceleration during which a fault was detected in the stabiliser system. The flight crew were alerted to the fault when the autopilot disengaged and the Master Caution annunciated with ECAM message STAB JAM. The co-pilot took control of the aircraft while the commander carried out the ECAM actions. The checklist required the flight crew to check that the manual trim was available and to move the stabiliser trim until the elevator was in the neutral position. The commander stated that they moved the stabiliser trim wheel a little but the co-pilot stated that he felt that the aircraft was largely in trim and so they decided not to move the stabiliser significantly after that.

As a result of the fault the control law degraded into 'Alternate Law', which provided reduced levels of protection and the use of the autopilot was lost. However, 'load factor demand law' was maintained as were load factor protection and low/high speed stability functions. During the time when the flight crew were performing the checklist items, the aircraft started a gradual climb 100 feet from its assigned altitude; however, the flight crew were able to bring the aircraft back to the assigned altitude with minor control stick inputs. The flight crew descended below RVSM[1] airspace and continued the flight to Gatwick with the autopilot disengaged. When the landing gear was lowered during the approach the control law changed to 'Direct Law', as designed, and an uneventful landing was carried out.

After arrival, maintenance actions were carried out and the trimmable horizontal stabiliser actuator (THSA) was removed for further examination to determine why the fault occurred.

Recorded information

The flight data recorder (FDR) data showed that from about 1401:50 UTC to 1402:10 the aircraft experienced oscillations in pitch and in normal acceleration before the aircraft returned to steady flight (Figure 1).

The maximum normal acceleration achieved was 1.37 g and the minimum acceleration was 0.65 g over a 4-second period. It was during these oscillations that the elevator aileron computer (ELAC) parameters showed that a handover from ELAC 2 to ELAC 1 had occurred in quick succession at 1402:06. The autopilot disengaged two seconds later.

The oscillation in pitch was caused by an oscillation in the stabiliser position, for which the elevator automatically tried to compensate. The stabiliser then settled in a positon that was about 0.6° more nose-down than before the upset, while the elevator settled at a position about 2° more nose-up.

The ECAM actions called for the flight crew to trim the stabiliser manually until the elevator was indicating zero degrees, the neutral position. The stabiliser moved about 70 seconds after the upset which was probably the manual stabiliser input by the flight crew, although the stabiliser was not moved sufficiently to bring the elevator to zero degrees. The fact that the stabiliser is seen to move in response to the manual input indicates that it was not physically jammed.

Stabiliser system description

The horizontal stabiliser is controlled by the THSA and it can be trimmed either electrically or manually with a trim wheel in the cockpit via the THSA. The electrical trim is, by default, controlled by ELAC 2 and if ELAC 2 detects that the system is not responding to its commands it will hand over control to ELAC 1. If both ELAC 2 and 1 detect that the stabiliser is not following their commands then control of the stabiliser will be handed over to spoiler elevator computer 2 (SEC 2) followed by SEC 1 if the same fault is detected by each respective SEC.

Footnote

[1] RVSM airspace is upper level airspace with Reduced Vertical Separation Minima.

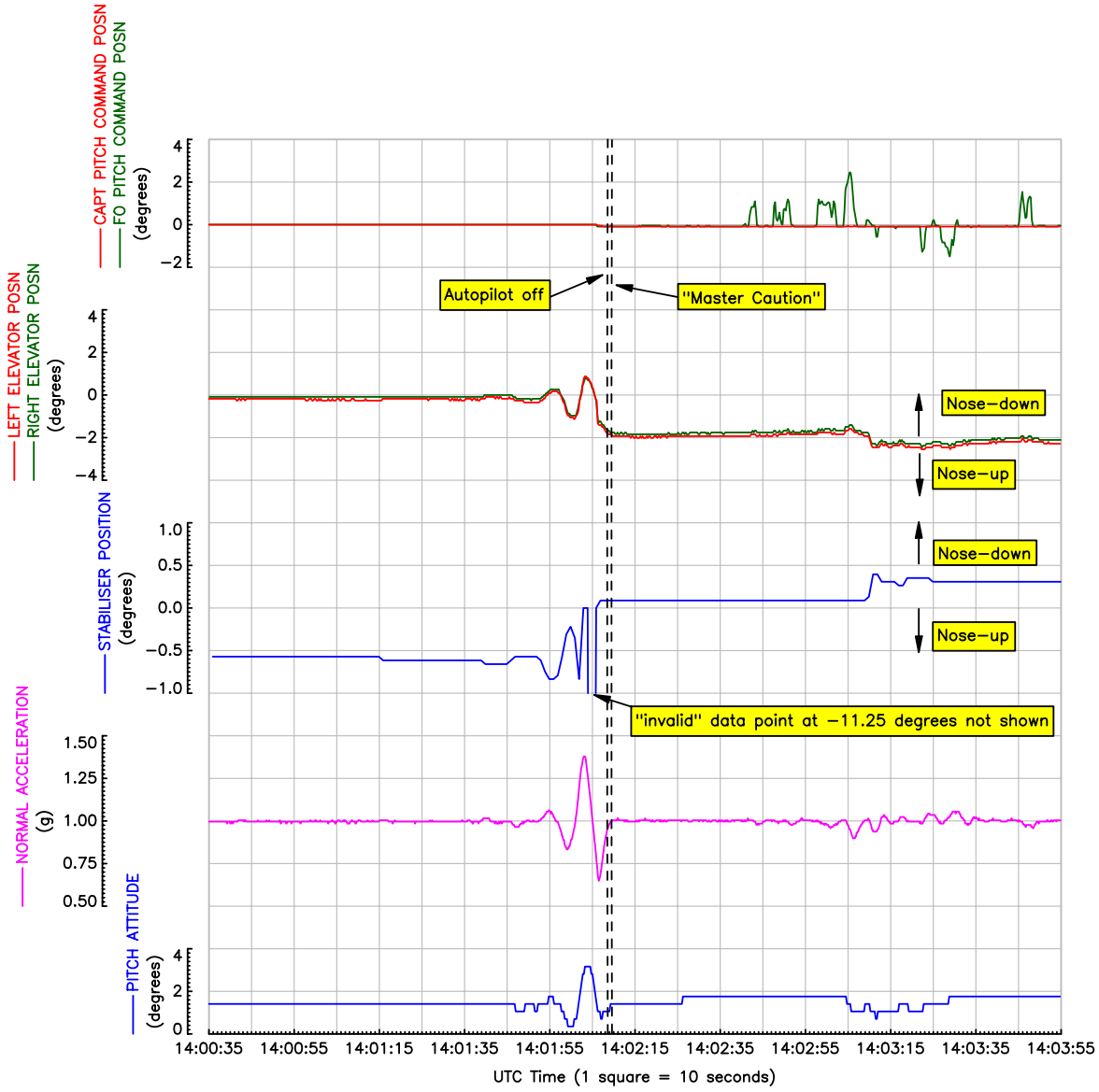

Figure 1

Salient FDR parameters at the time of the stabiliser malfunction

The ELAC sends commands to the THSA via the pitch trim actuator (PTA) which contains three electric motors, which control the two hydraulic motors that drive the stabiliser ball screwjack. An override mechanism downstream of the PTA allows the manual trim wheel in the cockpit to override any inputs from the PTA to the hydraulic motors. The commanded stabiliser position is measured by the COM transducer which contains three RVDTs[2]. A mini reduction gear assembly mechanically transmits the commanded stabiliser position to the COM transducer. A separate MON transducer measures the position of the stabilizer ball screwjack. The ELACs monitor both the COM and MON transducers and if there is a discrepancy the 'STAB JAM' message will be annunciated and stabiliser movement will cease.

Footnote

[2] An RVDT is a Rotary Variable Differential Transformer which is used to measure a rotating position.

THSA component examination

The THSA was sent to the component manufacturer for examination. They discovered that the mini reduction gear assembly was not driving the COM transducer, so the COM transducer could not sense the commanded stabiliser position. About 2 ml of water was found inside the mini reduction gear liner/cavity, which was an unusual finding (Figure 2).

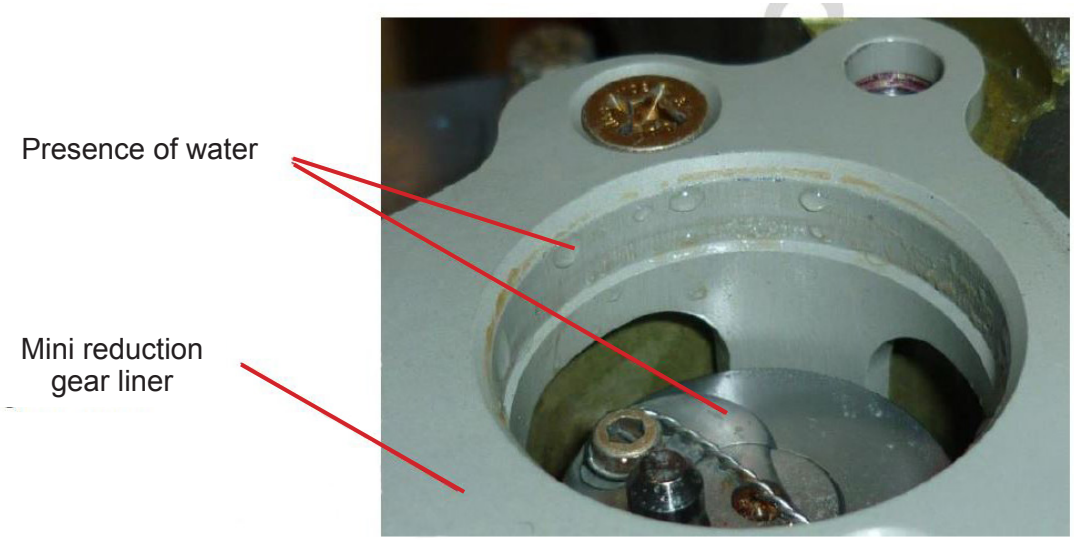

Figure 2

Water inside mini reduction gear liner/cavity

The output shaft of the mini reduction gear was found to be jammed and disassembly of the unit revealed damage to the gears.

The COM transducer was opened which also revealed the unexpected presence of water (Figure 3). Corrosion was also found within the transducer housing. The seals and sealant used to seal the component were in satisfactory condition. However, a leak check of the seal was not conducted before the transducer was opened as the manufacturer was not expecting water to be present. According to the manufacturer this was the first instance of water ingression into this component.

Operator comments

When the operator received confirmation from the THSA manufacturer that water ingress was the probable cause, the operator performed a detailed inspection of the area in which the THSA was installed on the incident aircraft. No signs of water, moisture or signs of previous wetting were identified in or around the area in which the THSA was fitted.

As a precaution, the COM transducer was removed from a similar age aircraft in the fleet and sent to the component manufacturer for analysis. The analysis included a pressure leak check of the case, electrical tests and visual inspections. None of these tests identified any issues with the sample unit and no signs of water were identified within the unit during inspection.

Figure 3

Water inside THSA COM transducer, cover (left) and internal RVDTs (right)

Analysis

Although the FDR data indicated that the elevator had not been trimmed to the neutral position, the flight crew were conscious of the need to keep the aircraft in trim. The commander checked the flight control page and the co-pilot confirmed that the aircraft was in trim. The flight crew did not encounter any difficulties controlling the aircraft.

According to the THSA manufacturer and the aircraft manufacturer the failure of the THSA was most probably due to water ingress into the THS COM transducer which then migrated into the mini reduction gear. The water in the mini reduction gear probably froze during flight and movement of the THSA caused torque on the gear to damage the mini reduction gear. The stabiliser would have moved as commanded and been sensed by the MON transducer but there would have been no movement sensed by the COM transducer; this discrepancy was detected and the system logic then prevented any further electrical commands to the THSA.

Although the source of the water and how it entered the transducer could not be determined, the aircraft manufacturer stated that the worst case scenario from water in this component is the one experienced by G-EZWX. Due to the system monitoring no increased attitude deviations would be expected, and the aircraft would remain fully controllable in 'Alternate Law' with manual stabiliser trim remaining available.