Aircraft Accident Report No 4/2007

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REPORT ON THE INCIDENT TO
AIRBUS 340-642, G-VATL
EN-ROUTE FROM HONG KONG TO LONDON HEATHROW
ON 8 FEBRUARY 2005

Registered Owner and Operator:	Virgin Atlantic Airways Limited
Aircraft Type:	Airbus A340-642
Nationality:	British
Registration:	G-VATL
Location of Incident:	En-route from Hong Kong to London Heathrow
Date and Time:	8 February 2005 at 0330 hrs All times in this report are UTC

Synopsis

The incident was reported to the AAIB by the operator who in turn notified the Dutch Transport Safety Board (DTSB). A Dutch investigation was opened but the following day a formal request was made by the DTSB for the AAIB to assume responsibility for the investigation. The AAIB investigation was conducted by:

Mr J J Barnett	Investigator-in-Charge
Miss G M Dean	Operations
Mr P Sleight	Engineering
Mr M Ford	Flight Recorders

Some 11 hours after takeoff, at about 0330 hrs with the aircraft in Dutch airspace and at Flight Level 380, the No 1 (number one) engine lost power and ran down. Initially the pilots suspected a leak had emptied the contents of the fuel tank feeding No 1 engine but a few minutes later, the No 4 engine started to lose power. At that point all the fuel crossfeed valves were manually opened and No 4 engine recovered to normal operation. The pilots then observed that the fuel tank feeding No 4 engine was also indicating empty and they realised that they had a fuel management problem. Fuel had not been transferring from the centre, trim and outer wing tanks to the inner wing tanks so the pilots attempted to transfer fuel manually. Although transfer was partially achieved, the expected indications of fuel transfer in progress were not displayed so the commander decided to divert to Amsterdam (Schipol) Airport where the aircraft landed safely on three engines.

The investigation determined that the following causal factors led to the starvation of Inner fuel tanks 1 and 4 and the subsequent rundown of engine numbers 1 and 4:

1. Automatic transfer of fuel within the aircraft stopped functioning due to a failure of the discrete outputs of the master Fuel Control and Monitoring Computer (FCMC).

2. Due to FCMC ARINC data bus failures, the flight warning system did not provide the flight crew with any timely warnings associated with the automated fuel control system malfunctions.

3. The alternate low fuel level warning was not presented to the flight crew because the Flight Warning Computer (FWC) disregarded the Fuel Data Concentrator (FDC) data because its logic determined that at least one FCMC was still functioning.

4. The health status of the slave FCMC may have been at a lower level than that of the master FCMC, thus preventing the master FCMC from relinquishing control of the fuel system to the slave FCMC when its own discrete and ARINC outputs failed.

During the investigation the AAIB issued six safety recommendations. Two were published in Special Bulletin S1/2005 on 08 March 2005 and four more in an interim report published in the February 2006 AAIB Bulletin.

Findings

1. The flight crew were properly licensed, adequately rested and medically fit to conduct the flight.

2. The flight crew operated the aircraft within the limits laid down by the operator's Flight Time Limitations scheme.

3. The crew carried out all normal operating procedures in accordance with their company Operations Manual, both before and during the flight.

4. The flight crew were aware of the FCMC resets which had occurred on the previous flight sector from Sydney.

5. Before departing Hong Kong Airport the flight crew performed a successful computer reset for both FCMC1 and FCMC2.

6. The first perception of a problem, by the flight crew, was when No 1 engine lost power at 0328 hrs.

7. No 1 engine ran down due to fuel starvation when its feed tank ran dry.

8. No 4 engine started to run down due to fuel starvation as its feed tank emptied.

9. At the time of the engine rundowns there was sufficient fuel on board the aircraft for the remainder of the flight to Heathrow.

10. There was no fuel leak.

11. The arousal levels of the flight crew at the time of the engine rundown were likely to have been low.

12. Following the run down of No 1 engine, the flight crew did not review the aircraft fuel status in sufficient detail to notice the impending fuel starvation of No 4 engine.

13. The flight crew attempted a relight of No 1 engine at FL380, whereas the QRH states that the maximum guaranteed altitude for a relight is FL300.

14. No 1 engine failed to relight due to the aircraft's high altitude when the relight was attempted.

15. Because there were no timely ECAM warnings of automatic fuel transfer failures, the flight crew invoked the 'TRIM TANK FUEL UNUSEABLE' procedure from the QRH.

16. The flight crew perceived that the TRIM TANK FUEL UNUSEABLE' procedure was not working because no fuel transfer arrows were displayed on the ECAM fuel SD page and significant changes to the quantity indications were not easily identified.

17. When the flight crew perceived that fuel was not transferring manually, they resorted to iterative use of other fuel transfer failure procedures listed in the FCOM compendium of emergency procedures.

18. ATC communications were good.

19. The FDR sampling rate of FCMC faults meant that it was possible for a fault lasting up to three seconds not being recorded.

20. Automatic fuel transfer ceased at 1934 hrs which was almost 8 hours before No 1 engine lost power.

21. The automatic fuel transfers stopped due to a failure of the discrete outputs from the master FCMC.

22. After 1934 hrs, the fuel remaining in Inner fuel tanks 1, 2, 3 and 4 became the only fuel usable by each engine respectively, until the selection of manual fuel transfers.

23. There were no fuel system related flight warnings following the failure of the automatic fuel transfer system.

24. Failure of the automatic fuel transfer system did not result in the aircraft's CG position exceeding the in-flight limits.

25. Total fuel quantity (as opposed to useable fuel quantity in the engine feed tanks) continued to be displayed on the SD fuel status page.

26. The flight crew did not recall seeing any amber on the fuel system display page throughout the flight.

27. The selection of the fuel cross feed valves prevented the complete rundown of No 4 engine.

28. Bench tests of FCMC1 and FCMC2 did not reveal any faults.

29. Bench tests of FDC1 and FDC2 did not reveal any faults.

30. The lack of fuel system flight warnings was due to a failure of the ARINC output buses A and B from the master FCMC.

31. A failure of both FWCs did not occur.

32. Bench tests of FWC1 and FWC2 did not reveal any faults.

33. Bench tests of SDAC1 and SDAC2 did not reveal any faults.

34. The FDC would have generated a low fuel quantity discrete, triggered at a fuel level below that for which a low fuel level signal was generated by the FCMC.

35. Because total fuel quantity was being displayed on the ECAM fuel SD page, at least one FCMC was still delivering an output.

36. The FWCs disregarded the FDC low fuel level discrete (the alternate or back-up warning signal) because one FCMC was still delivering an output.

37. FCMC2 was most likely the master FCMC at 1934 hrs.

38. The slave FCMC (probably FCMC1) may have had a lower health level, due to previous failures, than the master FCMC at 1934 hrs.

39. The slave FCMC was not able to take control as master FCMC due to its lower health status.

40. The slave FCMC was still outputting fuel quantity data on its ARINC output buses A and B.

41. The failure of the ARINC output buses A and B from the master FCMC caused a lack of fuel transfer arrows on the ECAM SD fuel display following the operation of manual fuel transfers.

42. The PFR and TSD, albeit with limitations, proved invaluable in this investigation.

43. The PFR limitations prevented a full determination of fault frequency and reasons for fault indications during the incident flight.

44. The FCMC TSD only recorded the last eight detected faults in its memory, limiting a determination of the first failure events.

45. The presentation of FWC and DMC TSD in hexadecimal code was difficult to interpret and required the aircraft manufacturer to decode the data.

46. 'FCMC1(2) FAULT' indications were common occurrences.

47. The reason for frequent 'FCMC1(2) FAULTS' was disagreements between the COM and MON processes created by asynchronous processor clocks.

48. There was an aircrew operational notice which removed the requirement for crews to make a technical log entry for a single FCMC failure with successful reset during flight.

49. Maintenance action following a 'FCMC1(2) FAULT' was to carry out a reset and BITE test. If this was satisfactory the aircraft was dispatched.

50. G-VATL had suffered a long term fault with the Inner 4 tank temperature sensor, later found to be due to a loose connector.

51. EASA CS-25 does not require an independent low fuel level warning system.

52. EASA CS-23, CS-27 and CS-29 all require independent low fuel level warnings.

Safety Recommendations

The following safety recommendations were made:

Safety Recommendation 2005-36

Airbus should review the FCMC master/slave determination logic of the affected Airbus A340 aircraft so that an FCMC with a detected discrete output failure or ARINC 429 data bus output failure cannot remain the master FCMC or become the master FCMC.

Safety Recommendation 2005-37

Airbus should review the logic of the low fuel level warnings on affected Airbus A340 aircraft so that the FDC low fuel level discrete parameter always triggers a low fuel level warning, regardless of the condition of the other fuel control systems.

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).