NASA Contractor Report 172246

Flight Service Evaluation of Advanced Composite Ailerons on the L-1011 Transport Aircraft

First Annual Flight Service Report

R.H. Stone

LOCKHEED-CALIFORNIA COMPANY
BURBANK, CALIFORNIA

CONTRACT NAS 1-15069
September 1983

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FOREWORD

This report was prepared by Lockheed-California Company, Burbank, California under Contract NAS 1-15069. It is the first annual report covering flight service evaluation of composite inboard ailerons on the L-1011 from March 1982 when the first set of ailerons entered airline service, through July 1983 when the first yearly inspections were completed. The program is sponsored by the National Aeronautics and Space Administration (NASA), Langley Research Center. Mr. Marvin B. Dow is the Project Engineer for NASA.

C. F. Griffin is the Lockheed Engineering Program Manager and is being assisted in the flight service evaluation by R. H. Stone.

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SUMMARY

Four shipsets of graphite/epoxy composite inboard ailerons were installed on L-1011 aircraft in March through May 1982 for a five-year maintenance evaluation program. These include two Delta aircraft and two TWA aircraft.

Results of the first annual inspection of these components are reported herein. These were visual inspections of the aileron exterior surfaces.

A fifth shipset of composite ailerons were installed in 1980 on Lockheed's flight test L-1011. A visual inspection was also conducted on these components.

No visible damage was observed on any of the composite ailerons, and no maintenance action has occurred on any of the parts except for repainting of areas with paint loss. Flight hours on the airline components at the time of inspection ranged from 2886 to 4190 hours, after approximately one year of service.

1. INTRODUCTION

In 1977 the Lockheed-California Company initiated a program to demonstrate the weight and cost-saving potential of secondary aircraft structures constructed of advanced composite materials. The component selected for this demonstration was the inboard aileron of the L-1011 transport aircraft. The program is sponsored by the National Aeronautics and Space Administration as part of the Aircraft Energy Efficiency (ACEE) Composite Structures Program.

The program scope included the evaluation of alternate designs and materials for the aileron; detail design and analysis; fabrication and test of subcomponents for design verification; fabrication and test of subcomponents for design verification; fabrication and testing of two ground test ailerons; fabrication of five shipsets of ailerons for installation on L-1011 aircraft; flight testing of one shipset on Lockheed's flight test aircraft; and the 5 year flight service evaluation discussed herein. The overall program is summarized in the executive summary report (Ref. 1). Lockheed's team member on this program was Avco Aerostructures Division of Avco Corporation. Avco was responsible for fabrication of the composite ailerons.

The composite aileron design, shown in Figure 1, is a multirib configuration with single piece upper and lower covers mechanically fastened to the substructure. Three basic materials were utilized in the aileron design: Narmco 5208/T300 graphite/epoxy unidirectional epoxy tape; Narmco 5208/T300 graphite/epoxy bidirectional fabric; and Hysol ADX 819 syntactic epoxy core.

The aileron covers, ribs, and front spar were fabricated using standard vacuum bag autoclave molding procedures. The aileron covers are thin sandwich plates with graphite/epoxy tape facesheets and a syntactic epoxy core. The ribs and spars are constant thickness channel sections, laid up and cured on male tools. The intermediate ribs are fabricated of bidirectional graphite/epoxy fabric. The main ribs which react hinge and actuator loads are fabricated of graphite/epoxy fabric, with the caps reinforced with graphite/epoxy tape. The front spar is fabricated of graphite/epoxy tape laid up in approximately a quasi-isotropic orientation.

The complete aileron assembly includes an aluminum leading edge shroud, aluminum bathtub fittings at the spar to main rib joints, fiberglass/epoxy fairings, aluminum hinge/actuator fittings, and a Kevlar 49/epoxy trailing edge. The composite aileron design is 26% lighter than the metal aileron and is predicted to be cost competitive since the composite aileron has 50% fewer parts and fasteners than the metal aileron.

The inboard aileron is located on the wing trailing edge between the outboard and inboard trailing edge flaps. It is supported from the wing at two hinge points and is actuated by three hydraulic actuators. It is a wedge-shaped, one-cell box, thinning slightly from root to tip. At the front spar

the aileron is 92 inches in length and approximately 10 inches deep. The width of the aileron is 50 inches. The upper surface, ribs, and spars are permanently fastened using titanium Triwing screws and stainless steel Hi-Lok collars. The removable lower surface, trailing edge wedge, and end fairings are attached with the same type screws but with nut plates attached to the structure with A286 Cherry Rivets. All fasteners are installed with sealant. The aileron is primed and painted with standard aircraft materials.

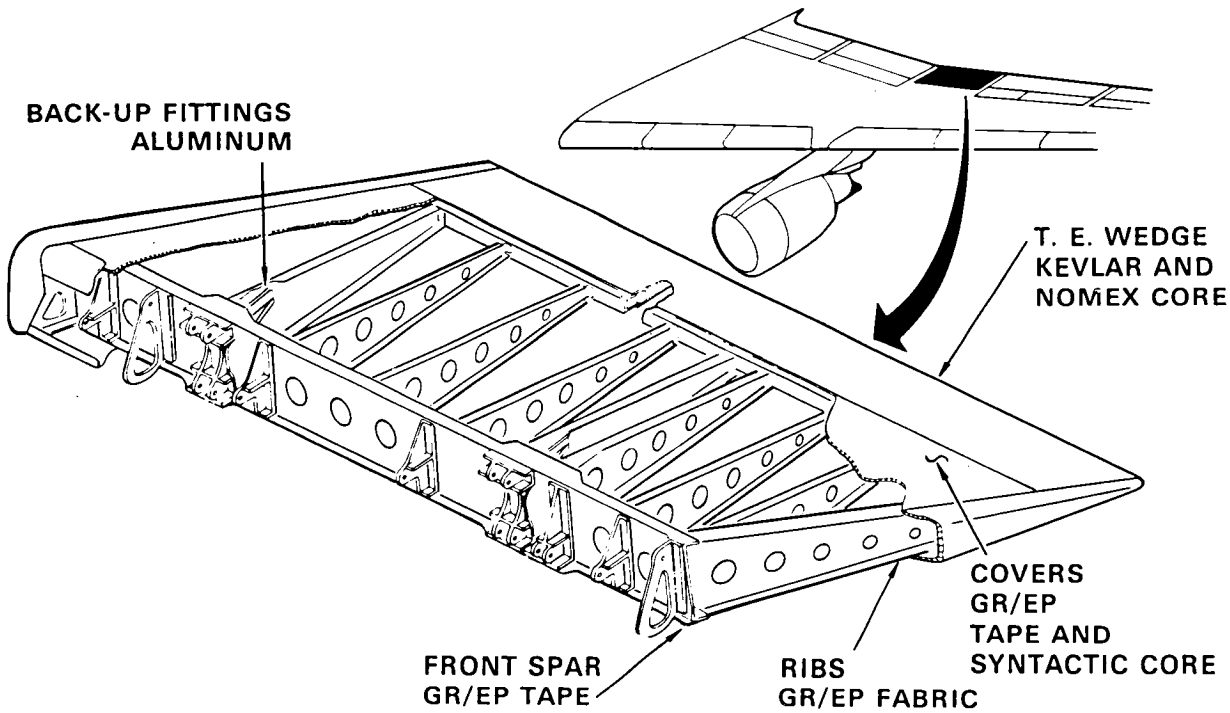

Figure 1. - Advanced composite aileron assembly.

2. FLIGHT SERVICE EVALUATION PLAN

The final phase of the inboard aileron program is a five-year flight service evaluation. A left-hand and right-hand aileron were installed on four new L-1011 aircraft. Two of these aircraft were subsequently delivered to Delta Air Lines, and the two others were delivered to Trans World Airlines. The Delta aircraft were the standard L-1011-1 model, while the TWA aircraft were longer range L-1011-100s.

The evaluation agreement between Lockheed and the two participating airlines consisted of the following elements:

1) The evaluation period is five years.

2) An exterior visual inspection will be performed by airline personnel and witnessed by Lockheed personnel at annual scheduled "C"-check inspections closest to the anniversary of installation.

3) An interior inspection, requiring removal of the lower cover, will be conducted at the end of the five-year evaluation by airline personnel, witnessed by Lockheed personnel.

4) The airlines will provide a written report to Lockheed on the results of each inspection. This report will include inspection results, a description of any maintenance or repair actions, flight hours, number of landings, and utilization rate for the year.

5) In the event visible damage is observed, the airlines will determine the extent of damage by ultrasonic inspection using standards provided by Lockheed. After notification of Lockheed, the airline will repair the damage in accordance with the L-1011 Structural Repair Manual, which was revised to incorporate specific repair procedures for the composite ailerons.

A fifth shipset of ailerons are being evaluated on the Lockheed flight test airplane. A visual inspection of the exterior and interior aileron surfaces was conducted by Lockheed personnel. The ailerons were originally installed on this aircraft for flight tests as part of FAA certification. These flight tests are described in the Task IV Final Report (Ref. 2).

3. AILERON FLIGHT SERVICE EXPERIENCE

The aircraft flight-hours and landings for the composite ailerons are summarized in Table I. A total of 29,368 component flight-hours was accumulated through July 19, 1983 on the 10 installed ailerons. The high time ailerons have 4190 flight hours in slightly over 14 months.

The first annual visual inspections of the five shipsets of composite ailerons revealed no damage, even of a minor nature, on any of the ten components. There was paint loss to varying degrees on all the ailerons, and in two instances touch-up paint had been applied. Paint loss of this type is a fairly common occurrence on metal or fiberglass components. The significance for the graphite/epoxy ailerons is: 1) paint loss indicates that the ailerons are being exposed to hydraulic fluid, and that the lack of damage verifies the resistance of graphite/epoxy to aircraft fluids; 2) the upper surface is exposed to ultraviolet, and epoxy resins are known to be affected by ultraviolet with significant weight losses after extended exposure. Airline maintenance personnel were advised of the need for repainting of exposed graphite/epoxy particularly on the upper surface. Inspection results are summarized in Table I.

The results to date of the flight service evaluation program indicate that these graphite/epoxy components perform satisfactorily in the high utilization environment of commercial transports. The satisfactory structural performance of the ailerons and the absence of damage or defects verifies the structural and durability data obtained in the composite aileron test program.

TABLE I. - FLIGHT SERVICE SUMMARY - FIRST YEAR

Operator	Aircraft Tail No. (Lockheed Serial No.)	Date of Delivery	Date of Inspection	Flight-Hrs. at Inspection	No. Landings at Inspection	Utilization Rate (Hrs/Day)	Inspection Results
Delta	N736DY (1227)	Mar. 11, 1982	Mar. 28, 1983	3226	1795	8.7	No discrepancies observed on either part
Delta	N737D (1228)	May 8, 1982	Apr. 14, 1983	2885.6	1602	8.6	No discrepancies observed on either part
TWA	N8034T (1230)	Apr. 7, 1982	June 20, 1983	4042	1067	9.8	LH Part: No damage or defects. Minor paint loss noted. RH Part: No damage or defects. Some paint loss; one area 6" x 4" repainted on upper surface.
TWA	N7035T (1231)	Apr. 29, 1982	July 19, 1983	4190	1123	9.7	LH Part: No damage or defects. Minor paint loss noted. RH Part: No damage or defects. Fairly extensive paint loss on lower surface; touch-up paint applied to some of this area.
Lockheed	(1001)	June 3, 1980 ⚠1	Apr. 22, 1983	340.6	52	0.32	No damage or defects, except paint chipping noted around several fasteners (6-8) on each part.
Totals				14684.2	5639		

⚠1 Date of composite aileron installation.

REFERENCES

1. Griffin, C.F. and Dunning, E.G., "Development of An Advanced Composite Aileron for the L-1011 Transport Aircraft," NASA Contractor Report 3517, February 1982.

2. Griffin, C.F., "Advanced Composite Aileron for L-1011 Transport Aircraft - Ground Tests and Flight Evaluation," NASA Contractor Report 165664, February 1981.

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15. Supplementary Notes

Langley Technical Monitor: Marvin B. Dow
First Annual Flight Service Report

16. Abstract

This report covers flight service evaluation of composite inboard ailerons on the L-1011 under Contract NAS 1-15069 for a period of 5 years. This is the first annual report of the maintenance evaluation program, and covers the period from March 1982 when the first set of ailerons entered airline service, through July 1983 when the first yearly inspections were completed.

Four shipsets of graphite/epoxy composite inboard ailerons were installed on L-1011 aircraft for this maintenance evaluation program. These include two Delta aircraft and two TWA aircraft. A fifth shipset of composite ailerons were installed in 1980 on Lockheed's flight test L-1011. A visual inspection was also conducted on these components.

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