Skunk Works Refines Quiet Supersonic Design

Aviation Week

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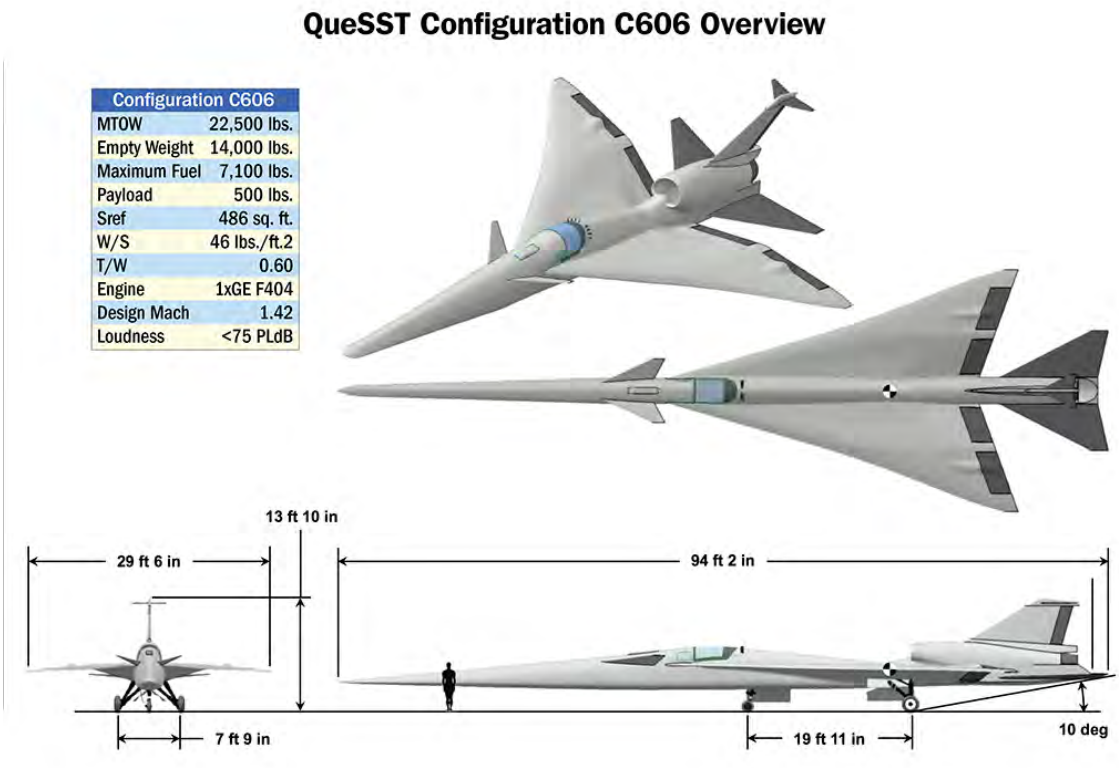
Lockheed Martin's Skunk Works is beginning a fast-paced year of preliminary design work on a low-boom demonstrator for NASA that the agency is increasingly optimistic will pave the way for environmentally acceptable supersonic business jets and airliners.

The single-engine Quiet Supersonic Technology (QueSST) aircraft is designed to test whether the shockwave signature of potential future Mach 1-plus vehicles would be acceptable to the public, clearing the way for supersonic flight over land. While the goal is targeted at validating tools and design approaches for potential 100-120-seat supersonic airliners, the principles of the demonstrator will also be directly applicable to the near-term development of business jets.

"We believe the technology is ready," says NASA Commercial Supersonic Technologies (CST) subproject manager Dave Richwine. "We feel [as if] we have got the sonic boom now to the stage where it is not going to be bothersome to the general public." Successfully mastering the amplitude and distribution of shockwaves that cause sonic booms presents "an opportunity for the U.S. to take the lead in a new class of aircraft manufacturing," he adds. NASA believes the QueSST research project opens the window to a potential market of 350-500 supersonic business aircraft and more than 500 airliners from the mid-2020s onward.



Credit: Lockheed Martin

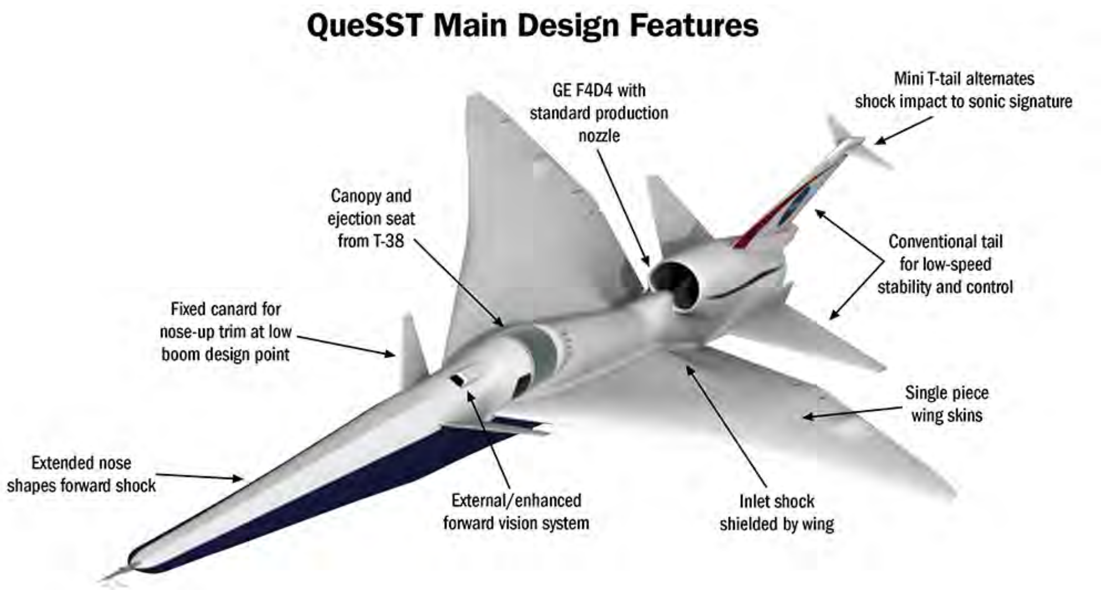
Richwine was speaking at a NASA Armstrong Flight Research Center event at which the contrast in sound levels between a standard sonic boom and several progressively quieter booms was demonstrated. The initial boom, which measured 104 PNLdB (perceived noise level decibel), was generated by a NASA F/A-18 flying straight and level overhead at Mach 1.2. Four subsequent booms were generated by the aircraft performing a special low-boom dive maneuver several miles from the Edwards AFB lakebed. Of these the quietest was measured at 77.5 PNLdB, just above the 75 dB target threshold for QueSST. All were characterized by the double "boom, boom" of the classic "N wave" shockwave boom signature, though the quieter events generated more of a muted "thump-thump" sound.

The intensity of the boom was modified by varying the distance away from spectators. Each dive was begun on the same heading by the F/A-18, flown by NASA chief research pilot Nils Larson, rolling inverted at 49,000 ft. and a speed of Mach 0.95. The aircraft was pulled into a 53-54-deg. dive angle before rolling upright and accelerating to hit Mach 1.1 at 40,000 ft. After passing this point the aircraft was pulled into a 3.5g recovery above 30,000 ft.

However, it is impossible in current aircraft to prevent the formation of N-waves in supersonic cruise, so the QueSST design is tailored to prevent shockwaves from the nose, cockpit, engine inlets, wing, tail and exhausts from coalescing as they propagate through the atmosphere. By keeping the shockwaves separated all the way to the ground, developers aim to produce an S-shaped signature that sounds like a soft rumble.

The 94-ft.-long QueSST is designed to produce a sine wave-shaped sonic boom level no louder than 75 PLNdB, 20 times quieter than Concorde's N-wave of 105 PNLdB. Lockheed Martin QueSST chief engineer Michael Buoanno says the "single engine concept is the lowest cost and the effects of its variability [spillage from the inlet] are shielded from ground observers."

He adds, "The design also has unusual features, including a large number of lifting surfaces," referring to canards, a miniature T-tail atop the vertical fin and conventional, all-moving horizontal tails. "They are designed to let us tailor the lift distribution and the strength of the shocks to keep them from coalescing before they impact the observer on the ground," he says.



Credit: Lockheed Martin

The shaping of the aircraft's extended nose and forward positioning of the fixed canards mean it is "not feasible to give the pilot enough natural visibility to safely operate the airplane, so we have integrated an external vision system that uses a TV camera," says Buoanno. The system is expected to combine a high-definition camera for "see and avoid" situational awareness and a baseline system for landing and takeoff. The imagery will be projected on a multifunction display, possibly one identical to that used on the F-35 fighter.

Lockheed began the aircraft system requirements review on June 1. "Then there are two other events, the first of which is the pre-preliminary design review (PDR) technical interchange meeting that will occur in November of this year and the actual preliminary design meeting which will occur in early June next year," says Lockheed Martin QueSST program manager Peter Iosifidis. "We are in the process of identifying the builder of the wind-tunnel model and doing the down select. We expect the wind-tunnel testing to take place probably in the winter to the first part of next year," he adds.

"The testing will take place at NASA Glenn Research Center in the 8 X 6-[ft.] high-speed wind tunnel," says Richwine. "It is really the ideal scale for our model and the Mach number, and it gives us the Mach number range. Lockheed has some plans to do some low-speed testing in its own facilities," he says.

The technical interchange meeting is designed to inform industry of the findings of the program to date. "When we competed for this contract, one of the requirements was that if we had won the contract, all the data that was developed [would be] under unlimited rights. Everything that we develop during this effort we share with industry, as NASA desires. Somebody can take this data and proceed where we left off. Certainly, our intention is to compete for the next phase, but it does not mean we are going to have the most competitive solution that NASA values in choosing that next supplier," says Iosifidis.

In the meantime final decisions continue to be made over parts of the configuration. "Right now, our baseline engine is the General Electric F404-400. However, we are [making] trades to ensure this is the best solution for our project," he adds. For its high-altitude operation, particularly in stratospheric testing above the tropopause where the atmosphere warms with increasing altitude, the QueSST will require an engine with slightly different operating characteristics found in other variants of the F404.

An open competition will follow next year's PDR to design and build an X-plane to fly by late 2019. Test flights to investigate the sonic boom are expected to start in 2020 and could ultimately expand to include international research agencies. "Supersonic flight is an unfulfilled promise but this time we really believe we understand the physics to shape the aircraft for low boom. We have got to engage the international community because if this aircraft is going to be successful it has to operate around the world," says Richwine.

Meanwhile additional community test campaigns are planned across the U.S. when the QueSST is available for flights beyond the bounds of Edwards AFB. At least four, but possibly six, test campaigns are set to take place from 2021-23 at sites yet to be determined across the country featuring different geography, climate and population densities.