Connecting the World through Environmentally Responsible Supersonic Flight

By International Coordinating Council for Aerospace Industries Association (ICCAIA)[1]

Introduction

ICCAIA is a global aviation manufacturing trade association, dedicated to a safe, secure, efficient, and sustainable international air transportation system. Composed of nine global national and regional associations, ICCAIA member products ensure safe and efficient transportation of millions of people a day, resulting in a deeply connected world. The benefits of being able to hop on an airplane and safely travel thousands of miles in a matter of hours are innumerable.

Historically, global travel has been constrained by the speed of available technology. Two hundred years ago, transatlantic travel was only possible via an arduous, month-long steamship journey. It was not until the advent of commercial aviation in the 1930's that transoceanic travel became practical, albeit still a challenge. In the late 1950s, the jet age fundamentally changed travel, making long-distance flights a part of many people's lives. With the introduction of the jet, week-long transpacific business trips became practical, and tourist destinations previously too distant of became commonplace.

The speed of commercial aviation peaked in the 1970's with the supersonic Concorde and Tupolev Tu-144. While both were technological marvels of the day, neither was environmentally or economically sustainable. Consequently, supersonic flight never entered the mainstream: only fourteen Concorde entered service, and the Tu-144 flew a total of only fifty-five scheduled passenger flights.

Innovations in jet engines, advanced computational analysis, composite materials, noise reduction technologies, and net-zero carbon fuels are enabling a new generation of environmentally responsible supersonic civil aircraft. This supersonic renaissance offers tremendous benefits–bringing families, businesses, and cultures closer together; enabling global leaders to solve crises face-to-face; and providing socio-economic benefits from responsible travel to rarely visited cities

One of ICCAIA's strategic priorities is fostering the introduction of emerging technologies in civil aviation, and member manufacturers have announced projects that will unlock the benefits of traveling twice as fast, at speeds up to Mach 1.8. Three-day transatlantic business trips can shrink to a single day. And these modern supersonic aircraft manufacturers are addressing the environmental concerns of the first-generation supersonic aircraft, which flew more than half a century ago.

The International Civil Aviation Organization (ICAO), where governments, aviation stakeholders, and the NGO community all work constructively and collectively, is critical in setting international standards for the emerging supersonic industry. The standards and regulatory procedures set through ICAO require manufacturers to continually improve environmental performance through technologically feasible and economically reasonable means, and this process offers broad benefits. Notably, the Supersonic Exploratory Study completed during the CAEP/12 cycle led ICCAIA manufacturers to voluntarily update supersonic aircraft designs to achieve quieter noise levels, moving from Chapter 4 to Chapter 14

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landing and takeoff noise limits using state-of-the-art noise reduction technologies and advanced operational procedures.

In addition to the landing and takeoff noise produced by all aircraft, supersonic aircraft produce sonic booms when traveling faster than the speed of sound. Industry is addressing sonic booms in two ways: first, by identifying hundreds of key markets that can be served through supersonic flight only overwater with subsonic flight over land, and second by undertaking innovative quiet boom research and development to reduce the intensity of a sonic boom to a "thump." However, until quiet boom technology matures and international sonic boom standards are developed, supersonic aircraft will not fly at supersonic speeds over land to avoid unacceptable noise impacts.

ICCAIA supersonic aircraft members are fully committed to ICCAIA's net-zero carbon goal by 2050, and supersonic airplanes and engines will be designed with fuel efficiency as a key consideration to enable economic and environmental performance. To achieve net-zero carbon, the aviation industry is taking active steps to help spur growth of the nascent sustainable aviation fuels (SAF) industry. Several supersonic aircraft manufacturers have partnered with e-kerosene producers, supporting one of the most scalable and environmentally friendly sustainable aviation fuel technologies. Supersonic engines are being designed to accommodate drop-in and non-drop-in sustainable fuels, maximizing the environmental benefits of SAF such as reduced particulate emissions.

Beyond carbon, leading climate scientists are developing a better understanding of the climate effects of stratospheric flight. Noteworthy recent publications from several institutions[2,3] suggest that contrail formation and associated climate impacts are greatly reduced in the stratosphere. Supersonic manufacturers will continue monitoring the latest literature to better understand non-CO_2 impacts, including NOx and water vapor, and mitigation strategies.

As with all new technologies, supersonic aircraft are starting near the beginning of the technology s-curve. The challenges of supersonic flight provide a catalyst for innovation, with future iterations continuing to reduce the environmental impact of supersonic flight. These innovations, driven by necessity for supersonic flight, may also benefit subsonic aircraft and reduce the environmental impacts of aviation overall.

Announced ICCAIA Member Supersonic Aircraft

ICCAIA members, including Boom Supersonic and Exosonic, are developing commercial supersonic transports for business, airliner, and government uses, supported by engine manufacturers such as Rolls-Royce. Cruise Mach for project vehicles spans from 1.4 to 1.8, and all manufacturers are now targeting landing and takeoff noise equivalent to Chapter 14 subsonic limits using innovative advanced procedures. These manufacturers continue to contribute technical expertise, modeling resources, and data to ICAO's Committee on Aviation Environmental Protection to inform future environmental standards for supersonic aircraft.

Boom Supersonic's mission is to make the world more accessible, extending the benefits of supersonic travel to communities and the planet. Boom's commercial airliner, Overture (shown in Figure 1), has undergone numerous design iterations and fidelity improvements over the past 3 years. Overture is a Mach 1.7, 4,250 nm (7,871 km), 65 passenger airliner. It is being designed to Chapter 14 noise levels using advanced procedures, balancing noise reduction with cruise fuel efficiency. Overture is expected to begin flight testing in 2026 and enter service by the end of the decade. The airplane is designed to accommodate 100% non-drop-in SAF, helping to enable net zero carbon operations. Boom is also committed to achieving net-zero carbon by 2040 as one of the first aviation signatories of The Climate Pledge. Boom's scaled supersonic demonstrator XB-1 will further provide design validation of key characteristics of the project airplane. This demonstrator began engine runs in November 2021, with first flight expected in 2022.

2 Zhang, J. et al, *Stratospheric Ozone and Climate Forcing Sensitivity to Cruise Altitudes for Fleets of Potential Supersonic Transport Aircraft*, *Journal of Geophysical Research: Atmospheres, Volume 126, Issue 16, 03 August 2021*

3 NASA/CR-20205009400, *Global Environmental Impact of Supersonic Cruise Aircraft in the Stratosphere*, February 2022

FIGURE 1: Boom Supersonic Overture Commercial Airliner

FIGURE 2: Exosonic Large-Scale Low Speed Wind Tunnel Test Surface Flow Visualization

Exosonic is dedicated to creating environmentally friendly and efficient supersonic transportation. Quiet sonic boom technology is being rapidly integrated into a low boom flight demonstration, and Exosonic is leveraging both computational and practical tools to accelerate supersonic innovation. Flow-visualization techniques employed to understand force measurements and develop design refinements are shown in Figure 2. Engine OEMs and engine modeling are being developed to meet Chapter 14 noise limits with margin while minimizing fuel burn, emissions, and ticket cost, and Exosonic recently signed a memorandum of understanding to collaborate on developing sustainable fuel for future supersonic aircraft. The Exosonic staff is rapidly growing and is expected to double next year. Exosonic hopes to have an aircraft certified by the end of the decade.

International Research Organizations

ICCAIA manufacturers also support the work being done by international organizations, national aviation authorities, and research institutions to advance state-of-the-art research and standards development for supersonic flight. These represent a global effort to increase the speed of aviation and facilitate the benefits of a more connected world.

ICAO

ICAO has the responsibility for developing global environmental standards for all aircraft, including emerging supersonic civil airplanes. ICAO completed a Supersonic Exploratory Study during the CAEP/12 cycle to improve understanding of the noise and emissions impacts of a representative supersonic fleet, based on industry project aircraft at the time. The result of the study contributed to ICCAIA members updating aircraft designs to Chapter 14 limits using advanced procedures, which is expected to reduce the overall noise impact of the fleet. Advancing

supersonic landing and takeoff noise and emissions standards is included in the CAEP/13 work programme, which is expected to provide the regulatory certainty ICCAIA members need to advance aircraft design and manufacturing.

Japan Aerospace Exploration Agency (JAXA)

JAXA has been making various R&D efforts on supersonic transport (SST) technologies to contribute to the realization of overland supersonic flight. Key technologies established to date include drag reduction technologies (NEXST-1 project / 1997-2005) and sonic boom reduction technologies (D-SEND project / 2010-2015). Following the successful completion of the D-SEND project, JAXA has conducted the R&D program for System integration of Silent SuperSonic (S4) technology from 2016 to 2020 for future economically viable and environmentally friendly supersonic airliners. As a result of the S4 program, a 50-passenger supersonic airliner (S4 airliner) was designed as a technology reference aircraft whose performance was over 3500nm of range, less than 85PLdB of sonic-boom, and ICAO Chapter 14 criteria of LTO noise.

MORE&LESS

MDO and REgulations for Low boom and Environmentally Sustainable Supersonic Aviation (MORE&LESS) is an EU research and innovation programme, sponsored by the European Commission. The program aims to shape global environmental regulations for future supersonic aviation through high-fidelity modeling and testing, evaluating a wide range of supersonic speeds (Mach 2 to Mach 5) and a variety of aircraft configurations, propulsion technologies, and sustainable aviation fuels. The objectives are “MORE” sustainable fuels, environmental protection, and citizens protection with “LESS” pollutant emissions, noise emissions, and impact on air quality, ozone layer, and climate.

National Aeronautics and Space Administration (NASA)

NASA has conducted extensive supersonic airplane research, with a focus on low boom technologies. NASA developed the X-59 Quiet SuperSonic Technology (QueSST) aircraft in partnership with Lockheed Martin. The X-59 is designed to fly at Mach 1.4 and create various sonic “thumps” between 70-80 decibels (PLdB), and will be used for a series of community response tests to inform potential future on-route supersonic noise standards. X-59 ground testing began in January 2022. Other NASA initiatives include shock-sensing probes, advancing Schlieren imaging techniques, and enhanced ADS-B system for supersonic aircraft.

SENECA

The EU programme noiSe and EmissioNs of supErsoniC Aircraft (SENECA) is focused on improved understanding, modelling, and quantification of noise and emissions in the vicinity of airports and the global climate impact of supersonic aviation SENECA builds on experience from previous EU programmes such as HISAC and RUMBLE. Four different SST platforms (Mach 1.4 & 1.6 business jets and Mach 1.8 & 2.2 airliners) are subjects of multidisciplinary design optimization regarding landing and takeoff cycle noise, emissions, performance, and environmental impact. Finally, SENECA is expected to deliver reliable data and recommendations for emission and noise certification regulations ensuring environmentally friendly supersonic aviation.

CONCLUSION

Supersonic and subsonic aircraft have fundamental technical differences, and ICCAIA members are addressing these challenges head on to achieve environmentally responsible supersonic transportation. Industry and research organizations continue to innovate in noise reduction technologies, sustainable aviation fuels, engine efficiency, and aircraft design. All of these innovations will be critical to further enhancing the benefits of civil aviation through shorter travel times while also addressing the pressing climate crisis. This ongoing research will undoubtedly make sustainable, environmentally friendly supersonic flight a reality.