Aviation's Next Advance: Sustainable High-Speed Flight

By Aerospace Industries Association (AIA)

In the 100 years since the Aerospace Industries Association (AIA) was founded to represent America's fledging aviation sector, our industry has transformed the way humanity lives, works, and thinks about the Earth. When far-off places are within our reach, we become more connected to the rest of the world around us. Today, anyone can get on an airplane and travel thousands of miles in a matter of hours – trips that simply would be too arduous and impractical by any other form of transport.

However, what we now take for granted is a result of the continuous advances our industry has made over the past century. In the 1930s, a business trip across the Pacific – now a regular occurrence – was far from an easy experience. Traveling from San Francisco to Hong Kong on Pan Am's *China Clipper* took 6 days. By the mid-1940s, a journey from Miami to Buenos Aires still took 71 hours. At these slow speeds, aviation – and long-distance travel more generally – would never become part of most people's lives. With the dawn of the commercial jet age in the late 1950s, everything changed. Travelers could fly across the Pacific in half a day.

While aviation has continued to develop in almost every other way, the speed at which we fly has remained largely the same since the 1960s. However, we are close to achieving the next great breakthrough in civil aviation that will shrink our world even further: environmentally responsible supersonic flight.

U.S. manufacturers have announced projects that will offer the possibility of traveling faster than the speed of sound, at speeds ranging from Mach 1.4 to Mach 2.2. At Mach 1.4, the voyage from Miami to Buenos Aires takes less than 6 hours. A transpacific flight from San Francisco to Hong Kong shrinks from 14 subsonic hours to 5.5 hours at Mach 2.2. And this could become a reality in just the next five to ten years.

The idea of supersonic air travel is not a new one, but the first generation of supersonic aircraft introduced in the 1970s were not environmentally friendly. Concorde and the Tupolev Tu-144 faced international challenges due to environmental concerns – in particular the sonic boom they generated limited the number of viable routes.

While these concerns were warranted, aviation technology has advanced considerably since then and its environmental impacts have been drastically reduced. These improvements from manufacturers are due in no small part to the work that takes place at the International Civil Aviation Organization (ICAO), where governments, aviation stakeholders, and the NGO community all work constructively and collectively. The standards and policies set through ICAO require manufacturers to continually improve environmental performance through technologically feasible and economically reasonable means, bringing broad benefits.

Modern airplanes are now 85% more fuel efficient than the first airliners and a flight today emits 50% less CO_2 than a comparable flight did as recently as the 1990s. Similarly, in the United States, aircraft noise affects a fraction of the population that it did in the 1970s, despite the number of daily flights more than quadrupling.

Advances in propulsion technologies, materials, and aerodynamic design capabilities mean the next generation of civil supersonic airplanes will be far more environmentally responsible than their predecessors.

Sonic booms are widely regarded as the least acceptable aspect of supersonic airplanes. Industry is undertaking extensive research and development to reduce or eliminate this problem, but until these solutions can be matured, supersonic aircraft are being designed to only operate at supersonic speeds over water – to avoid any unacceptable impacts over people. State-of-the-art aerospace technologies, when paired with advanced operational procedures, will also minimize noise impacts during the landing and takeoff phase of supersonic flight.

Airplane noise is only the most noticeable environmental impact; we also need to take our climate responsibilities seriously. AIA was part of the Air Transport Action Group's 2008 agreement that made aviation the first industrial sector to set goals to reduce its climate impact – including a long-term goal to deliver a 50% reduction in net CO_2 emissions by 2050 relative to 2005 levels. U.S. manufacturers remain fully committed to this goal and supersonic airplanes and engines will be designed with fuel efficiency as a key consideration for both economic as well as environmental reasons.

New technologies will allow stricter requirements to be set for supersonic aircraft in the longer term, but these aircraft also will be able to leverage other measures to reduce their environmental impact. Many American manufacturers, including those with an interest in supersonic aircraft, are taking active steps to help spur growth of the nascent sustainable aviation fuels industry. Supersonic engines are being designed to accommodate drop-in sustainable fuels as readily as subsonic engines. In addition, market-based measures such as ICAO's Carbon Offsetting and Reduction Scheme for International Aviation and optimized operational procedures also will play their part to ensure aviation meets its climate commitments.

AIA MEMBER ACTIVITY

Two U.S.-based manufacturers have announced plans for civil supersonic aircraft projects. Working through the International Coordinating Council of Aerospace Industries Associations and the International Business Aviation Council, these manufacturers are contributing technical expertise, modeling resources, and data to ICAO's Committee on Aviation Environmental Protection to inform future environmental standards for supersonic aircraft.

Aerion AS2

Aerion Supersonic is developing the AS2 supersonic business jet, which is expected to take flight in 2023. In 2018, Aerion and GE Aviation announced the first civil

FIGURE 1: Aerion AS2

supersonic engine program in 55 years, called the Affinity, which will power the AS2. The AS2 is being designed to be able to fly on 100% sustainable aviation fuels, and Aerion is dedicating one flight test airframe with the intention of performing its test campaign with 100% sustainable fuels. The AS2 will cruise at a top speed of Mach 1.4 and operate at "Mach cut-off" speeds over populated areas, taking advantage of atmospheric conditions to cruise at up to Mach 1.2 without generating a sonic boom that reaches the ground.

The AS2 is expected enter service in 2025, shaving hours from itineraries like New York to Cape Town and London to São Paulo. In February 2019, Aerion announced a partnership with Boeing, through which Boeing will lend engineering, manufacturing, and flight test resources to support the AS2 development program. For decades, Boeing has made significant contributions to supersonic technology. In recent years, Boeing has collaborated with the Japanese government and industry on wind tunnel testing and participated in a study on the use of a revolutionary new material called Shape Memory Alloy.

Boom Overture

Boom Supersonic is focused on making the planet dramatically more accessible through supersonic flight. The company's first commercial product will be a 55-seat,

FIGURE 2: Boom Overture

Mach-2.2 airliner called Overture, designed with operating costs similar to today's subsonic commercial business-class aircraft. Overture will enter service in the mid-2020s and could dramatically shorten flight times on hundreds of global routes by cruising at supersonic speeds over water. Boom is currently building XB-1, a two-seat demonstrator that will begin flight testing within the next year. XB-1 is the world's first independently-developed supersonic jet and will be the fastest civil aircraft in history when it reaches its Mach-2.2 design cruise speed.

Other U.S. manufacturer activity

FIGURE 3: NASA/Lockheed Martin X-59

In 2018, the National Aeronautics and Space Administration (NASA) awarded Lockheed Martin the contract to design, build, and complete initial flight testing of the X-59, which is scheduled to fly in early 2021. Producing shaped sonic boom signatures with a perceived level of noise between 70–80 decibels (PLdB), the X-59 is intended to inform the design of future commercial supersonic airplanes with sonic boom characteristics allowing for quiet overland supersonic flight. NASA is developing community response testing plans using X-59 to investigate public acceptance of quieter, shaped sonic booms. The efforts of Lockheed Martin and NASA will support future rulemaking on acceptable supersonic on-route noise levels.

Collins Aerospace is supporting Lockheed Martin's and NASA's work on the X-59 by working with them to develop avionics solutions allowing pilots to navigate without a forward-looking window – which is impractical on the long airframe necessary for low-boom flight. Collins Aerospace is also working with NASA on other areas of supersonic technology, including avionics displays that provide pilots with a prediction of how their sonic boom will propagate, enabling them to mitigate or avoid noise impacts.

Gulfstream is also a leader in supersonic airplane research, having invested in low- and high-speed aerodynamics, engine design and integration, field performance, and both landing and takeoff and sonic boom noise research. Since 2014, Gulfstream has contributed to NASA programs, validating sonic boom prediction models and developing flight research plans for NASA's low-boom flight demonstrator.

NATIONAL RESEARCH ORGANIZATIONS

U.S. manufacturers also support the work being done by NASA, other research agencies, and national aviation authorities to further state-of-the-art research in supersonic flight. Around the world, these organizations are making valuable contributions to sustainable supersonic travel.

NASA

NASA has undertaken a number of projects in different areas of supersonic airplane research. Among its collaborations with other national research agencies are partnerships with The French Aerospace Lab and the Japan Aerospace Exploration Agency on sonic boom prediction research. As mentioned above, NASA is developing the X-59 Quiet Supersonic Technology research X-plane in partnership with Lockheed Martin, which is intended to create a sonic "thump" to approximate sounds that may be produced by future large, quiet supersonic aircraft. Community response testing with the X-59 is expected to begin in 2022. NASA also has undertaken modelling of supersonic transport-category airplane environmental performance with contributions from manufacturers including Aerion, Boeing, Boom, GE, Gulfstream, and Rolls Royce.

Japan Aerospace Exploration Agency

Since 2016, the Japan Aerospace Exploration Agency has conducted research and development into future economically-viable and environmentally-friendly supersonic airliners through the System integration of Silent SuperSonic program. The associated project airplane is a 50-seat, Chapter 14-compliant airliner with more than 3,500 nautical miles of range and a perceived sonic boom signature of less than 85 decibels. The agency has also developed sophisticated sonic boom modelling capabilities as part of its low-boom concept demonstration “Drop test for Simplified Evaluation of Non-symmetrically Distributed sonic boom,” and created a sonic boom prediction code called “Xnoise,” validated with measurement data from the demonstration.

RUMBLE

RUMBLE (RegUlation and norM for low sonic Boom LEvels) is a three-year program sponsored by the European Commission and the Russian Federation. RUMBLE is coordinated by Airbus and involves 19 European and Russian partners, including advisory input from the European Union Aviation Safety Agency and Directorate General for Civil Aviation. The project seeks to address both technical and regulatory aspects of sonic booms. Ultimately, RUMBLE seeks to produce the scientific evidence necessary for governments and ICAO to develop an on-route supersonic noise standard, and the project will make recommendations for this sonic boom standard.

TsAGI and CIAM

The Russian research centers called TsAGI and CIAM, subsidiaries of the National Research Center -Zhukovsky Institute, conduct research on community noise produced by supersonic civil aircraft. Some results on noise reduction from takeoff thrust management and jet speed effect on supersonic transport-category airplane community noise were submitted at the Committee on Aviation Environmental Protection 11 meeting.

ICAO

As work continues on civil supersonic development programs and research initiatives, ICAO has a significant role in developing global environmental standards appropriate for future supersonic airplanes and engines. U.S. manufacturers are supporting ICAO’s efforts to develop a regulatory framework appropriate for civil supersonic airplanes. A set of exploratory studies was recently assigned to ICAO to develop understanding on supersonic aviation noise, emissions, and environmental modelling, with input from technical expert working groups. This work program is designed to assess environmental performance and demand scenarios for future supersonic airplanes and will afford a better understanding of the impacts of potential supersonic operations.

CONCLUSION

Despite fundamental technical differences between supersonic and subsonic airplanes, and the comparative lack of maturity in civil supersonic technology, U.S. manufacturers are fully committed to producing environmentally responsible supersonic aircraft and minimizing their environmental footprint. Reducing fuel burn, supporting the development of sustainable aviation fuels and mitigating or eliminating sonic booms are just some of the many activities and research projects being undertaken to improve performance and speed connections around the world. In light of civil aviation’s undeniably beneficial influence on modern society, and urgent needs to address the long-term impacts of climate change, this research is even more important. Current efforts by industry and research being performed by other organizations are the first steps towards making environmentally-friendly supersonic flight a reality.