Supersonic Research Program in NAL, Japan

Kimio SAKATA
Leader, Experimental Airplane Group
SST Program ,National Aerospace Laboratory

ABSTRACT

The experimental airplane R&D program has been initiated in NAL of Japan in order to establish the advanced technologies including the sophisticated CFD (Computational Fluid Dynamics)-design for the next generation supersonic civil transport. CFD technology will be developed through developing the experimental airplanes in the program for the optimized and automated design technology, which should become the major technology for designing aerodynamically high performance aircraft. The un-powered and jet-propelled airplanes will be developed and tested in the flight to verify the fruits of the NAL's research work. The program term would be between 1997 and 2004. International and domestic institutes are invited to the research cooperation.

1. Preface

NAL plans to establish the technological basis for the next generation supersonic civil transport (SST) through conducting the component research and the development of two kinds of unmanned experimental aircraft, which consist of the un-powered and jet engine propelled vehicles, together with those flight tests. High aerodynamic performance, high propulsion efficiency, light weight and environmental compatibility are required for realizing future SST to be anticipated in early 21st Century. The main subjects of the program are including CFD-based aerodynamic design technology for high lift/drag ratio, light weight composite structure technology, high performance propulsion system and associated control technology. The technological achievement of the component research will be applied to the experimental airplanes to be verified by the flight tests.

The program schedule is shown in the figure 1, which was initiated in 1997 and to last until 2004. The program cost was estimated as much as B¥ 20 in 8 years. NAL forms the SST project team consisting of the general affairs group, the experimental aircraft development group and component research group. Collaboration and cooperation with the universities, industries and research institutes, including the foreign organizations are strongly encouraged. Actually the cooperation with MITI's programs, which includes HYPR and the feasibility study done by SJAC (Society of Japanese Aerospace Companies), is performed. The major research subjects being dealt in the program are shown in the figure 2. Among many subjects categorized in 4 fields, aerodynamic design methodology utilizing CFD technology, composite materials and some of the propulsion theme are highly

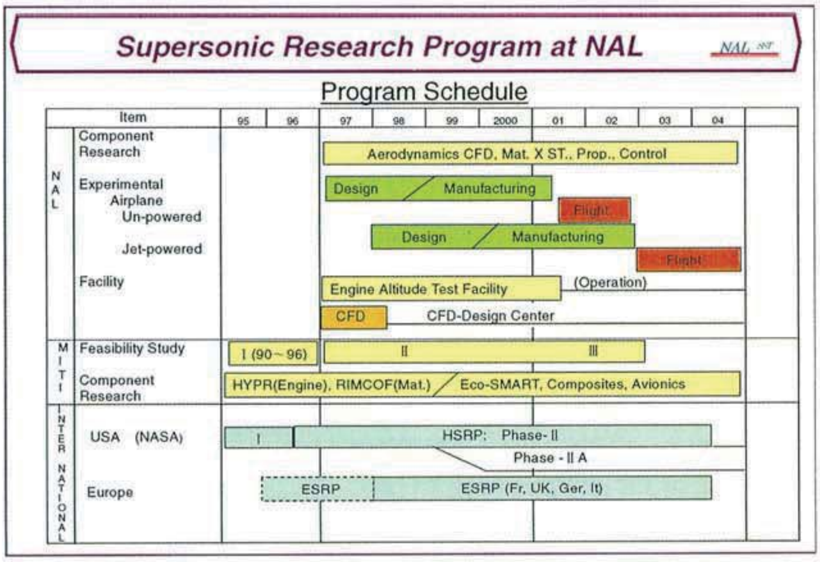

Fig.1 Program schedule

This document is provided by JAXA.

important. The program also conducts the equipment of the facilities, such as the small scale supersonic engine test facility with high-altitude capability and the CFD research center.

2. CFD technology

The CFD is one of the most promising technology for designing the advanced aircraft including the next generation supersonic civil transports, and evaluating those aerodynamic performance. NAL has been promoting the CFD research and development using the large scale supercomputer, which had grow up to the Numerical Wind Tunnel (NWT). Figure 3 shows comparison of the conceptual diagram of the aerodynamic design methodologies between the conventional and the inverse methods. The inverse method creates the new design capability including the optimization of the shapes and configurations with respect to high lift/drag ratio and other features. NAL tried to develop this kind of technology for lowering the friction drag with an optimized pressure distributions on the upper surface of the wing. NAL is developing the software for determining the aerodynamic shape with inverse method together with the accurate CFD code.

Figure 4 shows the concept of the verification of the aerodynamic design technology using flight tests of the experimental airplanes and the wind tunnel tests through comparison. The lift-drag curves and pressure distributions as the design target, to be carried out by those tests, will be compared and evaluated for establishing the design technology.

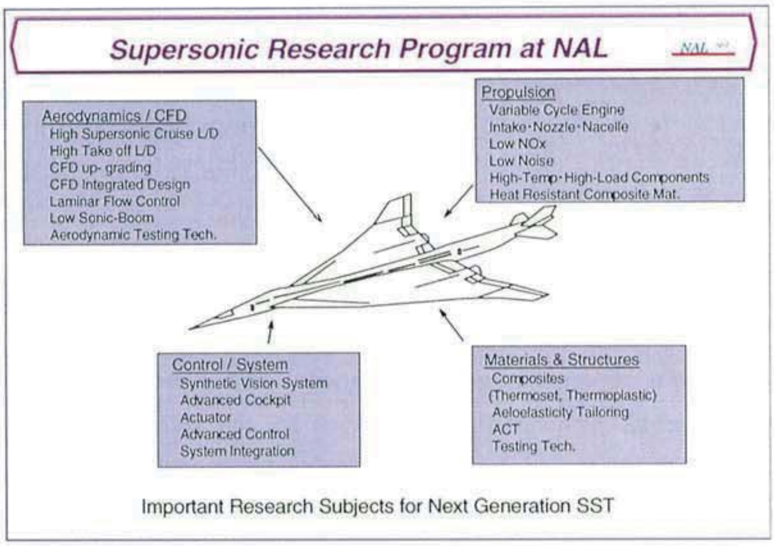

Fig.2 Important Research Subjects

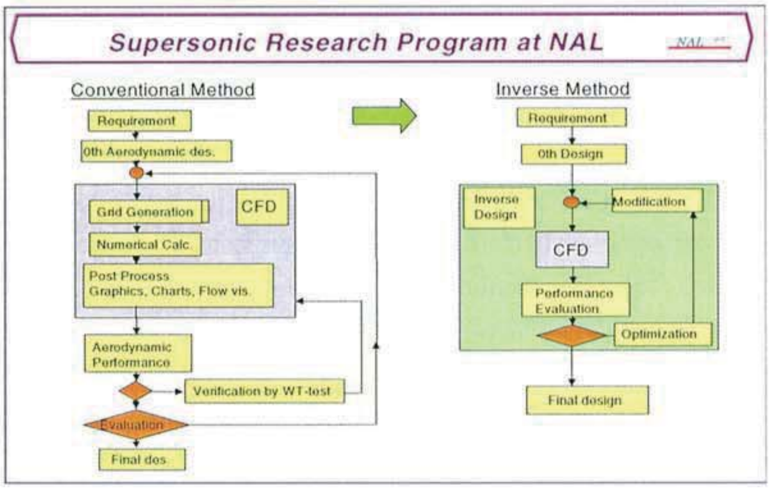

Fig.3 CFD: based design technology (Inverse / method & Optimization)

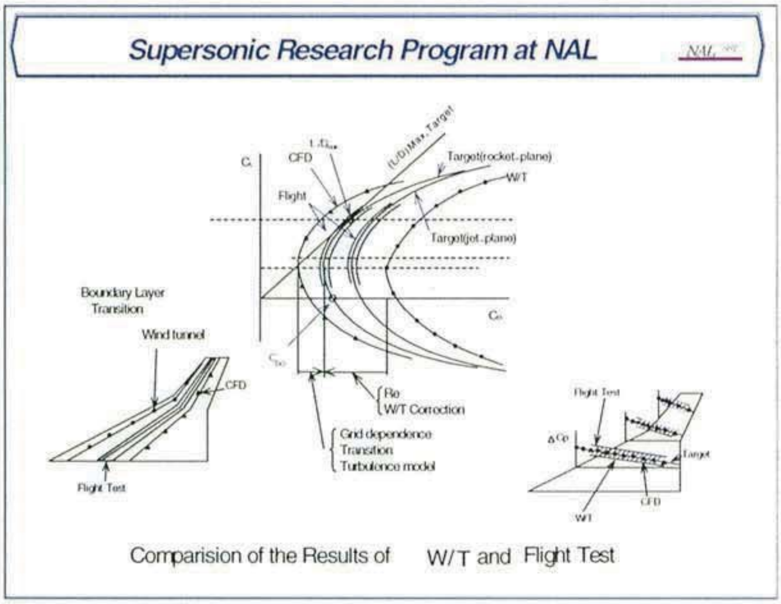

Fig.4 Concept of data verification

This document is provided by JAXA.

3. Experimental airplane development and flight testing

3.1 Un-powered airplane

The un-manned experimental airplanes with two types are being under designing, adopting NAL's original aerodynamic design technology together with CFD prediction. The design work of the un-powered airplane, which will be launched by a rocket booster, was initiated in the middle of 1997 in cooperation with the industries' design team called SSET (Super-Sonic experimental aircraft Engineering Team) in which MHI, KHI, FHI and Nissan Motors Co. are participating. The newly developed aerodynamic configuration designed with CFD technology, which is also developed in NAL using the inverse method, is being applied for a high lift/drag ratio at Mach 2.0. The design concept and configuration of the un-powered airplane is shown in Table 1 and Figure 5. The cranked-arrow wing, modulated warp, wing-body integration and the natural laminar wing are adopted.

The basic design will be finished and thereafter the detailed design will be started in FY1998. Many wind tunnel tests, CFD calculation, and related tests are being carried out. Since the instrumentation for measuring the aerodynamic features of the airplane

Table 1 Specification of Un-powered airplane

Un-powered,	Unmanned
Des. Mach	2.0
Nominal altitude	15,000 m
Length	11.5 m
Span	4.72m
Weight	2,000 kg(about)

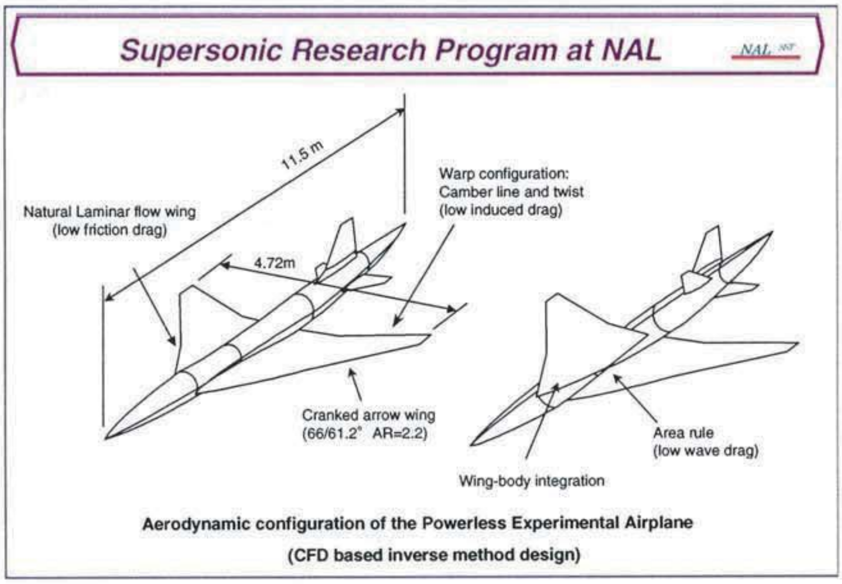

Fig.5 Aerodynamic configuration of the un-powered airplane

Fig. 6 View of the Un-powered Experimental Airplane

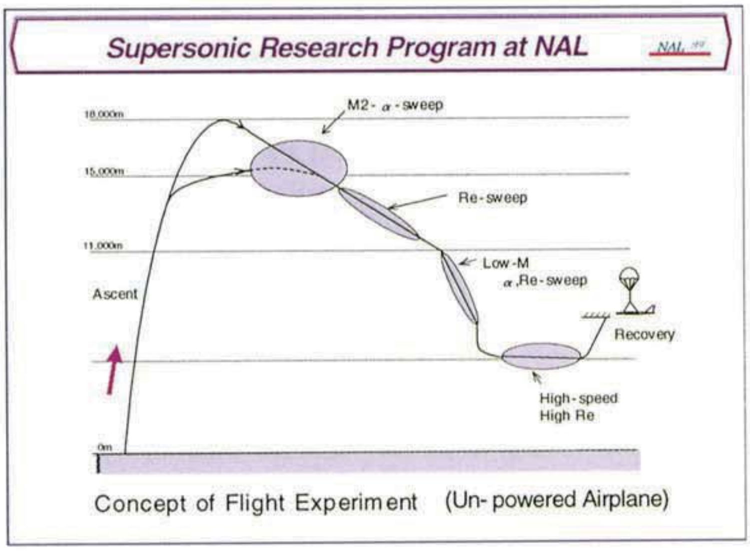

Fig.7 Flight plan for un-powered airplane

This document is provided by JAXA.

including the boundary layer information is extremely important, the design team makes effort for installation and integration of the object-fitted meas-urement system.

The flight tests are planned to be performed in 2001. Figure 7 shows the basic flight plan for accumulating the aerodynamic data. α -sweep and Reynolds-sweep at Mach 2 are the main flight pattern.

3.2 Jet-powered airplane

In order to develop the CFD-based total aerodynamic design software for full configuration and several advanced technologies, jet-powered experimental airplanes, which will fly in 2003, will be designed and manufactured as the successor of the un-powered airplane. The basic concept is shown in Figure 6. Modified warp, plan-form, wing-body shape and laminar wing cross section will be designed and two 8kN turbojet engine integrated with air-intakes and nozzles will be installed under the wing. The concept of the propulsion system is shown by Figure 7. A stable 2D air-intake and simple nozzle are equipped. Location and diverter of the engine nacelle are the major design variables to obtain low aerodynamic drag. CFD-based inverse method with optimization will be developed and applied. Utilizing the data accumulated through the wind tunnel tests of airplane and air-intakes, to be conducted in coming a couple years, the aerodynamic design will be completed in 2000. Precise CFD code and optimization with inverse method will be developed.

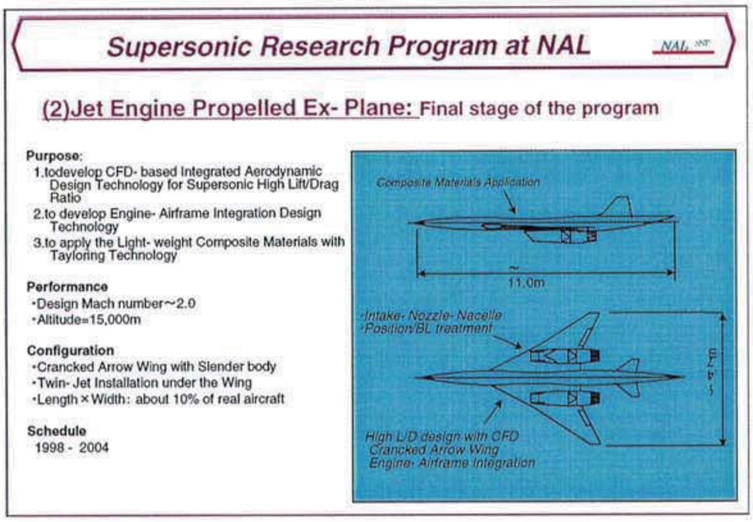

Figure 6 Concept of the Jet-engine powered airplane

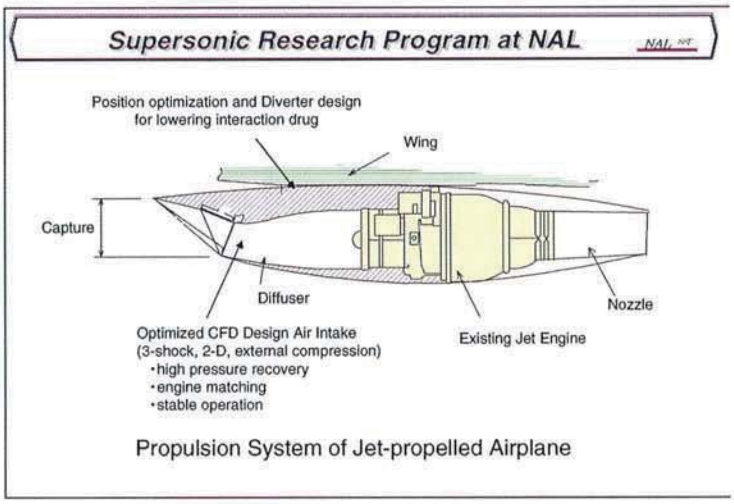

Figure 7 Concept of the propulsion system

Table 1 Component research in NAL

Aerodynamics with CFD
- Boundary layer control for high lift/drag ratio
- Optimization and inverse method with CFD
- High-speed testing technology

Materials and structures
- Heat resistant thermoplastic and 3D thermoset
- Aeroelastic tailoring

Propulsion
- Air-intake and nozzle
- Variable cycle engine and component

Control and avionics
- Cockpit, FBL, GPS

4.CLOSURE

The low drag airframe design technology with un-powered airplane plus the full configuration design software with twin-jet airplane will provide a technological base for development of the next generation supersonic civil transport. The component study in NAL as shown in Table 1 is also providing the database and technical base for the future. International and domestic research cooperation should be a key of success.

This document is provided by JAXA.