Review of Special Flight Authorization Procedures for Civil Supersonic Aircraft and Developmental Trends of New Noise Standards

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1. Background

In reference to civil supersonic aircraft, the European Concorde and Russian Tu-144 both began commercial operations in the mid-1970s. However, due to problems with fuel efficiency and noise, and without development of an upgraded aircraft, civil supersonic aircraft have fallen out of use, with none being operated since the end of Concorde's flights in 2003.

Under these circumstances, several civil supersonic aircraft development projects are underway in the United States with the aim of putting them into practical use in the mid-2020s, as reported[1)] in June 2020.

In this report, based on the progression of these civil supersonic aircraft development projects, special flight authorization procedures for operations on U.S. land and the development trends of new noise standards will be examined.

2. Review of Special Flight Authorization Procedures of Operations on Land

2.1 Existing Regulation and Review Direction

Due to the fact that the shock waves that inevitably occur when flying at subsonic speeds expanded the area subject to noise problems, which was previously limited to spaces around airports during takeoffs and landings for subsonic civil aircraft, sonic boom considerations grew to include entire flight routes. For this reason, the Federal Aviation Regulations (FAR) 91.817 stipulated in 1973 a principle ban on supersonic flight on land in the United States. However, FAR 91.817 was exempted for supersonic flight operations that had Federal Aviation Administration (FAA) approval, and the procedure was stipulated in Appendix B of FAR Part 91.

This exception was created for when supersonic flight was necessary during the development and examination of new aircraft, which at the time of the development of this procedure, 20 applications were estimated by the FAA to need approval annually. However, from then till now, developmental achievements have been extremely limited, with only 3 actually being approved.

Breaking down these three cases, two involved test flights for experimental space transport aircraft mounted onto another aircraft, and the other involved an aircraft manufacturing company needing to fly above sonic speeds to prove the safety of a subsonic aircraft.

Like FAR 91.817, the procedures for this exception have not been rescrutinized, but the FAA proposed a revision in June 2019 and published a finalized rule in January 2021 in light of the current progression of multiple supersonic aircraft development projects. [2)]

The following three points were the major aspects for the procedure review. The first was to clarify which FAA department to apply for approval. The second point was to list and sort the application requirements that were currently described separately. The third was to add test flights for measuring noise characteristics to see whether they comply with regulatory requirments in order for supersonic flights to be approved.

In the next section, the exact content of the newly developed procedure will be described.

2.2 Specific Contents in the New Procedure

Firstly, FAR Part 91's previous Appendix B has been deleted in the new procedure, and was formally specified anew as revised content in FAR 91.818. Regarding where applications should be sent for approval, while the existing procedure had not mentioned a FAA department, the new procedure explains that the FAA's Office of Environment and Energy is where they should be submitted. As the Office of Environment and Energy is under the Office of Policy, International Affairs and Enviroment, which reports directly to the FAA Administrator, all approval applications for exceptions were decided to be submitted to FAA headquarters in Washington DC rather than local FAA offices.

In regards to the composition of application documents, the existing procedure had only stated that they were to be in "a format and method instructed by the FAA Administrator," which is difficult for both the applicant and the FAA to understand. Additionally, the required documents to be submitted were listed separately in Appendix B, which contributed in this necessary information being overlooked. For this reason, in the new procedure, the requirements are listed and sorted in FAR 91.818 (a).

The new procedure includes space for information on the time of day when the flight is to be carried out in the application. If a flight were to take place at night, the expected noise would more greatly impact daily life, and thus additional explanation would be needed to be given to justify why the flight must be flown in the evening. For past applications, such additional explanation was requested during the middle of the review process, but its inclusion at the time of submission is anticipated to expedite application review.

Within supersonic flights that are approved, the new procedure has added test flights to measure noise characteristics to confirm regulatory requirement compliance. FAR Part 36, the U.S. noise standard, is not currently applied to supersonic aircraft, but it is expected that a noise standard will be formed in the future, and flight tests will someday provide noise certification. With respect to the approvals term of validity, there had been no special provision in the existing procedure, but the new procedure defines it as a period of time deemed necessary by the FAA Administrator. The FAA encourages applicants to submit separate applications if projects requiring supersonic flight have significant time lags between phases. Additionally, the existing procedure had a provision to approve supersonic flight outside of testing areas when an aircraft demonstrated that flights within testing areas did not cause an observable sonic boom on the ground. Regarding this point, although shock waves generated in the sky may not reach the ground, use of "Mach cut off," which isn't heard as a sonic boom, in supersonic commercial aircraft development is underway, and consideration was given of collected public comments that view requirements for a "sonic boom to not be observable on the ground" to be too strict, it was concluded that there was insufficent data necessary to make revisions, and the new procedure maintained the existing content.

3. New Noise Standards for Supersonic Aircraft

3.1 Current Standards and History

FAR Part 36, the current U.S. noise standard that was mentioned in the previous section, only applies to the Concorde rather than to all supersonic aircraft.

In 1990, a draft standard was published stating that supersonic passenger aircraft should meet the Stage 3 noise standard of FAR Part 36, but it was withdrawn in 1994 because of the need for further research. In light of the recent progress of multiple supersonic aircraft development projects, the FAA had to develop noise standards before issuing a safety certificate (type certificate) for these supersonic aircraft. For this reason, based on results from the Supersonic Transport Concept Airplane study conducted by NASA, information provided by the American Industry Association, and examinations conducted by the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP), an amendment to FAR Part 36 was proposed in April 2020 to add new takeoff and landing noise standards for some

civil supersonic aircraft.[3)]

Although this amendment provides a method for certifying noise for supersonic commercial aircraft, it does not address the problem of noise during supersonic cruising. Moreover, further research is necessary on noise during supercruing, including how it should be regulated. Because of this, the FAA has emphasized that the proposed amendment does not affect the aforementioned provisions of FAR 91.817 (prohibition of supersonic flight on land, in principle).

3.2 Specific Content of the New Noise Draft Standards

The new draft noise standards define supersonic aircraft as having a maximum takeoff weight of 150,000 pounds (68 tons), a maximum cruising speed of Mach 1.8 or less, and characterized as Supersonic Level 1 (SSL1) aircraft. As such, the draft standards are intended specifically for SSL1 aircraft. For supersonic aircraft that exceed the maximum takeoff weight or cruising speed, because they would be considered to have different design features from SSL1 aircraft, and the draft noise standards are specificaly for SS1 aircraft alone, the FAA will need to consider noise standards based on those for SSL1 and information provided by the aviation industry in the future.

Draft noise standards especially for SSL1 aircraft have been added as Appendix C in FAR Part 36, featuring the same points for noise measurements for takeoff and landing as for subsonic aircraft. On the other hand, the methods for noise measurements differ in that the use of the Variable Noise Reduction System (VNRS) is permissable. VNRS is an advanced technology that automatically controls the engine and control surface in order to reduce noise during takeoff and landing in supersonic aircraft, and with its allowance can be used by aircraft manufacturers for more design flexibility.

SSL1, having a maximum takeoff weight of 150,000 pounds (68 tons) and three engines, adhere to an upper noise limit of 94.0 EPNdB, 96.5 EPNdB and 100.2 EPNdB respectively for the three phases of takeoff, lateral, and approach, with the upper noise limit decreasing as the total takeoff weight decreases. These upper limits are the same as the standards defined in Stage 5, which is the noise standard for the latest subsonic aircraft.

However, noise standards require that the combined noise value of the three phases must have a certain margin from that of maximum noise value limit, with Stage 5 requiring at least 17 EPNdB or more, Stage 4 needing 10 EPNdB or more, and the new draft noise standard defining it as 13.5 EPNdB. Therefore, the new draft noise standards are stricter than those for Stage 4 subsonic aircraft, but more lenient than those for the latest Stage 5 subsonic aircraft.

Regarding the validity of adopting noise standards different from subsonic aircraft, the FAA has noted that due to the shape of the main wing to reduce air resistance at supersonic speeds, lift is insufficient at low speeds, which requires faster speeds and greateer engine thrust than subsonic aircraft during takeoff and landing. Furthermore, improvements in engine bypass ratios, which have greatly contributed to noise reduction in subsonic aircraft, are restricted.

4. Conclusion

There is a rationality as to the difference in noise standards for supersonic aircraft from those for subsonic aircraft, with moreover the welcomed significant reduction in noise compared to the Concorde. However, based on the new content[4)] announced by the FAA in November 2020, as well as those in the new procedures as described in Section 2 of this report, arrangements to revise the ban of supersonic flight on land, in principle, will be determined based on future collected data, and the outlook of the revision is still uncertain. The handling of noise during supersonic cruising remains an issue for relaunching civil supersonic aircraft, and it will be necessary to continue observing this trend.

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