ANALYSIS: WILL BOEING'S NEXT AIRCRAFT BE AN OVAL OR A CIRCLE?

News / Manufacturer

With speculation continuing about **Boeing**'s plans for its future **aircraft** development programme, two reports now predict that the airframer's next clean-sheet design will feature the aviation novelty of an **oval** fuselage cross-section.

Most recently, Merrill Lynch analyst and former Boeing applied research scientist Ron Epstein published a report for investors earlier this month, saying Boeing's "middle of the market" aircraft study was likely to yield an elliptical cabin for the so-called 7M7.

Epstein's findings echoed a conclusion reached in June by Bjorn Fehrm, an analyst for Seattle-based Leeham. Fehrm also predicted that Boeing's designers would select an ovoid fuselage.

Neither report claims special knowledge of Boeing's internal deliberations and, so far, the manufacturer has not revealed potential configurations under consideration.

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By pointing to the need for Boeing to break from traditional fuselage cross-sections, the analyses by Epstein and Fehrm reveal the challenge of optimising a new aircraft design with a historically unique combination of size and performance.

The 7M7, if launched, would fill what Boeing marketing vice-president Randy Tinseth has described as a "white space" in the market. Although some have called it a replacement for the 757 and the 767-200, the new aircraft would need to do more than either and at far lower operating costs.

As Epstein explains in his report, airlines today can choose between a narrowbody that seats up to 220 people with a maximum range of about 3,500nm (6,470km) or a widebody that accommodates between 250 and 500 passengers with a maximum range no shorter than 6,000nm.

The market Boeing is now targeting sits in between those combinations of size and endurance. The 7M7 would feature seating for about 220-270 people and be able to fly around 5,000nm.

If the requirements were only that simple, Boeing could rely on the circular or "double bubble" cross-sections of most aircraft in service today. The double bubble features two circles cinched at the floor line, usually with an elongated lower lobe to maximise space for cargo.

But it probably won't be that simple, as the Epstein and Fehrm reports suggest. Some of Boeing's most influential customers, such as Air Lease chief executive Steven Udvar-Hazy, have publicly demanded that the 7M7 deliver narrowbody-like economics on a per-seat basis. That creates quite a challenge. Widebodies provide slightly more cabin volume on a per-seat basis than narrowbodies, so the per-seat operating economics are higher.

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The 7M7 is set to fly much farther than the 737-900ER or Airbus A321, yet deliver at least equivalent operating economics. And that's why analysts such as Fehrm and Epstein expect Boeing to break the fuselage mould with the 7M7, producing an aircraft much wider than it is tall.

Both analysts also point to a string of Boeing patents published between 2003 and 2010, showing various designs and technologies necessary to produce an elliptical aircraft. Many of the patents were co-authored by Mithra Sankrithi, a 32-year Boeing veteran and now chief of product development for airplane integration and product evaluation.

One such patent drawing, published in 2007, presents a design for "pressurisable aircraft fuselage structures having near-elliptical cross-sections", with seven-abreast seating in a twin-aisle cabin, plus enough space below deck to fit a single row of standard LD-3 cargo containers.

That patent filing served as the basis for the concepts presented in both Epstein's and Fehrm's

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reports.

Fehrm traces Boeing's interest in elliptical cross-sections over that period to the now-delayed pursuit of a true 737 replacement. Until mid-2011, the Boeing Commercial Airplanes division seemed focused on replacing the 737NG series with a clean-sheet design, and the elliptical fuselage configuration was their preferred shape, he says.

Boeing had previously studied other options. The 7J7, for example, proposed to replace the 737 Classic series in the late-1980s with a new, clean-sheet aircraft with a 4.17m-diameter (13.6ft) fuselage. That would make it 0.21m wider than an Airbus A320, but 0.86m narrower than a seven-abreast 767. As a result, the 7J7 was not wide enough to be a twin-aisle, but offered a more comfortable cabin with wider seats and aisle.

Another decade would pass before Boeing would begin seriously considering elliptical cross-sections, based on the flurry of patents filed in the last decade.

The raw appeal of an elliptical fuselage shape is clear: for the same amount of wetted area – the portion of the hull in contact with the external airflow – a purely circular fuselage usually can't carry as many seats. A lower wetted area for the elliptical fuselage also means less drag.

Another consideration is the length of the fuselage. A six-abreast cabin in a narrowbody fuselage for 250 passengers would result in an excessively long cabin, causing slow and inefficient boarding and deboarding periods, he says.

The optimal seating for a 7M7-sized aircraft is instead a seven-abreast cabin, he adds. But achieving the narrowbody-like economics is only possible with an elliptical fuselage, not a circular shape with greater drag.

There are, however, drawbacks that must be considered. The geometric advantages of the elliptical shape have always been known, but concerns about pressurisation have forced manufacturers of large aircraft to use circular or double-bubble cross-sections.

Any pressurised vessel seeks to reshape the containment into a circle anyway, so any non-circular shape must be strengthened to resist these forces. Adding layers of strengthening increases the weight of the fuselage, leading designers to favour circular cross-sections.

But Fehrm points to a major innovation of the last decade that may overcome the concerns about pressurisation. Aircraft fuselages can now be made from composite material, such as the carbonfibre reinforced plastic (CFRP) used for the fuselage and wing skins of the 787. Adapting such materials to an aircraft with 5,000nm range should not be a technological stretch for the 7M7, which would enter service more than a decade after the Dreamliner.

Other criticisms of an elliptical cross-section are more difficult to dismiss. Hans Weber, president of San Diego-based consultancy TECOP, says he would be shocked if Boeing decided to use an elliptical cross-section for an aircraft with a 5,000nm range.

Airlines expect an aircraft with that kind of performance to carry a significant load of commercial cargo in addition to the passengers' luggage, he says.

Because an elliptical shape is wider at the middle than it is tall, there is less room below the passenger cabin available for cargo. The patent drawing cited in the Epstein and Fehrm reports shows room for a single row of LD-3 containers.

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"I still don't get it, because I'm still hung up on the loss of cargo area," Weber says. "I'm surprised. Somehow there's an inherent contradiction in a relatively long-haul airplane with an elliptical fuselage."

Weber is aware of the benefits of such a shape as it applies to a short-haul, narrowbody aircraft. Airlines don't expect short-haul aircraft to carry the same ratio of cargo as an aircraft that can fly up to 5,000nm, he says.

But Weber is not ruling out the idea of a long-haul aircraft with an elliptical fuselage. Instead, he sees that lack of cargo space as yet another challenge that Boeing will have to overcome, if conventional fuselage cross-sections are not quite sufficient.

"Innovation comes about because somebody breaks through the conventional picture," he says. "That would be fascinating to see if Boeing does it – if in fact it turns out that there are benefits."

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