Lockheed L188C, G-LOFA

AAIB Bulletin No: 5/97 Ref: EW/A96/7/2Category: 1.1

Aircraft Type and Registration:	Lockheed L188C, G-LOFA
No & Type of Engines:	4 Allison 501-D13 turboprop engines
Year of Manufacture:	1959
Date & Time (UTC):	30 July 1996 at 1941 hrs
Location:	Near Berlin Schonefeld Airport, Germany
Type of Flight:	Cargo
Persons on Board:	Crew - 5 - Passengers - None
Injuries:	Crew - None - Passengers - N/A
Nature of Damage:	Localised tearing of structure and failure of rivets in region of freight-door aperture, distortion of crown skin, failure of door operating mechanism and damage to door securing shoot bolts. Flattening of forward end of dorsal fin
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	5,880 hours (of which 850 hours were on type)
	Last 90 days - 145 hours
	Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Investigation authority

The accident notification and initial investigation was carriedout by the German authorities. However, as the aircraft and crewwere based in the United Kingdom and the aircraft was due to bereturning to its home base at Coventry Airport after temporaryrepair, the AAIB offered to complete the investigation. Subsequently,in accordance with Chapter 5.1 of Annex 13 to The Convention onInternational Civil Aviation, the German authorities delegatedthe investigation to the United Kingdom.

History of the flight

The crew arrived at the aircraft at 1850 hrs for a planned flightto Cologne-Bonn; they had operated the aircraft on the previousflight from Cologne-Bonn and had spent the day resting in an hotel. In

addition to the normal complement of commander, first officer,flight engineer and ground engineer, there was a trainee flightengineer with the crew. When they arrived at G-LOFA, the groundstaff were around the aircraft, the doors were shut, externalpower was connected and steps were adjacent to the crew door.

While the flight crew went to the cockpit to complete their normalpre-flight duties, the ground engineer carried out a daily maintenancecheck and signed for this in the aircraft Technical Log. Theflight engineer and his trainee also went to the cockpit wherethe flight engineer demonstrated his duties to the trainee. Oncethe company handling agent had been to the cockpit to inform thecommander that loading was complete and had left with his copiesof the Technical Log entry and Load Sheet, the commander initiatedthe pre-start checks. As he did so, the ground engineer enteredthe aircraft and closed the crew door; he had confirmed that theother external doors were shut by ensuring that they were flushwith the fuselage and confirmed that the appropriate door openindicating lights were not illuminated on the instrument panel.

For the subsequent engine start and flight, the flightcrew occupied their normal seats while the trainee flight engineerwas in the cockpit 'jump seat' and the ground engineer was inthe courier seat (located between the flight-deck bulkhead andthe 9G cargo bulkhead). The cockpit door was open in accordancewith normal company regulations with the courier seat occupied. Engine start was normal and no abnormal indications were notedthen, or during the subsequent taxiing to Runway 25. Pre take-offchecks were completed and the commander, as handling pilot, carriedout the take-off and established the aircraft in the climb. Theafter take-off checks were completed and during these, the flightengineer confirmed that pressurisation was satisfactory; the aircraftwas pressurising in accordance with his selection. As these checkswere being actioned, the ground engineer went back to the cargocompartment.

As the aircraft climbed through Flight Level (FL) 60, the groundengineer came back to the cockpit and informed the commander thatthere appeared to be 'smoke' in the cargo compartment. The crewchecked the appropriate systems, but detected no warnings. Onthis aircraft, the 'cargo smoke' warning light was immediatelyadjacent to the 'cargo door open' warning light located in frontof the first officer. Shortly afterwards, as the aircraft waspassing FL 115, with the ground engineer in the cockpit and thecockpit door shut, there was an explosive decompression. Thecockpit door detached from its hinges and the cockpit filled withfine debris. The aircraft rolled right, pitched down and thecrew were immediately conscious of significant airframe vibration. With the aircraft in cloud, the commander regained level flightusing minimum and gentle control inputs. As he did so, the othercrew members were making a thorough check of the aircraft systems. The flight engineer prepared to activate the crew oxygen but,with the aircraft descending below FL 100, decided that it wasnot required. The only apparent problem was the loss of aircraftpressurisation, but the commander was concerned about structuralintegrity. He therefore instructed the first officer to ask forradar vectors and a priority return to Schonefeld, and then commenceda shallow turn back towards the airfield.

As the flight crew were carrying out these actions, the groundengineer went back to the cargo compartment to ascertain whatdamage had occurred. There was cargo positioned close to thecargo door but the engineer was able to see daylight where thedoor should have been. As he got closer, he could see the doorjacks still connected between the frame and the door, and estimatedthat the door was then open by approximately one foot. However,after moving closer to the open door, he became aware that thedoor jacks and door were no longer visible. From his position,he could partly see the left stabiliser and observed no obvioussigns of damage. He then returned to the cockpit and reportedto the commander that the cargo door was open.

By this time, the commander had established on track to Schonefeldat 180 kt. The vibration, although still significant, had reducedslightly. ATC offered the crew radar vectors for an approachto Runway 25 but taking into account the light surface windthe crew requested, and were granted, the more expeditious approachto Runway 07. For the recovery, the normal checks were completedapart from the decision to use less than full flap. This wasselected gradually and at 78% flap, speed was reduced to 150 ktand the landing gear was lowered. With no control problems evidentin this configuration, the commander decided to use 78% flap forlanding and the appropriate threshold speeds were calculated. The subsequent landing on Runway 07 was uneventful and the cargodoor swung back into view as the speed reduced on the runway. After parking the aircraft on stand and securing the engines,the crew noted that the 'cargo door unlocked' light was stillnot 'on' and that the main annunciator door warning light onlyilluminated when the crew door was opened.

The commander then disembarked from the aircraft and went to theopen cargo door. He noted that the external door warning lightlocated beside the cargo door was illuminated. On returning tothe cockpit, he noted that the 'cargo door unlocked' warning lightstill appeared to be unlit but, as he touched it, he became awarethat it was illuminated but that its brilliance could be variedfrom 'full off' (where it had been set) to 'full bright'.

Subsequent enquiries revealed that the cargo door was closed bya member of the airport ground staff. He was certain that thedoor had been correctly closed and that the adjacent external'door unlocked' warning light had gone out.

Door design

The freight door on the aircraft was one of a variety of designson Lockheed L188 aircraft on the British register, being a SupplementaryType Certificate (STC) modification of the original passenger-carryingL188, under STC number ST 852SO . It is understood to be thelargest of the door designs available and is both actuated andlatched by an electro-hydraulic system controlled normally froma switch under a hinged panel on the outside of the fuselage,near the door.

The door is hinged at the top and is secured in the closed positionby a system of seven horizontal 'shoot-bolts' mounted at the junctionof the fuselage side and the cabin floor. These are hydraulicallydriven and pass through a system of lugs attached to the doorsill. When the door is fully closed, the shoot-bolts engage ina set of corresponding lugs attached to the lower ends of sevenframe members within the door structure. Thus the hoop loadsdue to cabin pressurisation are carried across the door aperturewhen the aircraft is in flight.

Two lights should be located under the hinged panel beside theexternal door operating switch, one of which should illuminatewhilst the hydraulic door operating motor is running, the otherilluminating whilst any of the door latching shoot-bolts are notfully engaged.

Aircraft examination

Examination of the aircraft showed that the door had not beenfully latched at the time of departure, *ie* the seven taperedshoot-bolts were only partly engaged. The hoop loading due topressurisation had become sufficient, as the aircraft climbed,to effectively 'guillotine-off' the small diameter ends of thebolts and thus release the door. Extensive damage to the fuselagestructure in the area of the door aperture had occurred, and failureof the door operating mechanism had allowed the door to overtravelopen to such an extent that the foremost section of the dorsalfin had been 'flattened' by

door contact and numerous rivets hadfailed in the fuselage structure. Local tearing of structuralmembers had also occurred.

Door mechanism and warning system

A detailed study of the door showed that it was of a design whichcould not be reliably checked for correct security from outside. Opening, followed by re-closing and latching of the door illuminatesand then extinguishes the door-latched light beside the operatingswitch to indicate that the door has correctly sequenced to thelatched condition, with all seven bolts fully engaged. Once thedoor is closed, however, the shoot-bolts cannot be viewed fromoutside the aircraft and the relevant area inside the fuselagecannot be accessed if the rear of the hold is occupied by freightcontainers.

The associated cockpit warning in the STC modification consistedof the routing of the 'freight door unsafe' warning signal throughthe 'cabin doors unsafe' annunciator light.

The arrangement of the system on G-LOFA contained a number ofmodifications relative to the STC design standard and also containedsome wiring changes which had either been made after the STC modificationwas complete, or were the result of failure to fully incorporatethe STC features.

In particular, the wiring of the 'freight door unsafe' signalto the 'cabin doors unsafe' annunciator was completely absent,although a dedicated 'freight door unsafe' warning light, originallypositioned beside the crew entry door (along with an alternativeoperating switch, which had been deleted at some time prior tothis accident) had been re-positioned on the co-pilot's panel. This light had a dimming facility which had the ability to dimto such an extent that the light filament could become completelyobscured. The light could thus be 'ON', yet not visible to thecrew. Its 'press to test' facility, a feature of the STC modification,was also totally absent from this aircraft and there was thusno ready means of realising that the light was set to the 'bulbfully obscured' position.

Under all normal sequences of aircraft operation, the forwardcrew entry door would have been closed last, and so there werenormally no circumstances when the crew would have been in thecockpit with the freight door open and all other doors closed. The absence of any warning on the 'freight door unsafe' annunciator,when the freight door was open or not correctly latched, wouldtherefore never have been evident to any crew members.

The second of the two lights beneath the external hinged panel,intended to illuminate when the hydraulic motor was running, wasabsent from the aircraft.

Documentation

The Electra 188 C Operating Manual, a copy of which was held inthe aircraft, incorrectly stated that the 'doors unsafe' annunciatorwould illuminate if any cabin door was not closed and latched. This statement not only failed to draw attention to the factthat the freight door warning was not connected to the annunciatoron G-LOFA, but was ambiguous in failing to mention that the rearemergency door (on the right side) was also not monitored by theannunciator system. This last discrepancy appears to have existedin the Operating Manual since it was written for the originalpassenger aircraft in 1959.

A Flight Manual Supplement covering the freight door modificationincluded a wiring schematic diagram which showed the 'freightdoor unsafe' signal as passing through the 'cabin doors

unsafe'annunciator. In this respect it agreed with the STC design standardbut did not reflect the modification standard of G-LOFA.

Modification status

The STC modification incorporating the freight door on G-LOFAwas designed by Aeronautical Engineers Inc (AEI) of the USA. At some later date it appears to have been modified in accordancewith hydraulic and electrical system drawings produced by GeneralAir Services Inc, also of the USA, to change from a system usinga micro-switch operated sequence valve to one of a hydraulic pressureoperated priority valve to control the sequence of door closingmotion and shoot-bolt engagement. It is not known when the changesto the wiring of the warning system were made from the AEI standardor to what extent, if any, the AEI design was not fully implementedat the time the original freight door modification was incorporated.

In summary, the study of the STC and details of its implementationon G-LOFA showed that:

1 The STC door design presents considerable difficulties in establishingreliably the state of door security after closure.

2 The wiring of the door warning system differed from that inthe STC and from the schematic in the Flight Manual Supplementfor the freight door. Some of these wiring differences underminedthe logic of the warning arrangements.

3 The dedicated warning light on the co-pilot's panel was designedso that its 'dimming' function could be adjusted such that itcompletely obscured the warning, yet had no placard warning tothat effect.

4 Important safety related information in the Electra 188 C OperatingManual on board the aircraft was incorrect.

Safety Recommendations

In view of the potentially critical consequences that can arisefrom the in-flight opening of aircraft doors, and since this eventcould have resulted in a serious accident, the following SafetyRecommendations have been made to the CAA and FAA.

96-66: In order to prevent the freight doors on LockheedL188 Electra freighter aircraft from opening in flight, as a resultof failure to ensure correct latching of such doors before flight,the CAA should require that the following safety action is appliedto all such aircraft on the UK register, and the FAA should requirethe same safety action for all other such aircraft worldwide:

1 An inspection to confirm that the 'cabin-doors unsafe' annunciatorilluminates when the freight door is not in the closed and fullylatched condition, and when all other cabin doors are in a fullysafe condition.

2 An examination of any wiring diagrams or schematics of the doorwarning system in L188 Flight Manual supplements and MaintenanceManuals to confirm that they correctly represent the state ofthe wiring of the individual aircraft to which they apply, arein accordance with an FAA approved design and have been the subjectof a design safety analysis.

3 The revision of the Electra 188C Operating Manual to identifyany door(s) which are not monitored by the 'cabin-doors unsafe'annunciator once the above actions have been carried out.

4 Consideration be given to providing a clear physical warning,in addition to the existing locks unsafe light, of the absenceof correct lock engagement, visible from outside of outward openingfreight doors on L188 freighter aircraft.