

FINAL REPORT ON THE INCIDENT TO AVRO RJ85 REGISTERED OO-DJK ON FRIDAY 11 FEBRUARY 2011

Ref: AAIU-2011-02-Marseille-OO-DJK

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Status: Final

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FOREWORD

This report is a technical document that reflects the views of the investigation team on the circumstances that led to the accident.

In accordance with Annex 13 of the Convention on International Civil Aviation, it is not the purpose of aircraft accident investigation to apportion blame or liability. The sole objective of the investigation and the Final Report is the determination of the causes, and define recommendations in order to prevent future accidents and incidents.

In particular, Art. 17.3 of EU Regulation 996/2010 stipulates that a safety recommendation shall in no case create a presumption of blame or liability for an accident, serious incident or incident.

Unless otherwise indicated, recommendations in this report are addressed to the Regulatory Authorities of the State having responsibility for the matters with which the recommendation is concerned. It is for those Authorities to decide what action is taken.

The investigation was conducted by L. Blendeman and S. Laureys of the Air Accident Investigation Unit of Belgium.

Accredited representative from the State of Design and State of Manufacturing: M. Jarvis of the UK Air Accidents Investigation Branch.

The report was compiled by S. Laureys

NOTE:

For the purpose of this report, time will be indicated in UTC, unless otherwise specified.

Synopsis

Date and hour of the accident

February 11, 2011 - 5:30 UTC

Airplane

Avro RJ85, registered OO-DJK

Serial number

E2271

Total aircraft hours and cycles

35177 FH and 28019 FC

Accident location

During climb from LFML passing 10.000 ft

Departure Airport

LFML - Aéroport de Marseille

Destination Airport

EBBR – Brussels Airport

Airplane owner and operator

Brussels Airlines

Type of flight

Commercial pax flight

Classification

Incident

Narrative:

During climb at approx 10.000 ft, a bang has been heard by the crew. There was some slight vibration but all parameters remained unchanged. Aircraft continued his flight to BRU and landed uneventfully. In BRU it was discovered that the composite top wing leading edge fairing panel above centertank was lost. No one got injured.

1. Factual information.

1.1. History of flight.

During climb at approx 10.000 ft, a bang has been heard by the crew. There was some slight vibration but all parameters remained unchanged. Aircraft continued his flight to BRU and landed uneventfully. In BRU it was found that the composite top wing leading edge fairing panel (identification number 282CT) above the centertank was lost. In this case this only caused secondary damage on the auxiliary attachment structure.

However the panel could have struck the aircraft, causing severe damage or damage the control surfaces, reducing the controllability of the aircraft.

The panel wasn't found back.

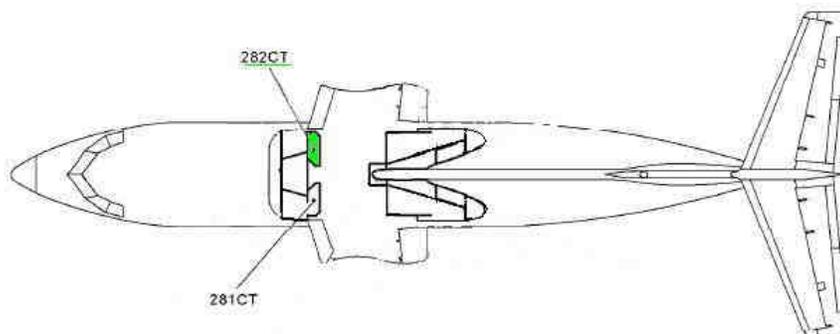


Figure 1: Location of the detached panel 282CT

1.2. Damage to aircraft.

Loss of fairing panel and damage on the auxiliary attachment structure: cracked angles and broken grommets holding the bolts. The bolts were all still located on the aircraft. No secondary damage on the fuselage or flight controls.

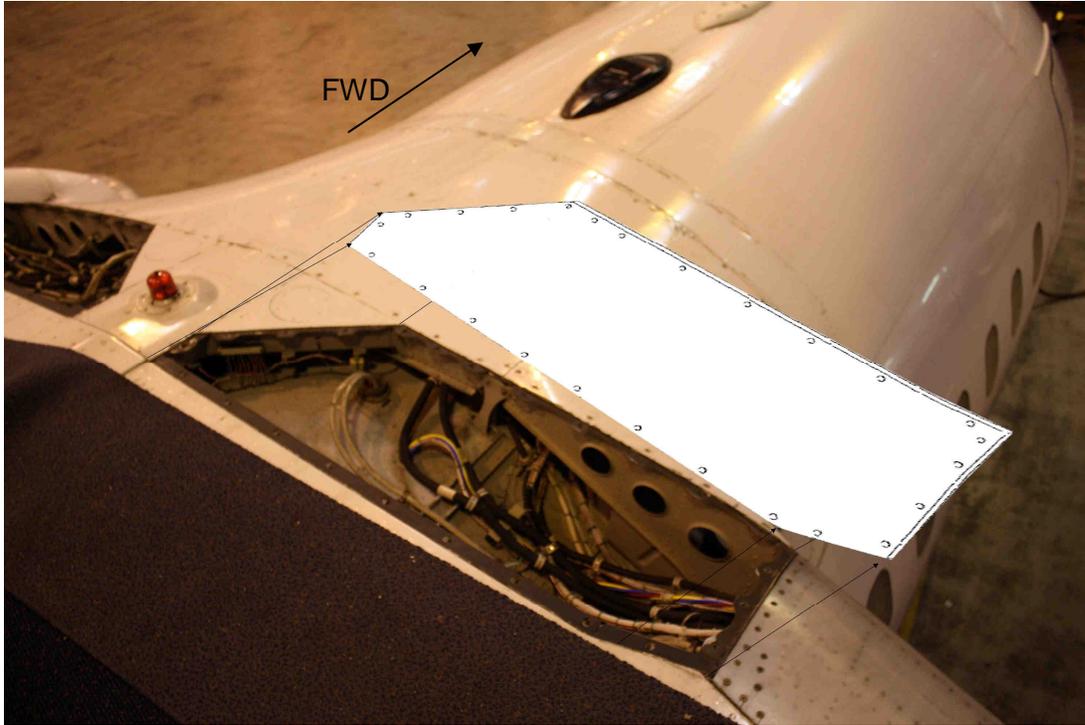


Figure 2: Schematic view of the detached panel



Figure 3: Picture of the similar opposite panel (281CT)

1.3. Aircraft information.

Airplane general information.

The Avro RJ is a high-wing cantilever monoplane with a T-tail. It has four turbofan jet engines mounted on pylons underneath the wings, and has retractable tricycle landing gear. The aircraft has very quiet operation, and has been marketed under the name Whisperjet. It sees wide usage at small city-based airports. In its primary role it serves as a regional jet, short-haul airliner or regional airliner. The Avro RJ series are upgraded developments of the BAe-146 family and like the 146 was built in three fuselage length variants, the RJ70, RJ85 and RJ100. The last RJ was delivered in 2002. In total 170 Avro RJ aircraft were built, of which 87 RJ85. Current major European operators are Brussels Airlines, Blue1 (Finland), Lufthansa CityLine, Malmö Aviation (Sweden) and Swiss International Airlines.

Brussels Airlines is the only owner of Belgian registered Avro RJ and has 14 RJ85 and 12 RJ100 aircraft in its fleet.

Characteristics of Avro RJ85:

Crew:	2
Capacity:	82-112 passengers. Brussels Airlines uses the configuration of 82 passengers.
Length:	28,61 m
Wingspan:	26,34 m
Height:	8,61 m
Wing area:	77,3 m ²
Empty weight:	24600 kg
Max takeoff weight:	43998 kg
Engines:	4 AlliedSignal/Honeywell LF-507 turbofan engines

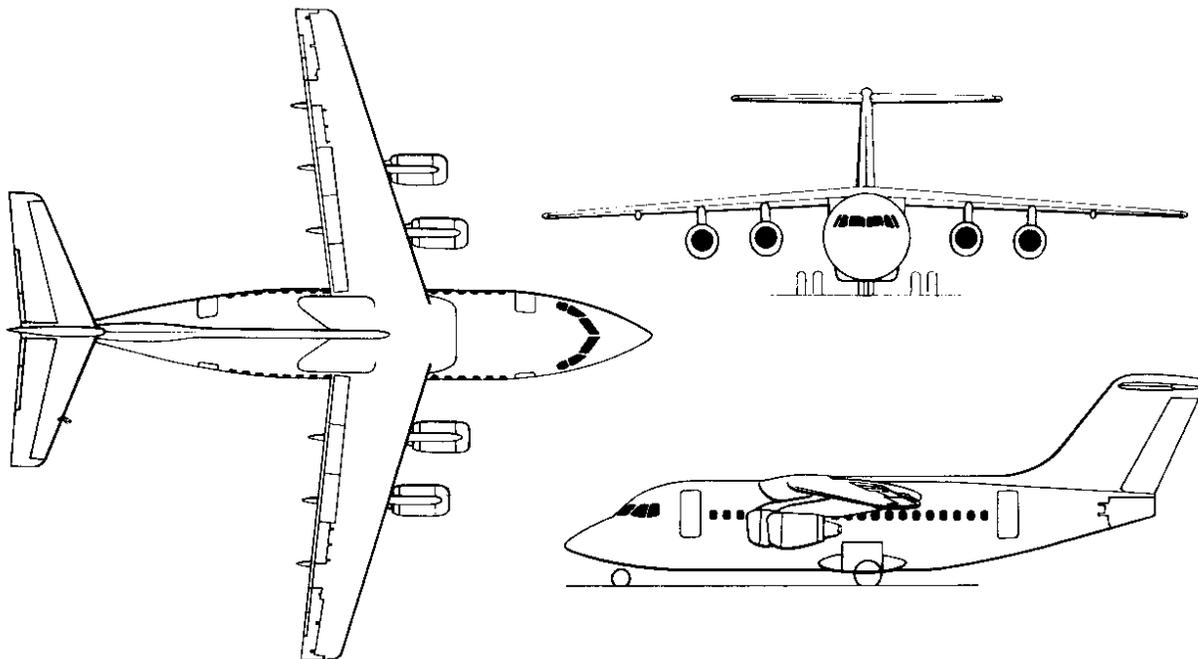


Figure 4: BAe AVRO RJ85

Airframe:	
Manufacturer:	BAe Systems (Operations) Ltd
Type:	AVRO 146 Serie RJ85
Serial number:	E2271
Built year:	1995
Registration:	OO-DJK
Certificate of registration:	N°4538 issued May 29, 2008
Certificate of airworthiness:	EASA Form 25 issued December 12, 1995
Airworthiness Review Certificate:	EASA Form 15B, Last issued on July 06, 2010. Valid until August 03, 2011

Fairing panel information

The panel is composite made of a woven pre-pregnated glass cloth with a Nomex honeycomb core and is used as wing-to-fuselage fairing. It covers the FQIS (Fuel Quantity Indicating System) and other wiring looms placed upon the pressurized fuselage.

An aluminum foil membrane is attached to the inner surface to provide protection against electrostatic effects.

In production, the panel was installed by 25 internal wrenching bolts (NAS5304-10) through steel grommets (SL5183) used as reinforcement of the composite holes. During manufacturing these grommets are inserted into the panels, prior to the grommet flanges being peened over on the upper surface of the panel using a special tool and a hammer (See Figure 5 and Figure 6). The bolts are held by anchor nuts.

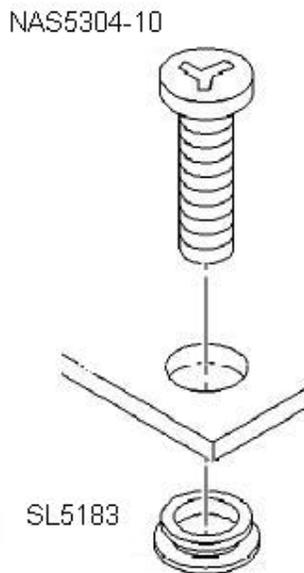


Figure 5: Exploded view of SL5183 installation



Figure 6: Peening tool

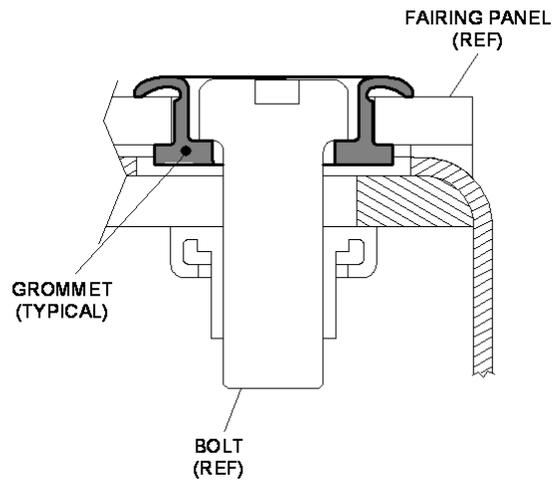


Figure 7: Cross section view of SL5183 installation

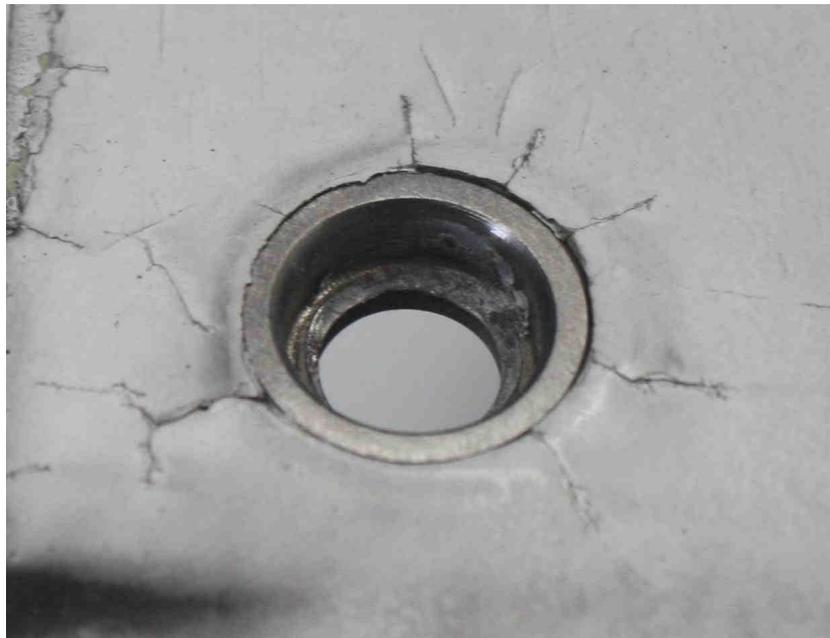


Figure 8: Installed SL5183

Maintenance:

The continuing airworthiness of the RJ fleet is performed by the Technical Department of Brussels Airlines, as approved EASA Part M subpart G Continuing Airworthiness Management Organisation.

The maintenance tasks on the RJ fleet are performed under the EASA part 145 approval of Brussels Airlines.

The current maintenance program (MP) of the RJ fleet is DAT BAe 146/Avro RJ/1 Rev 14 issued on 13/11/2009, approved by BCAA on 28/01/2010.

There are currently 2 maintenance tasks applicable to the panel:

1. MP – section 4 – zonal task ZL-281/282-2 with an inspection interval of 4000 FC.
This task asks for an external surveillance inspection of the forward fairings. In the introduction of this section an external surveillance inspection is defined as a visual inspection within a distance of one arms length.
2. MP – section 7 – Inspection Service Bulletin task SB 53-202 with an inspection interval of 8000 FC.
This task asks for a visual inspection of the steel grommets on the fairings in accordance with ISB 53-202 rev. 1 or later.

Grommet failure history

On September 6, 2005, a fairing panel (ref 281CT) similar to the one of this occurrence was detached during flight of OO-DJZ. The subsequent inspection, led by Brussels Airlines, concluded that it was caused by an improper installation of the steel grommets (P/N SL5183) during production (See DAT special maintenance report Issue 1 in appendix 1).

BAe Systems, the manufacturer of the RJ 85 was notified and reported that several operators reported similar occurrences of panel attachment problems.

On September 30, 2005, BAe Systems issued All Operator Message AOM 05/025V. This AOM recommends that operators inspect the grommets of the fairing panels.

On March 13, 2006 AOM 06/014 was issued, recommending that operators inspect grommets prior to painting.

On May 24, 2007, BAe Systems issued inspection service bulletin ISB 53-202 to introduce a detailed visual inspection of the steel grommets on all affected wing-to-fuselage and main landing gear door fairing panels to check for incorrect installation or damage within 4000 flights or two years, whichever occurs later. When damage is

found, the grommet has to be replaced by a redesigned grommet (PN SL5185) which has to be inserted into the panel from the external side. See Figure 9.

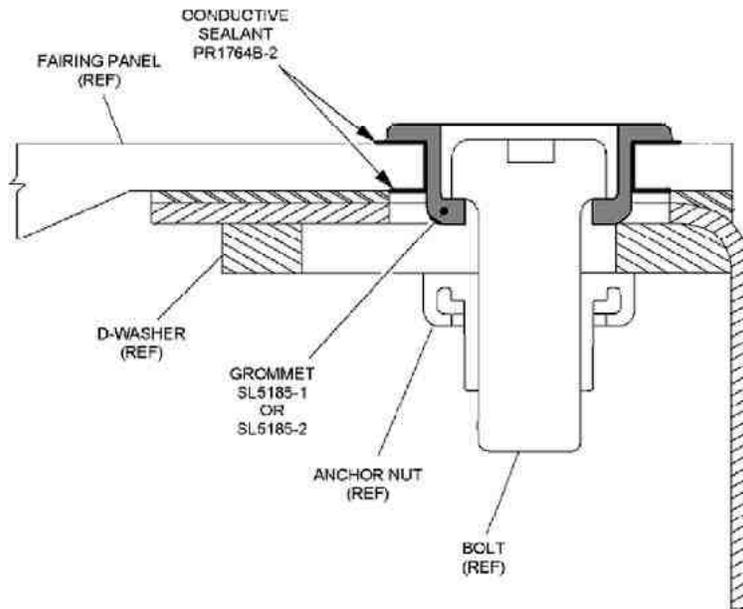


Figure 9: Cross section view of SL5185 installation



Figure 10: Installed SL5185

On June, 17, 2007, overwing fairing panel 281CT detached from aircraft registered OH-SAI when inbound to Stansted (UK) and descending to below FL 200. The aircraft was property of Blue1, a Finnish Airline owned by SAS group. The UK Air Accidents Investigation Branch (AAIB) performed an investigation and issued a report in AAIB Bulletin 2/2008. That panel has been found back and there was no evidence of damage to the panel in the region of the 25 holes where the grommets had been. The bolts were all still on the aircraft located in their respective grommets. All grommets were found to have failed. The conclusion of the report was that the panel became detached because the grommet flanges had failed. The grommet flanges were of reduced thickness and this was likely to be due to abrading prior to painting given that the aircraft had been repainted 11 weeks before the incident.

The report also mentions that there have been nine similar occurrences of panel attachment problems for this family of aircraft recorded by the manufacturer. Seven of these cases involved overwing panels and in two of these, the overwing panel became detached in flight.

On May, 1 2008, BAe Systems issued All Operator Message AOM 08/010V. This AOM introduced a modification of the SB inspection by adding in a requirement to remove paint from a sample of grommets. This requirement has been added to revision 1 of ISB 53-202.

These occurrences were also notified to EASA that mandated Airworthiness Directive EASA AD 2008-0180, rendering mandatory the implementation of ISB 53-202 revision 1 or later. This AD calls for a repetitive inspection of 8000 FC after the threshold of 4000 FC or 2 years after the effective date 14 October 2008 (WOL). After modification of an aircraft by replacement of all existing grommets with P/N SL5185 grommets, the repetitive inspections of this AD are no longer required for that aircraft.

Up till today, BAe Systems has recorded 5 reports, not including this one, of detached overwing fairing panels. There also several reports of damaged grommets.

Panel inspection history of OO-DJK

The aircraft has been last repainted in the brand colours of Brussels Airlines in 2007.

The last inspection on this A/C in accordance with ISB 53-202 revision 3 was performed in March 2009.

There was one finding of a damaged grommet on the forward side of panel 282CT. This was replaced by a new grommet (SL5185).

2. Analysis.

2.1. Comparison of grommets

Comparing Figure 7 and Figure 9 it is obvious that there's a change of design and the new grommets have a larger and thicker collar.

The main problem with the initial grommets (SL5183) is the peening process. When not applying the right process with the correct tool, it can occur that the grommet gets cracked or there is an excessive waisting of the material. This can happen during maintenance but BAe systems recognised this also could have occurred during initial production.

The SL5183 standard of grommet is also vulnerable because the radius formed by peening over the head provided only a small area at the top of that radius. Only a small amount of material needs to be removed to compromise the structural integrity of the grommet (See Figure 11).

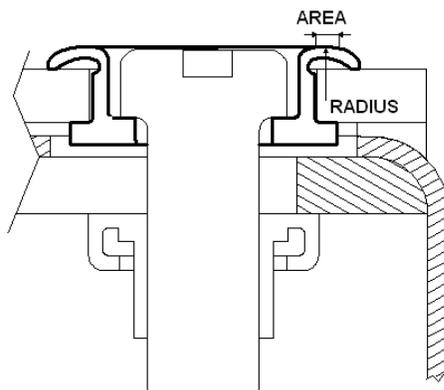


Figure 11: Illustration of vulnerability

The new SL5185 grommets are inserted from the external side, eliminating the need to form the flange with a peening tool.

2.2 Damage examination

When looking to the structure at the location where the panel was detached, the collars of grommets at the FWD side of the panel were found broken off. Some grommets at the AFT side still were intact. So we can conclude that the panel first detached at the FWD side allowing the air to enter under the panel. Due to the total air pressure the panel was pulled through the aft grommets and completely detached.



Figure 12 : Pictures of the torn grommets

The new grommet installed in 2009 was slightly deformed due to the excessive loads but did withstand.



Figure 13: Deformed collar of grommet SL5185

2.3 Inspection interval

The ISB inspection interval is based upon one previous event of fairing panel loss in flight where there was contact with the vertical stabiliser. If a similar incident occurs with one of the heavier panels, this could cause damage sufficient to significantly affect the handling characteristics. Therefore BAe Systems considered the effect as

“Hazardous” in accordance with EASA CS-25.1309. When an occurrence is deemed to be “Hazardous”, the probability of that occurrence is required to be less than 10^{-7} per flight. It has been calculated by BAe that with an inspection period of 8000 flight hours, the acceptable probability of occurrence in an aircraft life has been met, provided that inspections are being properly performed.

2.4 Panel inspection history

On the taskcard of the last inspection, there was made a distinction of damaged, undamaged and serviceable by the inspector. However there is no definition of serviceable in the ISB. When damage is found, whatever it might be, the grommet has to be replaced.

3. Conclusions.

3.1. Findings

- Panel was lost in flight. Angles were found cracked and grommets holding the bolts were broken off. The bolts were all still located on the aircraft. The fairing panel hasn't been found back.
- The last inspection of these grommets as per ISB 53-202 was almost 2 years ago (4519 flight hours prior to the incident).
- The design of SL5183 has some weak features, disallowing any damage margin. These features are the small area at the top of the peened radius and the peening process itself.
- When bolts are inserted, it isn't always that easy to recognize cracks or other damage on the grommet flanges, especially when they are painted.
- This is the second incident for Brussels Airlines. So a potential high risk of similar incidents exists. A fleet inspection of panels 281CT and 282CT after the second incident has revealed some crack initiation at several grommets.
- However this is the first recorded panel loss since the issuance of ISB 53-202 revision 4.

3.2. Causes

- Incident was due to failures in the steel grommets, part number SL5183, through which the attachment bolts are inserted.
- ISB 53-202 gives as possible causes of the grommet failures, the improper installation or damage resulting from maintenance procedures relating to paint stripping. This panel has been repainted in 2007 and inspected in 2009. Non-detected abrasion could be a probably cause.

3.3. Contributing factors

- During the last inspection of the panel, some grommets were considered as 'serviceable'. It can be that already slightly damaged grommets passed that inspection. The fact that a fleet inspection after the second incident revealed some crack initiation at several grommets supports this possibility.

4. Safety recommendations.

4.1. Actions of the company

Right after the second incident, Brussels Airlines launched an additional fleet inspection to look for signs of abrasion, cracking, looseness, deformation or damage on the grommet flanges heads. Critical damaged grommets were immediately replaced by the new ones as per ISB 53-202.

Brussels Airlines issued a planning instruction to modify all grommets at fairings 281CT and 282CT during weekends and C-check. All modifications should have been done by 31/12/2011.

AAIU(be) supports this decision and has no further recommendations.

4.2. Actions of BAe Systems

BAe Systems considered that the text of the SB describing the extent and nature of the inspection is adequate. However, it was noted that there are no drawings in the ISB which explicitly show the kinds of damage described in para 2C(2).

In consultation with the Operators, BAe Systems decided to produce illustrations showing the nature of the defects, as additional information to assist in identifying damaged grommets.

These illustrations have been provided to the Operators by a Electronic Service Information Leaflet issued on 25/08/2011. (See Electronic Service Information Leaflet issue 1 in appendix 2).

The illustrations are also being incorporated into ISB 53-202 at Revision 5, which is currently in progress.

AAIU(be) supports this decision and has no further recommendations.

4.3. Recommendation 2011-C-22 to EASA

AAIU(be) recommends EASA to revise EASA AD 2008-0180 to make reference to ISB 53-202 Revision 5, once the latter has been issued, and to make a clear statement that the next inspections have to be performed in accordance with the ISB 53-202 Revision 5. The current statement "*The use of later approved revisions of this document is acceptable for compliance with the requirements of this AD*" doesn't mandate compliance with the latest approved revision of the ISB 53-202.



APPENDIX 1: DAT special maintenance report Issue 1

Special Maintenance Report



ENG FORM 00/2004

ATA chapter: 53	Appendices: ASR 03688			Report status: Open: September 6 th , 2005 Closed: February 14 th , 2006
Aircraft AVRO	Registration: OO-DJZ	Type: RJ 85	S/N: E2305	Operator: Delta Air Transport
SMR issue nr: 1	Name: P/N:		S/N:	Maintenance Process:

1. Date, place, circumstances, stage,...

September 6th, 2005 Aircraft OO-DJZ (sn: 2305) was operating flight SN 3162 From Milan to Brussels. The Aircraft was transporting 39 passengers and crew (2 Cockpit and 2 Cabin). The aircraft was descending from Flight Level 250 to Flight Level 190 at a speed of 290 Kts.

2. Observations, comments,...

During the decent from FL250 to FL 190, in the vicinity of DIK (Dikirsch), at around FL 290. The crew felt a jaw movement, while hearing a bang and an increase in aerodynamically noise. The aircraft was flown manually immediately, and re-trimmed; the autopilot was re-engaged as was the auto Thrust, since the controllability was not affected. The crew slowed down the aircraft to 210 Kias and entered the holding at Florennes to assess; there were no indications in the cockpit, all gauges indicated normal. Subsequently the crew initiated the approach for landing in Brussels, where an uneventful landing was performed.

3. Cause of the incident/failure.

After the landing on walk around the crew found one fairing panel missing on the top of the LH wing root. This was later confirmed by maintenance as panel 281CT.
On closer inspection the auxiliary attachment structure was found damaged but all fasteners were still in position.

4. Corrective action.

The fairing 281CT was replaced as was the attachment structure per AMM 20-00-00 and SRM 51-00-00 standard practices. And a FOD inspection of the tail section was performed, to check for secondary damage, none was found. The aircraft was released for further flights.

- Investigation revealed improperly installed fastener grommets in the panel, as the grommets were never replaced on this aircraft it is presumed the problem was introduced on production.
- In this context, a fleet inspection was initiated per PI 05/53-041 to inspect wing root fairing panels, to avoid possible repetition on other aircraft.
- Concurrently BAE was contacted in order to provide the required tooling for possible replacement of those grommets, in the case of additional findings. And a Tool to install the grommets was produced and incorrectly installed grommets have all been replaced at this time.
- Attention will be given in the continuous/recurrent training to the engineers/inspectors in order to clarify the correctly fitted grommets and importance of the use of the correct tooling during future installation of those grommets.
- Additionally the engineers/inspectors have been made aware, that the "Zonal inspection" is the inspection type expecting to find such incorrectly installed or loose grommets.

Distribution list: Engineering, Belgian CAA (2ea), ACFT Design Organisation, DAT Safety officer (E-Mail). **Total 5 copy's**
Issued: 14 February 2006

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Special Maintenance Report



ENG FORM: ENG128

5. Conclusion.

Improperly installed fastener grommets in the panel at production.

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ENGINEERING

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Issued: 14 February 2006

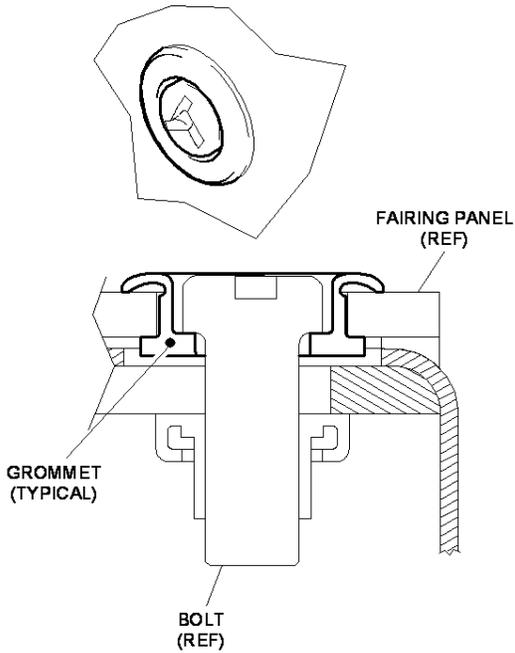
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APPENDIX 2: Electronic Service Information Leaflet issue 1

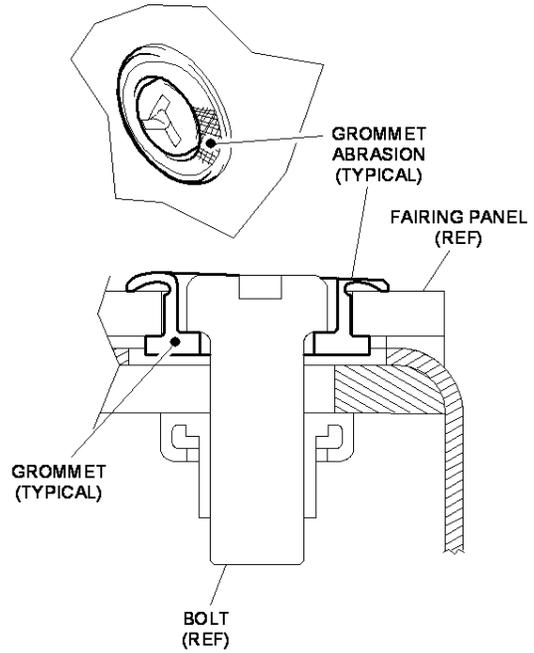
Electronic Service Information Leaflet

Reference	Creation Date	Issue Date	Issue Number	Status	Applicable Aircraft
53-146-RJ-690-1	24/08/2011	25/08/2011	1	In Vet	146-RJ

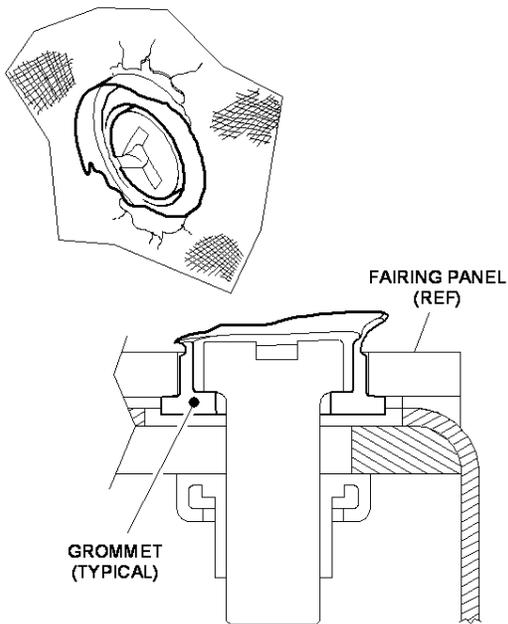
Title	Inspection of Fairing Panel Grommets				
Description	Following a recent incident, where a wing-to-fuselage fairing panel detached during flight, the inspection requirements of ISB 53-202 have been reviewed.				
<p>Current Status : Investigation of the recent incident has determined that the wing-to-fuselage panel had previously been inspected, without damage reported, in accordance with ISB 53-202.</p> <p>The ISB was reviewed to confirm if the inspection requirements were adequate. ISB 53-202 paras 2C(2)-(4) state; "(2) Perform a detailed visual of all grommets on any one panel. Look for any signs of abrasion, cracking, looseness, deformation or damage on the grommet flanges/heads. (3) Refer to Drawing 6 if there is paint on the grommets, remove the paint from the grommets at the corners of the panel and perform a detailed visual inspection of the stripped grommets. If there is no corner grommet, then the two grommets closest to the corner should be stripped of paint and inspected. Additionally, remove the paint from each grommet situated halfway between the corner grommets, Drawing 6 and perform a detailed visual inspection of the stripped grommets. (4) If any of the grommets inspected in parts (2) and (3) show any signs of damage then all the grommets on that panel must be stripped and inspected."</p> <p>From review of the ISB it is considered that the text describing the extent and nature of the inspection is adequate. However, it was noted that there are no Drawings in the ISB which explicitly show the kinds of damage described in para 2C(2).</p> <p>This issue was discussed with the OSMG at their meeting at Prestwick in June 2011. It was agreed that there would be benefit in BAE SYSTEMS producing illustrations showing the nature of the defects, as additional information to assist Operators in identifying damaged grommets.</p> <p>Initially, these illustrations are being made available to Operators via this eSIL. The illustrations are also being incorporated into ISB 53-202 at Revision 5, which is currently in work.</p>					
Reporting Airline	Brussels Airlines				
SIL		SB Number	ISB 53-202, Revision 5		
Other Tech Pubs					
Vendor		Vendor SIL or SB			



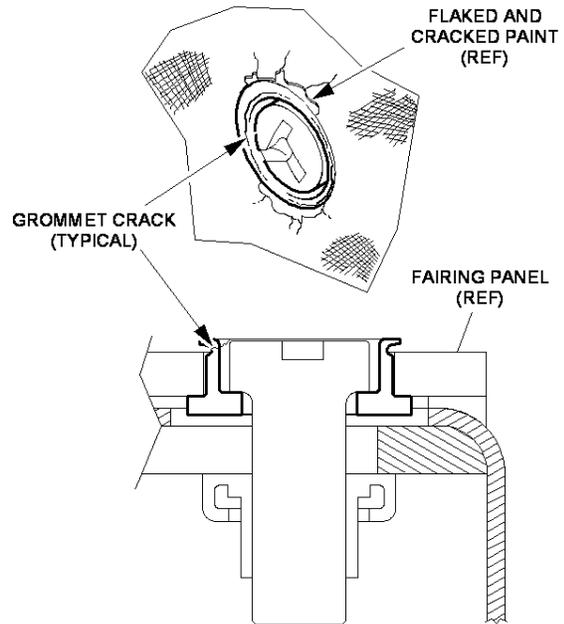
GOOD GROMMET IN-SITU



ABRADED GROMMET IN-SITU



GROMMET WITH 'RING-PULL' FAILURE



DAMAGED GROMMET IN-SITU

N5320211