Air Accident Investigation Unit Ireland

SERIOUS INCIDENT REPORT
Airbus A330-301, EI-ORD
Over Iceland
11 May 2010

An Roinn Iompair Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

AAIU Report No: 2012-015

State File No: IRL00910032

Report Format: Synoptic Report

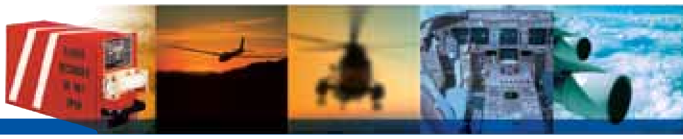
Published: 20/09/2012

In accordance with the provisions of SI 460 of 2009, the Chief Inspector of Air Accidents, on 12 May 2010, appointed Mr. Graham Liddy as the Investigator-in-Charge to carry out a Field Investigation into this Serious Incident and prepare a Report. Due to his retirement, on the 29 February 2012 the Chief Inspector appointed Mr. Paul Farrell as the Investigator-in-Charge to complete the Investigation. The sole purpose of this Investigation is the prevention of aviation Accidents and Incidents. It is not the purpose of the Investigation to apportion blame or liability.

Aircraft Type and Registration:	Airbus A330-301, EI-ORD
No. and Type of Engines:	2 x General Electric CF6-80E1A2
Aircraft Serial Number:	MSN 059
Year of Manufacture:	1994
Date and Time (UTC):	11 May 2010 @ 15.08 hrs (UTC[1])
Location:	Over Iceland; N64° 45.011′, W019° 20.001′
Type of Operation:	Scheduled Public Transport
Persons on Board:	Crew - 11 Passengers - 227
Injuries:	Crew - 0 Passengers - 0
Nature of Damage:	Right Hand (RH) inboard aileron, outside servo-control, outer bracket failure[2]
Commander's Licence:	JAA ATPL
Commander's Details:	Male, aged 52 years
Commander's Flying Experience:	19,200 hours, of which 4,931 were on type
Notification Source:	Aircraft Operator
Information Source:	AAIU Field Investigation

1 UTC: Universal Time Co-ordinated, which is the same as Greenwich Mean Time. All timings quoted in this report are in UTC.

2 Each wing has two ailerons, designated "inboard" and "outboard" in this Report. Each aileron has two servo-controls, designated "inside" and "outside" in this Report. Each servo-control has two attaching brackets, designated "inner" and "outer" in this Report. These conventions are not adhered to when quoting from official publications.



SYNOPSIS

The aircraft was cruising at 33,000 ft, when it encountered turbulence. This turbulence resulted in a moderate un-commanded roll.

While the autopilot was correcting this roll, the outer bracket supporting the outside servo-control of the RH inboard aileron failed, causing the RH inboard aileron to oscillate quickly from 14 degrees upwards deflection to 12 degrees downwards deflection and settling at an upwards deflection of the order of 15 degrees. This did not cause any control problems and the autopilot was able to continue to control the aircraft. The aircraft landed without difficulty at the intended destination, Chicago O'Hare (KORD). Subsequently a crack was detected in a corresponding bracket on the Left Hand (LH) wing.

1. FACTUAL INFORMATION

1.1 History of the Flight

The aircraft was on a scheduled public transport flight from Dublin (EIDW) to KORD. Around the date of this flight, the volcanic ash situation arising from the eruption at Eyjafjallajökull in Iceland was posing a major problem to aircraft operations in Europe and in the North Atlantic area. At the time of flight, a large cloud of volcanic ash was streaming down from Iceland in a south west direction. For this reason the flight was routed along a more northerly track than normal, routing initially from Dublin to Iceland and then in a westerly direction to KORD. Due to the funnelling of aircraft tracks in the Icelandic area, arising from the presence of the ash cloud to the south west, there was considerable congestion in the airspace over Iceland. As a result EI-ORD was given a cruising altitude of FL 330 (Flight Level 330 or 33,000ft). The Flight Crew, being aware of this situation prior to departure from EIDW and the increased fuel consumption resulting from this lower than normal cruising altitude, and also because of the longer route required to avoid the ash cloud, had taken on extra fuel. While over Iceland (**Figure No. 1**) the aircraft encountered some moderate turbulence which the Flight Crew suspected might have been caused by wake turbulence. The turbulence resulted in some aircraft roll and yaw. The autopilot, which remained engaged during the turbulence encounter, quickly returned the aircraft to level flight. Shortly afterwards the aircraft was cleared to climb to FL380. The Flight Crew inputted this new altitude into the altitude selector and the aircraft commenced a climb to the new cruising altitude, under control of the autopilot. During this climb, the Flight Crew observed a lower than expected rate of climb and a higher than expected fuel consumption rate.

Figure No. 1: Overview of aircraft location at time of event

The Flight Crew started to trouble-shoot the cause of this loss of performance. During this trouble-shooting they observed that the Electronic Centralised Aircraft Monitoring (ECAM) Flight Control page showed that the RH inboard aileron was 2/3 of full-scale above its normal position. The RH outboard aileron was deflected downwards by 1/3 of full-scale from its normal position. Both LH ailerons were deflected upwards by 1/3 of full-scale from their normal positions. There were no ECAM warnings or cautions. The Flight Crew for this particular flight consisted of three pilots so the Captain was able to leave the flight deck and go to the cabin where he obtained visual confirmation that the physical configuration of the ailerons corresponded with the indications on the ECAM. The Flight Crew noted that the Flight Crew Operation Manual (FCOM) gave no specific information on the cause of the observed problem, but it stated that in the event of an un-commanded flight control surface deflection, the flight could be continued as normal if no handling problems were noted. The FCOM included crew awareness guidance which predicted increased fuel consumption in the range 6-16%. The Flight Crew contacted the Operator's maintenance control centre in Dublin via the Aircraft Communications Addressing and Reporting System (ACARS). The possibility of resetting PRIM (Flight Control Primary Computer) 2 was discussed but Maintenance Control advised against this. Using the Heading (HDG) select facility, and without disconnecting the autopilot, the Flight Crew satisfied themselves that they could successfully manoeuvre the aircraft. The cockpit and cabin were secured (passengers and Cabin Crew seated and strapped in) and the Flight Crew then turned off the autopilot and verified that there were no difficulties in manually controlling the aircraft. They then re-engaged the autopilot, which continued controlling the aircraft without difficulty.

At this point the aircraft was to the west of Iceland. The Flight Crew considered their options. Based on the facts that:

- the aircraft was handling normally,
- they were approximately half way to their destination,
- they had more than adequate fuel to reach their planned destination even allowing for the increased fuel consumption, (because of the extra fuel uplifted at EIDW),
- the planned destination offered a long runway (13,000 ft), which could prove useful if they were to experience handling difficulties during the approach,
- a return to EIDW at this point would require the aircraft to manoeuvre around the volcanic ash cloud which was now behind them,

the Flight Crew decided to proceed to KORD, and the remainder of the flight passed without further incident.

On establishing contact with KORD, the Flight Crew advised ATC that they had a flight control systems problem, the nature of which they could not determine. They requested an approach to the longest runway at KORD (RWY 28/10) in case they experienced handling problems as the aircraft's speed was reduced and the aircraft was reconfigured for approach and landing (flaps and undercarriage deployed). ATC queried if they were declaring an emergency and the Flight Crew said no. ATC then decided that they would have to declare an emergency, as this would ensure that RWY 28/10 would be available to EI-ORD.

The aircraft approached and landed at KORD without difficulty or incident.

1.2 Injuries to Persons

There were no injuries sustained in this event.

Injuries	Flight Crew	Passengers	Other
Fatal	0	0	0
Serious	0	0	0
Minor/None	11	227	0

1.3 Damage to the Aircraft

1.3.1 System Description

On the A330 aircraft each wing is fitted with two ailerons, designated as inboard and outboard. Two electro-hydraulic servo-controls (actuator) are attached to each aileron (inboard and outboard). In normal operations only the outside servo-control actuates the aileron in response to inputs from the cockpit side sticks or the autopilot. The inside servo-control operates in a damping mode and prevents flutter in the event of multiple electrical or hydraulic system failures.

However, in the event of failure of the outside servo-control, the inside servo-control can take over the active/command function. Each wing is also fitted with six spoiler panels, numbered 1 to 6, the innermost panel being No 1. Roll control in flight is achieved by a combination of movements of inboard and outboard ailerons and deployment of spoilers 2 through to 6. At higher aircraft speeds (in the cruise) only the inboard ailerons are operated and the outboard ailerons are servoed to zero. One end of the servo-control is attached to the aileron it actuates; the other is attached to the wing rear spar through a pair of brackets (**Figure No. 2**).

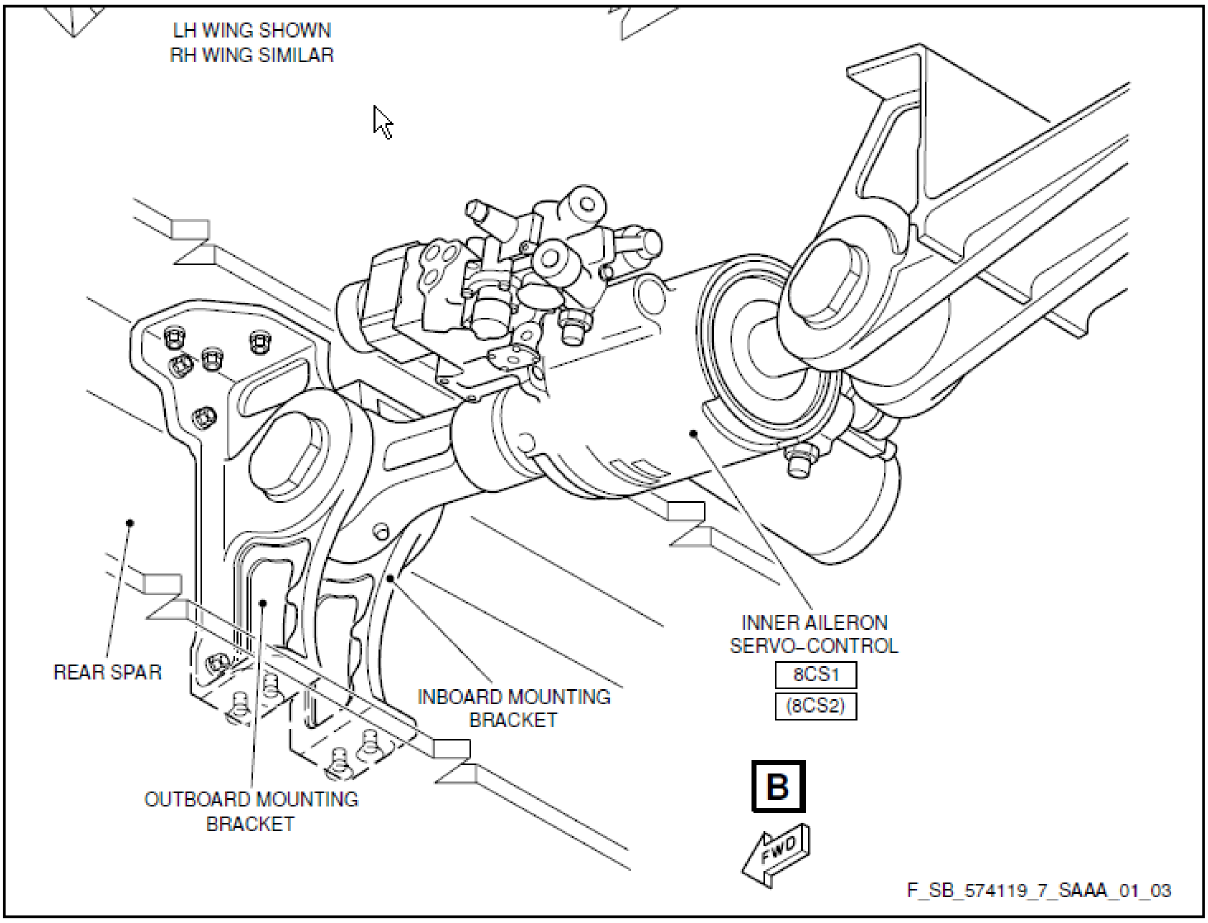


Figure No. 2: Engineering schematic of the assembly (LH Wing)

1.3.2 Damage Found on Arrival

On arrival at KORD the aircraft was inspected by maintenance personnel. The brackets (Part Number F575-50986) attaching the outside (active) servo-control, of the RH inboard aileron, to the RH wing rear spar, were found to be fractured (**Photo No. 1**), and the lower wing skin directly beneath the brackets' attachment points was deflected. Further inspection revealed that the corresponding outer bracket on the other (LH) side of the aircraft was cracked in the same area where the RH outer bracket had failed.

Photo No. 1: The fractured brackets

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 Commander

Personal Details:	Male, aged 52 years
Licence:	JAA ATPL, Issued by the IAA
Last Periodic Check:	4 Feb 2010
Medical Certificate:	Class 1

Flying Experience:

Total all types:	19,200	hours
Total all types P1:	16,909	hours
Total on type:	4,931	hours
Total on type P1:	4,900	hours
Last 90 days:	99	hours
Last 28 days:	42	hours
Last 24 hours:	9.92	hours

1.5.2 First Officer

Personal Details:	Male, aged 35 years
Licence:	JAA ATPL, issued by IAA
Last Periodic Check:	08 Oct 2009
Medical Certificate:	Class 1

Flying Experience:

Total all types:	6,386	hours
Total all types P1:	3,072	hours
Total on type:	2,108	hours
Last 90 days:	108	hours
Last 28 days:	30	hours
Last 24 hours:	9.9	hours

1.5.3 Third Pilot

Personal Details:	Male, aged 49 years
Licence:	JAA ATPL, Issued by the IAA
Last Periodic Check:	13 Jan 2010
Medical Certificate:	Class 1

Flying Experience:

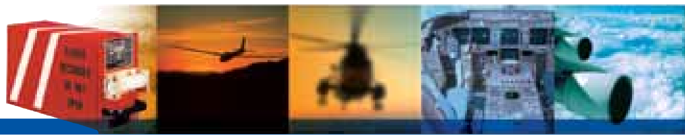
Total all types:	17,700	hours
Total all types P1:	10,000	hours
Total on type:	2,100	hours
Total on type P1:	2,000	hours
Last 90 days:	89	hours
Last 28 days:	23.15	hours
Last 24 hours:	9.53	hours

1.6 Meteorological Information

The aircraft encountered moderate turbulence at the start of the event.

1.7 Navigation

Aids to navigation were not a factor in this event.



1.8 Communications

Communications were not a factor in this event.

1.9 Aerodrome Information

KORD is a major international airport. It has a total of seven runways, which vary in length from 7,500 ft to 13,000 ft. RWY 10/28 is 13,000 ft long, and exceeds the length of all other KORD runways by at least 3,000 ft.

1.10 Flight Recorders

1.10.1 Cockpit Voice Recorder (CVR)

The aircraft was equipped with a solid state CVR, which had a recording duration of two hours.

The event occurred more than two hours before the aircraft landed. Consequently, the recording at the time of the event was not available and so the CVR was not of any assistance to the Investigation.

1.10.2 Flight Data Recorder (FDR)

Downloading of the FDR provided the following information:

The aircraft was in the cruise at 33,000 ft with AP1 (Autopilot #1) and FD (Flight Director) on; ATHR (Auto-thrust) was engaged.

At 15.08:03 hrs the aircraft encountered turbulence and vertical load peaks of 0.73 and 1.45G were recorded. The aircraft immediately started to bank to the left at this time. This roll was counteracted by ailerons and RH spoilers. A maximum bank angle of 11 degrees left bank was reached seven seconds later at 15.08:10 hrs.

The aircraft then started to roll to the right, starting at 15.08:12 hrs. This roll was counteracted by ailerons and LH spoilers. The RH inboard aileron deflected to 14 degrees up. three seconds later it was at 12 degrees down and one second later it was at 13 degrees up. Over the subsequent 6 seconds it moved to 15 degrees up. In response to this aileron movement the aircraft continued to roll to the right. A maximum right bank angle of 20 degrees was recorded at 15.08:15 hrs.

The bank angle then damped to the left reaching 6 degrees left and right bank and stabilised in level flight (zero degrees) at 15.08:50 hrs.

In the stabilised condition with the wings level, the inboard ailerons stabilised at RH Aileron 15 degrees up and LH aileron 7 degrees up while the outboard RH aileron stabilised at 7 degrees down and the LH outboard aileron at 6 degrees up.

At 16.32:44 hrs the Flight Crew disconnected the autopilot. The outboard ailerons then servoed to zero degrees (this is in accordance with the design specification when the aircraft is in the clean configuration above 190 kts). The aircraft initially rolled to the right due to the asymmetric position of the inboard ailerons. This was manually corrected with a left side stick input of 1/3 deflection. Roll control continued to be available by movements of the LH inboard aileron and the spoilers.

1.11 Damage Information

After landing at KORD the bracket pair supporting the outside servo-control on the RH inner aileron was found to have failed and was removed. The pair comprised the outside servo-control outer bracket (F575-50989) and the outside servo-control inner bracket (F575-50987). The bracket assembly was designated by part number F575-50986. The corresponding bracket assembly on the LH wing, which Non Destructive Testing (NDT) found to be cracked, was also removed. The failed bracket pair was initially shipped to the Operator's base at Dublin and then taken by the AAIU to the aircraft Manufacturer's facility in the UK for examination.

The Manufacturer's examination comprised: visual examination; NDT examination; Fractographic analysis; Hardness testing; Electrical Conductivity testing; Mechanical properties testing of the failed brackets and surface finish examination of a current production standard bracket.

The Manufacturer's examination revealed that the primary failure was of the outer bracket. The failure was caused by fatigue cracking which originated from a pit in the bracket surface. The pit, which was approximately 50 microns in depth, was believed to have been present in the bracket since it was manufactured. Following failure of the outer bracket due to fatigue cracking the inner bracket failed due to overload.

Detailed examination of the wing lower skin in the area directly below the failed bracket revealed an area of deformation between ribs 28 and 29. The deformation started at the aft spar fastener line and continued aft reaching a maximum value of 6.9 mm. (**Photo No. 2**)

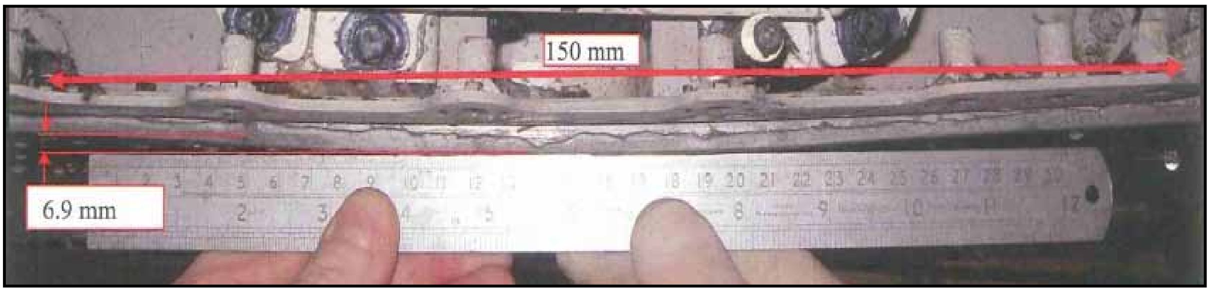


Photo No. 2: Deformation of lower wing skin, RH wing

There was no deformation of the bottom skin directly under the rear spar, nor was there any deformation of the rear spar flange fasteners, nor elongation of associated holes. The lower fastener holes in the rear spar web for attaching the brackets to the rear spar web were found to be elongated; the holes had an initial diameter of 7.94 mm but were found to be elongated to 8.6 mm approximately.

There was no fuel leak.

1.12 Medical and Pathological Information

There were no medical or pathological issues in this event.

1.13 Fire

There was no fire.

1.14 Survival Aspects

There were no survival aspects/issues in this event.

1.15 Test and Research

The Manufacturer carried out research as detailed below.

1.16 Organisational and Management Information

Not applicable.

1.17 Additional Information

At the time of this event the aircraft Manufacturer informed the Investigation that there had been a total of six events relating to failed or cracked brackets on A330 and A340 aircraft; the A340 has a similar wing with identical brackets. Four of these events had occurred prior to the EI-ORD event and another had occurred on the same day. Details of these bracket crack/failure events are shown in **Appendix A**.

Replacement of the servo-control brackets is not a straightforward task, in spite of the fact that the brackets were bolted onto the wing rear spar. This is because the brackets are supplied with only pilot holes for the attachment bolts and these need to be custom drilled to the finished size and location for the wing in question.

1.17.1 Manufacturer's Service Bulletin (SB) A330-57-3109

The Manufacturer published SB A330-57-3109 on 13 February 2009. This SB was titled "Wings – Inner Aileron Rear Spar Outer attachments – Inspection of Outer Brackets". The reason for issuing the SB was that "*an operator reported cracks on both brackets attaching the LH Active Servo control 8CS1 (inner aileron) at the rear spar. A subsequent inspection of the RH wing revealed similar cracks on both outer brackets. The aircraft in question had accumulated 14,261 flight cycles*". The SB was restricted (by Manufacturer's serial number) to aircraft which had completed more than 10,000 flight cycles (FC) and was classified as "Recommended" which means that it should be carried out at the earliest opportunity subject to the availability of facilities and qualified personnel.

The Operator's Maintenance Contracted Service Provider (CSP) received the SB in February 2009. The CSP determined that the SB was applicable to the subject aircraft and another of the operator's aircraft. The SB called for a High Frequency Eddy Current (HFEC) inspection of inner and outer servo-control attachment brackets, designated 8CS1 (left hand wing) and 8CS2 (right hand wing). The SB included a picture of the pair of brackets to be inspected; however, the picture incorrectly showed the brackets for the inactive servo control rather than the intended active servo control brackets. The CSP raised the necessary Engineering Order and related instructions for the accomplishment of the SB. The SB was accomplished during a C-Check at a Maintenance, Repair and Overhaul (MRO) facility, on 22 December 2009. No adverse findings were recorded following accomplishment of the SB.

On 9 July 2009, SB A330-57-3109 was revised (Revision 01, 09 July 2009) following the discovery of cracking on the brackets of an aircraft which had accumulated 8,930 flight cycles i.e. less than the original inspection threshold set by the Manufacturer. The new threshold was set at 7,500 flight cycles.

1.17.2 HFEC Inspection

The Investigation interviewed the Inspector who carried out SB A330-57-3109 at the MRO facility. The Inspector held certification issued by the British Institute of Non-Destructive Testing, which was valid until 6 November 2011. The Investigation was also shown his Company Procedures and Human Factors training certification, which were also valid and in date.

The Inspector informed the Investigation that on the day of the SB accomplishment, it was his only work task and that he had not been subject to any distractions. Using another aircraft at the MRO facility, the Inspector demonstrated how he had carried out the Inspection. The demonstration showed that using the prescribed method of inspection it was difficult for an inspector to prevent the probe from slipping off the edge of the bracket being surveyed. Such slipping caused false readings. During the demonstration the Inspector showed good understanding of the technique, and repositioned the probe each time it slipped to ensure that the final result of the HFEC inspection was valid.

The Investigation reviewed the calibration history for the test equipment. The unit had been calibrated on 28 January 2009 and was next due calibration on 28 January 2010. At the calibration on 28 January 2010 the unit was found to be within the calibration tolerance. In addition, prior to each use of the HFEC equipment Airbus Non-Destructive Testing Manual requires local calibration using sample calibration blocks. These calibration blocks are locally manufactured blocks with machined slots running to a variety of depths. The Investigation found that there was appropriate certification for these blocks.

During his interview the HFEC Inspector recalled that the FIN code marking decal was missing from the RH inboard aileron active servo-control. Subsequent inspection of EI-ORD by the Operator confirmed the Inspector's recollection. The Operator arranged for replacement decals to be fitted.

1.18 Meetings with the Aircraft Manufacturer

1.18.1 June 2010

On 16 June 2010 the Investigation met with the Aircraft Manufacturer to discuss the matter. The Manufacturer informed the Investigation that at that time there had been a total of seven (7) aileron active servo bracket cracking events recorded. (**Appendix A**) Of these, two resulted in fracture and separation; this included the subject event. Four of the events were detected as a result of the application of SB A330-57-3109 Version 00.

At the time of the meeting laboratory tests on six affected brackets had revealed surface pitting to depths of 50 microns; this pitting was the site of the crack initiation. Fatigue striations were in evidence in most of the cracks; cracks with a length up to about 4 mm exhibited a typical striation spacing of approximately 2 microns.

There was little evidence of corrosion within the pits and the presence of primer in the pits suggests that the pitting was there since manufacture.

The Manufacturer had identified a degreasing process known as "pickling" used in the manufacturer of the brackets as the likely cause of the surface pitting. Prior to May 2003 the pickling process was a manual process, thereafter it was automated. The Manufacturer stated that a bracket randomly selected from the production line in 2008 was found to generally have a surface finish better than the production drawing requirement of 2.4 microns, though a small number of isolated pits of up to 20 microns depth were identified and believed to be due to machining. During manufacturing the brackets are fully machined before the surface finish is checked. The brackets are then degreased and cleaned prior to anodising and post-anodising the brackets are painted and re-worked as necessary. With no surface finish check after the degreasing ("pickling") the variability associated with the manual nature of the process meant that pits of varying depth could be present (undetected) in the finished bracket.

The Investigation raised a number of issues with the Aircraft Manufacturer, namely,

- The lack of clarity in the title of SB A330-57-3109. "WINGS – INNER AILERONS REAR SPAR OUTER ATTACHMENTS – INSPECTION OF OUTER BRACKETS" could mistakenly be construed to mean that only the outer brackets on the outside servo-control of the inboard aileron required inspection.
- The diagram in the SB showed the bracket pair for the inside servo-control instead of the bracket pair for the outside servo-control. (**Figure No. 3**)
- Why was the SB one-off rather than repetitive in nature?
- Why did the SB not prescribe a compliance period?
- Why were some aircraft excluded from the applicability table?
- Was there a risk of a fuel leak due to the associated deformation of the bottom skin of the wing?
- Need to review the aircraft handling implications of EI-ORD's bracket failure.
- Need to conduct a crack age study on EI-ORD's failed brackets to assess if it was likely that there were cracks present when the brackets were HFEC inspected in December 2009.

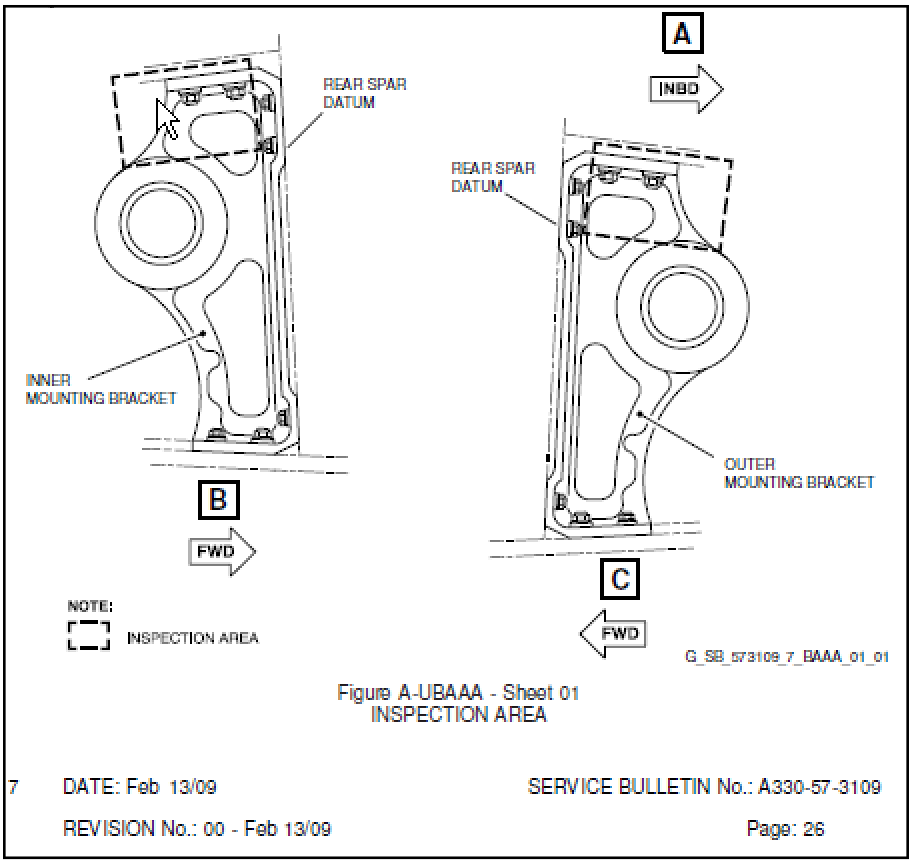


Figure No. 3: Original SB Diagram showing incorrect bracket pair

1.18.1 October 2010

On 27 October 2010 the Investigation met with the Aircraft Manufacturer again to review progress on the matter since the previous meeting.

In relation to the SB, the Aircraft Manufacturer advised that it was re-issued (Version 02, 08 September 2010) with a new title "WINGS - INNER AILERONS REAR SPAR ATTACHMENTS - INSPECTION OF OUTBOARD ACTUATOR BRACKETS". Service Bulletin A330-57-3109 Version 02 increased the recommended number of operators required to accomplish the inspection from one to two. The reason for the SB was changed from "*An operator reported cracks on both brackets attaching the L/H Active Servo Control 8CS1(inner ailerons at the rear spar …*" to "*An operator reported a rupture of both the pair of attachment brackets for the outboard L/H Servo Control *8CS1) of the inner aileron ...*" Service Bulletin A330-57-3109 Version 02 also pictures the correct bracket pair (**Figure No. 4**), includes notes on non-destructive testing, graphics depicting the typical crack location and details for a locally manufactured plastic guide to address the problems with the probe slipping off the bracket edge. On the question of repetitive intervals the Manufacturer subsequently informed the Investigation that the following intervals were published in the Service Bulletin A330-57-3109 Revision 03 on 31 May 2011:

- For the A330, ISB 57-3109R3 sets the repetitive interval as Threshold=6000FC/19400FH[3], Interval=1800FC/5700FH.
- For the A340, ISB 57-4119R3 sets the repetitive interval as Threshold=3600FC/20600FH, Interval=1700FC/9600FH

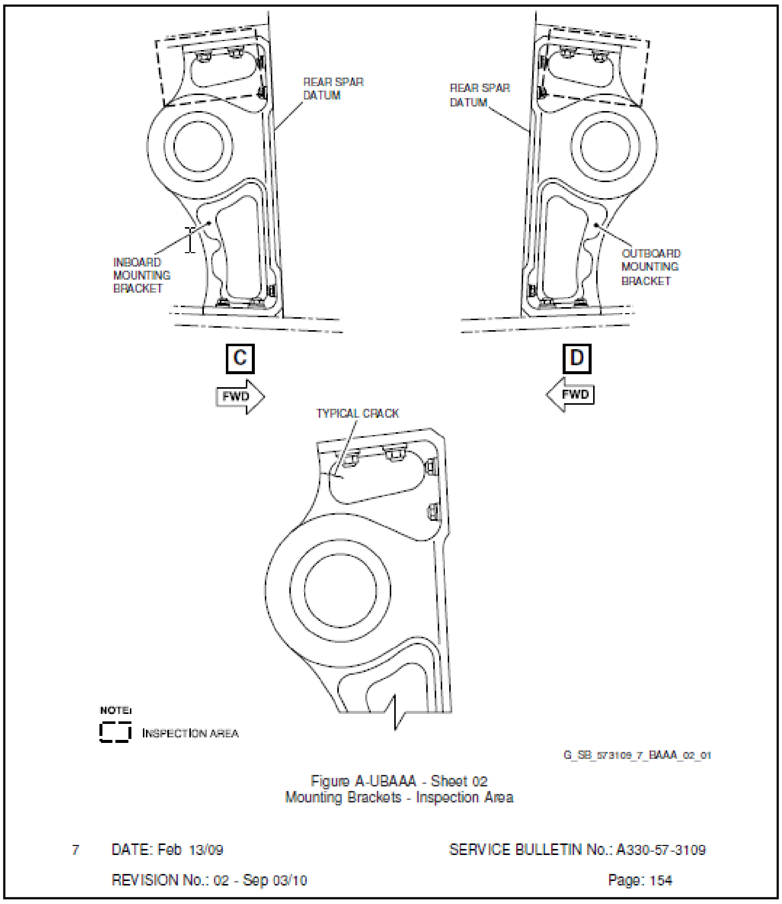
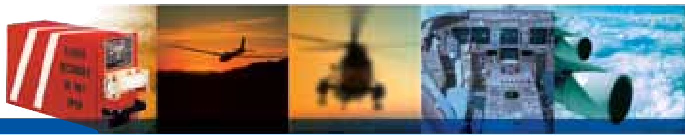


Figure No. 4: Revised SB diagram showing correct bracket pair

3 FH: Flight Hours



On the question of possible fuel leak, the Aircraft Manufacturer stated that in both events involving bracket fracture there was no deformation of the bottom skin under the rear spar nor was there any hole elongation or recorded damage to the spar flange fasteners. The Manufacturer concluded that there was thus no risk of fuel leak from the spar flange bolting (Primary leak path). In the case of EI-ORD there was some localised deformation of the two lower fasteners through the aileron attachment bracket and Rear Spar web locations. However, the Manufacturer concluded that there was a low risk of fuel leak from these fasteners and that in any case the risk was mitigated by the sealing and overcoating of the fasteners during installation and the low magnitude of the hole deformation.

As a result of this analysis by the Manufacturer it was concluded that the risk of a significant fuel leak due to the fracture of an aileron bracket was classified as very low.

The Aircraft Manufacturer also considered the possible implications for aircraft handling of a bracket failure. The Manufacturer conducted an engineering assessment of the handling qualities/behaviour of the aircraft with 1 or 2 inboard ailerons at zero hinge moment position, as a result of ruptured active servo control brackets. The Manufacturer concluded that there is always enough lateral control (usually, less than 5 degrees spoiler deflection with over 35 degrees available) to counter the failure(s) with very similar dynamics. The Manufacturer advised that the risk of flutter had been reviewed and presented to EASA at the 75th Airworthiness Review Meeting (ARM) on 22/23 September 2010). The minutes of the ARM meeting record: *"Flutter can only be caused by the complete separation of both active and damping servo controls. This cannot be caused by the present issue as only the active servo control brackets of the inner ailerons is impacted. There is no risk of flutter"*. The Manufacturer stated that the classification of "*MINOR impact on Airworthiness*" was agreed by EASA (at the 75th ARM).

On the question of crack age estimation, the Manufacturer advised that the growth of a small flaw (defect) to the point of rupture could not be determined exactly, but is estimated to be several thousand flight cycles. EI-ORD was inspected in accordance with the SB at 15,987 FC (55,303 FH). The bracket fractured at 16,183 FC (56,180 FH). Thus 196 FC (877 FH) had elapsed between the SB accomplishment and the rupture of the brackets. Examination revealed that the final crack had grown to 48 mm prior to bracket fracture. Striation spacing was relatively uniform for the first 10 mm of growth at 1micron. Although it was difficult to relate FC directly to load applications Manufacturer's engineering data and analysis indicated that an assumption of one major fatigue striation per flight cycle would be representative. Based on this assumption the laboratory analysis suggests that the crack would have been of the order of 10 mm in length at the time of the SB accomplishment (HFEC inspection). In conclusion, the Manufacturer's laboratory testing and analysis suggested that it was highly probable that the cracks were present during the original SB inspection in December 2009.

1.19 Useful or Effective Investigation Techniques

Not applicable.

2. ANALYSIS

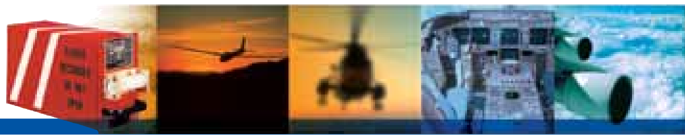
This event was caused by the failure of the inboard aileron outside servo-control outer bracket (F575-50989) on the RH wing due to fatigue cracking. The outside servo-control inner bracket (F575-50987) failed in overload as a consequence of the failure of the outer bracket. The corresponding bracket pair on the left hand wing was inspected and found to be cracked. The triggering event for this failure was an aircraft encounter with turbulence over Iceland.

The Flight Crew detected the effects of the failure although there was no specific indication of the event on the ECAM. The Flight Crew followed a structured approach to trouble shooting the problem and considered all pertinent factors before making the balanced decision to continue to their destination.

The Manufacturer had issued a recommended SB requiring inspection of the affected brackets using HFEC. The Operator's Maintenance Management System correctly scheduled the SB for accomplishment. On 22 December 2009, 196 FC prior to failure, the SB was carried out by a suitably qualified inspector using properly calibrated equipment, free from any distractions. The Inspector who carried out the inspection had clear recall of the aircraft and even recalled a missing decal which the Operator subsequently confirmed (and replaced). However, the inspection did not detect any cracks. Following the event, the Manufacturer indicated from studies of the features of the fatigue crack in the failed bracket that it was likely that cracks were present when the SB was carried out. There is no clear explanation as to why the initial application of the SB did not detect the presence of cracks. However, the Investigation did identify that the procedure prescribed in the SB was prone to probe slippage which caused false positive readings. In addition the original SB contained a diagram of the wrong bracket pair and could have caused confusion, although there is no evidence that such confusion was a factor in this particular application of the SB. The Manufacturer re-issued the SB with, *inter alia*, a diagram of the correct bracket pair and details of a locally manufactured guide to ameliorate the probe slippage problem.

The failed bracket's fatigue cracks were found to have originated from a 50 micron pit which was probably present since manufacture. The pit was likely due to a manual "pickling" process, which has been automated since 2003. Tests on a production stock bracket indicate that the automated procedure has addressed the pitting problem.

The event was classified by the Manufacturer (and accepted by EASA) as having a minor impact on airworthiness and the risk of any associated fuel leak was deemed to be very low.



3. CONCLUSIONS

(a) Findings

1. The aircraft encountered turbulence over Iceland and during autopilot corrections to level the aircraft the outer bracket attaching the RH inboard aileron's active (outside) servo to the wing rear spar fractured.
2. The inner bracket attaching the RH inboard aileron's active (outside) servo to the wing rear spar failed as a result of the outer bracket fracturing.
3. Pitting of up to 50 microns depth was found on the surface of the failed bracket.
4. Such pitting provided the site for the initiation of fatigue cracking.
5. The production drawing called for the bracket surface finish leaving no pitting greater than 2.4 microns in depth. Quality control checks on production stock brackets in 2008 found that generally the surface finish was better than the production drawing requirement of 2.4 microns, though a small number of isolated pits of up to 20 microns depth were identified and believed to be due to machining.
6. The cause of the pitting was traced by the Manufacturer to a manual pickling process used prior to May 2003, and which had been automated since then.
7. In February 2009, the Manufacturer published a recommended SB calling for HFEC inspection of the affected brackets to determine if cracks were present.
8. This bulletin was accomplished on EI-ORD in December 2009 and no cracks were detected.
9. The Inspector who carried out the HFEC check was properly qualified and the equipment used was properly calibrated.
10. During the examination prescribed in the original SB it was found the testing probe was prone to slipping off the edge of the bracket causing false readings.
11. The original SB had a potentially misleading title and contained a diagram showing the wrong set of brackets.
12. The Manufacturer re-issued the SB three times reducing the inspection threshold to 7,500 flight cycles (Version 01, 9 July 2009), correcting the title and bracket diagram, recommending two Inspectors carry out the work and detailing a plastic guide for the HFEC inspection (Version 02, 8 September 2010) and mandating repetitive inspections (Version 03, 31 May 2011).
13. The Manufacturer's laboratory testing and analysis suggested that it was highly probable that cracks were present during the original SB inspection in December 2009.
14. In total, across the A330/A340 fleet, there were five partial cracking events and two full rupture events, the last of which (partial crack) was in 2010.
15. At the 75th Airworthiness Review Meeting between EASA and the Manufacturer the event was classified as having "*MINOR impact on Airworthiness*".
16. The risk of fuel leak following the failure of the brackets was classified as very low.

(b) Probable Cause

1. Fracture of the outer bracket attaching the RH inboard aileron's active (outside) servo, due to fatigue.

(c) Contributory Cause(s)

1. Manual "pickling" process which caused surface pitting greater than that allowed or prescribed in the Manufacturer's drawings
2. Failure to detect cracks during HFEC inspection prescribed in a Manufacturer's SB.

4. SAFETY RECOMMENDATIONS

As the Manufacturer has changed the bracket manufacturing process since 2003 and has revised the SB to take account of issues identified during this Investigation, this Investigation does not sustain any Safety Recommendations.

APPENDIX A

Year	Aircraft	Bracket Finding	LH/RH	FC	FH	P/N
2007	A330-300	Full crack on both lugs of the Inboard Aileron outer bracket (8cS1). Static failure on IB bracket	LH	14216	45346	F575-50989 (OB bracket) F575-50987 (IB bracket)
2007	A330-300	Partial cracks on both brackets; fatigue growth evident	RH	14853	48116	F575-50989 (OB bracket) F575-50987 (IB bracket)
2009	A340-300	Partial crack	LH	8930	71688	F575-50989 (OB bracket)
2009	A340-200	Partial crack	RH	10198	71989	F575-50989 (OB bracket)
2010	A330-300	Full crack (subject aircraft)	LH/RH	16183	56180	F575-50989 (OB bracket) F575-50987 (IB bracket)
2010	A330-300	Partial cracks	LH/RH	17457	59106	F575-50989 (OB bracket) F575-50987 (IB bracket)
2010	A330-300	Partial crack Multiple brackets	LH & RH	16828	58853	

- END -

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Regulation (EU) No 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of these investigations is to prevent aviation accidents and serious incidents. It is not the purpose of any such accident investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

Produced by the Air Accident Investigation Unit

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