Serious Incident

Aircraft Type and Registration:	Bombardier CL-600-2B16 (604 Variant), D-AAAY
No & Type of Engines:	2 General Electric CF34-3B turbofan engines
Year of Manufacture:	2004 (Serial no: 5602)
Date & Time (UTC):	10 August 2022 at 1640 hrs
Location:	In the climb after departing Farnborough Airport, Hampshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew – 3 Passengers – 7
Injuries:	Crew – None Passengers – None
Nature of Damage:	Damage to the No 1 flap retract relay
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	13,091 hours (of which 5,655 were on type) Last 90 days – 102 hours Last 28 days – 41 hours
Information Source:	AAIB Field Investigation

Synopsis

In the climb, after departing Farnborough Airport, D-AAAY had an uncommanded[1] flap movement above the maximum flap extension speed during which the flaps moved to their fully extended position. The aircraft returned to Farnborough with the flaps extended where it landed without further incident.

An uncommanded and unarrested flap movement requires the flaps to move without movement of the flap lever and then for a failure in the flap arrest system to stop this movement. The flap surfaces are moved by two drive motors that are commanded by the sequencing of four extend and retract relays. These four relays also form part of the system to arrest an uncommanded flap movement.

The reason for the uncommanded movement of the flaps during the flight, and later during fault finding on the ground, could not be determined.

It was established that there had been a latent failure in the No 1 flap retract relay for at least the previous 64 flights, which caused the flaps to retract at half their normal retraction speed and prevent the arrest of an uncommanded flap movement. The failure of the relay resulted

Footnote

[1] Throughout the report the term 'uncommanded flap movement' means movement of the flap that was not commanded by the pilot by operation of the flap control lever.

from damage to the D contacts which provide electrical power to the flap Brake Detector Units. This damage was caused by electrical arcing resulting from an unsuppressed back-EMF generated when the Brake Detector Units were de-energised to apply the flap brakes when the flaps reached their selected position.

The AAIB published two Special Bulletins in which four Safety Recommendations were made: S2/2022[2] on 22 September 2022, and S1/2023[3] on 2 March 2023. A number of Safety Actions have been taken by Transport Canada and Bombardier Aviation, and additional action is planned in response to the recommendations.

Introduction

This serious incident occurred on 10 August 2022. On the evening of 14 August 2022, the AAIB was informed of the uncommanded and unarrested flap movement and commenced a field investigation on 15 August 2022.

On 9 January 2023 the AAIB was advised by the operator of D-AAAY that, while carrying out a manufacturer's Service Bulletin (SB) on two other Challenger 604 aircraft, they found the flaps to be operating at half-speed. The AAIB deployed a field team who, with representatives from the aircraft manufacturer, undertook an examination and test of the flap systems on these aircraft. The operator also permitted the examination of a third Challenger 604 aircraft, where the flaps operated at the correct speed while actioning the SB. These additional aircraft are identified in this report as Aircraft 2, 3 and 4. The flap extend and retract relays from all four aircraft were examined as part of the AAIB investigation.

History of the flight

The crew arrived at Farnborough Airport at 1300 hrs to operate a private charter flight to Málaga – Costa Del Sol Airport, Spain. The aircraft took off at 1618 hrs from Runway 06 using flap 20, after which the crew selected flap 0 and the flaps fully retracted. Following a standard instrument departure to the south-west, the flight was cleared to climb to FL350. As the aircraft passed through FL190 at approximately 300 KIAS, with the autopilot engaged, the crew saw a FLAPS FAIL caution[4] on the EICAS display primary page. The copilot, who was the PF, reported that the aircraft pitched nose-up slightly and started to decelerate. The EICAS primary page also displays a flap position indicator which indicated to the crew, by an animated green bar extending from left to right on the display, that the flaps were extending (Figure 1). The crew reported that the flap overspeed audio warning did not operate, which was contrary to their expectation[5]. The crew checked the flap control lever and noted that it was still in the flap 0 position.

Footnote

2 https://www.gov.uk/aaib-reports/aaib-special-bulletin-s2-slash-2022-bombardier-cl-600-2b16-604-variant-d-aaay [accessed January 2024].

3 https://www.gov.uk/aaib-reports/aaib-special-bulletin-s1-slash-2023-bombardier-cl-600-2b16-604-variant-d-aaay [accessed January 2024].

4 An amber caution indicates '*information that is considered important and may negatively impact the safe outcome of the procedure or lead to adverse effects or damage if not considered by the crew' (*Non-normal procedures PSP 604-15-QRH Vol. 2, REV 111, Nov 19/18. Bombardier Aerospace).

5 The aircraft manufacturer stated that the audio warning is not intended to operate in this scenario.

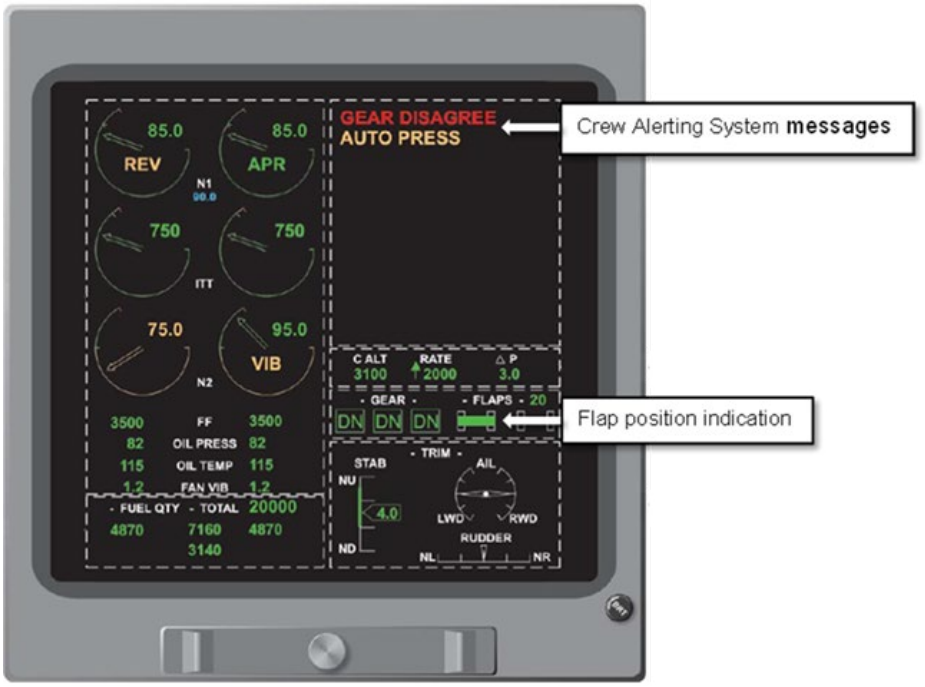

Figure 1

Illustration of EICAS primary page information

The commander switched on the seatbelt sign and took control of the aircraft. He disengaged the autopilot, reduced thrust to slow down, and initiated a descent. The crew informed ATC of the situation, requesting a descent to FL100 and radar vectors to Gatwick Airport. Subsequently, they decided to divert to Farnborough as it was closer than Gatwick and avoided extending the flight longer than necessary.

The crew established that the aircraft was responding normally to control inputs and decided to maintain FL150 at approximately 180 KIAS, which was below the V_{FE}[6] of 189 KIAS for flap 45. They reported that it required nearly full engine power to maintain this condition. The autopilot was re-engaged. The flight attendant made a visual inspection of the flaps from the cabin and reported that they appeared to be fully extended and symmetrical. The crew consulted the *'FLAPS FAIL'* procedure in the '*Non-normal Procedures'* section of the Quick Reference Handbook and found that no further actions were required. They established that they would land approximately 1,000 lbs over the maximum landing weight of 38,000 lbs and planned to increase the landing reference speed accordingly.

The aircraft was positioned for an ILS approach to Runway 06 at Farnborough and the crew configured the aircraft for landing, selecting the flap control lever to the flap 45 position (fully extended) to match the observed flap position. The aircraft landed without further incident at 1651 hrs, at an airspeed of 135 KIAS.

Footnote

[6] V_{FE} is the maximum speed with flaps extended for a given flap position.

Meteorology

High pressure dominated across the south of the UK bringing clear, dry and warm conditions to the region. The forecast and actual conditions at Farnborough relevant to the time period of the occurrence flight reflected the stable conditions.

Challenger aircraft fleet size

The CL600-2B16 Challenger 604 is predominantly used for private business operations. The total Challenger 600 series fleet, which includes the Challenger 600, 601, 604, 605 and 650, is approximately 1,000 aircraft.

Description of flap operating system

General description

The aircraft has two double-slotted flap panels (inboard and outboard) which are externally hinged on the trailing edge of each wing. A flap lever on the cockpit centre pedestal sends an electric signal to the Flap Control Unit (FCU) to initiate flap movement.

The flap lever incorporates two sets of break-before-make[7] electrical contacts that provide the position of the lever. One set of contacts is connected to the FDR system and the second set to the flap overspeed warning and FCU.

When the FCU commands a change in flap position, the flap brakes in the Brake Detector Units (BDU) are released, and two 200 V 3-phase AC-powered motors mounted on a flap gearbox are energised by relays located in junction boxes. The motors and gearbox, which are part of the Power Drive Unit (PDU), rotate flexible shafts to move the flap ball-screw actuators, extending or retracting the flaps. When the desired flap position is reached, measured by a flap position sensor on the PDU, the motors are de-energised and the brakes in the BDUs are applied. The flaps are mechanically interconnected for simultaneous movement of the inboard and outboard flap sections. A schematic diagram of the flap system is shown in Figure 2.

The flaps can be set to one of four positions: 0°, 20°, 30°, and 45°. Flap position is displayed on the EICAS primary page and the Flight Controls Synoptic Page in both analogue (coloured bar) and digital formats. This EICAS indication comes from a separate flap position sensor attached to the right inboard flap. The indications on the EICAS primary page are only shown if the flaps are extended, or if the landing gear is not up and locked.

Footnote

[7] A switch that is configured to break (open) the first set of contacts before engaging (closing) the new contacts.

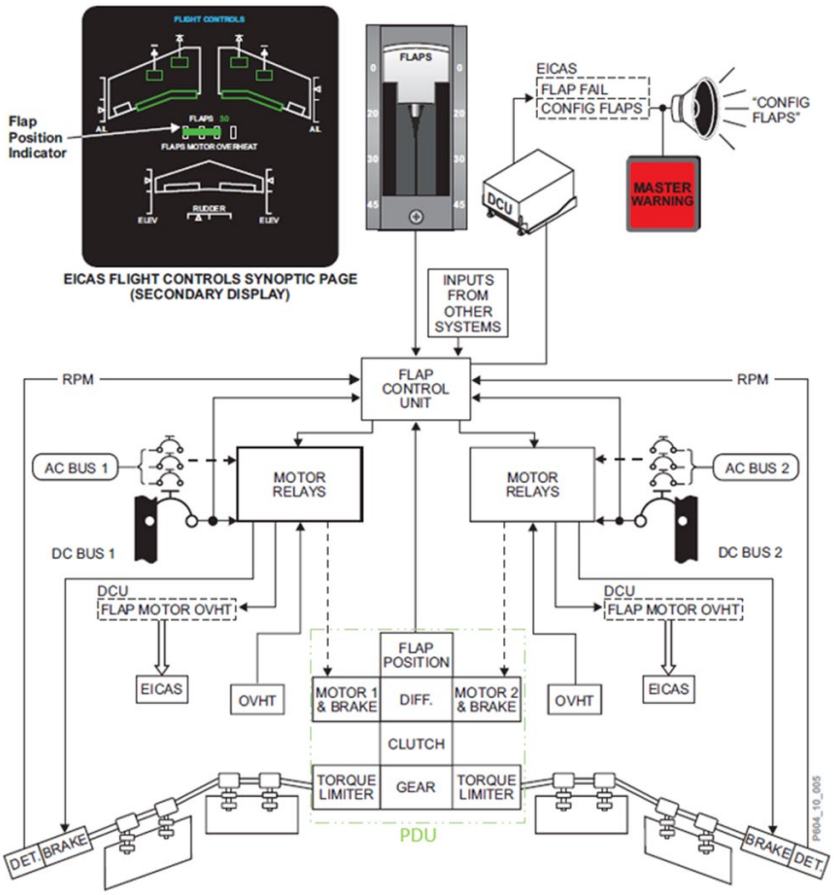

Figure 2

Schematic diagram of flap system
(Image from 2004 Pilot Training Guide amended to show PDU components)

When both motors operate, the flaps move at normal speed. If one motor fails or is not commanded to operate due to a failure in its control system, the remaining motor will continue to drive the system, but the flaps will move at half-speed due to the gearbox arrangement in the PDU. If a motor fails due to overheating, a FLAPS MOTOR OVHT EICAS status message will be displayed.

If a complete failure of the flap system occurs, such as both motors failing to operate, an asymmetry of greater than 2.75°, or an uncommanded flap movement, a FLAPS FAIL caution will be displayed on the EICAS.

Flap extend and retract relays

Control of the flap motors and the BDU is through four relays[8] with one extend and one retract relay in each of the two motor channels. The relays are identical and contain four sets of contacts identified as A, B, C and D. Each contact consists of two parts, a stationary contact and a moving contact. All four moving contacts are mounted on a single 'rocker' assembly, so if one set of contacts sticks, it can stop the other contacts from changing state.

Footnote

[8] Part number K-D4L-050.

The schematic layout of the relay is shown in Figure 3.

- Contacts A1, B1, C1 and D1 are normally OPEN.
- Contacts A2, B2, C2 and D2 are the input to be switched.
- Contacts A3, B3, C3 and D3 are normally CLOSED.
- Contacts +X1 and -X2 are for the operating coil.

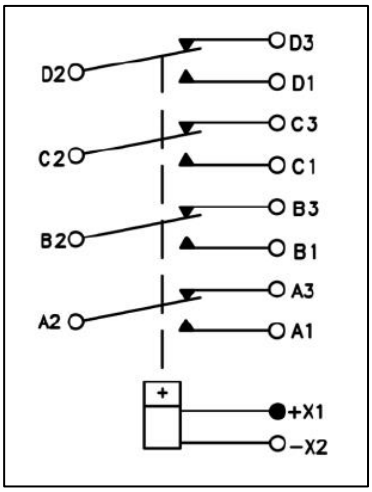

Figure 3
Schematic of relay arrangement

Relay contacts A, B and C are used to switch each of the three 115 V AC phases to the flap drive motors. The D contacts switch the 28 V DC power supply to the BDU brake solenoid coils, which are an inductive load. The manufacturer's datasheet for the relay states that, for an inductive load, the relay contacts are specified for a minimum operating cycle life of 20,000 operations.

The aircraft manufacturer reported that the relays are sourced as commercial off-the-shelf components (COTS). During this investigation the aircraft manufacturer established that the relay manufacturer changed the contact material in 1993; no amendments were made to the relay datasheet.

The aircraft manufacturer also observed that the shape of the contacts on relays taken from one aircraft, no longer in-service, were a different shape to the contacts in relays removed from in-service aircraft as part of this investigation.

Brake Detector Units

The aircraft has two BDUs. Each consists of a 28 V DC solenoid operated brake and a speed sensor detector unit (Figure 4). To provide redundancy each brake solenoid has two operating coils, one powered by each operating system, and each system powers an

operating solenoid in each of the two BDUs; these are connected in parallel. The brake solenoids are energised to release the brake and are de-energised to apply the brake.

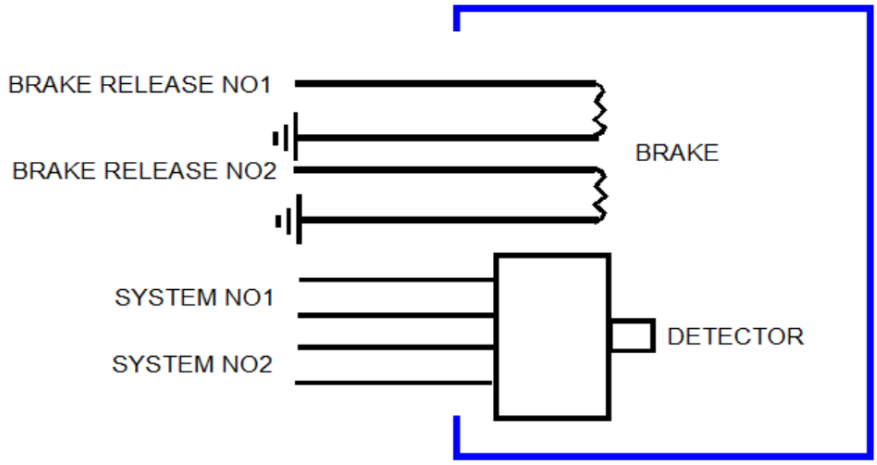

Figure 4

Schematic of BDU Brake Solenoid arrangement

Uncommanded flap movement arrest system

The FCU monitors for uncommanded movement of the flaps. If the flap position provided by the PDU exceeds the commanded position by more than 3°, the FCU activates the flap arrest system to apply power to both flap motor extend and retract relays. This:

- Engages the flap brakes, by de-energising the BDUs.
- Removes power from both flap drive motors, arresting their movement.

At the same time a FLAPS FAIL caution is displayed on the EICAS. This condition remains latched until the FCU power is cycled.

PDU flap position sensor fault protection

The FCU monitors the PDU flap position sensor for faults. If a short circuit to the sensor supply voltage or a loss of the sensor output signal occurs for more than about 7 milliseconds (ms), the FCU simultaneously provides power to the flap motor extend and retract relays. This removes power from both flap drive motors and engages the flap brakes, and a FLAPS FAIL EICAS caution is displayed. This condition remains latched until the FCU power is cycled.

Flap lever fault protection

If more than one flap lever position signal is simultaneously received by the FCU, power is removed from the flap motor extend and retract relays and a FLAPS FAIL EICAS caution is displayed. This condition remains latched until the FCU power is cycled.

Maximum flap operating speeds

The maximum flap operating speeds are shown at Table 1:

Flap setting	Maximum operating speed (V_{FE})
20°	231 KIAS
30°	197 KIAS
45°	189 KIAS

Table 1

Maximum flap operating speeds

If the flap lever is set to a flap position other than flap 0, and the aircraft's airspeed is above the limiting speed for that position, an aural 'clacker' warning will sound in the cockpit and an overspeed awareness cue will be presented on the airspeed tape on the PFD. The aural clacker will not sound in the event of an uncommanded flap movement when the flap lever remains at flap 0.

Flight Recorders

Recorded data

Data for the occurrence flight was available from the aircraft's FDR, which provided a recording of the last 154 hours of operation and the aircraft's previous 64 flights. The FDR parameters included the aircraft's indicated airspeed, the position of the flap lever and right-wing flaps. The CVR recording of the incident flight had been overwritten during subsequent maintenance activity, which had taken place prior to the AAIB being informed of the occurrence. The aircraft's track during the flight was captured by radar and recordings of RTF communications with the flight crew were also available.

Interpretation of recorded data

Prior to takeoff, the flaps extended to 20° at the normal rate of about 2.4°/sec. During their retraction after takeoff, they moved at half the normal speed at about 1.2°/sec.

As the aircraft climbed through FL190, at a recorded airspeed of 305 KIAS, the flaps started to extend while the flap control lever remained in the flap 0 position (Figure 5, Point A). The rate at which the flaps extended was about 1.1°/sec. The flaps extended at a near linear rate from the flap 0 position, with no evidence of prior flap creep[9]. The autopilot remained engaged, and the aircraft's speed started to progressively reduce while the aircraft pitched down from 4° nose-up. Shortly after, a FLAPS FAIL caution was recorded which occurred when the flaps had extended by about 3°.

As the flaps reached 20°, the airspeed was 296 KIAS which was 65 kt above flap 20 V_{FE}. This coincided with the flight crew disconnecting the autopilot and reducing engine thrust from

Footnote

[9] Where the flaps gradually extend by a small amount but then stop for a period of time before extending again.

91% to 47% N1 (Figure 5, Point B). The flaps continued to extend over the next 21 seconds until reaching 45° where they stopped, at which point the airspeed was 234 KIAS, 45 kt above flap 45 V_{FE} (Figure 5, Point C).

The aircraft's speed continued to reduce over the next 10 seconds, and as it approached 200 KIAS the crew started to increase engine thrust. This coincided with the aircraft starting to descend, having briefly climbed to FL200. The crew subsequently stabilised the aircraft's speed at about 183 KIAS with the engine thrust set at 92% N1. The autopilot was then engaged (Figure 5, Point D), and the aircraft levelled off at FL150. The flaps had experienced an overspeed for a period of about 170 seconds, which was the time between the flaps starting to extend from 0° and the airspeed stabilising at just below 189 KIAS with the flaps at 45°. During this period, the maximum flap overspeed was about 103 KIAS.

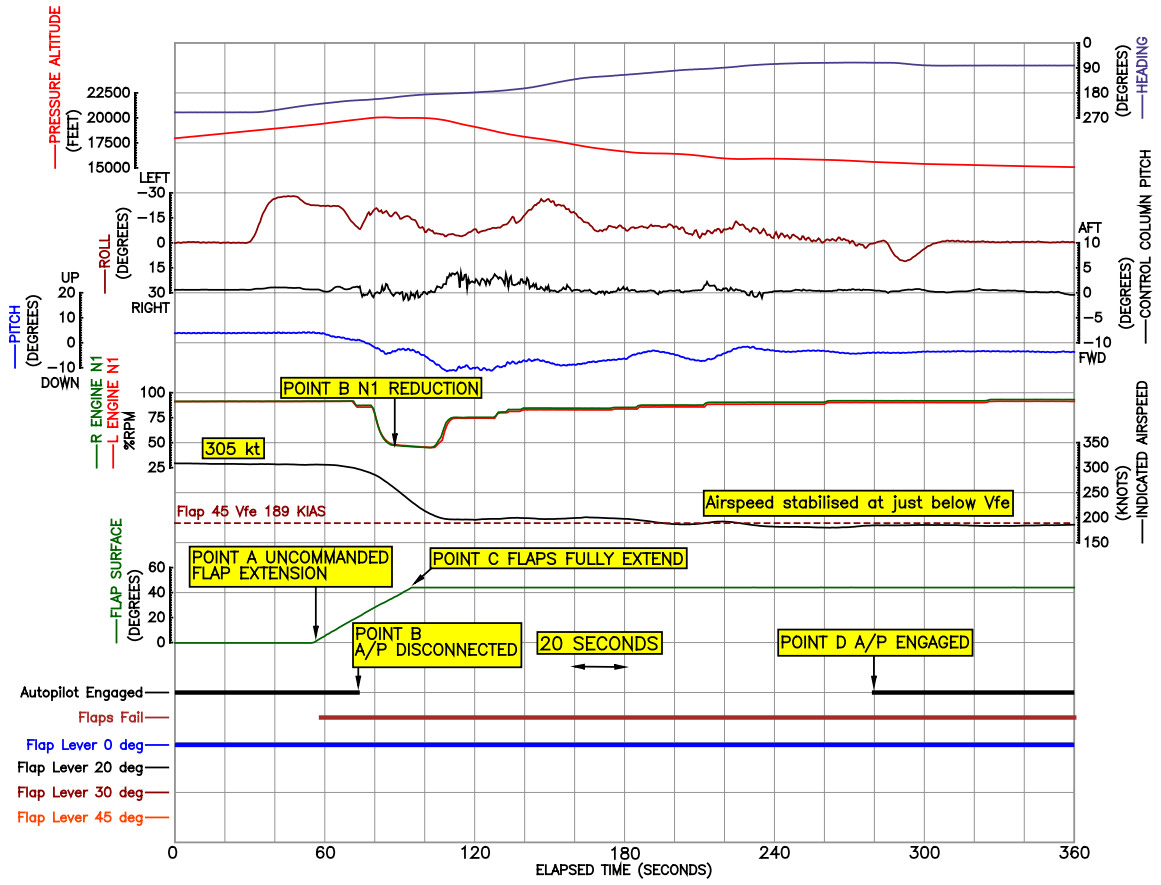

Figure 5

FDR data of uncommanded flap extension

During the 64 previous flights recorded on the FDR, flap extension occurred at normal speed, but retraction was at half-speed. There was no evidence in these flights of uncommanded movement of the flaps or flap creep. The oldest flight recorded on the FDR was on 4 July 2022.

Review of FDR data from Aircraft 2, 3 and 4

FDR data from Aircraft 2, 3 and 4 showed the following:

Aircraft 2 FDR download contained 260 flights recorded between 22 May 2022 and 30 December 2022. From the 6 October 2022 onwards, the flaps extended at half-speed. During all the recorded flights, the flaps retracted at normal speed.

Aircraft 3 FDR download contained 34 flights recorded between 22 November 2022 and 11 January 2023. During all the recorded flights, the flaps extended at half-speed and retracted at normal speed.

Aircraft 4 FDR download contained 25 flights recorded between 22 December 2022 and 17 January 2023. During all the recorded flights, the flaps extended and retracted at normal speed.

Aircraft examination

Findings prior to AAIB involvement

Engineers from a maintenance organisation began fault finding on D-AAAY after it landed. During this activity the aircraft was left unattended with electrical power applied and after approximately two hours, the flaps moved to their fully extended position, despite the flap lever being in the flap 0 position.

Testing and examination

The aircraft manufacturer, maintenance organisation and the AAIB worked closely during the extensive on-aircraft testing and examination, which included:

- Visual checks, where possible, of the electrical wiring, connectors and components in the flap operating system.
- Voltage, resistance, and continuity checks.
- Testing of the flap operating system using dedicated test equipment (break-out box). The tests were conducted with the existing and replacement flap extend and retract relays fitted.
- Structural examination of the flaps.

Structural damage

The flaps and associated structure were undamaged, but as a precaution the aircraft manufacturer recommended the replacement of several bolts and fasteners.

Findings

The examination and testing of the aircraft found that:

- No cause could be identified for the uncommand extension of the flaps.
- The flaps extended at normal speed but retracted at half-speed.
- The BDUs became warm when the flaps were not operating, indicating that electrical power was still being supplied to them when they should have been de-energised.
- When the No 1 flap retract relay was replaced the flaps operated at the normal speed during extension and retraction.

Scheduled check of the operation of the flaps

A check of the flap extension and retraction time is included in a regular inspection of the flap system. This is carried out every 600 flight hours on the Challenger 600 and 601 aircraft and every 1,200 flight hours on the Challenger 604, 605 and 650 aircraft.

A functional check of the uncommanded flap movement arrest system is carried out every 4,800 flying hours on the Challenger 604, 605 and 650 aircraft. At the time of this occurrence, D-AAAY had flown 8,151 hours and the last check was carried out in December 2018, approximately 1,696 flight hours prior to the occurrence.

Recent maintenance on the flap operating system

D-AAAY had recently undergone a 96-month *'Major Check'*, which was completed in June 2022. The only work carried out on the flap system at this time was the replacement of one flap ball-screw actuator.

In August 2021, approximately 500 flight hours before this occurrence, the PDU flap position sensor was replaced. The technical records stated that the reason for the removal was '*flap fail at 45 degrees. Intermittent signal loss during flap movement.'* As part of the maintenance task, an operational test of the flaps was carried out which included measuring flap extension and retraction time; they were both within acceptable limits. The removed flap position sensor was subsequently tested by its manufacturer and no fault was found.

Manufacturer's Service Bulletins

Requirement

On 29 December 2022, the aircraft manufacturer issued five SBs for operators to check the flap system on the Challenger 600 series of aircraft.

The SBs recommended an operational test to verify the extension and retraction time of the flaps. The test was to be carried out within 100 flight hours, and repeated every

100 flight hours for 600/601 series aircraft and every 400 hours for 604/605/650 series aircraft. The frequency of the checks aligned with existing scheduled maintenance tasks. On 10 February 2023, Transport Canada issued an Airworthiness Directive requiring the initial test to be carried out within 100 flight hours or 15 months, and repeated at the interval specified in the relevant SB.

Initial findings from the Service Bulletins

On 9 January 2023, the AAIB was contacted by the operator of D-AAAY after two of their Challenger 604 aircraft failed the SB because the flaps were operating at half-speed. The AAIB deployed a field team who, with representatives from the aircraft manufacturer, undertook an examination and test of the flap system. The operator also permitted the examination of a third Challenger 604 aircraft where the flaps had operated at the normal speed during the test. The extend and retract relays from these three aircraft were examined as part of the AAIB investigation. The following summarises the significant findings from the aircraft testing:

Aircraft 2

Aircraft 2 was manufactured in 2006 and had accumulated 10,300 hours and 4,687 flight cycles since new.

The results of the test were as follows:

- The flaps extended at half-speed; the flap retraction speed was normal.
- A break-out box was connected between the aircraft and the FCU to allow a functional test of the uncommanded movement arrest system to be conducted and the following was observed:
    - During step E3 of the procedure, the system operated normally; flap movement stopped within the specified limits and a FLAPS FAIL caution was annunciated on the EICAS display.
    - During Step E8 of the procedure, the system did not operate normally; the flaps stopped at 20° without the expected, slight, overtravel and the expected FLAPS FAIL caution did not annunciate on the EICAS display.

Following extensive testing during which the flaps continued to extend at half-speed, the flaps started operating normally without any corrective action having been taken. The cause of the half-speed flap operation was believed to be sticking contacts in the No 1 flap extend relay.

All four extend and retract relays were replaced and examined as part of this safety investigation.

Aircraft 3

Aircraft 3 was manufactured in 2000 and had accumulated 8,915 hours and 4,344 flight cycles since new. The results of the test were as follows:

A break-out box was connected between the aircraft and the FCU to allow a functional test of the uncommanded flap movement arrest system to be conducted.

- During Step E3 of the procedure the system did not operate normally; the flaps stopped at 20° without the expected slight overtravel and the expected FLAPS FAIL caution was not annunciated on the EICAS display.

- During Step E8 of the procedure the system did not operate normally. The flaps moved past 20° and stopped momentarily at 23° and a FLAPS FAIL caution was annunciated, which was as expected. But the flaps then retracted, uncommanded, until reaching the up-limit stops; the No 2 motor circuit breaker tripped after the flaps had been in this position for a few seconds.

Extensive testing of Aircraft 3 established that the contacts on the No 2 motor extend relay were stuck in their energised positions. The relay was replaced, and the system operated normally.

Aircraft 4

Aircraft 4 was manufactured in 2002 and had accumulated 6,487 hours and 4,241 flight cycles since new.

The SB was carried out and the flaps were found to operate normally. As a precaution, and to provide additional evidence to the safety investigation, the operator replaced the four extend / retract relays so that they could be examined by the AAIB.

Examination of the flap extend and retract relays

Relays removed from D-AAAY

The relays from D-AAAY were subject to electrical testing and forensic examination. The testing found that the contacts in the No 1 retract relay did not always change state (switch) when the relay coil was energised.

When the relays were disassembled, the D contacts were found to exhibit varying amounts of damage that was typical of electrical arcing:

- On the No 1 extend relay, material had transferred from the moving contact to the stationary contact which reduced the airgap between the contacts.
- On the No 2 extend relay, the contact was significantly discoloured (blueing) indicating that it had been subject to localised heating. There was no significant material transfer between the moving and stationary contacts.
- On the No 1 retract relay, the material forming the stationary contact had melted and reformed and there was distortion of the moving contact which reduced the airgap. Figure 6 shows the damaged D contact alongside the undamaged C contact.

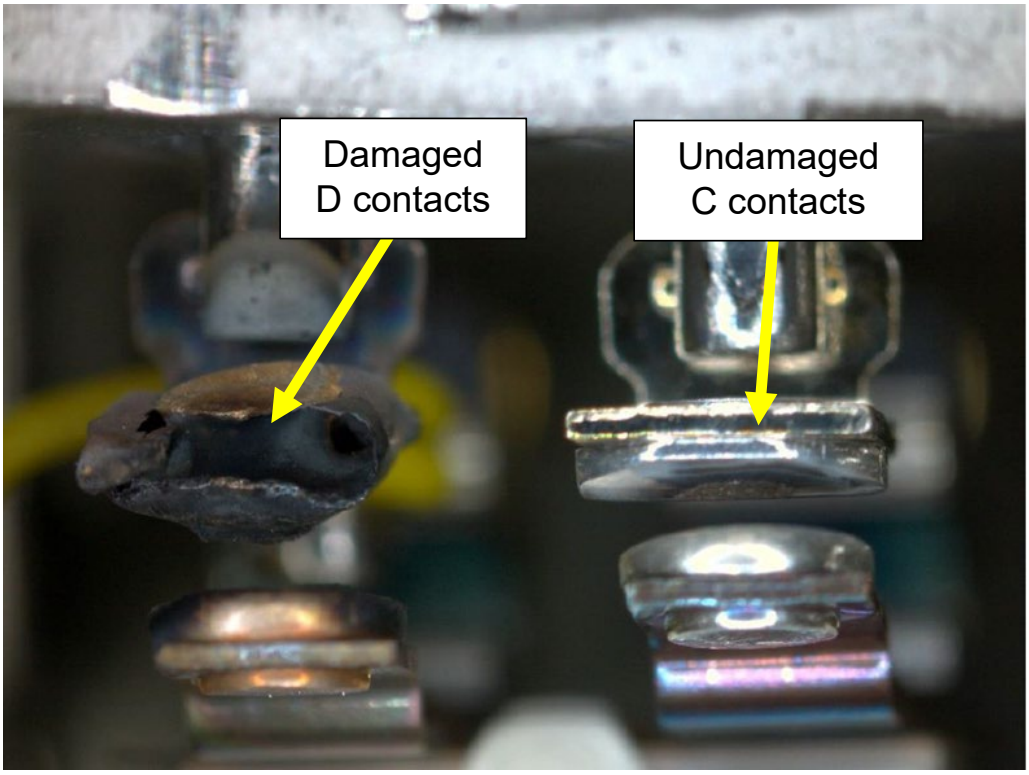

Figure 6

Damaged D contact (left) and undamaged C contact (right)

Relays from Aircraft 2, 3 and 4

Externally, the relays from Aircraft 2, 3 and 4 appeared to be in good condition; however, computerised tomography scanning found damage on some of the D contacts. In comparison, no obvious damage was found on the A, B or C contacts. The significant findings from the examination of the relays from the three aircraft was as follows:

Aircraft 2

There was evidence of erosion and material transfer between the D contacts on the No 1 extend relay (Figure 7). It is possible that the contacts were initially welded together, which would explain why the flaps extended at half-speed during the on aircraft testing. Failure of the weld after the flaps had been cycled a number of times would allow the contacts in the relay to move, and the flaps operate at their normal speed.

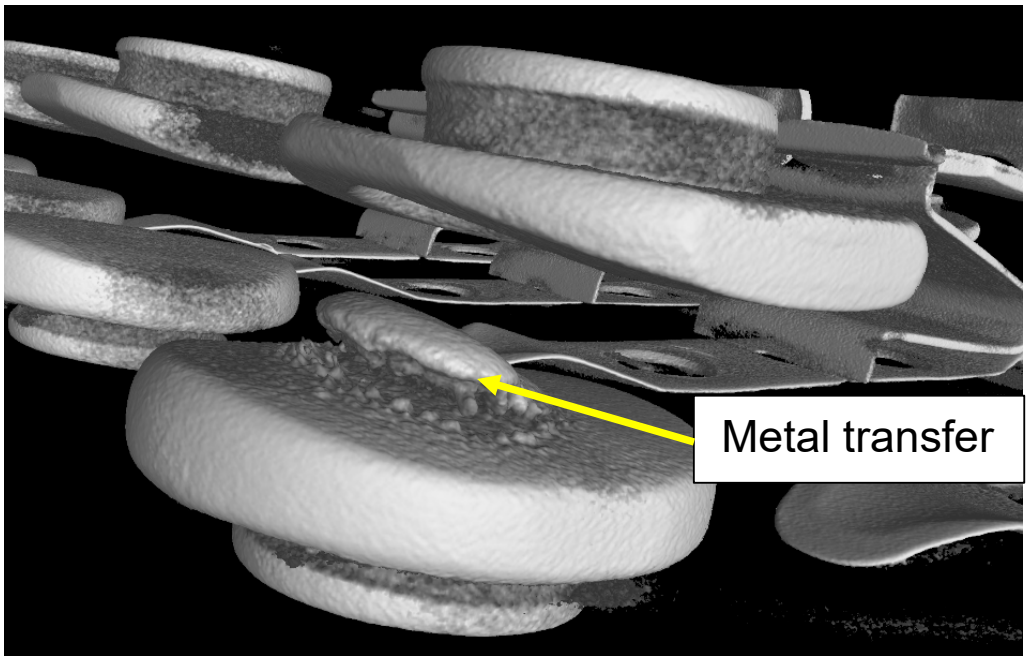

Figure 7

Erosion and metal transfer on the D contacts

The No 2 extend relay, which had been in-service for approximately 2,700 flight hours and 1,372 flight cycles, showed evidence of material erosion and transfer between the D contacts (Figure 8). The aircraft maintenance records showed that this relay was fitted in April 2018 following a defect that generated a FLAPS FAIL EICAS caution; it was found that the BDU brake solenoids were permanently energised.

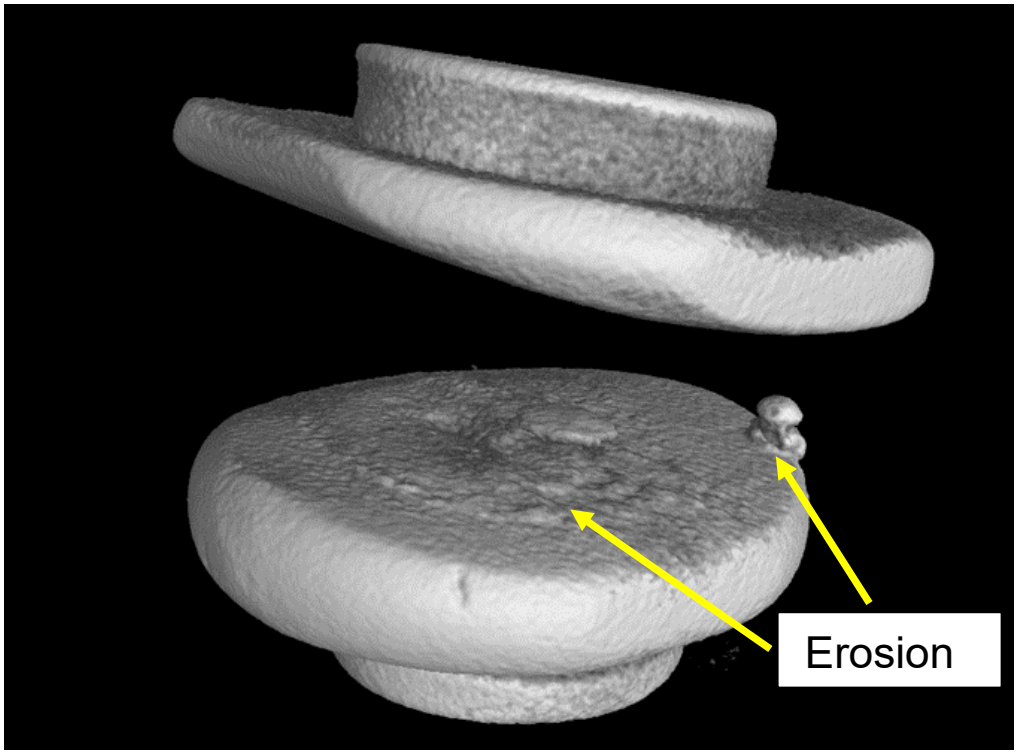

Figure 8

Material erosion on D contact

Aircraft 3

The D contacts on the No 2 extend relay were welded closed (Figure 9). In normal operation, when the relay is in a de-energised condition, these contacts would be open. In the welded condition, if the uncommanded flap movement arrest system was activated, the flaps would retract instead of their movement being arrested. This was observed during the testing of Aircraft 3.

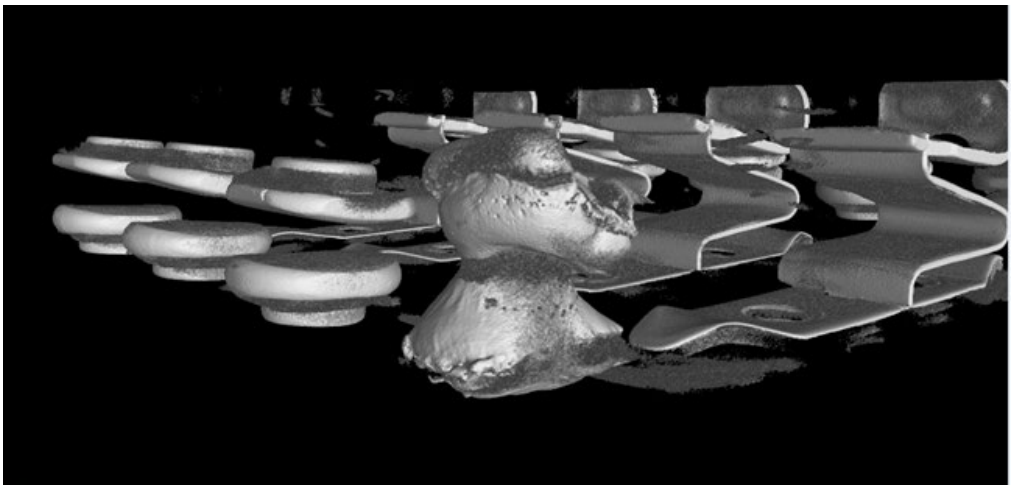

Figure 9

D contacts welded closed

Aircraft 4

While the flaps operated normally during testing, on the No 1 retract relay, material had transferred across the D contacts. This damage was typical of electrical arcing, which leaves a 'pit' where material is eroded and a 'pimple' where it accumulates (Figure 10).

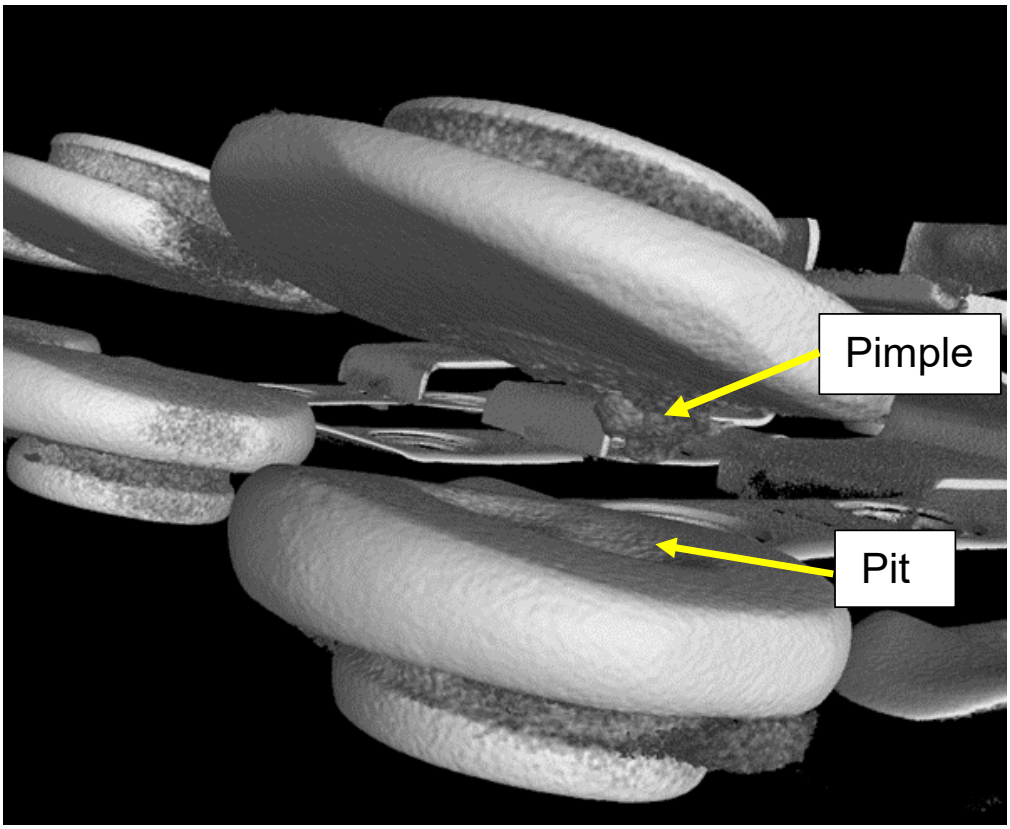

Figure 10

Metal transfer between the D contacts as seen by the pit and pimple effect

Examination of the Brake Detector Units

Independent testing commissioned by the AAIB

The resistance of the BDU brake solenoid coils was within specification.

The current and voltage during solenoid switching was measured using an oscilloscope (Figure 11). When the solenoid was de-energised a maximum transient voltage spike of 300V was seen; this spike regularly exceeded 150V during repeated switching of the BDU. The voltage spike is caused by a back electro motive force (EMF), which occurs when removing electrical power from inductive loads such as the solenoid coils. There was no protection or suppression provided within the flap operating system to prevent or reduce this back-EMF, which could cause arcing across the D contacts.

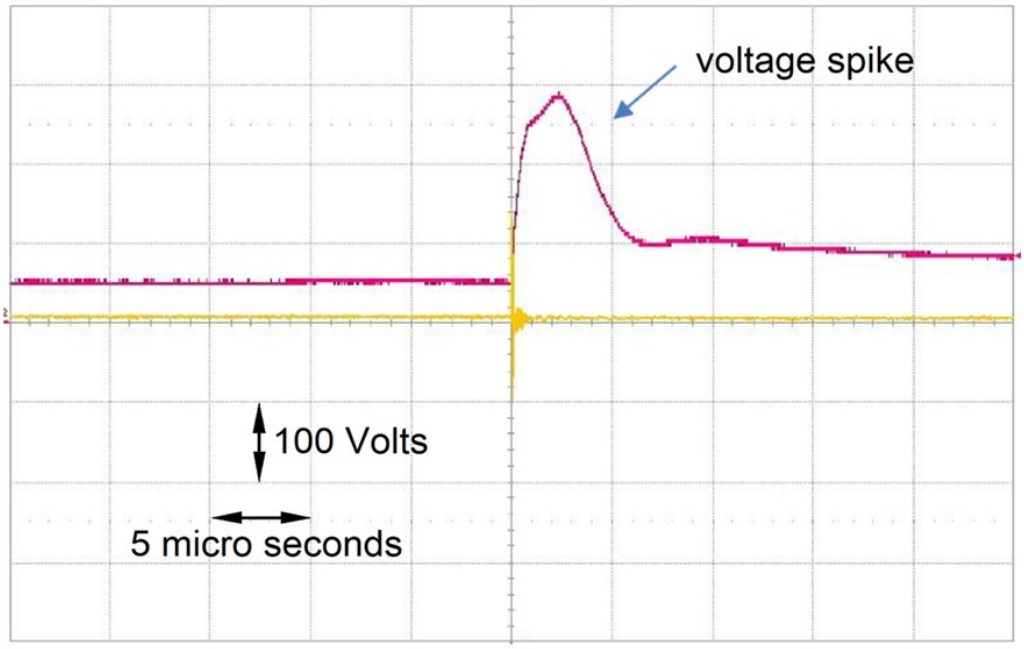

Figure 11

Oscilloscope output showing voltage spike after de-energising coil

Testing performed by the aircraft manufacturer

The aircraft manufacturer explored the electrical switching characteristics of the BDUs during laboratory tests and on a representative aircraft. Their testing indicated that the damage to the D contacts of the relay was probably associated with a back-EMF and arcing under initial low voltage, high current conditions.

The aircraft manufacturer is conducting additional testing to support their response to the safety recommendations made during this investigation.

Examination and testing of flap operating system components

Detailed examination of the FCU, PDU, and flap position sensor from D-AAAY were carried out at their respective manufacturer's facilities. No faults were found during testing that would have caused the uncommanded flap movement or contributed to the flap arrest system failing to operate correctly.

Testing of the FCU showed that if the flap position sensor signal was lost for more than about 7 ms, the FCU would apply power to both the extend and retract relays and the FLAPS FAIL caution would be displayed on EICAS. Testing of the flap position sensor included a check for an intermittent loss of signal of greater than 1ms. No fault was found.

The manufacturer of the flap position sensor advised that of the 116 sensors tested during the previous five years, one sensor had failed the intermittent signal test. No details were available as to whether the fault was repeatable or not.

Examination of flap actuators

Following the serious incident the maintenance organisation removed three of the eight flap actuators from D-AAAY after finding 'excess play'. The actuators are classified as 'oncondition[10]' and the hours / cycles since installation were:

Actuator	Hours since installed	Cycles since installed
Left inboard flap inner	5,791	2,926
Left inboard flap outer	8,151	3,847
Right outboard flap inner	8,151	3,847

Uncommanded flap movement on a second aircraft

The aircraft manufacturer advised that they had investigated an uncommanded flap movement that occurred on a second Challenger 604 on three occasions during March and April 2023.

On the first occasion the operator reported that the flaps "failed" at 2° while the aircraft was on the ground with the engines running. The crew reset the flap control circuit breakers and the flaps extended, uncommanded, to 45° after which the No 2 flap motor circuit breaker tripped. The flap lever and the flap control circuit breakers were reset, and the flaps extended normally. The aircraft departed with the No 2 flap motor circuit breaker tripped.

On the second and third occasion the operator reported that the flaps "failed" on the ground while extending to 20°. On both occasions the crew reset the flaps and continued the flight. On the second occasion, when the flaps were commanded to retract after takeoff, they retracted to 18°, where they stopped for around 20 seconds before extending uncommanded to 45°. On the third occasion they retracted to 14°, where they stopped for around 20 seconds before extending uncommanded to 30° where they stopped for around 7 seconds before extending to 45°. During both flights, the movement of the flaps (retract and extend) was at half-speed and the No 2 flap motor circuit breaker tripped when the flaps reached 45°. After the pilots carried out a flap reset, by cycling the flap circuit breakers, the flaps were reported to have worked normally.

The manufacturer reported that the FDR data showed that the flaps had been retracting, and occasionally extending, at half-speed for some time. The manufacturer's SB, which had been issued on 29 December 2022 to verify the extension and retraction time of the flaps, had not been carried out.

The manufacturer's assessment of the FDR data from the three fights was that the flaps 'crept' when the engines were running. This 'creep' would have gone unnoticed until the flaps had travelled 3° from their selected position, when the uncommanded flap movement protection system would operate. They concluded that a dormant failure in one of the flap control relays had prevented the flap protection system from stopping the movement, and instead caused the flaps to fully extend at half-speed.

Footnote

[10] On-condition maintenance is only performed when the condition of an item requires it.

The manufacturer reported that wear and backlash was found in the flap operating system. They concluded that flaps travelling at half-speed could excite the natural frequency of the flap driveshaft, potentially leading to increased wear and backlash in the flap operating mechanism. This would make the system more susceptible to flap 'creep' under vibration.

Certification standard

The Type Certificate[11] for the Challenger 604 aircraft was issued by Transport Canada and, with a number of listed exemptions, is compliant with Title 14 of the Code of Federal Regulations Part 25 (FAR 25).

FAR 25.1309 covers equipment, system and installations and the following sections are applicable to the arrest of an uncommanded flap movement:

> *'(b) The airplane systems and associated components, considered separately and in relation to other systems, must be designed so that -*
>
> > *(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane is extremely improbable, and*
> >
> > *(2) The occurrence of any other failure conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions is improbable.'*

Flight safety risk

As part of the certification process for the aircraft, a safety analysis was conducted by the aircraft manufacturer. For the flap system, a Fault Tree Analysis was conducted which considered multiple failures and identified an uncommanded and unarrested flap extension in cruise as a potentially catastrophic event. The analysis concluded that this would require two concurrent failures, and the probability of this occurring was calculated as being extremely improbable[12].

The manufacturer's original safety case considered that failure of a relay would go undetected for one flight at most. It was assumed that the flight crew would observe that the flaps were either extending or retracting at half-speed.

Endurance testing

The aircraft manufacturer carried out endurance testing as part of the Challenger aircraft certification programme. This included rig testing the flap system and the related electrical components and wiring.

Footnote

[11] Transport Canada, Type Certificate Data Sheet, Number A-131, Issue 18, Issue Date September 20, 1995.

[12] FAA Advisory Circular 25.1309-1A, which outlines acceptable means of compliance, defines extremely improbable as '*failure conditions are those so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type*'.

Test reports indicated that the flaps were operated for 67,880 extend operations and 40,728 retract operations; the manufacturer said that this equated to 16,970 flight cycles (extend) and 20,364 flight cycles (retract)[13]. No relay failures were mentioned in the endurance test reports and no records could be found to show the internal condition of the relays at the end of the testing.

Communications

Communication with ATC during the flight

Following the occurrence, the crew of D-AAAY informed ATC that they were descending to FL100. From this communication up to their final vectors for an ILS approach at Farnborough, the crew were asked if they were declaring an emergency on five separate occasions by air traffic controllers on London Control and Farnborough Radar frequencies. At each prompt the crew declined to declare an emergency; however, they did request Farnborough Radar to "ARRANGE PRIORITY" for the ILS approach.

Guidance to pilots

The CAA publishes Civil Aviation Publication (CAP) 413 '*Radio telephony Manual'* and CAP 493 '*Manual of Air Traffic Services – Part One'.* These CAPs are based on national and EU legislation, and ICAO Standards and Recommended Practices. They are published to provide guidance and clarification on the means of complying with UK regulatory requirements.

CAP 413 provides the following guidance to pilots:

> *'Pilots are urged – in their own interests – to request assistance from the emergency service as soon as there is any doubt about the safe conduct of their flight. Even then, the provision of assistance may be delayed if a pilot does not pass clear details of their difficulties and requirements, using the international standard RTF prefix 'MAYDAY, MAYDAY, MAYDAY' or 'PAN PAN, PAN PAN, PAN PAN' as appropriate'.*

In CAP 493, the CAA informs air traffic controllers that,

> *'Pilots have been advised that, in the event of an emergency situation, an ATSU can only provide the necessary priority and handling if the controller is made aware of the emergency by the crew's formal declaration on the RTF. Pilots have also been advised that the extent to which an ATSU will be able to offer assistance will depend on the amount of information provided and on its being transmitted at the earliest opportunity. Furthermore, it is preferable that if pilots believe that they are facing an emergency situation, to declare it as early as possible and cancel it later if they decide that the situation allows'.*

Footnote

[13] The aircraft manufacturer assumed four flap extension selections per flight and two flap retraction selections.

and that,

> *'When a pilot has given certain items of information normally associated with an emergency message but has not prefixed the transmission with 'MAYDAY' or 'PAN', the controller is to ask the pilot if he wishes to declare an emergency. If the pilot declines to do so, the controller may, if he thinks it appropriate, carry out the necessary actions as if the pilot had declared an emergency.'*

In the absence of a declaration of an emergency by the pilot, the nature and extent of the actions taken by the controller can be open to individual interpretation. National Air Traffic Services (NATS) explained that when an aircraft is transferred between controllers, the interpretation of each controller may change, especially in situations of high workload. A PAN or MAYDAY call removes the potential for ambiguity and can play an important part in the safe and successful resolution of an emergency.

Action taken by the Operator of D-AAAY

Following the finding of damage to the D contacts on four of their Challenger 604 aircraft, the operator introduced their own precautionary life policy for the flap extend and retract relays.

Analysis

Introduction

The uncommanded and unarrested extension of the flaps was classified by the manufacturer during certification as a potentially catastrophic event that would have required an initiating event to cause the flaps to extend, and then for the uncommanded flap movement arrest system not to stop the movement.

The investigation did not identify the reason for the uncommanded flap movement. It did, however, establish that the flap movement was not arrested due to a latent failure within the No 1 flap retract relay.

Possible causes for the uncommanded flap extension on D-AAAY

The following scenarios were considered by the investigation as possible causes for the uncommanded flap extension on D-AAAY

Erroneous flap lever command

If an erroneous signal from the flap lever was provided to the FCU to extend the flaps, power would be applied to both flap motors causing the flaps to extend at normal speed. However, the flaps extended at half-speed, indicating that only one motor was powered. This reduction in the flap speed would have required an additional fault with one of the extend relays, but there was no evidence of the flaps having extended at half-speed during the previous 64 flights recorded on the FDR.

An erroneous flap lever signal would not cause a FLAPS FAIL EICAS caution to be displayed, but this caution was seen by both pilots and recorded on the FDR as having been generated. An erroneous signal from the flap lever to extend the flaps would have also resulted in the aural 'clacker' warning in the cockpit but the pilots did not report hearing this.

Therefore, the scenario that an erroneous signal from the flap lever caused the flaps to extend is considered unlikely.

FCU internal fault

Two possible scenarios were considered that might have resulted from an internal fault in the FCU:

- If either the No 1 or No 2 flap drive motor extend signals were inadvertently powered due to a fault in the FCU, the flaps would start to extend at half-speed. Upon exceeding 3° flap, the uncommanded flap movement arrest system would activate and apply power to both extend and retract relays. A FLAPS FAIL caution would also be displayed on the EICAS. Due to the fault in the No 1 flap retract relay, the flaps would continue to extend at half-speed.

- A FCU fault causing the inadvertent activation of the uncommanded flap movement arrest system, in conjunction with a fault within the No 1 flap retract relay, could also have resulted in the flaps extending at half-speed. A FLAPS FAIL caution would also be displayed on the EICAS.

During testing of the FCU neither of the No 1 or No 2 flap drive motor extend signals inadvertently activated. However, the possibility that an intermittent fault existed, but could not be replicated during testing, could not be discounted.

PDU flap position sensor intermittent signal

If the flap position sensor signal was lost for more than about 7 ms, the FCU would apply power to both the extend and retract relays and the FLAPS FAIL caution would be displayed on the EICAS. The flaps would have then extended at half-speed because of the fault in the No 1 flap retract relay.

No fault was found during testing of the flap position sensor during checks of the aircraft wiring between the flap position sensor and the FCU. However, it is possible that the initial fault-finding activity carried out prior to the AAIB commencing their investigation, which included disconnecting electrical connections, may have cleared a fault.

A review of the component records showed that of the 116 sensors tested during the previous five years, one sensor had failed the intermittent signal test.

Although no fault was found during testing of the flap position sensor, the possibility that an intermittent fault existed but was not replicated during testing could not be discounted.

Fault in the aircraft wiring – flap extend relays

A fault in the electrical wiring that lasted for a continuous period of at least 40 seconds, would have been required in order for electrical power to be provided to either the No 1 or No 2 flap extend relays to cause the flaps to fully extend. However, initial testing and fault finding on the aircraft prior to and after the AAIB began their investigation did not identify a wiring fault. Therefore, this scenario is considered unlikely.

Aircraft manufacturer's scenario for the uncommanded movement of the flaps

Following three occurrences of uncommanded flap movement on a second aircraft, which was investigated by the aircraft manufacturer, the manufacturer concluded that wear and backlash in the flap operating system was sufficient for the flaps to 'creep', under airframe vibration when the engines were running. When this movement reached 3° it caused the flap protection system to operate and a dormant failure in a flap relay then caused the flaps to fully extend at half-speed. The aircraft manufacturer considered this scenario to be the most likely explanation for the uncommanded flap movement on D-AAAY.

This scenario cannot be discounted as a possible explanation for D-AAAY, but the AAIB considers it unlikely because the FDR data from D-AAAY did not show any evidence of flap 'creep' during the previous 64 flights or during the event. Additionally, the uncommanded movement on D-AAAY occurred when the aircraft was stationary on the ground and the engines were not running.

Failure of the uncommanded flap movement arrest system

The arrest of an uncommanded flap movement relies on the four extend / retract relays operating correctly to remove electrical power to the flap motors. Evidence from aircraft inspected by the AAIB shows that these relays can fail and prevent correct operation of the uncommanded flap movement arrest system.

The failure of the relays on three aircraft inspected by the AAIB was caused by damage to the D contacts, which switch electrical power to the BDU brake solenoids. The damage was consistent with arcing between the contacts, which caused metal transfer and contact welding. As all the moving contacts in the relay are mounted on a common rocker, the welding of one set of contacts can stop the other three sets of contacts from working properly. Examination of relays provided to the investigation, which had not failed in-service, also found damage to the D contacts, showing that the damage accumulates over a period of time.

During testing, when the BDU brake solenoids were de-energised a back-EMF was observed, which could cause arcing across the D contacts in the flap relay. As the flap system on the Challenger aircraft has no protection to suppress this back-EMF, the following Safety Recommendation was made to Bombardier Aviation on 1 March 2023:

Safety Recommendation 2023-004

It is recommended that Bombardier Aviation introduce a modification on the Challenger 600 series of aircraft to protect the D contacts within the extend and retract relays of the flap operating system from unsuppressed back-EMF electrical arcing.

Response from Bombardier Aviation

Bombardier Aviation responded on 4 June 2023 that they are:

'…still collecting data and evaluating potential design changes to address the findings from the investigation. The AAIB's specific proposals will be taken into consideration. Bombardier has committed to introducing a design change to the Challenger 604/605/650 flaps system no later than February 28th, 2025, and a design change to the Challenger 600/601 flaps system no later than November 30th, 2025.'

AAIB assessment of response

The AAIB assessed the response to Safety Recommendation 2023-004 as Partially Adequate (Open) and provided the following feedback:

'The planned action by Bombardier Aviation meets the intent of the Safety Recommendation to prevent damage to the flap operating relays from unsuppressed back-EMF electrical arcing. The AAIB would request an update on the revised design and its implementation by 28 March 2024.'

The rate of accumulating damage on the D contacts is not known. The manufacturer's datasheet for the relays shows a minimum inductive load life of 20,000 operating cycles. Exceeding this life does not necessarily mean that a relay will fail, but it is a reasonable assumption that failure will become more likely as the relay moves towards, or into, its end-of-life operating phase. During a typical flight it is assumed there will be four flap extensions and two flap retractions, with each selection energising and de-energising the BDU brake solenoids. Consequently, the relays would reach their minimum operating life after approximately 5,000 flight cycles for the extend relays and approximately 10,000 flight cycles for the retract relays. The three aircraft on which the relays failed had flown 4,687 (extend), 4,344 (extend) and 3,900 (retract) flight cycles respectively. Certification testing replicated 19,970 (extend) flight cycles and 20,364 (retract) flight cycles without failure, but the condition of the relay contacts after this testing is not known.

Airworthiness Directive AD CF-2023-07 requires a timing check on flap movement to be conducted within 100 flight hours or 15 months and, dependent on aircraft variant, repeated every 100 or 400 flight hours. This check will determine if a relay has failed, but it does not assess the condition of the contacts and will not identify a degraded relay that is close to failure or is operating intermittently.

The aircraft maintenance programme does not reflect the component manufacturer's suggested minimum life of 20,000 operating cycles, but instead allows the relays to remain fitted until a failure is detected. However, this safety investigation established that detection of a failed relay can be many flight hours after the failure occurred. As the correct function of these relays is required for the operation of the safety critical uncommanded flap movement arrest system, the following Safety Recommendation was made to Bombardier Aviation on 1 March 2023:

Safety Recommendation 2023-005

It is recommended that Bombardier Aviation introduce a life policy for the flap operating system relays on the Challenger 600 series of aircraft, which takes account of the component's specified life and is sufficient to ensure that any in service damage on the D contacts on the extend and retract relays remains acceptable for continued operation.

Response from Bombardier Aviation

Bombardier Aviation provided an initial response on 4 June 2023 and the following response on 27 October 2023.

'Bombardier has evaluated the risk to the fleet following an industry-standard continuing airworthiness risk assessment process. This process has resulted in several mitigation actions being taken by Bombardier, as well as a terminating action to address the safety risk to the fleet, as outlined below.

On December 29th, 2022, Bombardier published Service Bulletins recommending initial and repeat measurement of the flap extension and retraction times in order to detect faulty flap relays. These Service

Bulletins have since been mandated via Airworthiness Directive (AD) by Transport Canada, EASA, and the FAA.

On January 30th, 2023, Bombardier's Corrective Action Review Board (CARB) mandated that Bombardier revise the Challenger 600 series Airplane Flight Manuals (AFMs) to include a procedure for in-flight uncommanded unarrested flaps operation, no later than June 30th, 2024. The CARB further mandated that Bombardier recommend Transport Canada issue an AD requiring that operators incorporate the new procedure in their flight manuals.

Finally, Bombardier's Corrective Action Review Board (CARB) convened again on March 31st, 2023, and committed Bombardier to introducing a design change to the Challenger 604/605/650 flaps system no later than February 28th, 2025, and a design change to the Challenger 600/601 flaps system no later than November 30th, 2025.

With the mitigating action already taken, the mitigating action scheduled for second quarter 2024, and the terminating action scheduled for 2025, Bombardier's industry-standard continuing airworthiness risk assessment process indicates that the residual safety risk to the fleet is at an acceptable level.

Bombardier believes that the AAIB's proposal to introduce a life policy for the flap operating system relays on the Challenger 600 series of aircraft represents an undue burden to operators. As the safety risk to the fleet is already at an acceptable level, Bombardier does not agree that imposing such an undue burden on its operators is justified.

Bombardier continues to monitor the in-service fleet and will re-assess the risk and mitigating actions should that become necessary.'

AAIB assessment of response

The AAIB assessed the response to Safety Recommendation 2023-005 as Not Adequate (Closed) No Planned Actions and provided the following feedback:

'The response from Bombardier Aviation has been assessed as Not Adequate as it does not satisfy the intent of the Safety Recommendation to introduce a life policy for the flap operating system relays.

The relay manufacturer has set a minimum life of 20,000 cycles; in service aircraft can exceed this life and the investigation has shown that relays have failed before reaching this minimum life. While the Service Bulletins will detect a failure at the time it is carried out, it cannot establish the condition of the D contact in the relay. Latent failures are not annunciated to the crew or engineers.

The proposed changes to the Aircraft Flight Manuals are not due to be published until mid-2024 and the proposed design changes are not expected to be introduced until 2025. Safety Recommendation 2023-006 has been made to Transport Canada to reassess the safety case for the flap operating system.

The AAIB acknowledges that, at this time, Bombardier Aviation does not intend to take any further action and has, therefore, Closed Safety Recommendation 2023-005.'

The uncommanded and unarrested movement of the flaps, which is classified by the manufacturer as potentially catastrophic, requires two concurrent failures. The original safety case considered this to be extremely improbable and assumed that a relay failure would go undetected for one flight at the most. However, it was established that on three different aircraft a relay was in a failed condition for a significant number of flights, and the failure was not detected even though the flaps moved in one direction at half-speed.

The failure of a flap extend or retract relay is a latent failure because it is not annunciated to the pilots or maintenance staff. The protection offered by the flap arrest system may no longer be available and a single failure of another part of the system could be sufficient to cause a catastrophic outcome.

At the time of certification, FAR 25.1309 required the occurrence of any failure condition that would prevent the continued safe flight of the aircraft to be 'extremely improbable'. To ensure that the Challenger 600 series of aircraft meets this requirement, the following Safety Recommendation was made to Transport Canada on 1 March 2023:

Safety Recommendation 2023-006

It is recommended that Transport Canada reassess the safety case for the flap operating system on the Challenger 600 series of aircraft to ensure it meets the requirements of Title 14 of the Code of Federal Regulations Part 25.1309.

Response from Transport Canada

Transport Canada responded on 5 April 2023 that they concurred with the intent of the Safety Recommendation and that they continue:

'… to investigate this serious incident with the full cooperation of the type certificate holder. The objective of this continuing airworthiness investigation is to determine what further mandatory corrective actions may be required to ensure that an acceptable level of safety is maintained for the CL-600 aircraft type. An assessment of the flap system Part 25.1309 safety case will be conducted as part of the investigation.'

On the 2 November 2023 they provided the following update:

'…investigation into the CL-600 series flap system performance has concluded that system improvements are required. As a result, Transport Canada has required Bombardier Inc. to develop and implement corrective actions that reduce the safety risks to an acceptable level.

Bombardier Inc., under the oversight of Transport Canada, is currently developing various corrective action options which are expected to be finalized no later than June 30th, 2024.

Airworthiness Directive CF-2023-07, which requires recurrent operational checks of the flap system, remains in effect as an interim risk mitigation measure.'

AAIB assessment of response

The AAIB assessed the response to Safety Recommendation 2023-006 as Adequate (Closed) Planned Action Complete and provided the following feedback:

'The planned action by Transport Canada meets the intent of the Safety Recommendation to reassess the safety case for the flap operating system on the Challenger 600 series of aircraft.'

Communication with ATC

Following the decision to discontinue the flight to Málaga and return to Farnborough, the crew of D-AAAY chose not to declare an emergency when prompted by ATC. This had no operational impact on the successful outcome of the flight. However, had there been a higher density of air traffic in the London Terminal Area, the decision to not formally declare an emergency might have affected the options available to the crew, or the wider traffic management by ATC.

Guidance for pilots in the Aircraft Flight Manual

At the time of the occurrence on D-AAAY, there was no guidance or procedure in the Challenger Aircraft Flight Manual to assist the pilots in handling an uncommanded and unarrested flap movement. Therefore, the following Safety Recommendation was made to Bombardier Aviation on 16 September 2022:

Safety Recommendation 2022-017

It is recommended that Bombardier inform operators of the Challenger 600 series of aircraft of the actions to take in the event of uncommanded flap operation in flight.

Response from Bombardier Aviation

Bombardier Aviation provided the following response on 14 February 2023:

'On January 30th, 2023, Bombardier's Corrective Action Review Board (CARB) mandated that Bombardier revise the Challenger 600 series of AFMs to include a procedure for in-flight uncommanded unarrested flaps operation, no later than June 30th, 2024. The CARB further mandated that Bombardier recommended Transport Canada issue an Airworthiness Directive (AD) requiring that operators incorporate the new procedure in their flight manuals.

Bombardier submits that this CARB decision meets the intent of AAIB Safety Recommendation 2022-017.'

AAIB assessment of response

The AAIB assessed the response to Safety Recommendation 2022-017 as Adequate, Planned Action Ongoing, Update Due 30 June 2024 (Open) and provided the following feedback:

'The mandated action by the CARB meets the intent of the Safety Recommendation, and Bombardier Aviation has shown that given the complexity of introducing a new AFM procedure the timescale set in the CARB is realistic as a 'Do not exceed date'. The AAIB would request an update on the actions taken by 30 June 2024.'

Conclusion

This serious incident occurred because there was an uncommanded flap movement, which the flap protection system did not stop.

The reason for the uncommanded flap extension could not be identified.

The failure to arrest the uncommanded flap movement was caused by the welding of the D contacts in the No 1 flap retract relay which prevented it from operating. This welding probably occurred because of an unsuppressed back-EMF when the BDU brake solenoid was de-energised.

Safety Actions

The following Safety Actions have been taken:

Bombardier Aviation

On 26 September 2022, Advisory Wire AW600-27-2631 was issued to advise operators of the event on D-AAAY.

On 29 December 2022, five Service Bulletins were issued for operators to check the operation of the flap system on the Challenger 600 series of aircraft.

Transport Canada

On 16 February 2023, Airworthiness Directive CF-2023-07 was issued and became effective on 24 February 2023 to mandate Bombardier Aviation's Service Bulletins to check the operation of the flap system on the Challenger 600 series of aircraft.

Safety Recommendations

The following Safety Recommendation was made on 16 September 2022:

Safety Recommendation 2022-017

It is recommended that Bombardier inform operators of the Challenger 600 series of aircraft of the actions to take in the event of uncommanded flap operation in flight.

The following Safety Recommendations were made on 1 March 2023:

Safety Recommendation 2023-004

It is recommended that Bombardier Aviation introduce a modification on the Challenger 600 series of aircraft to protect the D contacts within the extend and retract relays of the flap operating system from unsuppressed back-EMF electrical arcing.

Safety Recommendation 2023-005

It is recommended that Bombardier Aviation introduce a life policy for the flap operating system relays on the Challenger 600 series of aircraft, which takes account of the component's specified life and is sufficient to ensure that any in-service damage on the D contacts on the extend and retract relays remains acceptable for continued operation.

Safety Recommendation 2023-006

It is recommended that Transport Canada reassess the safety case for the flap operating system on the Challenger 600 series of aircraft to ensure it meets the requirements of Title 14 of the Code of Federal Regulations Part 25.1309.

The responses to these recommendations is covered earlier in the report. No additional safety recommendations are made in this report.

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