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

Fourth Annual Flight Service Report

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BURBANK, CALIFORNIA

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FOREWORD

This report was prepared by Lockheed-California Company, Burbank, California under Contract NAS 1-15069. It is the fourth annual report covering flight service evaluation of composite inboard ailerons on the L-1011 from May 1985 when the third yearly inspections were completed, through July 1986. 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. A fifth shipset of composite ailerons was installed in 1980 on Lockheed's flight test L-1011.

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

One incident of minor damage was observed on one of the composite ailerons and was repaired. No other 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 12,051 to 14,046 hours, after approximately four years of service.

SECTION 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 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/

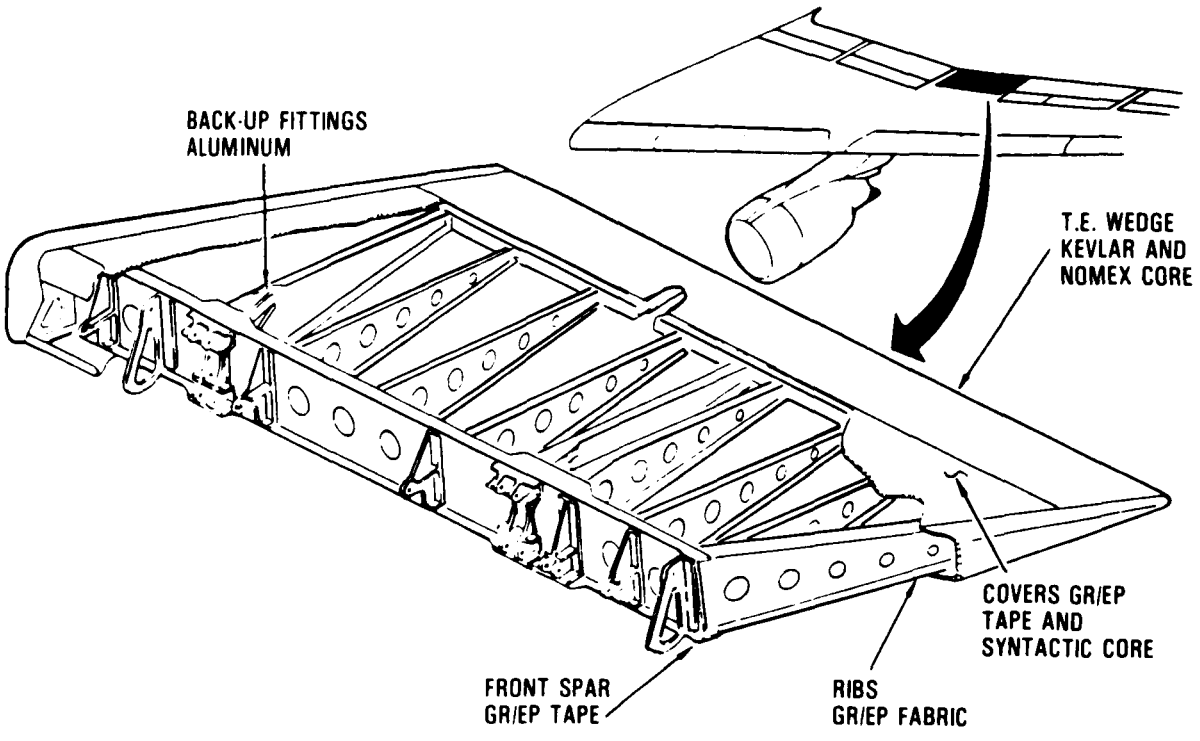

Figure 1. - Advanced Composite Aileron Assembly

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 233.7 cm (92 in.) in length and approximately 25.4 cm (10 in.)

deep. The width of the aileron is 127 cm (50 in.). 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.

SECTION 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 were installed on the Lockheed flight test airplane as part of FAA certification. These flight tests are described in the Task IV Final Report (Ref. 2). A visual inspection of the exterior and interior aileron surfaces was conducted by Lockheed personnel after the first

and second years of flight service, but the third-year inspection was cancelled since there had been only 10 1/2 hours flight-time during the previous year. This aircraft has recently undergone additional flights prior to delivery in late July 1986 to Aviation Sales Co. of Miami, Florida. Aviation Sales will use the aircraft for spares, and will thus acquire the composite ailerons. A final visual inspection was therefore performed by Lockheed personnel prior to delivery. Lockheed will maintain contact with Aviation Sales to monitor future disposition of these components.

SECTION 3
AILERON FLIGHT SERVICE EXPERIENCE

The first, second and third annual flight service inspections of the five ailerons shipsets were conducted in March through July of 1983, April through July of 1984 and April and May of 1985. the results of these inspections are given in the First, Second and Third Annual Flight Service Reports (Refs. 3, 4 and 5). No damage or defects were observed in any of the ten ailerons in those inspections.

The inspection results for the fourth year of flight service are summarized in Table 1, along with utilization rate and aircraft flight-hours and landings as of the inspection date for the composite ailerons. A total of 106,066 component flight-hours were accumulated through July 1986 on the ten installed ailerons. The high time ailerons have accumulated 14,046 flight hours in four years.

The fourth annual visual inspections of the composite ailerons revealed only one minor damage incident on the ten components. This was an area of delaminated and loose surface fibers on either side of one fastener along the forward edge of the left-hand aileron lower surface on the Lockheed flight test airplane. This fastener was near the area where the outboard hinge actuators attach to the front spar and main rib. The delaminations were approximately 3.8 cm. (1 1/2 inches) long by 1.3 cm. (1/2 inches) wide, and were evenly spaced on either side of the fastener equidistant between it and the adjacent fasteners. This damage was of minor nature and was repaired by application of an epoxy resin to bond the fibers back into place followed by repainting.

Minor paint loss was observed on all the ailerons, and touch-up paint was applied in some cases. Extensive paint loss (15-20%) was noted on the lower surface of one TWA component and on the upper surface of one of the Lockheed components. In addition, Delta reported repainting of all surfaces of one

aileron shipset in November 1985, after poor paint surface condition was noted. Paint chipping around fasteners was noted on most surfaces to varying degrees. There was also evidence of Skydrol exposure in most cases, particularly along the main rib attachment locations directly aft of the actuators.

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 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. Lockheed and airline maintenance personnel were advised of the need for repainting of exposed graphite/epoxy, particularly on the upper surface.

There was one instance of minor damage to components which are part of the inboard aileron assembly, but which are not made of graphite composite material. A small damage area was noted on a fiberglass end fairing on one of the Delta components. This was repaired by scarfing 3.8 cm. (1 1/2 inches) around the damage, and applying two layers of 181 glass cloth impregnated with epoxy resin. The repair was cured at room temperature, and then finished to match the component. This incident does not reflect on the graphite aileron serviceability, but is indicative of the potential for in-service damage of this component and also illustrates a suitable repair scheme for repair of negligible damage on the graphite components.

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

TABLE 1. CUMULATIVE FLIGHT SERVICE SUMMARY - FOURTH YEAR

Operator	Aircraft Tail No. (Lockheed Serial No.)	Date of Delivery	Date of Inspection	Cum. Flt-Hrs at Inspection		Cum. Landings at Inspection		Util. Rate (Hrs/Day)	Inspection Results Third Annual Inspection	Inspection Results Fourth Annual Inspection
				3rd Annual Insp	4th Annual Inspec	3rd Annual Insp	4th Annual Inspec	Four Yrs Flt Svc Period		
Delta	N736DY (1227)	Mar 11, 1982	Apr 28, 1986	9631	12,531	5287	6820	8.3	No discrepancies observed on either part.	No defects or damage to graphite components. Surface damage on fiberglass end fairing noted and repaired. Parts repainted Nov 1985.
Delta	N737D (1228)	May 8, 1982	Apr 22, 1986	8787	12,051	4769	6431	8.3	No discrepancies observed on either part.	No discrepancies observed on either part
TWA	N8034T (1230)	Apr 7, 1982	May 9, 1986	10,600	13,943	2691	3618	9.3	No defects or damage to the graphite component. Paint chipping upper and lower surfaces, torn lightening hole covers observed on both parts.	No defect or damage to graphite components Paint chipping noted on all surfaces.
TWA	N7035T (1231)	Apr 29, 1982	May 19, 1986	10,804	14,046	2718	3626	9.5	No defects or damage to the graphite component. Paint chipping noted on upper and lower surfaces of both parts, including a small area around nearly all fastener holes. Torn lightening hole covers on both parts, plus two missing covers on LH part.	No defects or damage to the graphite components. Paint chipping noted on all surfaces, with 20% loss noted on lower surface of RH part.
Lockheed	(1001)	June 3, 1980 (1)	July 3, 1986	376	462	295	360	0.21		Loose fibers noted around one fastener on forward edge, lower surface of LH part. Paint chipping noted on all surfaces, with 15% loss on upper surface of LH part.
	Totals			40,198	53,033	15,760	20,855			

(1) Date of composite aileron installation

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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.

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5. Stone, R.H., "Flight Service Evaluation of Advanced Composite Ailerons on the L-1011 Transport Aircraft - Third Annual Flight Service Report," NASA Contractor Report 177960, July 1985.

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15. Supplementary Notes

Langley Technical Monitor: Marvin B. Dow
Fourth 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 five years. This is the fourth annual report of the maintenance evaluation program, and covers the period from May 1985 when the third yearly inspections were completed, through July 1986.

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.

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