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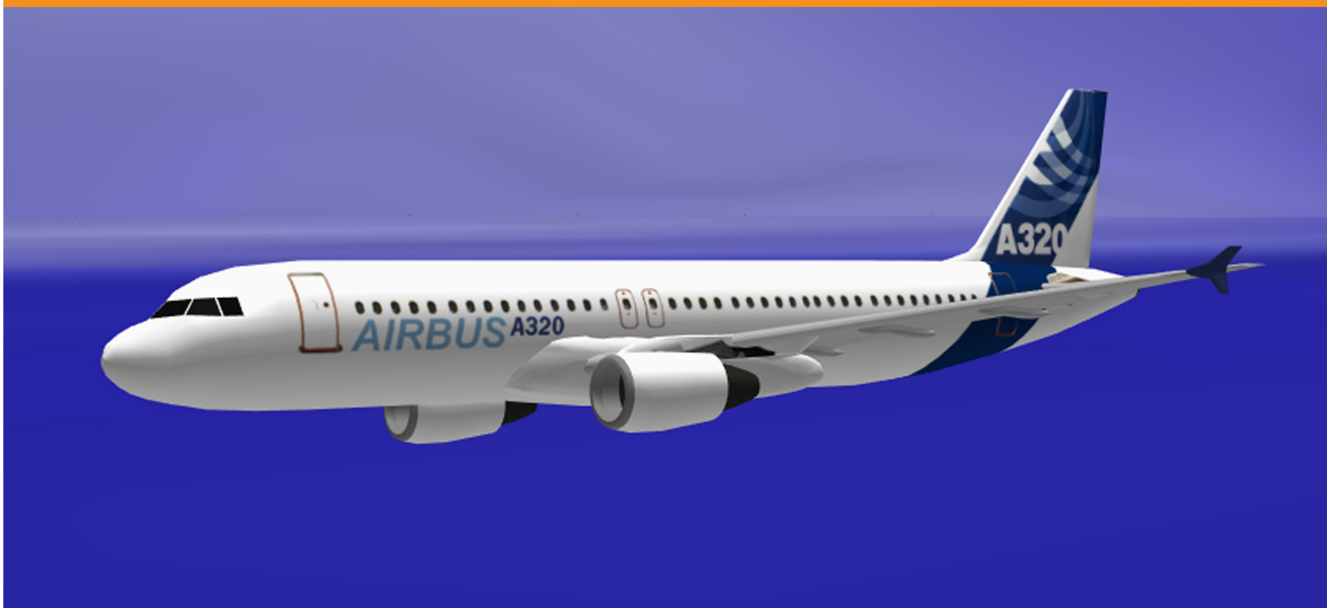

ATSB TRANSPORT SAFETY REPORT

Aviation Occurrence Investigation AO-2009-021

Final

Flight control system event 520km NW of Gold Coast Aerodrome Queensland 18 May 2009 VH-VNC Airbus Industrie A320-232

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VH-VNC, Airbus Industrie A320-232

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Published by: Australian Transport Safety Bureau
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ISBN and formal report title: see 'Document retrieval information' on page v.

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DOCUMENT RETRIEVAL INFORMATION

Report No.	Publication date	No. of pages	ISBN
AO-2009-021	August 2010	15	978-1-74251-088-0

Publication title

Flight control system event – 520 km NW of Gold Coast Aerodrome, Queensland - 18 May 2009
VH-VNC, Airbus Industrie A320-232

Prepared By

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Reference Number

ATSB-Aug10/ATSB119

Acknowledgements

Figure 1: Airbus Industrie

Abstract

On 18 May 2009, an Airbus Industrie A320-232 aircraft, registered VH-VNC was on a regular public transport flight from Mackay, Queensland (Qld) to Melbourne, Victoria when at about 1249 Eastern Standard Time, the aircraft started to vibrate. Cockpit indications showed that the left aileron was oscillating. The crew diverted the aircraft to the Gold Coast Aerodrome, Qld and landed.

The source of the aileron oscillation was an internal fault in one of the left aileron's hydraulic servos. The fault was introduced during manufacture by an incorrect adjustment of the servo, which caused internal wear in a number of the servo's hydraulic control components. The aileron servo manufacturer has incorporated a new method of adjusting the aileron servos during assembly to minimise the likelihood of a recurrence of the problem.

During the investigation, it was found that an identical fault had occurred to the same aircraft 8 months prior to this incident. The previous incident was not reported to the Australian Transport Safety Bureau by the operator as required by the *Transport Safety Investigation Act 2003*. The operator has improved the training of its staff and the reportable event requirements in its safety management system manual in an effort to address the non-reporting risk.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 18 May 2009, an Airbus Industrie A320-232 (A320) aircraft, registered VH-VNC departed Mackay Aerodrome, Queensland (Qld) on a fare-paying passenger service to Melbourne, Victoria with 125 passengers, four cabin crew and two flight crew on board. The copilot was the handling pilot for the takeoff and climb and the pilot in command (PIC) was the non-handling pilot.

The flight crew stated that the departure and initial climb from Mackay was normal. At 1249 Eastern Standard Time[1], as the aircraft was passing through 1,500 ft above mean sea level (AMSL), an Electronic Centralized Aircraft Monitor (ECAM)[2] caution message ‘flight controls aileron servo fault’ was displayed. The crew reported that there appeared to be no flight control problems.

The operator’s standard operating procedures required the crew to continue to climb to the minimum safe altitude, fully retract the flaps and to complete the after take-off checks. The checks were completed passing through 6,000 ft, where a review of the flight deck documentation did not identify any specific procedures for the crew to action, and that the caution was for crew awareness only. As there were no other caution messages and the flight controls were operating normally, the flight crew decided to climb to the cruise altitude of flight level (FL)[3] 350 and continue to Melbourne.

When the aircraft was established in the cruise at FL 350, a light continuous shaking within the aircraft became evident. The PIC selected the ECAM flight controls page, which indicated that the left aileron was continuously moving up and down by ‘a couple of degrees’. He then selected the ECAM current leg report, which advised of an ‘Elevator Aileron Computer (ELAC)[4] 1 aileron order disagree’, indicating a fault in ELAC 1. The flight crew were not sure how the ‘flight control aileron servo fault’ and the ‘ELAC 1 aileron order disagree’ messages were related; however, they identified that ELAC 2 had taken over primary control of the ailerons at that point. Ten minutes later, the left aileron was moving up and down by an estimated 5°. The PIC called the cabin manager to the flight deck and asked her to return to the cabin and look at the left wing and aileron for any unusual movements. The cabin manager returned to the flight deck and

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1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

2 The ECAM system displays configuration or failure warning, caution and advisory messages to the flight crew via two central display screens, the Engine Warning Display (E/WD) and the System Status Display (SD).

3 Level of constant atmospheric pressure related to the datum of 1013.25 hPa, expressed in hundreds of feet. FL 350 equated to 35,000 ft AMSL.

4 Two Elevator Aileron Computers (ELAC) control the aircraft’s elevator and aileron control surfaces, which control roll and pitch commands from the pilots’ side stick controls, or from the autopilot system. In normal operation ELAC 1 controls the ailerons and ELAC 2 controls the elevators; however, if there is a fault within either ELAC, the remaining ELAC can control both the aileron and elevator systems.

reported seeing the left wing moving up and down, and that the left flap did not appear flush with the wing's surface. The PIC checked the ECAM flight controls page and noted that the wing flaps were in the fully-retracted position. Shortly after, the cabin manager reported to the PIC that there was 'quite a bit of shaking' at the rear of the aircraft.

The PIC took control of the aircraft from the copilot and varied the cruise speed. There was no change to the level of vibration or aileron movement.

The copilot got out of his seat and looked out of the cockpit left side window behind the PIC. He identified to the PIC that the left aileron was moving up and down continuously, and that the left wing was moving up and down through about 1 m.

At 1330, after reviewing the aircraft's position, the flight crew elected to divert and land at the Gold Coast Aerodrome, Qld. The crew advised air traffic control and the passengers that they were diverting to the Gold Coast due to technical difficulties.

Descending through FL 200, the vibration intensified and the aileron oscillations and wing flexing increased. The manufacturer's Quick Reference Handbook (QRH)[5] permitted flight crews to turn off an ELAC in flight, although it was not recommended. The flight crew decided to turn off ELAC 1, which had no effect on the oscillations. The crew then turned ELAC 1 on again, after which the vibrations and left aileron oscillations ceased. The crew reported no further control problems or ECAM messages during the remainder of the descent, approach and landing.

A Licensed Aircraft Maintenance Engineer tested the aileron control system and conducted an external inspection of the aircraft but was unable to identify a fault with the aircraft. Following discussions with the PIC and the operator's maintenance watch personnel, the aircraft was dispatched to Melbourne.

After an uneventful flight to Melbourne, the aircraft operator conducted a second inspection and test of the aircraft's aileron control system. In addition, the operator supplied the aircraft manufacturer with flight data recorder (FDR) information from the incident flight. The manufacturer's analysis of the FDR information indicated two faults in the aircraft's aileron control system leading to the incident.

Personnel information

The PIC held an Airline Transport Pilot (Aeroplane) Licence (ATPL(A)), was type rated on the A320, held a current medical certificate, and had accumulated 13,300 flight hours, including 6,000 hours on the A320. He had completed 232 flight hours in the previous 90 days.

The copilot held an ATPL(A), was type rated on the A320, held a current medical certificate, and had accumulated 3,200 total flight hours, including 600 hours on the A320. He had completed 260 hours in the previous 90 days.

Both flight crew reported having adequate rest during the 72 hours before the incident.

---

5 A flight deck publication that includes emergency procedures, an abnormal checklist, normal procedures for the aircraft, operational and in-flight data, and so on.

Aircraft information

Aircraft details

Aircraft manufacturer	Airbus Industrie
Aircraft model	A320-232
Aircraft serial number	3275
Year of manufacture	2007
Date of registration	15 October 2007
Aircraft hours/cycles	6,071 hours/3,314 flight cycles

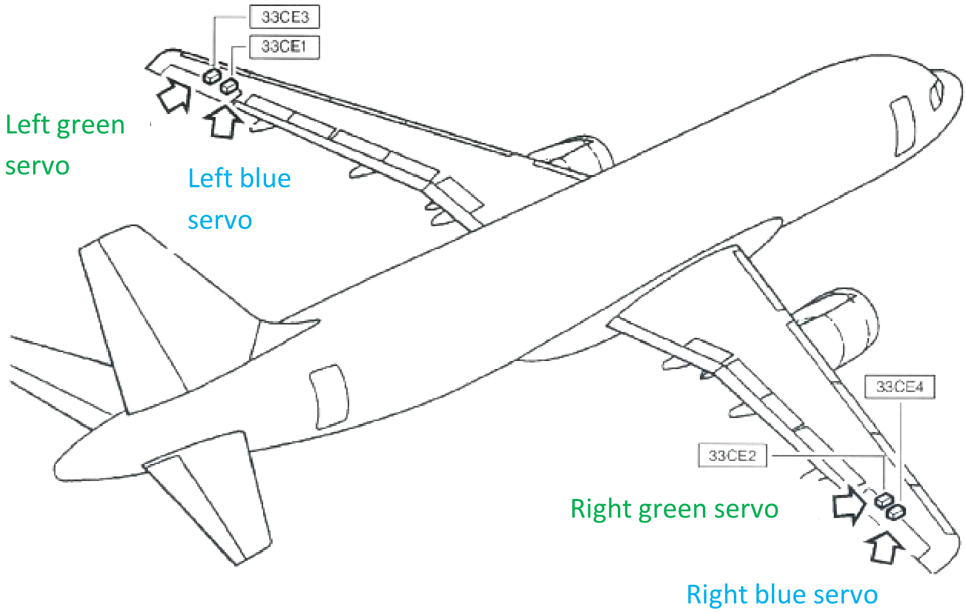
Aileron system description

The ailerons are controlled electrically by inputs from the PIC's and copilot's side stick controllers, or by the autopilot systems through either ELAC 1 or 2. The ELAC 1 or 2 electronic output signals control the hydraulically-actuated aileron servos, which deflect the ailerons up or down as required to control the aircraft about its roll axis.[6] Each aileron has two servos (Figure 1), and only one servo on each side operates at any one time (active mode). The other two servos remain on standby (damping mode). For added redundancy the aileron servos are operated by two independent hydraulic systems, identified as blue and green.

In normal operation, ELAC 1 has primary control of the ailerons through the left blue aileron servo and the right green aileron servo. In the event that ELAC 1 malfunctions, ELAC 2 will take over primary control of the ailerons through the left green aileron servo and the right blue aileron servo, this allows for complete aileron control system redundancy.

6 Rotation about the aircraft's longitudinal or fore and aft axis.

Figure 1: Aileron servo locations



System faults found

The first fault that was indicated by the FDR data was in the ELAC 1 unit, which caused a transfer of the primary control of the ailerons to ELAC 2. When the ELAC 1 unit was ground-tested, it passed the functional tests and the actual fault condition could not be replicated. The aircraft manufacturer stated that an intermittent ELAC fault was a known problem and that a solution to the problem had been provided in service bulletin (SB) upgrade SB A320-27-1173 that was initially issued on 27 June 2006. The SB was not mandatory, and had not been incorporated in the faulty ELAC 1 at the time of the incident.

The second fault, a failure of the left green aileron servo, was replicated during oscillation testing of the aircraft's aileron control system. The faulty servo was removed from the aircraft and sent to the servo manufacturer in France for testing and inspection under the supervision of the French Republic Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA).

Left green aileron servo testing

The aileron servo testing by the servo manufacturer confirmed that there was an internal fault in the unit, which caused the aileron servo to oscillate. The fault was isolated to a servo valve sub-assembly. That valve utilised electronic signals from the ELAC to control the flow of hydraulic fluid to either side of the servo actuator, which in turn moves the aileron up or down as required.

The servo valve was sent to another facility for testing. That testing found that during the manufacture of the servo valve, the neutral or null bias position had been incorrectly set. The incorrect setting led to the abnormal wear of the ball and seat within the servo (Figures 3 and 4). That wear allowed the bypass of hydraulic fluid within the unit, which caused the aileron servo oscillations.

Figure 3: Abnormal ball wear

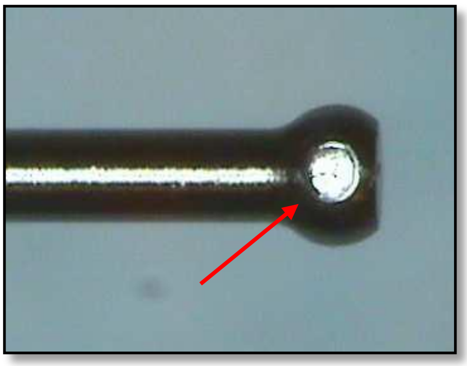


Figure 4: Abnormal seat wear

Left green aileron servo service history

The left green aileron servo was fitted to the aircraft new during the aircraft's manufacture in 2007, and had not been removed or changed from its original position since aircraft manufacture.

Previous A320 aileron oscillation faults

The aircraft manufacturer advised that there had been a number of cases of aileron servo control oscillations caused by a faulty servo valve. The servo manufacturer stated that the problem had occurred before but, not to the level identified in this case. The aircraft manufacturer had addressed the problem with the publication of a dedicated trouble-shooting manual and an aircraft maintenance manual instruction on the issue.

Flight data recorder information

The FDR data was downloaded and forwarded to the Australian Transport Safety Bureau (ATSB) for examination. That examination showed an ELAC 1 roll fault for the duration of the flight until ELAC 1 was turned off and then on (reset) 15 minutes before landing. Left aileron deflections, with an oscillatory effect, were also noted up until ELAC 1 was reset. The FDR readout showing the left aileron oscillations is at Appendix A.

Unreported previous incident

During the investigation, the operator advised that the aircraft sustained a similar left aileron oscillation incident 8 months prior to this occurrence, and that the flight crew in that case had conducted an air return to the flight's point of origin. During that incident, an ELAC 1 fault was also noted, and the fault cleared on landing without any maintenance action.

The previous incident was not reported to the ATSB, even though it was a reportable matter in accordance with regulation 2.4(1) of the *Transport Safety Investigation Regulations 2003*, which stated:

> For the purposes of the definition of ***routine reportable matter*** in subsection 3 (1) of the Act, the following investigable matters, in relation to an air transport operation ... are prescribed:
>
> (g) any of the following occurrences, if the occurrence compromises or has the potential to compromise the safety of the flight:
>
> (ii) malfunction of an aircraft system, if the malfunction does not seriously affect the operation of the aircraft;

Section 19(1) of the *Transport Safety Investigation Act 2003* (TSI Act) defined the requirements for the compulsory reporting of routinely reportable matters, and stated:

> If a responsible person has knowledge of an immediately reportable matter or a routine reportable matter, then the person must within 72 hours give a written report of the matter (containing the particulars prescribed by the regulations) to a nominated official.

ANALYSIS

Aileron oscillations

The aileron oscillations were a consequence of two separate faults within the aileron control system. The initial fault was within Elevator and Aileron Computer (ELAC) 1, which occurred shortly after takeoff. The effect of that fault was that ELAC 2 automatically took over primary control of the ailerons, causing the left green and right blue servos that were in standby mode to switch to the active mode.

When activated, the left green aileron servo, which had been incorrectly adjusted at manufacturer and worn abnormally as a result, caused the aileron to oscillate. The action by the pilot in command to switch ELAC 1 off and then back on reset ELAC 1 to its normal control function. The actuation of the ailerons reverted to the left blue and right green aileron servos, and the oscillations ceased.

The ELAC 1 functioned normally for the remainder of the flight, indicating that the fault within the unit was intermittent in nature. That was consistent with the previous similar left aileron oscillation incident, the cause of which was not able to be identified at that time. In effect, the fault in the left green aileron actuator had remained 'dormant' from manufacture until the ELAC 1 malfunction reoccurred. Had the non-mandatory service bulletin (SB) upgrade SB A320-27-1173 been incorporated in the operator's fleet, the green servo fault would most likely have remained dormant, and the aileron oscillations may not have occurred in this instance.

Unreported previous incident

The enhancement of transport safety is a shared responsibility between the Australian Transport Safety Bureau (ATSB) and all elements of the aviation industry. Whereas the nature of the previous incident, and inability at that time to isolate the fault might have influenced the operator to not report the incident, the incident was a routine reportable matter in accordance with the *Transport Safety Investigation Act 2003.*

Although the ATSB may not have investigated the earlier incident, all reported incidents are entered into the ATSB's occurrence database. That data can then be searched to establish safety trends, potentially contributing to the initiation of a safety issues investigation, or become part of wider safety research and/or education initiatives.

FINDINGS

From the evidence available, the following findings are made with respect to the flight control system event that occurred 520 km north-west of the Gold Coast Aerodrome, Queensland on 18 May 2009, involving an Airbus Industrie A320 aircraft, registered VH-VNC and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The servo valve within the left green aileron servo was incorrectly adjusted during manufacture. *[Minor safety issue]*
- The incorrect adjustment of the left green servo valve led to the abnormal wear of a number of components within the servo valve.
- The Elevator and Aileron Computer (ELAC) 1 sustained a fault during the flight, and the ELAC 2 automatically switched to primary control of the ailerons by utilising the stand-by aileron servos.
- Control of the ailerons by the Elevator and Aileron Computer 2 meant that the incorrectly-adjusted left green aileron servo switched to active control of the left aileron, causing oscillations of the aileron, left wing flexure and the vibration of the aircraft.

Other safety factor

- A non-mandatory aircraft manufacturer service bulletin that was designed to prevent Elevator and Aileron Computer faults similar to the one sustained in this occurrence had not been incorporated in the aircraft at the time of the incident.
- The aircraft operator did not comply with the reporting requirements of the *Transport Safety Investigation Act 2003*. *[Minor safety issue]*

Other key findings

- The left aileron oscillations ceased when Elevator and Aileron Computer 1 (ELAC 1) was cycled OFF and ON. That action reset the ELAC 1 to the primary control of the ailerons and reverted the left green aileron servo from active to standby or damping mode.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Servo valve manufacturer

Incorrect servo valve adjustment

Minor safety issue

The servo valve within the left green aileron servo was incorrectly adjusted during manufacture.

Action taken by the servo valve manufacturer

The manufacturer has introduced a semi-automated setting of the null bias, which replaced the previous manual setting. This will prevent the incorrect adjustment of the null bias during the assembly of the servo valve.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the servo valve manufacturer adequately addresses the safety issue.

Aircraft operator

Incident reporting requirements

Minor safety issue

The aircraft operator did not comply with the reporting requirements of the *Transport Safety Investigation Act 2003*.

Action taken by the aircraft operator

The aircraft operator has advised that in response to this incident, the content of the operator's safety management system in respect of incident reporting has been revised, and additional training in that regard has been incorporated into the operator's cabin and flight crew induction processes.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Intermittent Elevator and Aileron Computer fault

Although not identified as a safety issue, the aircraft operator has advised of the incorporation of the aircraft manufacturer's non-mandatory service bulletin (SB) upgrade SB A320-27-1173 in its entire A320 fleet.

APPENDIX A: FLIGHT DATA RECORDER INFORMATION

APPENDIX B: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included the:

- Bureau d'Enquêtes et d' Analyses (BEA).
- aircraft manufacturer
- aileron servo and servo valve manufacturers
- aircraft operator
- flight crew
- cabin manager
- aircraft maintainer.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the BEA, the aircraft operator, the flight crew, the cabin manager, the licensed aircraft maintenance engineer, the aileron servo and servo valve manufacturers and the Civil Aviation Safety Authority.

Submissions were received from the flight crew. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Flight control system event, 520km NW of Gold Coast Aerodrome, Queensland, 18 May 2009, VH-VNC, Airbus Industrie A320-232