A GREENER SUPERSONIC FLIGHT – SOMEDAY

NASA INVESTS IN FUTURE MACH 2-PLUS COMMERCIAL AIRLINE TRAVEL

Report by:
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SINCE THE Concorde's retirement in November 2003, commercial supersonic air travel has been non-existent. However, this has not stopped NASA from continuing the quest to develop solutions that will return supersonic passenger travel to the air again.

With air travel expected to double in the next five to 10 years, NASA has been working on a concept for an environmentally-friendly supersonic passenger jet. This jet would fly 300 passengers at more than 1 500 miles per hour (more than twice the speed of sound) across the Pacific or Atlantic oceans — all in less than half the time of modern jets. Ticket prices would be about 20 percent above comparable, slower flights.

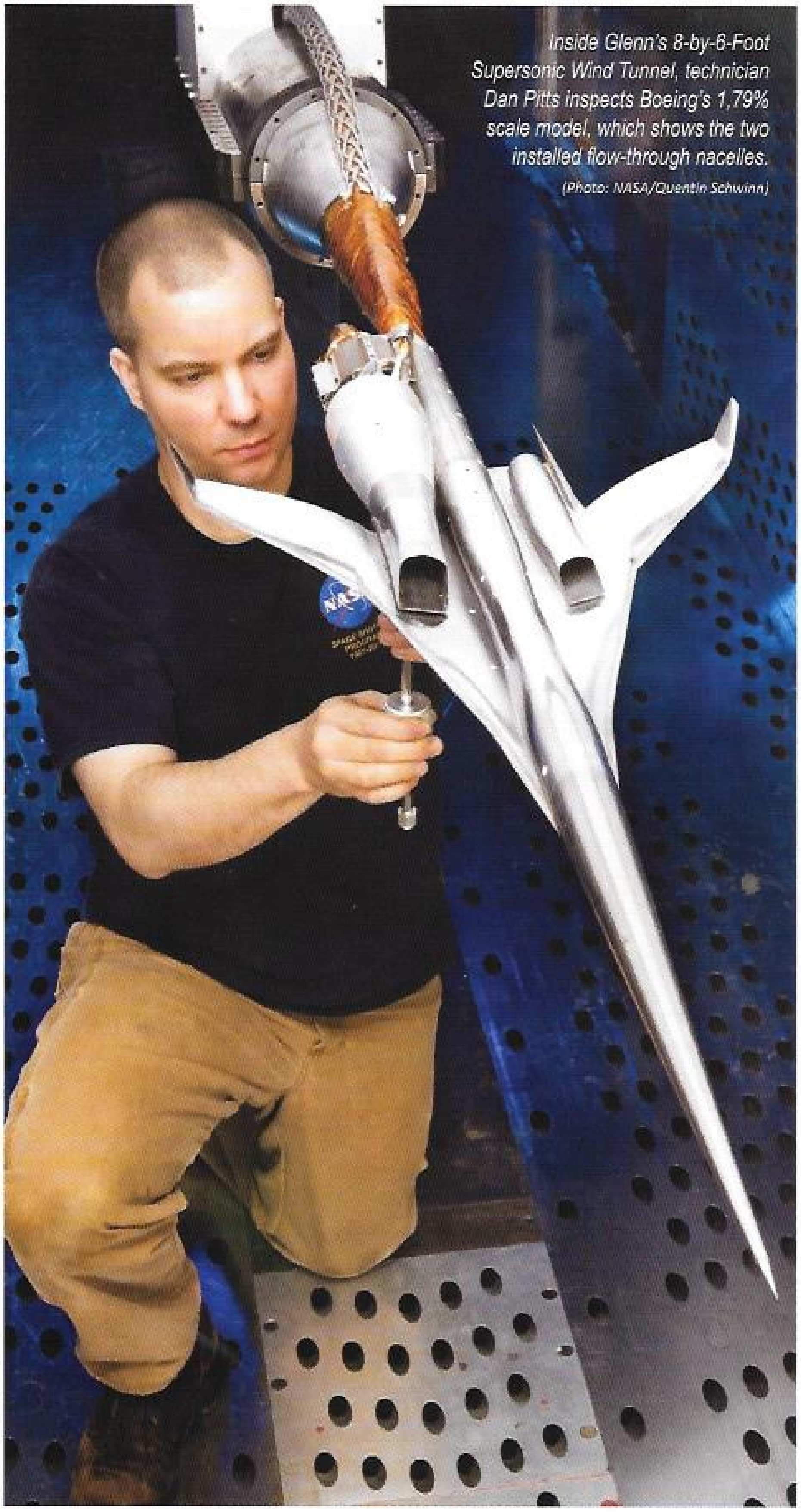
In a seemingly never ending effort to make the planet "greener", NASA commissioned eight studies and has spent about $2,3-million in funding to overcome the remaining barriers to commercial supersonic flight.

Aerospace engineers have made significant progress in their understanding of supersonic flight and the high altitude emissions issues, but one major challenge remains: the disruptive sonic boom.

Any future supersonic airliner will operate from existing international airports and must, therefore, meet local airport community noise requirements, as well as any national or international noise certification regulations.

The NASA High-Speed Research (HSR) programme is moving forward with the assumption that a future supersonic passenger jet must be as quiet as today's commercial subsonic aircraft.

"Lessening sonic booms – shock waves caused by an aircraft flying faster than the speed of sound – is the most significant hurdle to reintroducing commercial supersonic flight," said Peter Coen, manager of NASA's High Speed Project with the agency's Aeronautics Research Mission Directorate's Fundamental Aeronautics Programme.



Inside Glenn's 8-by-6-Foot Supersonic Wind Tunnel, technician Dan Pitts inspects Boeing's 1,79% scale model, which shows the two installed flow-through nacelles.
(Photo: NASA/Quentin Schwinn)

ACCEPTABLE NOISE LEVEL

The annoyance over sonic booms became so significant that the Federal Aviation Administration (FAA) prohibited domestic civil supersonic flight over the US in 1973.

This prohibition helped quieten the skies and reduce potential impacts on the environment. However, it also dashed hopes of introducing supersonic overland passenger service within US airspace during the Concorde era.

The maximum acceptable loudness of a sonic boom is not specifically defined under the current FAA regulations. NASA has been researching ways to identify a "loudness" level that is acceptable to both the FAA and the public.

Previous research by NASA, the military, and the aircraft industry has determined that a variety of factors, from the shape and position of aircraft components to the propulsion system's characteristics, determine the make-up of a supersonic aircraft's sonic boom.

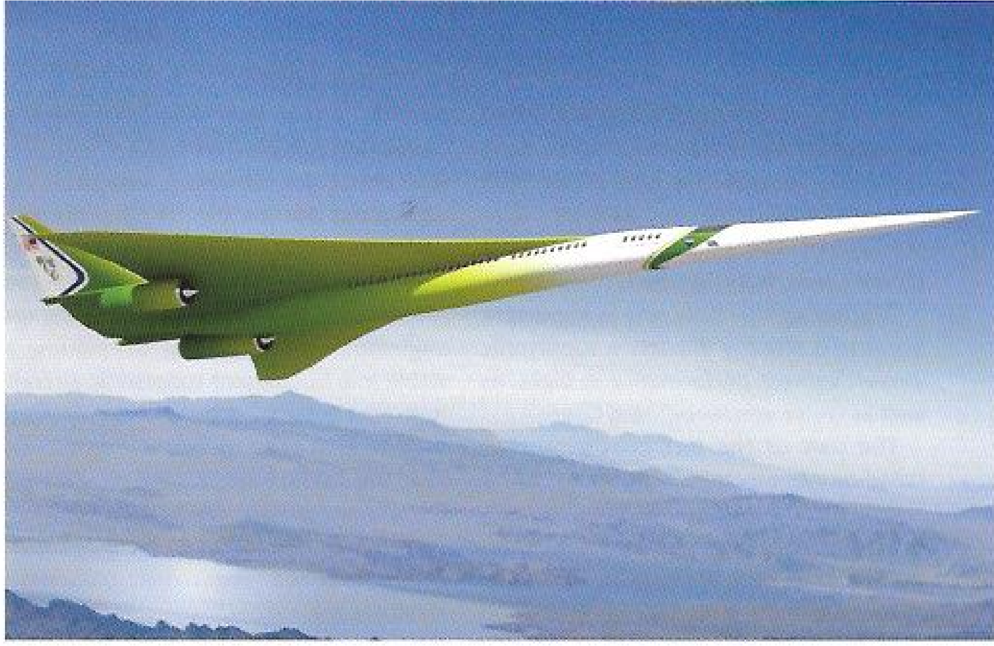
Similar to designs of the past, the current concepts are characterised by a needle-like nose, a sleek fuselage and a delta wing or highly-swept wings. It is the details of how those designs are shaped that engineers hope will result in the reduced sonic boom.

One design, proposed by Lockheed Martin, mounts two engines under the wing in a traditional configuration with one additional centreline engine above the wing *(see image at top right)*. The Boeing Company proposes two top-mounted engines in a departure from historical aircraft design.

"Engine installation is a critical part of achieving an overall low boom design," said Coen. "If we mount the engines in a conventional manner, we need to carefully tailor the shape of the wing to diffuse the shock waves. If we mount the engines above the wing, the shock wave can be directed upward and not affect the ground signature. However, such installations may have performance penalties," he added.

NASA's focus on supersonic research testing began in November 2010, as part of the project's Experimental Systems Validations for N+2 Supersonic Commercial Transport Aircraft effort. Its goal was to capture boom-relevant data from supersonic scale models built by Boeing and Lockheed.

First engineers designed full-sized aircraft on their computers, and then scaled down the designs to build wind tunnel models that exhibit the same flight characteristics during testing as would their full-size counterparts in actual flight.



Top: *This image shows the Lockheed Martin future supersonic advanced concept featuring two engines under the wings and one on top of the fuselage (not visible in this image).*

(Photo: NASA / Lockheed Martin.)

Above:- *Concorde's cruising speed was around 1 350 mph which is over Mach 2, or more than twice the speed of sound or a mile every 2,5 seconds. To put this in context, it is faster than a standard rifle bullet and faster than the rotation of the earth.*

(Photo: Eduard Marmet, Wikimedia.org)

Once the scale models were delivered to NASA, the project's engineers focused on obtaining data from two distinct aspects of supersonic design; the measurement of the sonic boom pressure signature at various points around the aircraft, and the measurement of engine inlet performance for the top-mounted engines.

Both Boeing and Lockheed Martin then refined their designs for better boom characteristics and improved aerodynamic performance.

Tests continued on the Phase II designs through to 2013, focusing on the engine nacelle integration with the overall vehicle.

One of these tests was a propulsion integration test at Glenn's supersonic wind tunnel, in March 2013. This test of a 1,14-metre-long, 1,79-percent scale model built by Boeing focused on capturing performance data from the engine air inlets.

NASA tested this model both with the inlets integrated on the overall aircraft, mounted above the wings, as well as with one of the inlets by itself.

A remotely-controlled mass-flow plug assembly (a movable cone that varied the size of the nacelle exit area) was fitted behind the inlet, which gave engineers the capability to vary the rate of air flow through the inlet to capture data throughout the duration of the scale model's test "flight" in the tunnel.

"Capturing this flow rate is important because it directly impacts a supersonic aircraft's thrust performance in flight, as well as cruise efficiency," said Coen.

The part of the test consisting of a stand-alone air inlet, mounted on a support cone within the wind tunnel, enabled engineers to capture inlet performance data without the influence of the rest of the aircraft.

By comparing the measured data of the two configurations, NASA and Boeing will be able to learn if the shape of the airframe has a big effect – good or bad – on the performance of the inlet.

A final test was done at Ames Research Centre where engineers worked with the 1,14 metre as well as 406 mm scale models provided by Boeing, similar to a test the year prior with a 483 mm scale model provided by Lockheed Martin.

During these tests, researchers sought to capture data that indicated how well the nacelles were integrated with the overall designs, and how they affected the aircraft's boom characteristics and aerodynamic drag.

The Boeing scale models underwent testing using two different nacelle shapes, and also with the nacelles not installed. Lockheed Martin's scale model also underwent one set of tests with nacelles installed and one without.

"The purpose of our testing was to measure the impact of the nacelle configurations on the boom signatures," said Don Durston, a high speed project engineer at Ames Research Centre.

"Preliminary results showed that as expected, with Boeing's nacelles being on top of the wing, any small changes there had negligible effects on the boom, Lockheed's model having the two of the nacelles under the wing, did show a measurable impact on boom; however, that effect was predicted, and could be accounted for in the design process Lockheed used."

In the meantime, Coen thinks the research over the past year brings engineers one step closer to realizing a viable low-boom, civil supersonic aircraft transport design.

"We've convinced ourselves that we have the design tools and we've validated the level we need to design to," said Coen. "We've reached a point where quiet, low-boom overland supersonic passenger service is achievable."

The window in the sidewall of the 2,44 metre by 1,83m supersonic wind tunnel at NASA's Glenn Research Centre shows a 1,79 percent scale model of a future concept supersonic aircraft built by The Boeing Company.

(Photo: NASA Glen Research Centre.)

GETTING CIVILIANS INVOLVED

A recent flight research campaign at NASA's Armstrong Flight Research Centre in Edwards, California, had residents explore ways to assess the public's response to sonic booms in a real-world setting.

Researchers at Armstrong have an advantage – pilots are permitted to fly at supersonic speeds because the facility is located on Edwards Air Force Base.

"People here are more familiar with sonic booms," said Armstrong aerospace engineer, Larry Cliatt.

"Eventually, we want to take this to a broader level of people who have never heard a sonic boom."

Similar work is conducted at NASA's Langley Research Centre in Hampton, Virginia, where local community volunteers rated sonic booms according to how disruptive they determined the sound to be.

ESTIMATING REACTIONS

"They each listened to a total of 140 sounds, and based on their average response, we can begin to estimate the general public's reactions," explained Langley acoustics engineer, Alexandra Loubeau.

"Because of the interaction with the atmosphere, it is important to be as consistent as possible in the implementation and usage of these tools," Loubeau said. "The comparisons done so far have shown good agreement, but there are some inconsistencies that need to be studied as well."

Mike Park, a fluid mechanics engineer at Langley said: "We are working to understand the worldwide state of the art in predicting sonic booms from an aircraft point of view. We found for simple configurations we can analyse and predict sonic booms extremely well."

NASA and industry engineers say they believe research has progressed to the point where the design of a practical low-boom supersonic jet is within reach.

The most recent potential supersonic aircraft designs indicate the possibility that second generation beyond the current technology aircraft design, could be flying by the years 2020 to 2025.

Meanwhile, in Europe, Aerion the company building the first supersonic corporate aircraft, continues to expand its engineering organisation and deepen ties with the Airbus Group as the two entities participate in a joint definition phase refining the AS2 design. New low speed wind tunnel tests are planned for the AS2 soon. +