inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 13.1.2

SECOND GENERATION SST: NOISE CHARACTERISTICS AND OPERATIONAL NOISE PERFORMANCE

A K Mortlock

McDonnell Douglas Aerospace, USA

1. INTRODUCTION

The design requirements of the next generation supersonic commercial aircraft present a formidable technical challenge to achieve environmental compatibility and economic viability. The Concorde has proven to be a technical success but failed to provide an environmentally friendly aircraft with an economic solution.

Over the past 10 years McDonnell Douglas has been studying and developing the technologies necessary to produce a viable commercial supersonic airliner. This has been mainly accomplished through the NASA High Speed Research Program (HSRP). Internal funded High Speed Civil Transport (HSCT) studies have demonstrated that achievement of the HSRP technology goals can produce an environmentally friendly and economically viable aircraft.

One of the environmental focuses of the HSCT project is community noise acceptability. The associated acoustic technologies, noise characteristics and projected operational noise performance of the vehicle are discussed in this paper.

2. THE ISSUES

In order for the HSCT to be compatible with the subsonic fleet towards the end of the first decade of the next century the selection of noise certification goals and airport operational procedures that minimize community noise are of paramount importance.

However, the selected noise goals will have an inherent effect on vehicle size for a given range and passenger capacity thereby affecting the cost of the aircraft and its operating economics.

The development of safe unique automated operational procedures can significantly reduce the HSCT impact on noise exposure around international airports.

3. TECHNOLOGIES ASSOCIATED WITH NOISE REDUCTION

In order to make the HSCT compatible with the long range subsonic fleet towards the end of the first decade of the next century a number of technologies have to be aggressively developed. The following main technology areas that affect noise (illustrated in Fig. 1) are under development:

(i) Variable engine cycle that operates with high flow, low exhaust jet velocities at takeoff and climb-out speeds and converts to a higher specific thrust cycle for supersonic cruise efficiency
(ii) Noise suppression nozzle depending on engine cycle selection
(iii) Advanced fan-inlet noise reduction
(iv) Low-speed high lift devices to maximize lift/drag to reduce thrust requirements and to increase aircraft altitude over communities
(v) Light weight materials and structures to minimize thrust requirements and
(vi) Advanced flight deck to manage noise abatement operational procedures that minimize noise over communities.

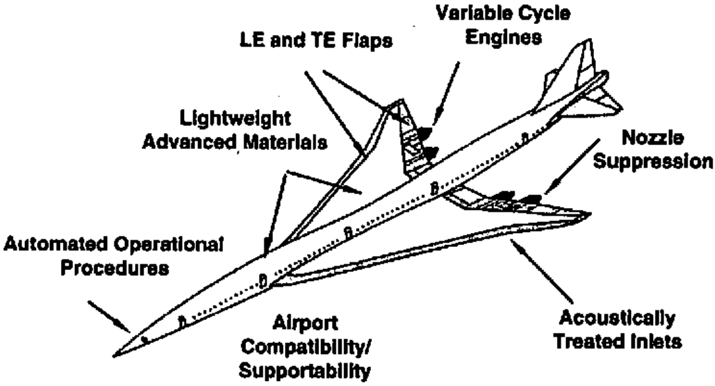


Fig. 1 - HSCT Key Noise Technologies

4. HSCT NOISE CHARACTERISTICS

There are a number of candidate variable cycle engine designs emerging from the worlds major large engine manufacturers that may satisfy subsonic and supersonic operational requirements. The US engine manufacturers are concentrating on a mixed flow turbofan (MFTF) cycle incorporating an exhaust mixer-ejector (M/E) nozzle for noise reduction purposes. In Europe, the engine manufacturers have favored a Mid Tandem Fan (MTF) cycle which has high mass flow during take-off and approach conditions and incorporates a simple thrust reverser aft (TRA) nozzle. However, all the engine company teams are continuing to study alternative engine cycles.

Sideline Noise

In order to comply with FAR Part 36 Stage 3/ICAO Annex 16 Chapter 3 noise limits the major requirement is obviously to minimize jet noise. The M/E nozzle, which draws in external air to mix with the core and fan flow, reduces mixed exhaust jet velocity. However, the mixer also generates additional noise which subsequently has to be attenuated by internal absorptive liners. The MTF will also have some contribution of turbomachinery noise at the full power takeoff condition which will need inlet and rear fan duct noise reduction treatment. Attention has to be given to the possibility of fan noise escaping through auxiliary inlet doors. In both the M/E nozzle and TRA nozzle some sideline attenuation benefits due to nozzle exit shape asymmetry effects may be achievable.

Takeoff (Cutback) Noise

For this condition, jet noise is still the major noise source for the MFTF M/E with a small contribution from turbomachinery noise. However, the MTF is likely to have jet noise and turbomachinery noise (predominately fan noise) of similar source strength.

Approach Noise

On approach the M/E concept could have some jet noise source contribution if the cycle has a exhaust jet velocity above 1000 fps. The main noise sources are likely to be turbomachinery (fan and turbine). The MTF has to mainly deal with the attenuation of the fan and turbine noise sources. Two other noise sources (i) core noise (low NOx combustor) and (ii) airframe noise are currently estimated well below the fan and turbine noise. Near term model airframe noise tests should reveal whether current prediction methods are in the "ball park". As for low NOx combustor noise, information from combustor noise tests will not be available for 4-5 years.

5. NOISE CERTIFICATION GOALS

At the last ICAO Committee on Aircraft Environmental Protection (CAEP3) meeting held in Montreal in December 1995 there was no decision to further increase the noise rule stringency of the current subsonic Chapter 3 noise limits for new designs. Since the late 1980's the MDC noise certification design goal for the HSCT has been to be no noisier than the Chapter 3 noise limits. A strong emphasis has also been to achieve a sizable margin from the takeoff (cutback) noise limit. This is in consideration that the majority of community noise problems at international airports are under the takeoff flight path and many of the existing Chapter 3 aircraft that will be potentially replaced by an HSCT operation, are quieter than the Chapter 3 limits.

In-order to achieve the above noise certification goals the development of automatic thrust and aerodynamic management systems are being considered during takeoff and approach as standard operational procedures. The development of appropriate HSCT noise certification rules is about to commence in the ICAO arena. The FAA will also be addressing the HSCT noise rule needs and industry will help in promoting harmonization with ICAO and FAA/JAA rule making.

6. COMMUNITY NOISE GOALS

In the past takeoff and approach procedures for noise certification have varied widely from the procedures used by the airlines when operating from and to airports. Therefore, more consideration has been given in achieving commonalty of the certification and operational procedures to achieve lower community noise.

The MDC airport and climb noise goals for the HSCT are as follows:

Distance from Brakes Release (DFBR) (nm)	Noise Goals
2-5	- No greater than 17% growth of 65 Ldn fleet contour
	- No greater than + 1.5 Ldn at a community point (FAA Guideline - DOT 1050.ID)
	- Meet existing airport noise limits/ regulations
5-10	- Compatible with B747-400 dBA levels as a function of DFBR
	- Also check % growth of 55 Ldn fleet contour
10+	- Compatible with B747-400 dBA levels as a function of DFBR down to 65 dBA

Fig. 2 illustrates the above community noise goals around the airport.

The subsonic aircraft that the HSCT will replace during its introduction into the commercial fleet is an important consideration. The reason for selecting the B747-400 for climb noise comparisons is that this aircraft will still be operating in the fleet during the HSCT fleet growth phase. We are also unaware of nay current B747-400 climb noise problems operating from the world's international airports.

An HSCT with a range of 5,000 - 6,000 nm and a payload of 250-300 passengers is currently being evaluated. Therefore many 4 engine, 3 engine and 2 engine aircraft operating in this vehicle class could be substituted by an HSCT depending on individual airline operational plans. To date many noise exposure studies have been conducted to compare the airport operational noise levels of the latest technology subsonic aircraft with HSCT operated in a minimum noise mode by using automated thrust and aerodynamic management systems for all phases of the takeoff, climb and approach.

Hypothetical International Airport

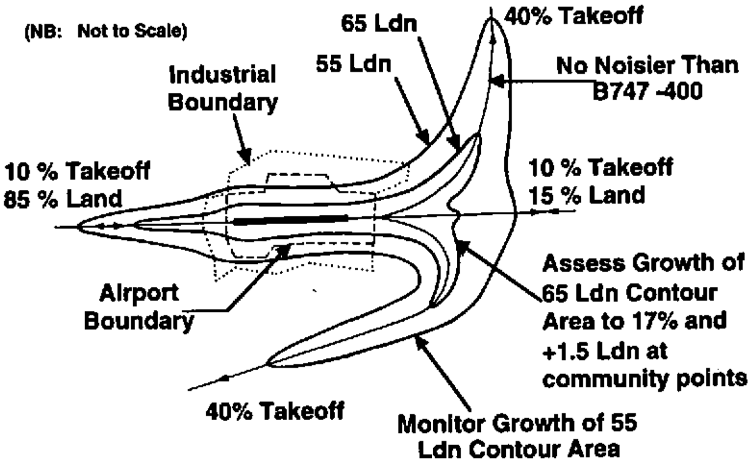


Fig. 2 - Ldn Noise Exposure Contours

Most of the latest technology subsonic aircraft operating from HSCT candidate airports use the Air Transport Association (ATA) or International Air Transport Association (IATA) takeoff procedure which basically cuts takeoff power to max-climb power at 1000-1500 ft altitude. This generally produces a modest noise reduction. In order to make the HSCT more compatible with the subsonic aircraft a need to adopt a deeper cutback than climb power may be necessary.

During approach, aerodynamic efficiency optimization to maximize lift/drag and minimize engine thrust and hence total noise under the approach flight path are being studied. Flight deck systems are being evaluated to use steeper glide slopes and deceleration techniques where appropriate. The impact on Air Traffic Control (ATC) of these procedures are being evaluated. These flight deck systems could give the HSCT an environmental approach noise reduction edge over the current subsonic aircraft in production that will be operating well beyond 2010.

The objective of the community noise exposure studies is to determine the number of daily HSCT takeoff and landings that could be utilized before exceeding the guideline 17% growth of the 65 Ldn contour. The number of daily takeoff and landings at a given airport can be related to fleet size by reviewing the assumed HSCT demand

and route network (see Fig. 3). Hence, the impact of HSCT operations/fleet size can be evaluated as shown in Fig. 4.

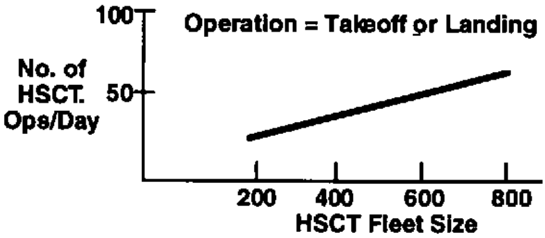
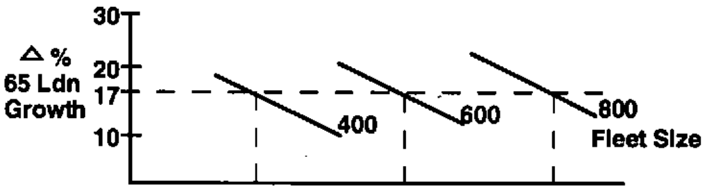


Fig. 3 - No of Ops/Day Versus Fleet Size



Takeoff (Flyover) Noise Certification Goal (Re. Stage 3 Limit)

Fig. 4 - Takeoff Noise Goal Effects on Fleet Size

To prevent any potential down range community noise problems during the takeoff/climb phase the HSCT has been compared with the B747-400 noise performance. The typical 747-400 climb noise has been programmed as a noise constraint. The HSCT has been automatically flown, using an optimizer computer code, to match this constraint by varying, where required engine thrust, aircraft speed, acceleration and aerodynamics (L/D). These studies have evaluated many procedures to an altitude of 30,000 feet. The feasibility of developing an automated on-board flight deck system to match the B747-400 noise constraint under the climb-out flight path is on-going.

7. CONCLUSIONS

The HSCT can be designed to be an environmentally friendly aircraft when operating to and from international airports. This can be achieved by selecting relevant noise certification and community noise goals in the design process.