05 February 2013

A400M – Towards Entry Into Service

by Brian Kitson, Head of Overall Aircraft Aerodynamics AIRBUS

1. Overview

The A400M has been developed and built in response to a European Staff Requirement. It has been ordered by Belgium, France, Germany, Luxemburg, Spain, Turkey and the United Kingdom together with Malaysia. These orders total 174 aircraft but there are hopes for further export orders.

In terms of payload and range the A400M falls midway between the strategic airlifters such as the C17, which demand fully prepared runways, and the much smaller tactical transport aircraft, such as the C130J, which can use rough take-off/landing strips. As such the A400M is able to fulfil the roles of both these aircraft categories; it has a full tactical/rough field take-off and landing capability yet it is able to fly at altitudes of up to 40,000 ft thereby giving it a significant strategic range. In addition its wingspan of 42.4 M is little larger than the 40.4 M of the C130J hence it is likely to fit into the same hangers as a C130J.

Fig. 1 – A400M During a Rough Terrain Landing Trial

2. Design

The A400M has been designed to carry armoured vehicles, armoured personnel carriers, army trucks and helicopters as well as personnel including paratroopers. Many of the vehicles it can carry are larger than can be carried by a C130J. In addition it can be used for in-flight refuelling of other aircraft as well as being refuelled itself. Other applications include medivac operations.

The A400M carrying capabilities have demanded a fuselage which is close to the ground, partly to facilitate easy loading and off-loading, a high wing, undercarriage sponsons either side of the fuselage, and a large cargo door/ramp at the rear of the fuselage. In addition it has a high trimable T-tail.

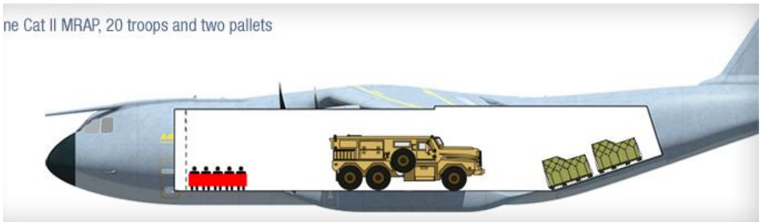

Fig. 2 – A400M Carrying Capacity

The aircraft uses high power turboprop power plants. This makes it easy to reverse the pitch of the propeller blades and thereby reverse the aircraft on the ground. The assymetric effects produced by propellers are minimised by having the propellers rotate clockwise (engines 1 and 3) and counter-clockwise (engines 2 and 4). It also minimises the adverse swirl effects of a turbulent airflow passing over the wings and tailplane. A combination of computational fluid dynamics modelling and wind tunnel testing has been used to optimise the design in the presence of the propeller effects. This has resulted in the aircraft having exceptionally good handling characteristics. The FADEC controls both the engines and the propellers and is one of the most complex ever designed.

3. Structural Testing

The A400M wings have been structurally tested to a limit of 1.5 x max. design load. During this testing the wing deflection was small compared with that of an Airbus A380 or a Boeing 787. This is despite the fact that carbon fibre was used extensively in the construction of the aircraft wings. The stiffness is due to the specific geometry of the A400M wings

Fatigue testing equal to 5 x annual usage has already been completed and is on-going.

4. Route to Certification, Qualification (Civil and Military) and Manufacture

The aircraft was first flown at the end of 2009. It received a restricted type certificate during 2012 and is expected to receive full type certification during early 2013.

The aircraft's fly-by-wire control (FbW) system was set at direct law control for the first flight take-off in 2009. Pre-defined flight control laws were then switched in, tested and optimised at altitude. From then on the aircraft's permitted functionality has increased as further testing proceeded and the FbW control system further optimised. One advantage of such a control system is to allow the setting of protections to prevent pilots unduly stressing the aircraft.

Fig. 3 – First Completed A400M

The first aircraft will be delivered to France and Turkey during 2013 and the UK will receive its first aircraft during 2014.

5. Flight Testing

Flight testing has included optimisation of the wing flap take-off and landing settings and the design of the engine nacelle and rear fuselage strakes. The use of strakes has increased aircraft stability and reduced drag.

Stall testing has included an evaluation of the buffet loads on the tail and also the effects of a deep stall. The latter was also tested with the engines operating a full power despite this being outside the margins required for type certification.

The stall testing was followed by testing over the remainder of the flight envelope up to Mach 0.72 and 40,000 ft.

Certification testing has been concerned with cruise, take-off and landing performance. Here the stall performance has been crucial in obtaining low take-off and landing speeds. Further tests have included the minimum un-stick speed, minimum control speed on the ground and the effects after an engine failure, especially on take-off.

Runway testing has included take-offs and landings on unprepared and water soaked runways.

Icing tests have been carried out to confirm the aircraft's performance under icing conditions. N.B. In common with most aircraft the bleed air requirements to provide a full anti-icing capability are too high for them to be met by the aircraft's engines.

Further testing has included a stepped process leading to paratroopers jumping from the aircraft, a series of in-flight refuelling trials and flying in formation.

6. Conclusions

After some delays during development, the A400M is now fully back on track for production. Significant flight testing has already been completed and has confirmed the aircraft's excellent handling capabilities.

The lecture was attended by 80 people.

Notes written by Colin Moss, RAeS Loughborough Branch