

NASA unveils a supersonic plane with a quiet boom

A simple concept, a sophisticated process: Reshape contours to prevent coalescence of shock waves.

A plane first surpassed the speed of sound in 1947. Now, more than three-quarters of a century later, NASA aims to do it again, but this time quietly. When a plane flies faster than the speed of sound—about 1100 km/h at typical flying altitudes and atmospheric conditions—the resulting shock waves create a signature double boom. The explosion-like noise can scare livestock, rattle windows, and disturb people. In 1973, strongly influenced by public opinion, the Federal Aviation Administration banned overland commercial supersonic flight in the US; similar restrictions were also enacted in other countries.

In the coming months, Lockheed Martin Aeronautics will test-fly a plane it designed and built for NASA under a \$247 million contract. The X-59 is intended to create a quiet “sonic thump” at

supersonic speeds. Starting in 2026, NASA will ask the public to weigh in to see whether the noise is sufficiently muted to gain acceptance for overland supersonic flights.

Greg Ulmer is the executive vice president of Lockheed Martin Aeronautics. At the 12 January unveiling of the X-59, he called it “an experimental technology demonstrator that has the potential to completely revolutionize aviation.” If the X-59 is deemed quiet enough, and if the law banning commercial supersonic flight over land is overturned, then companies could pick up where Lockheed Martin and NASA have left off and commercialize supersonic flight.

A computational feat

Every change in a plane’s shape and every feature on its surface, from the tiny screws to the engines, creates a shock wave at supersonic speeds. The shock waves are nonlinear and tend to coalesce at the front and back of the plane; each generates a sudden change in pressure, hence the double boom, explains Jay Brandon,

NASA’s chief engineer on the project.

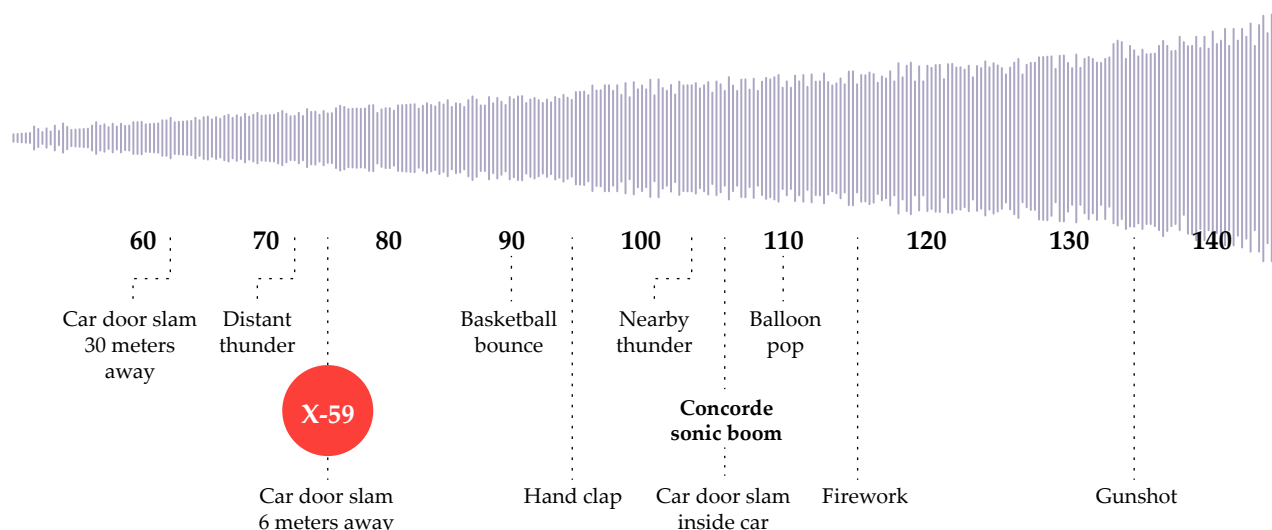
The concept of shaping a plane to minimize the amplitude of the generated shock waves and to prevent them from aggregating has been around for decades. The aim “is to spread out the shocks. We want to smooth the pressure changes,” says Brandon. “That way we prevent a loud sonic boom that sounds like an explosion.”

Advances in supercomputers have “enabled us to model the equations for airplane shape and the surrounding fluid dynamics,” Brandon says. Modeling the flow effects that the airplane shape produces wasn’t possible with earlier generations of computers, he adds.

Simulations can be used to help design the shaping characteristics needed for a low-boom airplane operating in realistic flight conditions, says Brandon. The traditional approach of building physical models and testing them in wind tunnels would miss some aspects of shock wave propagation, he notes, and it would have been much slower and costlier: A single iteration could take years, compared to



DESIGNED TO FLY SUPERSONICALLY YET QUIETLY, NASA’s X-59 was unveiled by Lockheed Martin Aeronautics in Palmdale, California, earlier this year. The plane is being developed as a first step to future overland supersonic commercial travel.



COMPARED WITH OTHER SHORT-DURATION SOUNDS, the boom from NASA's new supersonic plane, the X-59, is perceived to be about as loud as a car door slamming from a distance of 6 meters. The perceived level in decibels increases from left to right. (Adapted from a diagram provided by NASA.)

weeks or months with simulations. With the X-59, wind tunnels were used to validate computational predictions.

The X-59 has a sleek, 30-meter-long body. It is about 4.2 meters tall, and its wingspan is about 9 meters. Its single engine is located atop its body to divert downward-propagating shock waves produced by the engine inlet. Its elongated nose spreads out the shock waves to reduce the noise heard on the ground. The plane has no front window, says Brandon, because the shape and angle of a window needed for good visibility are inconsistent with the streamlined contours that minimize shock waves. Instead, the pilot will use high-definition camera images that line up seamlessly with the views from side windows.

Flying without a front window has been vetted in tests with subsonic aircraft. The engine, hydraulics system, and other aspects of the X-59 have also been adapted—and in some cases, refurbished—from existing craft. For example, says Brandon, the landing gear is from an F-16 fighter jet, the canopy is from the back seat of a T-38 aircraft, and the engine is a slightly modified version of the one used in the F/A-18E fighter jet.

Lockheed Martin designed the plane with a target perceived level in decibels (PLdB) of 75. For comparison, the Concorde, which transported passengers

across the Atlantic Ocean for three decades at Mach 2, or twice the speed of sound, produced sonic booms of about 108 PLdB. It was discontinued in 2003 after a crash in 2000 and the terrorist attacks of 11 September 2001 dampened demand.

NASA set an upper limit of 75 PLdB for the X-59 based on laboratory experiments. "Volunteers inside simulators indicated low levels of irritation at that level," says Jonathan Rathsam, an acoustics specialist and the technical co-lead for NASA's community-response phase for the X-59. "It's also what is currently achievable with an aircraft of this size." The energy in the thumps peaks around 10 hertz, he says. Volunteers likened the sound to that of a car door slamming 6 meters away.

The aircraft will fly at Mach 1.4; at its design altitude of about 16 000 meters, that's about 1488 km/h.

Testing public acceptance

For the public-perception surveys, Rathsam says, flights will regularly traverse large swaths of land for a month at a time, and people below the flight path will be asked for their opinions via online surveys. "We have our models, predictions, and wind-tunnel data," he says. "But we can't know for sure what the response from communities will be. The effort requires real response data. There is no way to simulate that."

The perception tests will run for about three years. NASA will also conduct acoustic measurements of the absolute noise from the X-59.

After that, it will be up to industry to take on the jobs of requesting that the overland speed limit be removed or amended and of developing commercial passenger carriers. Lockheed Martin and NASA officials say they do not foresee military applications.

The pilot is the lone person aboard the X-59. But, says Brandon, a key design requirement was that results from the craft be scalable. A possible passenger carrier would be, per Lockheed Martin's calculations, about twice as long as the X-59 and able to seat up to 44 passengers.

But the boom and legal overland speed limit are not the only hurdles to commercial supersonic travel. Emissions, fuel consumption, and the noise at takeoff and landing must also pass muster. Originally the X-59 was supposed to be designed to use sustainable fuel, says Brandon, but NASA dropped that requirement. "We focused on the thump."

"If you look at the history of air travel, it was for the elite at the beginning," notes Brandon. "But as the technology matured, it became more accessible. I would expect that supersonic flight will eventually be for everyone."

Toni Feder **DT**