Research Activity in Japan toward the Next Generation SST

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Abstract: Current status and future perspectives of research and development for the next generation supersonic transport (SST) in Japan are overviewed. At first, status of the research and development for JSRP (Japan Supersonic Transport Program) and the relations with the associate programs and institutions are described. Secondly, the feasibility studies for the next generation SST are presented in the standpoint of aircraft technology accomplishment, market viability and environmental compatibility.

Introduction

A forecast of air traffic demand by JADC (Japan Aircraft Development Corporation) suggests that the annual increase rate of RPK (Revenue Passenger Kilometer) in the world is 5.9 % during the year of 1979 and 1998 and 4.9 % during 1999 and 2018[1]. The world RPK in 2018 will be 7.5 trillion which is approximately 2.5 times of the present (see Fig. 1). Especially RPK in the area of Asia-Pacific is higher than average of the world. In order to satisfy these future passenger demands, both the performance of high-speed and large amount of transport is needed.

From the end of 1980's, the research and development of the next generation Supersonic Transport (SST) has been activated in the world for the satisfaction of passenger demand by virtue of high-speed transportation. The technology innovation through lessons learned with the Concorde and other projects in US and Russia is also motivation of those research and development. The HSR (High Speed Research) Program in the US ended in 1999 due to difficulty of solving engine noise problem and small amount of allocation of NASA budget, and ESRP (European Supersonic Research Program) is not yet lifted off. However the HSR Project is followed by UEET (Ultra Efficient Engine Technology) Project and in the age of 2010s the research and development of next generation SST will be surely recovered.

In Japan, SJAC (The Society of Japanese Aircraft Companies, Inc.) has continued a feasibility study of JSRP (Japan Supersonic Transport Program) (Fig. 2)[2] under the support of MITI (Ministry of International Trade and Industry) from 1989. In the JSRP, (1) accomplishment of aircraft technologies, (2) viability of market and (3) compatibility to environment are required as the fundamental issues to be resolved. The current status of research and development activities for the next generation SST in Japan associated with JSRP is overviewed in this paper.

Status of Research and Development for the Next Generation SST

The JSRP composes of R & D stages of Phase 1 (1989-1994), Phase 2 (1995-2002) and Phase 3 (2003-) as shown in Fig. 3[3]. It is associated with ACDMT (Advanced Composite Design and Manufacturing Technology) Program (1998-2002) for light-weighted heat-resistant composite material and HYPR (Supersonic/Hypersonic Transport Propulsion System) Program for combined-cycle jet engine (1989-1998). The ESPR (Research and Development of

Environmentally Compatible Propulsion System for Next-Generation Supersonic Transport) Program started in 1999 as a successor of the HYPR Program.

The Council for Aeronautics, Electronics and other Advanced Technologies of STA (Science and Technology Agency) suggested the necessity of research for the next generation SST in 1994. Following this suggestion, the experimental supersonic aircraft project NEXST (NAL's Experimental Airplane for SST) has started in NAL (National Aerospace Laboratory) in 1997 for accomplishment and demonstration of aerodynamic design technology. Several national research institutes such as Mechanical Engineering Laboratory and National Institute of Material and Chemical Research are in cooperation in innovation of infra-structural technologies. DOT (Department of Transportation) and airlines relates with operational requirement and environmental regulation-making. Academic societies such as JSASS (The Japan Society for Aeronautical and Space Sciences) and universities contribute in the basic research for aircraft technologies, environmental issues and so on. These relations are illustrated in Fig. 4. All these activities will contribute to development of the next generation SST.

Feasibility Studies for the Next Generation SST

1. Aircraft technologies accomplishment

The JSRP reference configuration of airplane is shown in Fig. 5[3)], having a length of 94.5 m, a span of 43.4 m. The key technologies for the research and development of SST are illustrated in Fig. 6.

(a) Aerodynamics

High lift/drag ratio technologies with wing plan form like a cranked arrow configuration, natural laminarized airfoil, wing warp design and fuselage area rule and airframe/engine integration design technology are studied by the use of low-speed, transonic, and supersonic wind tunnel testings and CFD (Computational Fluid Dynamics) with Euler and Navier-Stokes solvers. Aerodynamic characteristics of high-lift device such as a vortex flap are predicted.

(b) Structure and material

Several structural analyses including FEM (Finite Element Method) are adopted for structural feasibility study. Since light-weighted and heat-resistant characteristics are required, research and development of feasible material including composite and titanium are progressing through ACDMT Program. Aero-elastic tailoring technology is also studied.

(c) Propulsion

The HYPR Program accomplished the combined cycle engine system consisting of turbo-jet and ram-jet up to Mach 5 as a ten-year National Project from 1989 to 1998 as described in Chapter 2. The ESPR Program was started in 1999 having the ecological goals of noise reduction of 3 dB below ICAO Chapter 3 level, NO_x reduction to 1/7 of the current level and CO_2 reductions of 25 % of the current level.

(d) Total Integration System

Researches for cockpit with SVS (Synthetic Vision System), thermal management system with regenerative cooling by fuel and total integrated system are under way.

2. Market viability

According to market research by SJAC including passenger forecast, minimum flight path, operational economy, development / manufacturing cost, passenger stimulation effect, fare flexibility, etc., the most feasible SST in Japan should have seat of 300, cruising Mach number of 2.2, range of 10,200 km (5,500 nm) as shown in Fig. 5[3)].

Assuming that half of aircraft passengers is carried by SST, the fleet of 500 to 1,000 with reasonable air fare is expected. The expected cruising route is illustrated in Fig. 7[4]. It will have a potential of economical benefit of approximately 3.8 trillion Yen at 1992 prices[2].

3. Environmental compatibility

Three issues for environmental compatibility of the next generation SST are recognized as reduction of community noise, suppression of sonic boom and protection of global ozone layer.

(a) Community Noise

The noise issue is studied in two aspects of technology innovation of propulsion system and ICAO assessment. Noise prediction with mixer-ejector nozzle at HYPR Program and noise abatement of flight procedure using engine cut-back, etc. at take-off are studied.

(b) Sonic Boom

Acceptability study with a sonic boom simulator of SJAC and boom propagation study for the planned SST configuration with use of Hayes' Program, etc. are conducted. Development of design technique for low-boom / low-drag configuration is also continued. Figure 8 shows the optimized airplane configuration having ramp-typed sonic boom signature at ground[5].

(c) Ozone Chemistry

Ozone change prediction with use of 2-D chemistry transport model and its application to NASA AESA (Atmospheric Effect of Stratospheric Aircraft) Scenario IV is studied[3]. Figure 9 is global ozone change due to influence of aircraft cruise, which forecasts decrease of ozone at upper stratosphere (dashed lines), but increase in lower troposphere (solid lines). Technologies for reduction of engine noise, CO_2 and NO_x will be studied in the ESPR Program as described above.

Conclusion

Current status and future perspectives of research and development for the next generation supersonic transport (SST) in Japan including research and development organization, feasibility studies for (1) aircraft technologies accomplishment, (2) market viability and (3) environmental compatibility were overviewed. All activities will contribute to the next generation supersonic transport.

References

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3) SJAC: Study Report on the Next Generation Supersonic Transport, March 1999 (in Japanese).

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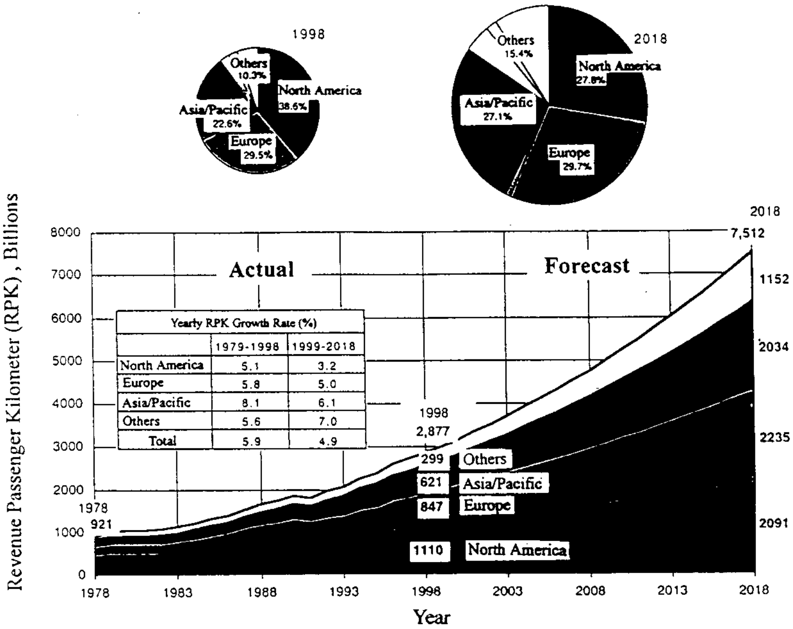


Fig. 1 World air traffic forecast[1]

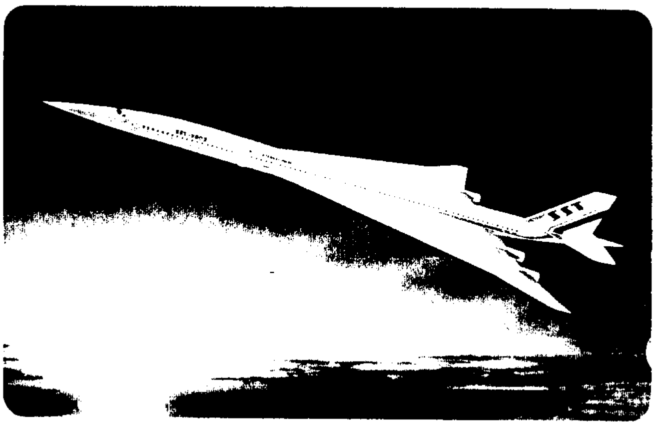


Fig. 2 JSRP airplane image[2]

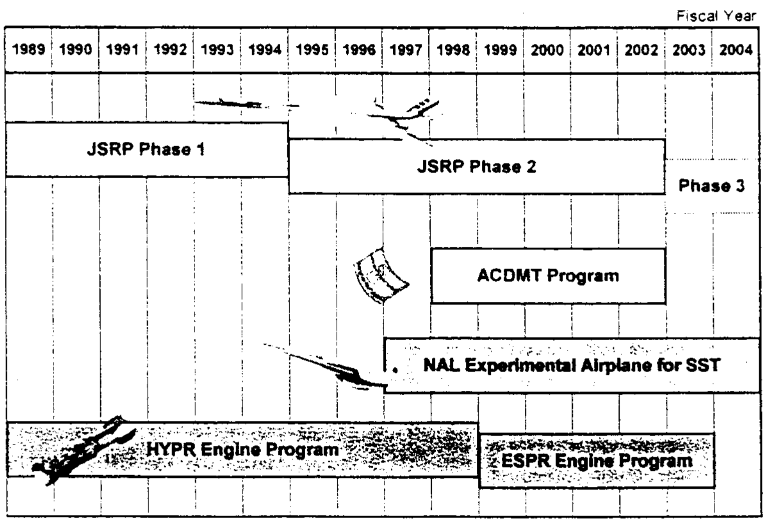


Fig. 3 Program schedule[3]

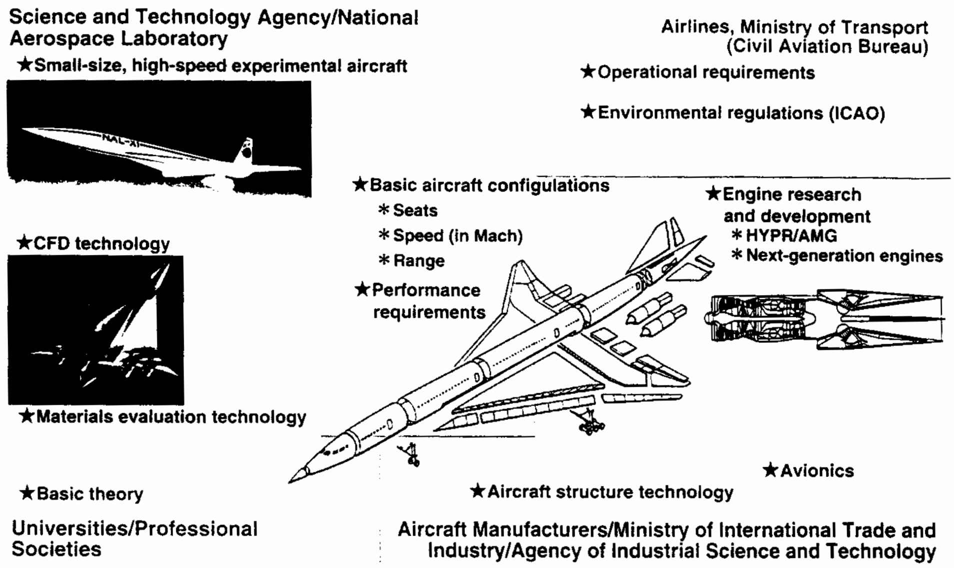
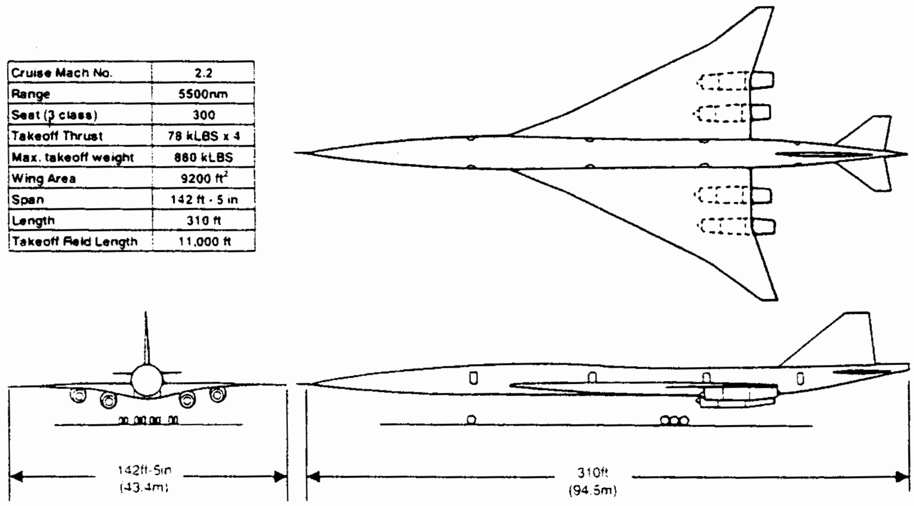


Fig. 4 Relation between institutions for R & D of SST in Japan



Cruise Mach No.	2.2
Range	5500nm
Seat (3 class)	300
Takeoff Thrust	78 kLBS x 4
Max. takeoff weight	880 kLBS
Wing Area	9200 ft²
Span	142 ft · 5 in
Length	310 ft
Takeoff Field Length	11,000 ft

Fig. 5 Airplane configuration[3)]

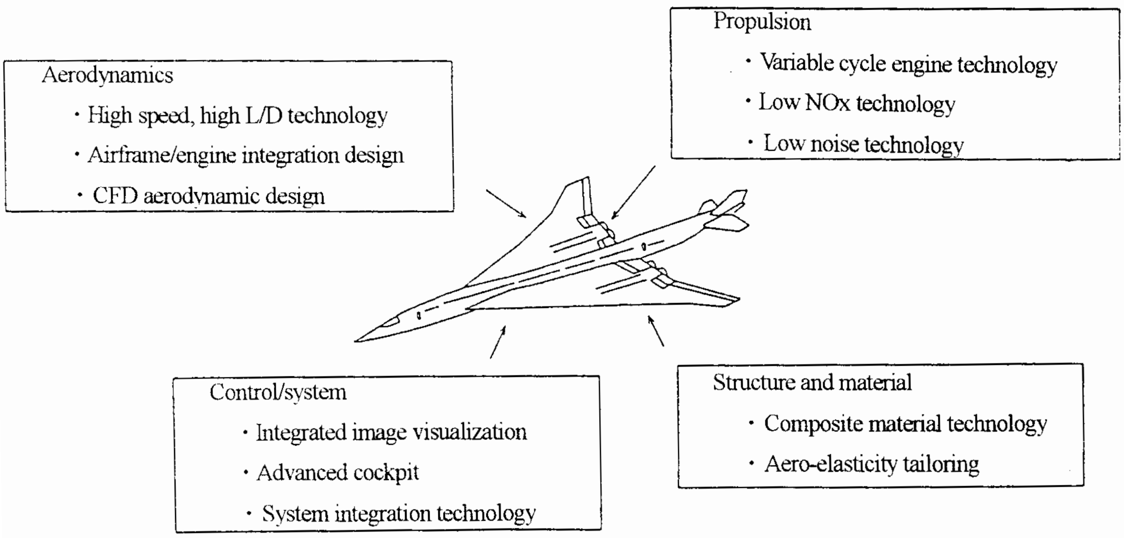


Fig. 6 Key technologies for R & D of SST

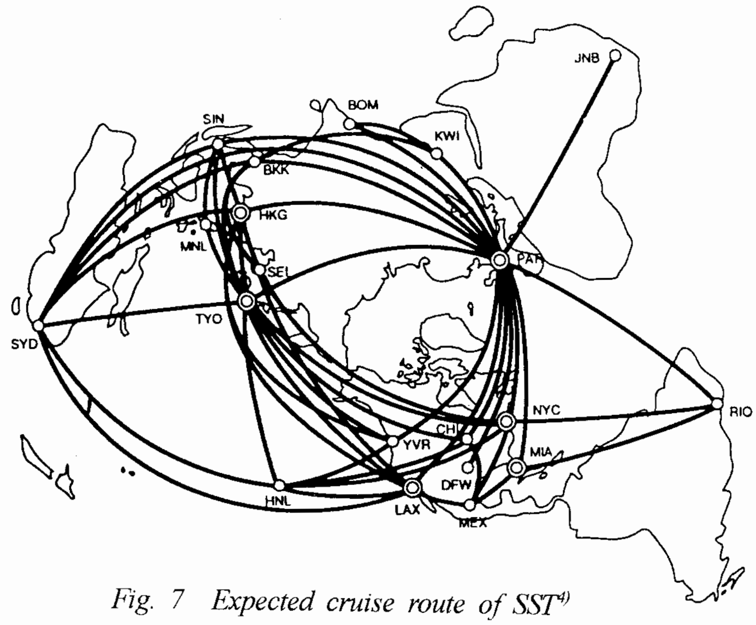
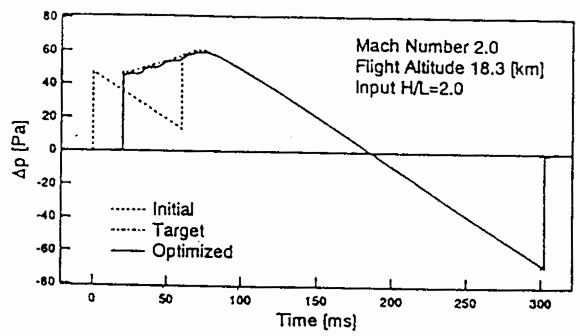
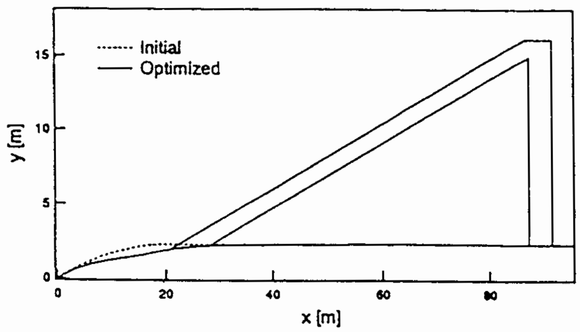


Fig. 7 Expected cruise route of SST[4]



(a) **Ground pressure signature**



(b) **Fuselage configuration**

Fig. 8 Optimized airplane Configuration for sonic boom reduction[5]

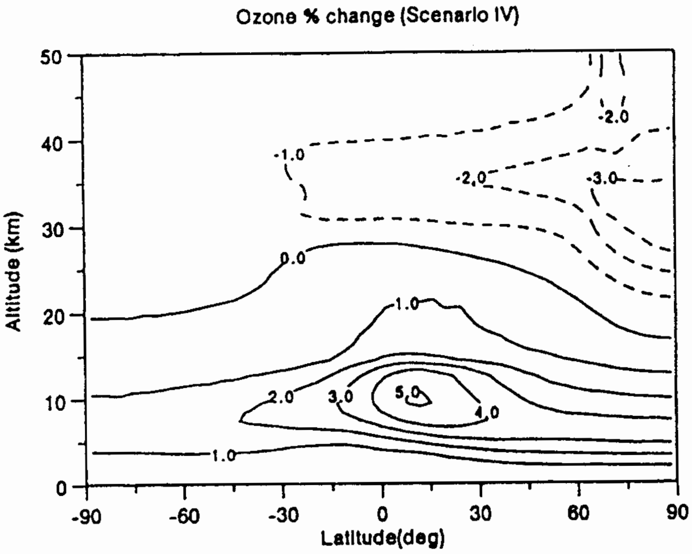


Fig. 9 Predicted ozone change[3]