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**INTERIM REPORT AND SAFETY RECOMMENDATIONS**

<b>Aircraft Type and Registration:</b>	Airbus A340-642, G-VATL	
<b>Manufacturer's Serial Number:</b>	376	
<b>No &amp; Type of Engines:</b>	4 Rolls-Royce Trent 556-61 turbofan engines	
<b>Year of Manufacture:</b>	2001	
<b>Date &amp; Time (UTC):</b>	8 February 2005 at 0330 hrs	
<b>Location:</b>	En-route from Hong Kong to London Heathrow	
<b>Type of Flight:</b>	Public Transport (Passenger)	
<b>Persons on Board:</b>	Crew - 18	Passengers - 293
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	None	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	43 years	
<b>Commander's Flying Experience:</b>	7,000 hours (of which 3,100 were on type) Last 90 days -120 hours Last 28 days - 85 hours	
<b>Information Source:</b>	AAIB Field Investigation	

**Synopsis**

This report follows on from AAIB Special Bulletin S1 of 2005 which published the circumstances and facts established during the early part of the investigation. Investigative work continues and the final report will not be published before February 2006. This interim report contains safety recommendations addressed to the primary certification bodies for large transport category aircraft.

**History of the flight**

The flight was scheduled to depart Hong Kong at 1535 hrs (2335 local) on 7 February with a scheduled arrival time at London Heathrow of 0450 hrs the next day. There was one relevant entry in the technical log prior to departure; both Fuel Control Monitoring Computers (FCMCs) had

been reset at separate times on the previous sector. During the pre-flight preparation period for this flight there was one FCMC 2 and one FCMC 1 failure; the crew were able to carry out successful resets on each occasion.

The aircraft took off from Hong Kong at 1621 hrs. Shortly after takeoff there was an Electronic Centralised Aircraft Monitor (ECAM) alert advisory 'FCMC2 FAULT' displayed. There were no ECAM actions associated with this fault and the commander decided to delay any attempt at a computer reset until the aircraft had reached its cruising level. When the aircraft reached its initial cruise level the crew attempted an FCMC2 reset using the computer reset procedure in the Quick Reference

Handbook (QRH). The reset attempt was unsuccessful. There were no further fuel system warnings, cautions or messages throughout the remainder of the flight.

The aircraft was cruising at FL380 in Dutch airspace when, at 0330 hrs, No 1 engine lost power. The flight crew secured the engine and the commander decided not to attempt to relight it but to continue towards Heathrow on three engines. The flight crew noticed that the fuel contents for the inner 1 fuel tank, which feeds engine No 1, was reading zero. Suspecting a possible fuel leak, a flight crew member was sent aft to inspect the engine area from the passenger cabin but nothing unusual was seen. However, soon afterwards, the crew observed the No 4 engine power fluctuate and noticed that the inner 4 fuel tank was also indicating zero fuel contents. The commander opened all the fuel crossfeed valves and the No 4 engine recovered. A 'MAYDAY' was declared and a diversion to Amsterdam Schipol Airport was initiated.

When the diversion commenced the total fuel on board was in excess of 25,000 kg but there were significant quantities of fuel located in the trim, centre and outer wing fuel tanks. Manual fuel transfer was started by the flight crew but they did not see immediately the expected indications of fuel transfer on the ECAM. Consequently, the flight crew remained uncertain of the exact fuel status. The diversion to Amsterdam continued and the aircraft landed there without further technical problems.

### Investigative work in progress

To assist in the understanding of the events that surrounded the incident, the fuel system computers fitted to G-VATL have been installed onto a development A340-600 which will allow close monitoring and recording of the fuel system operation during all phases of flight. This, coupled with other investigative actions, may help to determine the root cause of the incident. Also, a detailed examination is underway into the presentation of fuel

system data to the flight crew during a flight, especially following a FCMC failure, and also data used by the maintenance engineers for troubleshooting following a flight in which a fuel system anomaly was discovered.

### Fuel system regulations

#### Large aeroplanes

A review of the current European EASA and US FAA regulations for large aeroplanes revealed that neither EASA CS-25 nor FAA FAR-25 contain a requirement for a low fuel level warning. The only specified requirement for fuel level is a fuel quantity indicator as quoted below:

*CS 25.1305 Powerplant instruments*

*(a) For all aeroplanes*

*(2) A fuel quantity indicator for each fuel tank.*

This basic requirement is amplified as follows:

*'CS 25.1337 Powerplant instruments*

*(b) Fuel quantity indicator. There must be means to indicate to the flight-crew members, the quantity, in litres, (gallons), or equivalent units, of usable fuel in each tank during flight. In addition –*

*(1) Each fuel quantity indicator must be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under CS-25.959;*

*(2) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators; and*

*(3) Each exposed sight gauge, used as a fuel quantity indicator, must be protected against damage...'*

Despite this lack of a stated requirement for a low fuel level warning, EASA CS-25.1309 Equipment, systems and installations paragraph c) has a generic requirement for all aircraft systems, including fuel, which states:

*“Information concerning unsafe operating conditions must be provided to the crew to enable them to take appropriate corrective action. A warning indication must be provided if immediate corrective action is required. Systems and controls, including indications and annunciations must be designed to minimise crew errors, which could create additional hazards.”*

#### **Normal, Utility, Aerobatic, and Commuter Category Aeroplanes**

A review of similar regulations for other aircraft and rotorcraft reveals that there is a requirement for a low fuel level warning on some aircraft. The requirement is contained in EASA CS-23 Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Aeroplanes:

*‘CS-23.1305 Powerplant instruments...  
... (c) For turbine engine-powered aeroplanes  
In addition to the powerplant instruments required by sub-paragraph (a), the following powerplant instruments are required:  
(1) A gas temperature indicator for each engine.  
(2) A fuel flowmeter indicator for each engine.  
(3) A fuel low pressure warning means for each engine.  
(4) A fuel low level warning means for any fuel tank that should not be depleted of fuel in normal operations...’*

#### **Small Rotorcraft**

The EASA CS-27 Certification Specifications for Small Rotorcraft state:

*‘CS-27.1305 Powerplant instruments  
... (l) A low fuel warning device for each fuel tank which feeds an engine. This device must:  
(1) Provide a warning to the flight crew when approximately 10 minutes of usable fuel remains in the tank; and  
(2) Be independent of the normal fuel quantity indicating system...’*

#### **Large Rotorcraft**

The EASA CS-29 Certification Specifications for Large Rotorcraft state:

*‘CS-29.1305 Power plant instruments  
... (4) A low fuel warning device for each fuel tank which feeds an engine. This device must:  
(i) Provide a warning to the crew when approximately 10 minutes of usable fuel remains in the tank; and  
(ii) Be independent of the normal fuel quantity indicating system...’*

The FAA regulations FAR-23, 27 and 29 are similar to the EASA regulations above.

#### **Discussion**

Large aircraft, especially those equipped with glass cockpits and computerised management systems, are very complex and to that end the flight crew have to rely on the aircraft’s systems warning them of problems. Although a low fuel level in the engine feeding fuel tanks should normally never occur (when the system is operating correctly) this investigation has shown that

when the system fails to operate correctly and if the crew are not aware of the situation, they are unable to act in an appropriate manner and prevent engine fuel starvation. It could be argued that the need to indicate fuel system failures to the crew on complex aircraft is covered by EASA CS-25 1309 paragraph c. Indeed, when the fuel control system is operating normally on the A340-600 this is true, but this incident demonstrated a need for more specific requirements for certain warnings such as low fuel level in an engine feeder tank.

Another argument for not having the requirement for a low level fuel warning could be that aircraft certified to EASA CS-25 are operated by a minimum of two flight crew and therefore at least one of these would be monitoring the fuel status. However, the flight crew have to monitor several systems at once placing more reliance on warning systems and flags to identify an impending problem. Also, with the larger aircraft, the fuel system may be used for centre of gravity control. Fuel tank feeding sequences may be complicated and some fuel tanks may be depleted and replenished frequently during a long flight. Consequently, although fuel sequencing may be automated, deviations from the correct sequence due to automation failure may be difficult to determine simply by looking at the synoptic display. Moreover, the synoptic display of the fuel system may be 'congested' and the information difficult to assimilate unless the pilots' attention is drawn to the problem area by an automatic status or failure warning.

Finally, contemporary large rotorcraft are as complex as some large aeroplanes and they are operated by a minimum of two flight crew, yet there is a requirement, in EASA CS-29, for a low fuel level warning system.

## Findings

From the above regulations it is clear that there is currently no requirement within EASA CS-25 or JAR-25 for a low fuel level warning on large aircraft. This is at variance to the smaller aircraft and to all rotorcraft which, under European regulations, require such a system as defined by the relevant EASA Certification Specifications CS-23, CS-27 and CS-29. Despite the lack of a regulation to install a low level fuel warning, most large aircraft certified to FAR-25, JAR-25 or EASA CS-25 do have an independent low fuel level warning system installed.

## Safety Recommendations

If the low fuel level warning system is not independent, it can be inhibited by a failing fuel control system. An independent low level fuel warning system would enable the flight crew to be made aware of a failure of the automatic fuel control system and enable them to act accordingly, either by taking control of the fuel system or by landing prematurely. There are two main certification agencies for very large aircraft: the European Aviation Safety Agency which has taken over responsibility for certification of large aircraft from the Joint Aviation Authorities, and the US Federal Aviation Administration. Consequently, each of two safety recommendations is addressed to both bodies.

### Safety Recommendation 2005-108

It is recommended that the European Aviation Safety Agency introduces into CS-25 the requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent of the fuel control and quantity indication system(s).

### Safety Recommendation 2005-109

It is recommended that the European Aviation Safety Agency should review all aircraft currently certified to

EASA CS-25 and JAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

**Safety Recommendation 2005-110**

It is recommended that the USA's Federal Aviation Administration should introduce into FAR-25 a requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent to the fuel control and quantity indication system(s).

**Safety Recommendation 2005-111**

The Federal Aviation Administration should review all aircraft currently certified to FAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).