6 FINDINGS

The following findings are made with respect to the uncontained engine failure that occurred overhead Batam Island, Indonesia on 4 November 2010 and involved Airbus A380 aircraft, registered VH-OQA. They should not be read as apportioning blame or liability to any particular organisation or individual

6.1 Contributing safety factors

6.1.1 Disc failure during the occurrence flight

- Over time, a fatigue crack had developed in the thin-wall section of the oil feed stub pipe in the No. 2 engine to the extent that, during the occurrence flight, opening of the crack through normal movement within the engine released oil into the HP/IP buffer space.
- Auto-ignition of the oil leaking from the oil feed stub pipe created an intense and sustained fire within the HP/IP buffer space that resulted in localised heat damage to the intermediate pressure (IP) turbine disc.
- The IP turbine disc separated from the drive arm and accelerated.
- Following the separation of the IP turbine disc from the drive arm, the engine behaved in a manner that differed from the engine manufacturer's modelling and experience with other engines in the Trent family, with the result that the IP turbine disc accelerated to a rotational speed in excess of its design capacity whereupon it burst in a hazardous manner. *[Safety issue]*

6.1.2 Manufacture and release into service of engine serial number 91045

- During the manufacture of the HP/IP bearing support assembly fitted to the No. 2 engine (serial number 91045), movement of the hub during the machining processes resulted in a critically reduced wall thickness within the counter bore region of the oil feed stub pipe.
- It was probable that a non-conformance in the location of the oil feed stub pipe interference bore was reported by the coordinate measuring machine during the manufacturing process, but that the non-conformance was either not detected or not declared by inspection personnel, resulting in the assembly being released into service with a reduced wall thickness in the oil feed stub pipe.

6.1.3 Opportunity to manage the non-conforming oil feed stub pipes in the Trent 900 fleet

- The statistical analysis used to estimate maximum likely oil feed stub pipe counter bore misalignment, and resulting thin wall section, did not adequately represent the population of actual misalignments in engines already released into service, nor did it implicitly provide a level of uncertainty in the results.

- The language used to define the size of the non-conformance on the retrospective concession form did not effectively communicate the uncertainty of the statistical analysis to those assessing and approving the concession.
- The engine manufacturer did not have a requirement for an expert review of statistical analyses used in retrospective concession applications. *[Safety issue]*
- The engine manufacturer's process for retrospective concessions did not specify when in the process the Chief Engineer and Business Quality Director approvals were to be obtained. Having them as the final approval in the process resulted in an increased probability that the fleet-wide risk assessment would not occur. *[Safety issue]*
- The retrospective concession was not approved by the Chief Engineer and Business Quality Director, as required by the group quality procedures relating to retrospective concessions, denying them the opportunity to assess the risk to the in-service fleet.

6.2 Other Safety Factors

6.2.1 Release of Trent 900 engines with non-conforming oil feed stub pipe counter bores

- Numerous other engines within the Trent 900 fleet were also found to contain a critical reduction in the oil feed stub pipe wall thickness. *[Safety issue]*
- During preparation of the manufacturing process for the HP/IP bearing support assembly structure, a manufacturing datum was introduced because the location of the oil feed stub pipe counter bore could not be referenced to the design definition datum. That manufacturing datum was not constrained to the location of the oil feed stub pipe and as such could not ensure that the counter bore was concentric with the stub pipe, as the designers had intended.
- The engine manufacturer did not require its manufacturing engineers to consult with the design engineers to ensure that design intent would be maintained when introducing manufacturing datums. *[Safety issue]*
- The use by an inspector, during the first article inspection process, of the manufacturing stage drawings to verify the oil feed stub pipe counter bore features precluded the inspection from showing that the manufacturing process could produce an item that conformed to the design definition, or the intention of the design.
- The procedure for the first article inspection process contained ambiguities that resulted in an interpretation whereby the use of the manufacturing stage drawings was deemed to be acceptable. *[Safety issue]*
- A culture existed within the engine manufacturer's Hucknall facility where it was considered acceptable to not declare what manufacturing personnel

determined to be minor non-conformances in manufactured components. *[Safety issue]*

- The coordinate measuring machine was programmed to measure the location of the oil feed stub pipe interference bore with respect to the manufacturing datum, instead of the design definition datum as specified on both the design and manufacturing stage drawings. *[Safety issue]*
- During the production of a number of HP/IP bearing support assemblies, the coordinate measuring machine identified a non-conformance in the location of the oil feed stub pipe interference bore.
- It was likely that when making the determination that the non-conforming HP/IP bearing support assemblies were acceptable for use, the manufacturing personnel did not know that the coordinate measuring machine referenced a different datum to the design definition drawings and unknowingly released thin-walled pipes into service based on an alternative (wire gauge) measurement method.
- The engine manufacturer's group quality procedures did not provide any guidance on how manufacturing personnel were to determine the significance of a non-conformance, from a quality assurance perspective. *[Safety issue]*
- When the retrospective concession was processed, the non-conformance was not reported to the Quality Review Board because manufacturing personnel did not identify it as a significant non-conformance.
- The manufacturer's classification, relating to the criticality of failure, of the HP/IP bearing support assembly was inappropriate for the effects of a fire within the buffer space and hence, the requirement for an appropriate level of process control was not communicated to the manufacturing staff. *[Safety issue]*
- The partial first article inspection carried out in 2009 on the HP/IP support structure was not compliant with the engine manufacturer's procedures.

6.2.2 Minimisation of hazards resulting from an uncontained engine rotor failure

- The evolution of the current advisory material relating to the minimisation of hazards resulting from uncontained engine rotor failures was based on service experience, including accident investigation findings. The damage to Airbus A380-842 VH-OQA exceeded the modelling used in the UERF safety analysis and, therefore, represents an opportunity to incorporate any lessons learned from this accident into the advisory material. *[Safety issue]*

6.2.3 Landing distance performance application

- The calculation method in the aircraft manufacturer's landing distance performance application was overly conservative and this could prevent the calculation of a valid landing distance at weights below the maximum landing weight with multiple system failures. *[Safety issue]*

6.3 Other Key Findings

- A large fragment of the hot intermediate pressure turbine disc passed through the left inner fuel tank, which resulted in a short-duration low-intensity fire. Conditions within the fuel tank were not sufficient to sustain combustion and a hazardous situation did not result.
- There was a short-duration oil fire in the No. 2 engine lower nacelle that self-extinguished, resulting only in localised damage to the nacelle.
- Despite significant system and structural damage following the uncontained engine rotor failure, the aircraft was capable of continued safe flight and landing.
- The duration of the CVR recording was insufficient to capture the entire occurrence that included the engine failure and subsequent ground operation up to passenger disembarkation.
- The crew's decision to perform a precautionary disembarkation via the stairs likely provided the safest option, particularly given the low immediate safety threat and the elevated risks associated with an emergency evacuation into a potentially hazardous external environment.
- The flight and cabin crew managed the event as a competent team in accordance with standard operating procedures and practices.