MINISTRY OF DEFENCE

Military Aircraft Accident Summary of a Royal Air Force Board of Inquiry

Aircraft:	Tornado GR1 ZD845
Date of accident:	26 February 1996
Place of accident:	9 nm southeast of RAF Laarbruch, Germany
Casualties:	1 major, 1 minor

Synopsis

1. Tornado GR1 ZD845 from RAF Brüggen was engaged on a flight test sortie when a fault developed in the right-hand engine. This was followed by indications of a number of seemingly unrelated failures and cockpit warnings which led the crew to diagnose that a fire had taken hold in the rear fuselage. Some nine minutes later, the aircraft stopped responding to the crew's control inputs and they ejected, the aircraft crashing into a wood some 9 nm southeast of RAF Laarbruch. In spite of an exhaustive investigation, the Inquiry was unable to determine positively what had led to the fire, but considered that failure of a clutch mechanism situated between the two engines was the most likely cause.

Background

2. From July 1995 to February 1996, ZD845 was used for ground training at RAF Brüggen. Because of the length of time spent on the ground, and the fact that both engines and a number of avionics units had been removed, it was considered prudent to carry out a full air test schedule on ZD845 once it was recovered for flying duties. The first air test was carried out on 19 February 1996, during which the right-hand engine failed to maintain windmilling

RPM when it was shut down prior to checking the airborne relight systems. (When a jet engine is shut down, normally by stopping the supply of fuel, the engine continues to rotate, or 'windmill', at a rate dependent on aircraft speed and attitude.) The crew, suspecting a possible engine malfunction, terminated the air test and began to recover the aircraft to RAF Brüggen. However, during the recovery, the right-hand engine RPM increased from zero and stabilised to indicate normally windmilling RPM. Exhaustive engineering checks failed to find the reason for the fault, and eventually, satisfied that the engine was safe for flight, the aircraft was released for a further air test a week later. A different crew was tasked and, fully briefed on the events a week earlier, they were detailed to carry out a number of tests, including a repeat of the unsuccessful test of the airborne relight system.

Circumstances

3. Some 15 minutes into the flight and after a number of tests had been completed successfully, the crew began to carry out the test of airborne relight system. However, as had occurred the previous week, the right-hand engine RPM again fell to zero once the engine was shut down. As a result, the crew terminated the air test and positioned the aircraft for recovery. However, about eight minutes after the engine was shut down, the RPM increased to indicate the correct windmilling RPM as it had also done on the earlier test sortie. The crew decided to relight the engine and continue with the rest of the air test schedule. The right-hand engine responded normally during the next relight sequence, but during a third test, the RPM again fell to zero. Believing the fault might be time-related, the crew decided to wait to see if, as in the previous incidents, the RPM recovered to the normal value.

4. As the crew waited, the audio attention-getters sounded in the cockpit, and the pilot noticed that pressure in one of the two hydraulic systems was decreasing. The crew declared an emergency and set a heading for RAF Laarbruch, the nearest diversion

airfield. Shortly afterwards, most of the cockpit warning captions indicating failure of the fly-by-wire control system illuminated, as did the Auxiliary Power Unit caption. The crew diagnosed a rear fuselage fire. During the recovery to RAF Laarbruch, a number of other warning captions illuminated indicating that the fire was spreading and, realising that the aircraft was no longer responding to control inputs, the pilot ordered that the aircraft be abandoned. The ejections were carried out successfully, and the aircraft crashed into a wooded area about a mile northwest of the town of Issum.

Rescue operation

5. Both crewmen were assisted on landing by civilians before being transferred to a local hospital by ambulance. Despite sustaining a blow to the head during the ejection sequence which caused him momentarily to lose consciousness during his descent, the pilot sustained only minor injuries. The navigator landed awkwardly and broke his ankle, his injuries being classified as major.

Aircraft damage

6. The aircraft was destroyed, although the wreckage was recovered for inspection.

Investigation

7. The Inquiry was able to draw on evidence from the aircraft's Accident Data Recorder, a technical inspection of the wreckage carried out by the Department of the Environment, Transport and the Region's specialist Air Accidents Investigation Branch (AAIB), ZD845's maintenance records, and the statements of the both crews who had flown the aircraft during the air tests. The Inquiry was able therefore to discount structural failure, taileron actuator failure and hydraulic failure as possible factors in the accident, as well as mishandling, disorientation and maintenance error.

8. Initially, the Inquiry felt that the right-hand engine malfunction and subsequent loss of control may have been connected. A strip examination of the engine was therefore carried out and this showed evidence that the rotating and static parts of one of the turbine seals had been rubbing together. This action could have resulted in metal transfer, which the Inquiry considered would have restricted windmilling RPM. Moreover, repeated relight attempts would only have exacerbated the problem by increasing the rate of metal transfer. The Inquiry considered that, as the Tornado is capable of operating on a single engine, this fault in isolation was insufficiently serious to have led to the control loss. However no other major engine faults were detected and the Inquiry therefore concluded that the engine malfunction was not a factor in the accident.

9. The Inquiry turned its attention to determining the cause of the rear fuselage fire and, from examination of the wreckage, it was clear that the area housing fuel and hot air pipes, wiring looms (including those transmitting flight control signals) and the mechanical control rods for use should the fly-by-wire system fail, had suffered severe heat damage. It was also evident that the fire had burned through two of the four fly-by-wire control channels (the other two were inoperative because the right-hand engine was shut down) and that the ferocity of the fire had eventually burned through the mechanical controls, thereby rendering the aircraft uncontrollable. All the evidence suggested that the most likely source of the fire was in the base of an area between the two engines in the rear fuselage, known colloquially as the 'chimney'. However, despite an exhaustive investigation, the Inquiry was unable to determine positively the exact chain of events.

10. The Inquiry considered a number of possible sequences of events and, in consultation with specialist Support Authority personnel, eventually concluded that the most plausible was that the cross-drive clutch mechanism, which allows one of the engines to run the other engine's auxiliary gearbox following an engine shut down, had failed, probably because of prolonged running with

the clutch open at high differential engine settings. The Inquiry considered that this most probably ruptured a fuel pipe at the base of the chimney, which in turn started the fire. The heat generated increased pressure in a fuel dump line further up the chimney, whose coupling eventually failed, introducing an atomised fuel spray into the upper part of the chimney. This spray was then ignited by the fire lower down in the chimney, forming an intense fire around the mechnical control rods.

Safety recommendations

10. As a result of recommendations made by the Inquiry, restrictions have been introduced on the installed life of the cross-drive clutch mechanism. In addition, work is in hand to improve the integrity of the the coupling which failed around the fuel dump line, and a one-piece stainless steel flexible pipe offering improved resistance to heat has been proposed to replace the current alloy fuel dump line. To detect earlier any failures in the rear fuselage, an overheat detection system is to be installed in Tornado GR1s during the forthcoming mid-life upgrade programme, and retrofitted to all Tornado F3s. Finally, to minimise the risk of injury to crews on ejection, a new energy-absorbing head-box has been fitted to all Tornado ejection seats, and steering lines have been introduced to the current parachute. A new parachute is to be introduced in 1999 which will reduce the rate of vertical descent which, in turn, will further reduce the risk of injury on landing.

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