No: 6/92 **Ref: EW/C92/3/1** **Category: 1a**

Aircraft Type and Registration:	Lockheed 1011 Tristar, 9Y-TGJ
No & Type of Engines:	3 Rolls-Royce RB211 524 B4 02 turbofan engines
Year of Manufacture:	1979
Date & Time (UTC):	9 March 1992 at 1450 hrs
Location:	Near KIRN VOR, Germany
Type of Flight:	Public Transport
Persons on Board:	Crew - 12 Passengers - 173
Injuries:	Crew - None Passengers - None
Nature of Damage:	Major portion of No. 1 engine thrust reverser translating cowl detached, scoring of adjacent wing top and bottom surfaces and severe damage to No. 3 segment of the left horizontal stabiliser leading edge.
Commander's Licence:	Airline Transport Pilot's Licence (Republic of Trinidad & Tobago) first issued 23 November 1973; reissued 15 May 1986; valid until 14 May 1996
Commander's Age:	52 years
Commander's Flying Experience	12,903 hours (of which 4,000 were on type) Last 90 days - 90 hours Last 28 days - 50 hours
Information Source:	AAIB Field Investigation

History of Flight

On arrival at the L1011 aircraft at Frankfurt, the flight engineer saw in the technical log that the number one engine thrust reverser had been "locked out" inhibiting its use. During his subsequent walk round of the aircraft the ground engineer told him that a thrust reverser "blocker door" on the number one engine was hanging down and that it would have to be removed prior to the flight to St Lucia. This deficiency was permitted by the Configuration Deviation List (CDL). When the ground engineer had completed the job the flight engineer checked that all of the screws connecting the thrust reverser translating cowl to its leading edge ring were in place. A full power take-off was made out of Frankfurt at 1435 hrs. On climbing through FL 100 there was a bang accompanied by what seemed like a compressor stall and the aircraft shuddered. The first officer was the handling pilot; he called "engine failure No. 1 engine". The commander noted that it had not failed but that the N1 on the

number one engine had fallen and was now running back up to normal and that the EPR had stabilised below normal at 1.2 compared with 1.55-1.60 on the other two engines. There was slight vibration. The commander kept the No. 1 engine running for five to six minutes, including a period at flight idle, and then shut it down. During that period he received a passenger report that a 'bit' had come off the engine. The commander discussed his intentions with the company's ground handling staff at Frankfurt on the radio and decided that, taking into account the time needed to reduce his aircraft's weight to below the maximum landing weight, it would be preferable to divert to London Heathrow (LHR). His reasoning was that as LHR was the company's main European maintenance base he would get a better technical response to the aircraft's problem there. He elected to maintain FL140 for the flight to LHR and to dump fuel to get below maximum landing weight as soon as practicable. The commander and flight engineer carried out a visual inspection of the No. 1 engine and concluded that the thrust reverser translating cowl had become detached but no other damage was visible.

On arrival in UK airspace the first officer flew the aircraft round a race track pattern, as advised by ATC, while fuel was jettisoned Only one of the two fuel pumps in the No. 1 fuel tank was working so the jettison rate was almost halved from 1595 lb/min to only 990 lb/min. The result was that not only did it take much longer to jettison the required amount of fuel but an imbalance became apparent just prior to landing. While the fuel was being jettisoned a passenger reported that there was damage to the left horizontal stabiliser. He had actually seen it at the time of occurrence but had not mentioned it until he thought its condition had deteriorated. This information, coupled with the length of time it was taking to jettison the fuel, convinced the commander that an overweight landing should be made. The request for an immediate approach was made to London Air Traffic Control Centre (LATCC) but no emergency was declared. During the crew briefing the commander was interrupted by ATC instructions and frequency changes. At one point ATC passed on a message to the commander, from the British Airports Authority, that he should divert to London Stansted airport although no reason for this request was given. The Tristar commander maintained his intention to land at LHR.

On the descent through 7,000 feet the landing gear was selected down but the commander decided to keep the aircraft flaps up until later in the approach. The two main wheel green lights were obtained but the nose wheel indication displayed red DOOR and TRANSIT lights, indicating it was not locked down. All of the hydraulic indications were normal so the commander asked for Manual Gear selection, which was successful, at which time the aircraft was approaching the outer marker, about three miles from touchdown. At that point an air traffic control officer noticed that the aircraft was still dumping fuel and advised the commander of the fact. An overweight landing was made 28,000 lb above the normal maximum landing weight of 372,000 lb. On landing the DLC AUTO SPOILER fail light illumunated and the automatic spoilers did not function. A manual selection was made and on turning off the runway a RESERVOIR HI TEMP light illuminated on the C hydraulic system and the

quantity showed ¼ full. The airport fire service which had been brought up to "runway standby" despite the fact that no emergency had been declared by the commander, inspected the aircraft and gave the commander the "all clear" to continue taxiing to his stand.

Maintenance History

During landing at London Heathrow on 7 March, two days before the accident, it was found that reverse thrust could not be obtained on No. 1 engine; the thrust reverser 'IN TRANSIT' light illuminated and would not extinguish. The airline's duty ground engineer found the reverser's translating cowl to be jammed about mid-way in its traverse and distorted. He informed his airline's operations control that he aircraft would not be ready for its next scheduled departure and, supervising the assistance of engine ring staff from another airline which was under contract to provide servicing support, he began a systematic process to free the cowl and achieve a safe stowed and locked condition.

The thrust reverser was of the Rolls-Royce 'standard weight' type, driven by an air motor through a closed loop flexible drive system the connecting six gearboxes and screwjacks (see attached Figs.). In the process of investigating and manipulating the cowl the team disconnected the dual flexible drives from the air motor and found that the drive from the left hand output of the air motor was broken. Attempting to move the cowl through its manual drives at jacks Nos 2 and 5 they observed that jacks Nos 4 and 6 appeared to be jammed. They disconnected the drive into No. 6 gearbox and found that it had failed (the failure was later found to be at the air motor end of the drive). They also isolated No. 4 gearbox by disconnecting its associated drives on either side at Nos 5 and 3 gearboxes. At Nos 4 and 6 screwjacks they detached the ball nuts, which translate along the screws, from the cowl itself whereupon the distortion in the cowl straightened out and they were able to wind the cowl manually to the fully deployed position. The ball nut on No. 6 jack was still not free to move on the screw and so a cascade vane box was removed to give access and the flexible drive on the inboard side of No. 6 gearbox was disconnected (where the drive was later found to have failed). It then proved possible to wind No. 6 ball nut and also No. 4 ball nut to their fully forward positions and the vane box was refitted. When an attempt was made to wind the cowl forward for stowing and locking its movement became stiff and it again jammed. A cascade vane box was again removed for access and the drive into No. 1 gearbox disconnected. The cascade vane box was re-installed and the reverser was successfully wound to the fully forward position where both latches engaged.

The procedure for 'locking out' the thrust reverser was then completed; locking pins were inserted at Nos 2 and 5 gearboxes and at the Pressure Regulating and Shut Off Valve (PRSOV) and a baulk was installed on the inboard pneumatic lock actuator. In the cockpit the No. 1 thrust reverser lever was

wire locked down and the thrust reverser lever and the 'REVERSER PRESSURE' light on the flight engineer's panel were labelled 'DE-ACTIVATED'. The aircraft was declared serviceable, a description of the work carried out was entered in the Technical Log and an entry made in the 'Deferred Defects Control Sheet'. The engineer made a telephone call to the airline's Maintenance Control Centre at the main maintenance base at Port of Spain in Trinidad to inform them of the actions taken. In addition to the standard aircraft departure telex he also sent a separate signal describing the actions taken and asking for an inspection of the reverser to be carried out when the aircraft arrived at Port of Spain. The entry made in the Deferred Defects contained a specified time limit for rectification of 10 days from the time of the entry. This was derived from the Lockheed Master Minimum Equipment List Procedures Manual for the case where a thrust reverser is locked out and is unuseable (Repair Interval - Category C).

9Y-TGJ had completed six further sectors and a total of 30 flying hours when it arrived at Frankfurt on 9 March. On his post flight inspection the ground engineer observed that the thrust reverser was still locked out and he saw that a blocker door in the top left hand side of the reverser, *ie* adjacent to the disconnection between the translating cowl and the No. 6 screwjack ball nut, was unattached at its forward end. He found that the front attachment finger between the blocker door and the cowl had fractured and assumed that this failure was the result of damage dating from the previous jamming incident when the cowl had suffered visible distortion. He removed the blocker door and made appropriate entries in the Technical Log and the Deferred Defects Control Sheet. It was on the following flight out of Frankfurt that a major portion of the cowl detached.

Maintenance and Operational Procedures

The Lockheed Master Minimum Equipment List Procedures Manual is the manufacturer's document which advises operators of procedures which will enable them to operate the aircraft within the constraints of the mandatory Federal Aviation Administration Master Minimum Equipment List (MMEL). The MMEL Procedures Manual permits one thrust reverser to be inoperative provided it is locked out and secured according to the procedures laid down in the Lockheed or Rolls-Royce Maintenance Manuals and appropriate operational procedures are observed.

If the inoperative reverser is the result of a malfunctioning cowl screwjack then the MMEL Procedures Manual permits one screwjack, only No. 3 or No. 4, to be removed and it is not permitted therefore that No. 6 be removed. If the translating ball nut on a jack is detached from the cowl then, even if the jack is not removed one of its functions, structural support of the cowl, is eliminated.

The Rolls-Royce manual contains advisory troubleshooting and corrective procedures. For the case where the reverser partially extends these procedures lead to the replacement of screwjacks or flexible drives where any are found defective.

The Configuration Deviation List (CDL) in the Tristar Flight Manual (UK version applies to 9Y-TGJ) contains additional limitations for operation of the aircraft without certain secondary airframe or engine parts. The CDL allows one blocker door to be missing on each engine and operational restrictions apply. Up to three doors can be removed from a reverser if it is locked out.

Examination of Wreckage

The German authorities recovered wreckage in the locality of Kirn, 45 nautical miles west-south-west of Frankfurt Airport and made arrangements for it to be sent to the UK where it was examined together with the rest of the engine. The cowl was in two major parts and a number of small fragments.

The engine and aircraft were first examined at Heathrow. It could be seen that there were score marks and indentations on the undersurface of the wing immediately inboard of the No. 1 pylon and also some score marks on the wing leading edge above the pylon showing that some debris had gone over the top of the wing. Horizontal stabiliser damage was restricted to the No. 3 structural segment of the left leading edge but that segment had been disrupted leaving a large ragged hole.

The structure of the translating cowl comprises a leading edge ring (interrupted by the pylon) which is attached through the ball nuts to the screwjacks which themselves transfer cowl loads to the engine. A double skin structure is attached to the ring and provides the sealing of the bypass duct. The blocker doors do not seal the periphery of the bypass duct when the reverser is stowed and it is the cowl which sustains the duct pressure loads. Finger brackets attach the front, translating, end of the blocker doors to the cowl ring. When reverse thrust is selected the screwjacks open the cowl which, in turn, folds the blocker doors rearwards to block the cold nozzle.

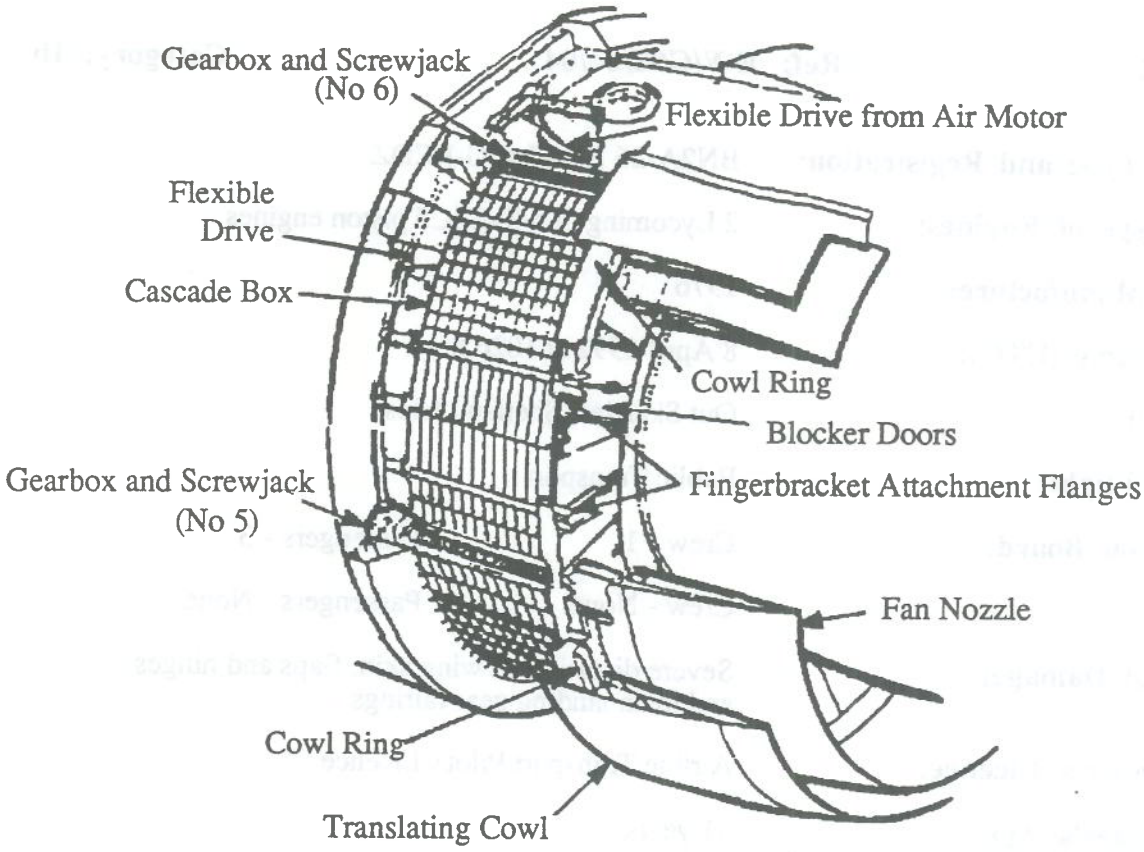
Examination of the engine and the recovered cowl parts showed that the failure and separation of the cowl had begun with the loss of structural support from the No. 6 ball nut attachment when it was disconnected on 7 March. As the unsupported end of the cowl deflected under bypass pressure the next point of support was the attachment finger bracket of No. 15 blocker door; the blocker door itself would have been pulled outwards until it contacted the cascade vanes. It was this finger bracket which was found failed (in overload) at Frankfurt. The cowl was then restrained by the next blocker door finger bracket, No. 14, which separated from the cowl through failure of its attachment flanges during take-off or climb from Frankfurt. During the progressive bracket failures the maximum bending

moment in the unsupported end of the cowl would have been rapidly increasing (by a factor of, roughly, 6 with the failure of the first finger bracket and 16 with the failure of the second). The cowl structure finally collapsed in outward bending at the point of the next finger bracket just short of No. 5 jack whose gearbox contained one of the reverser's two stowing locks. This collapse resulted in the rest of the ring structure remaining in place and the other blocker doors remaining locked stowed; the one blocker door which had been liberated in the cowl separation sequence was free to slide to any position between its normal stowed position and its bypass blocking position. Though the cowl's main structural ring separated at the point of collapse the double skin assembly attached to it continued to detach around the reverser's whole periphery. The skin assembly had also broken part way around the periphery and had probably left the aircraft as two main pieces together with the smaller fragments found on the ground. At either end of the cowl outer skin some heavy abrasion and distortion was found which probably corresponded to the impacts with the wing and stabiliser.

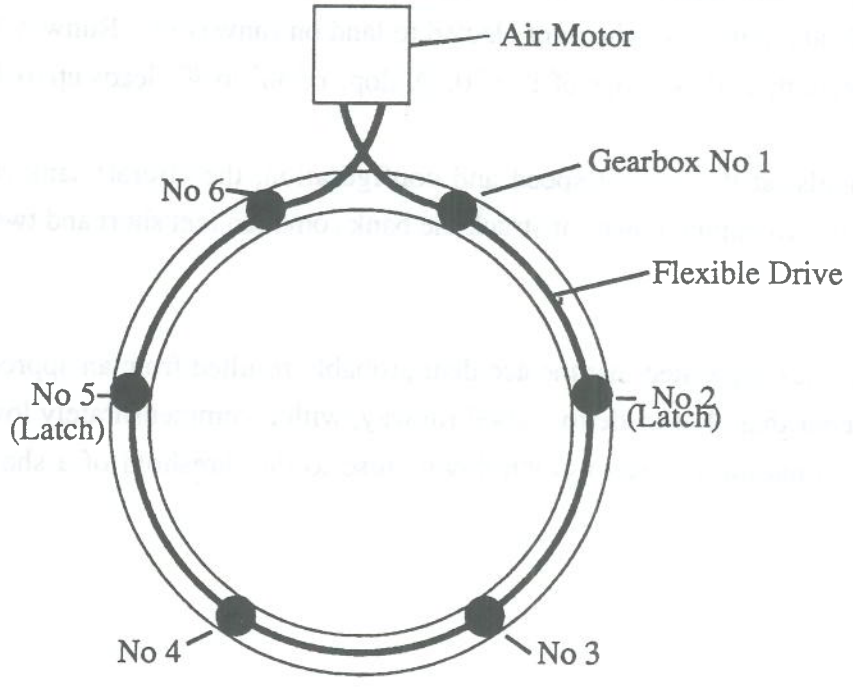
Safety Actions

Rolls-Royce have circulated two notices to operators describing the circumstances of the cowl detachment and are reviewing the engine Maintenance Manual to determine what changes in instructions and in the supporting descriptive material are appropriate to support the requirements of relevant MMEL's and Dispatch Deviations Procedures Manuals.

The Chief Inspector of Air Accidents has ordered a Formal Investigation into this accident under the provisions of The Civil Aviation (Investigation of Air Accidents) Regulations 1989.



Rolls-Royce RB211 Standard Thrust Reverser



Translating Cowl Gearbox and Screwjack Positions
Viewed from Rear