Notes on Lecture to RAeS Loughborough Branch on 1 November 2011

(Notes written by Mike Hirst)

The Future with the Boeing 787 Dreamliner
J. Miguel Santos, FRAeS, Director, International Sales, Boeing Commercial Airplanes

1. Introduction

Miguel has led the Boeing sales efforts in numerous countries. He is US-based, but was born in Angola and has Portuguese roots, and has been a member of the commercial team that has promoted numerous Boeing types for many years. He has strong interests in the commercial exploitation of technology, which became a theme within his lecture. In addition to sales work, and has become associated with academia, and in the UK he is a regular visitor to the Air Transport department of Cranfield University.

2. The Boeing 787 Dreamliner

Boeing 787-8 landing at Everett – completion of final certification flight
(Photo credit: Boeing)

The lecture concentrated on the development of the Boeing 787 Dreamliner, with the presenter stressing that the first in service flight had been over 3 years after the proposed schedule. He was keen to explain the reasons for the delays, and the lessons that had been learned. His candid summary of the content he would cover was a story, that in respect of the ambitious timescale to produce it in, was of a revolutionary aircraft, and a programme that suffered because it was much more new technology all at once than the development processes they invoked could manage.

He outlined the requirements that drove the design programme, whereby improved operating costs were sought, not just through improved fuel usage and lower maintenance costs, but also from using new materials, and simplified ('more-electric') systems. Customers sought too a versatile payload-range capability from shorter runways, and wished for an aircraft that could serve 'thinner' demand, long and medium-range routes, point-to-point. They also perceived a need to offer

improvements in passenger comfort. Boeing decided this should include having better seating, higher ambient pressure and humidity cabin conditions that ever before, large windows, and greater volumes available for of in-cabin baggage storage.

Boeing 787 mock-up of typical seating arrangement and cabin design
(Photo credit: Boeing)

Before describing the aircraft's features he summarised the project attainments at the time of the presentation:

- The order book was 821 aircrafts from 56 customers (admitted to be reduced from the 957 orders from 57 customers at the peak)
- Aircraft 56 was already in production
- Flight test has led to certification in August 2011. It was the most tested aircraft in commercial aviation history, having flown 5,200 hours in over 1,800 flights and addressed over 25,000 pre-determined test conditions.
- Ground testing has also exceeded 4,000 hours
- The aircraft had entered commercial service with ANA, flying Tokyo-Hong Kong in the previous week

2. The technology

The key feature of the 787 design was the decision to produce an almost-all carbon-fibre airframe. Several aspects of the design's unique attributes stem from this. They include not only the mass saving, but the fact that with a much reduced fatigue and corrosion risk, the cabin could use a higher pressure differential, and cope with greater humidity than metal-based airframes. (He eschewed the press term 'plastic' aeroplane).

Boeing 787 carbon-fibre moulded nose–section
(Photo credit: Boeing)

The lecture material included videos and slides of the nose section moulding – that takes some 8 hours to be 'woven' on a mandrel jig, using automated tape-laying machinery, and then is 'baked' for 8hr 15 minutes in a tailored autoclave. This process delivers a complete nose section, one of six sections that comprise the whole fuselage, into which holes are cut by laser and water-jet to accommodate transparencies. This is a radically different process to the traditional method of developing frames and longerons, with chemically-etched stressed skin panels, all riveted and/or bonded together. He stressed how clean and quite the production spaces were, as they were devoid of metal swarf, and the chatter of rivet guns. Boeing has two assembly and completion centres in the US, at Seattle and in North Carolina.

The implementation of this radically new production technique was the major contributor to delay in the programme. Carbon-fibre comprises 55 per cent of the primary structural mass, the rest being aluminium, titanium and steel, and Boeing sub-contracted manufacturers of major elements worldwide, with many of these taking longer than anticipated to climb the new-technology learning curve, or having to have their supply arrangements changed.

There were some design problems too, especially in the wing centre-section, where the carbon fibre wing-box penetrates the mid-fuselage. The re-design was completed and the wing eventually tested to the ultimate stress level required for certification. He showed impressive photographs and videos of the test-specimen airframe wing reaching this condition, with the wing-tip deflected some 25ft (7.6m) vertically. The test was successful, and terminated before the structure reached it ultimate failure point because the test rig integrity was not necessarily equal to that of the airframe.

Miguel also paid tribute to the improved engine performance offered by suppliers, in their Rolls-Royce Trent and General Electric GEnx engines. These have higher by-pass ratio gas cycles, embody no engine air bleeds and have laminar-flow nacelles. Whilst the technical features improve carbon emission performance by up to 20 per cent, the suppliers have agree also on a physical design definition that allows total interchangeable at the wing-pylon interface, thus standardising the wing in production.

3. Conclusions

He concluded with a summing up that Boeing believe they should have involved their suppliers 2 to 2.5 years earlier in the development stages of the programme. They have faced not just delay, but mounting project costs too, and have been able to write-down the difficulties, and would not wish to pretend there are not lessons to learn and share within industry. He stressed that there is nevertheless still considerable intellectual-property covered by patents and undisclosed that stems from the research and development work undertaken on the programme.

Boeing expect variants of the 787 (the 787-8 is in service, whilst the slightly larger, and longer-range, 787-9 has yet to complete testing) to prove so successful that they will account for a large proportion of company production long into the future. He quoted planned production rates in the next few year of:

- Boeing 737 42 per month
- Boeing 747-8 8 per month
- Boeing 777 7-8 per month
- Boeing 787 8, rising to 20, per month.

He commented on the challenges of supplying such large programmes, and cited that there are only 5 aircraft seat, 5 galley systems and 2 in-flight entertainment (IFE) suppliers world wide.

Miguel took questions throughout the lecture, and provided answers through accessing a tremendous amount of supporting material that made everyone aware that his 90-minute presentation was a skilful condensation of a vast amount of data, information and insight.

This lecture received a resounding expression of thanks by an audience of approximately 200 RAeS Members, Branch Friends, students and members of the public, some of whom has travelled in by coach from Cranfield University.