Supersonic Experimental Airplane Program in NAL (NEXST) and its CFD-Design Research Demand

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ABSTRACT

In order to upgrade Japan's technological base and then to increase the chance of participation of Japanese aerospace players in collaboration for the development of the next-generation supersonic transport, being anticipated within 20 years. R&D program for the next generation supersonic transport (NEXST), being initiated in NAL of Japan in 1997 and to be completed in 2005, is aiming at establishing the advanced and emerging technologies. The program contains two types of the unmanned experimental airplanes to be developed, a non-powered and a twin-jet airplanes. The computational design system introducing NAL's original CFD (Computational Fluid Dynamics) code is the main technology to be proved by the experimental airplane. Inverse method, optimization and integration including multi-disciplinary treatment are studied and the results from those are applied to the aerodynamic design of the experimental airplanes and tested for technological poof. The program is managed by NAL's program office in cooperation with in-house collaboration and Japanese aerospace industries. Research cooperation is also encouraged with domestic and international institutions.

Table.1 Design Requirements compared with Concorde

CONCORDE		Next Generation SST	SSBJ
2.05	Cruise Mo	2.0～	1.6～
100 Pax	Payload	250 Pax	8 Pax
6,000 km	Range	11,000 km	8,000km
62.1m	Length	100m	25m
174 ton	Max Weight	360 ton	30 ton
Very large	Noise	Stage3-3dB	Equivalent
20	NOx Index(EI)	＜5	＜5

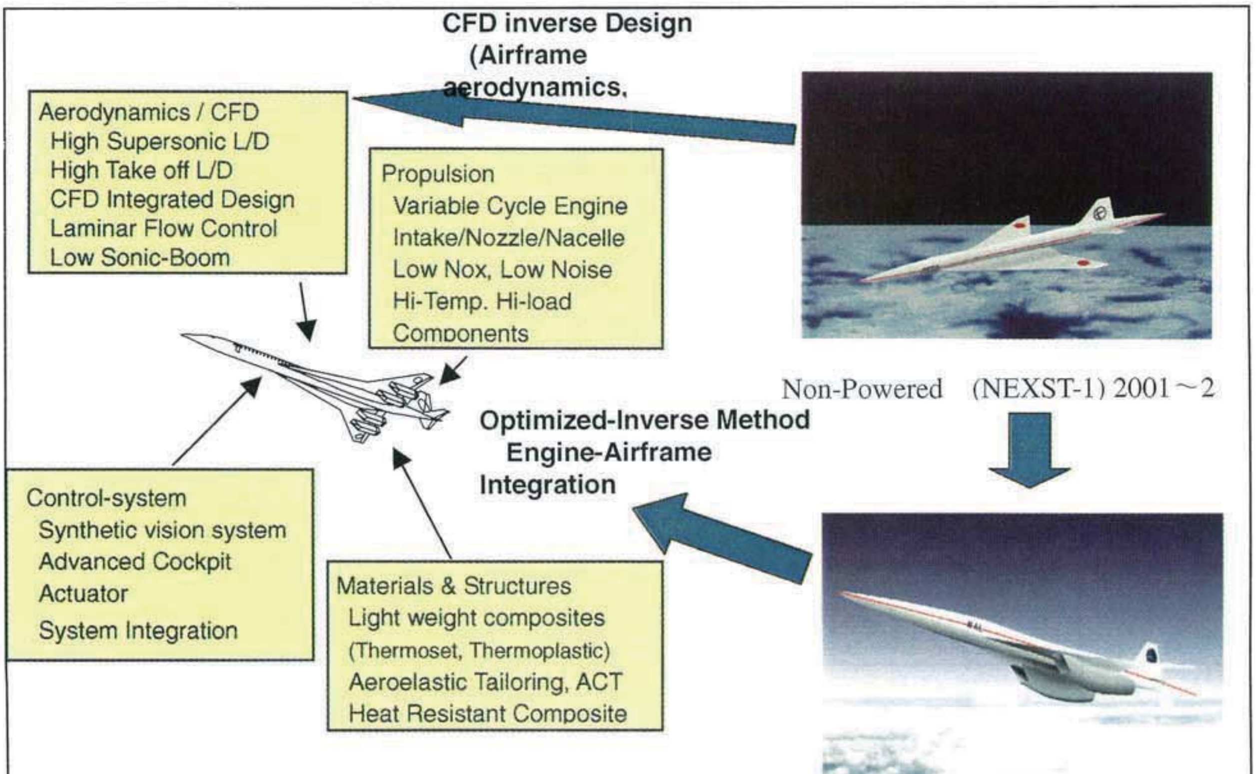

Figure 1 General design of R &D

1. Program outline

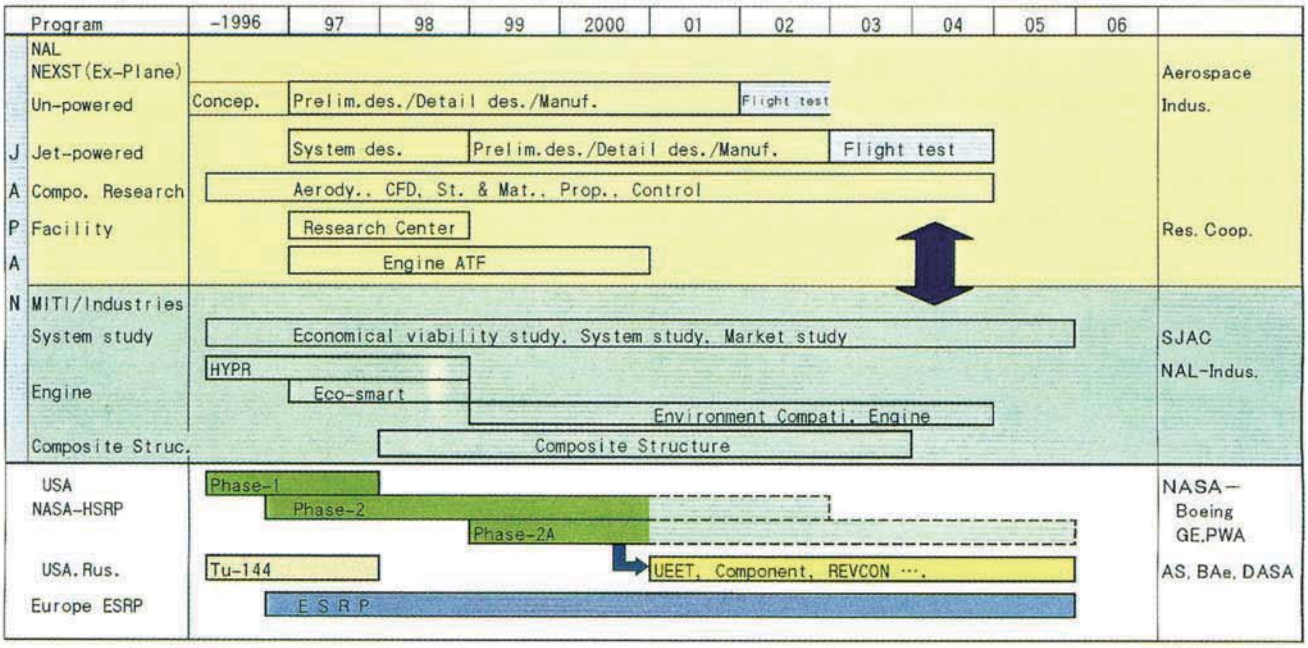

Figure 2 NEXST program schedule and related programs

NAL of Japan has her own heritage of CFD and aerodynamic design researches mainly using the large scale super-computer complex. Realization of the next generation supersonic civil transport (SST) requires many technological preparation such as high-lift drag ratio, light weight composite structures and highly efficient supersonic engine, together with environmental compatible technologies. Comparing to the Concorde, the next generation SST should be much larger and more productive as shown in Table 1. Japan thinks that her aerospace activities should be activated by establishing richer technological basis, typically to match those requirements for the future aircraft developments and productions. As a major part of Japan's research activities, NAL conducts the NEXST project using its accumulated research achievement. The grand design of NEXST project, which consists of development and flight tests of two types of the unmanned experimental airplanes and

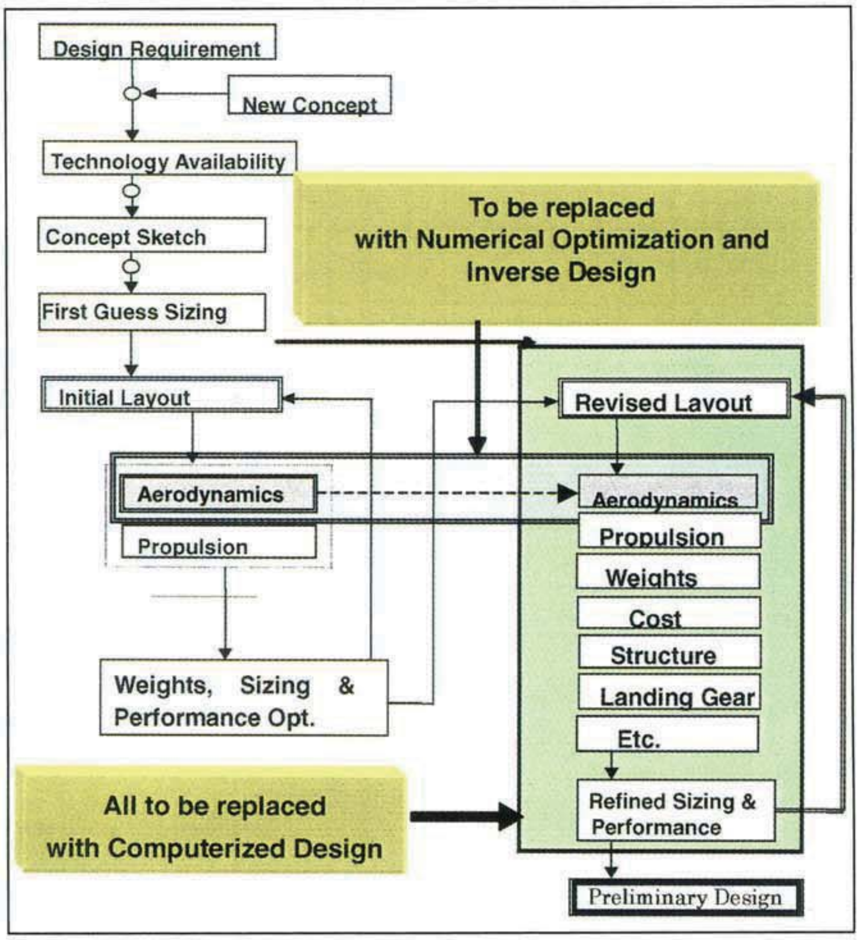

Figure 3 Conceptual design process and its modernization

component researches, is shown in figure 1. The main subjects of the program are including CFD-based aerodynamic design technology so called NAL's computational optimized design system. 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. Figure 2 shows the program schedules together with ones of another National and overseas projects subjected to the SST. NEXST projects is harmonizing to other programs conducted in Japan mainly by MITI management.

Technical objectives of the NEXT program are; ①to obtain the system integration technology of the aircraft,② to establish the CFD-based aerodynamic design system with inverse method and optimization, ③ to upgrade the emerging component technologies including composite structure and propulsion system, and so on.

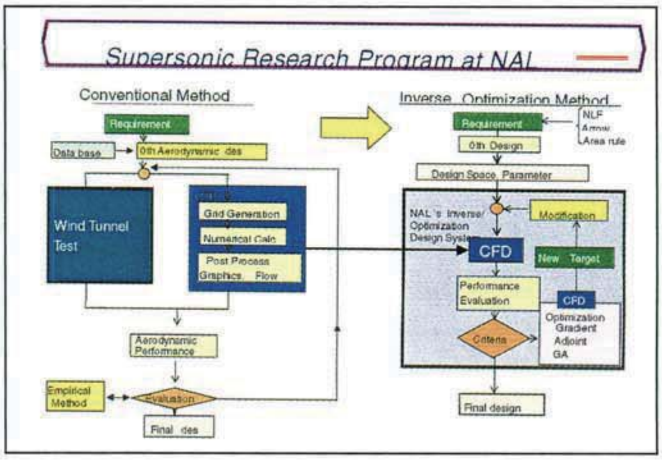

Fig.4 Inverse-Opt. design system vs. conventional

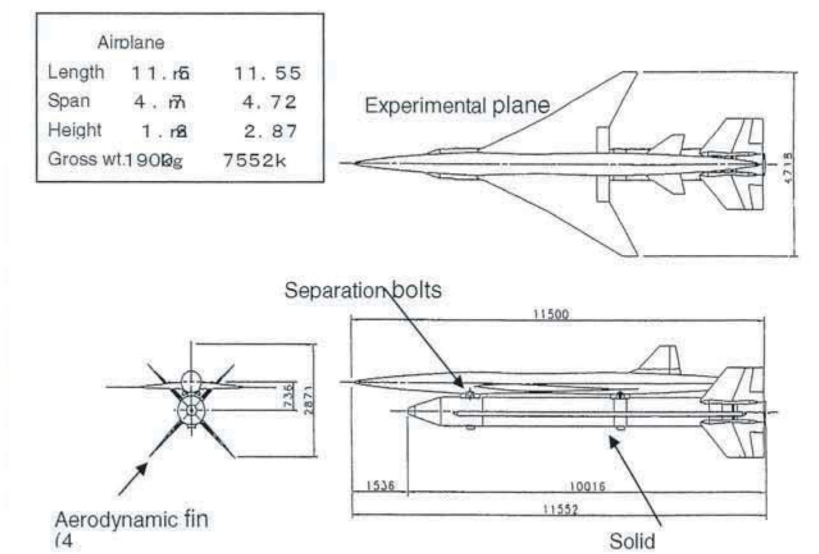

Figure 5 Experimental Airplane and Solid Rocket

2. Design system development

The reasons for choosing the CFD based design system as the technical objective are:

(1) Importance of development of the advanced technology to be applied to the conceptual design and/or preliminary design of the new aircraft is recognized for Japanese aerospace community.

(2) Utilization and further progress of the accumulated heritage of world class research on numerical simulation technology is very promising. So that CFD is as the first trial introducing the computerized code into the conceptual design process. The simulation of the structural dynamics, control, engine and other components may join in the future together with multidisciplinary optimization.

(3) Cost reduction achieved by using the computerized design, manufacturing, and other process for aircraft development and production is strongly anticipated and its effect should be large.

The computerized design process introducing the inverse and optimization methods, is promising for the complex systems such as the next generation supersonic transport. Figure 3 shows the existing conceptual design process and its modernization by introducing the advanced design system being developed in the program. Figure 4 shows the conceptual diagram of the new aerodynamic design system by using CFD, comparing to the conventional aerodynamic design process which is mainly relied on the wind tunnel tests and empirical database.

The design technology will be proven by applying those to the experimental airplane designing.

Undoubtedly, the numerical simulation or modeling of the design components is necessary for the computerized design system, so that the accurate and easy-to-use CFD codes are required for the aerodynamic component. Optimization is inevitable for significantly complex system, such as engine installation to the supersonic airframe, because of its unknown factors in designing. So, a kind of non-deterministic design system should be introduced for the jet-powered experimental airplane. Multidisciplinary simulation and optimization, in which the numerical simulations of structure, control, heat transfer and so forth are involved simultaneously, is another technological target in the future.

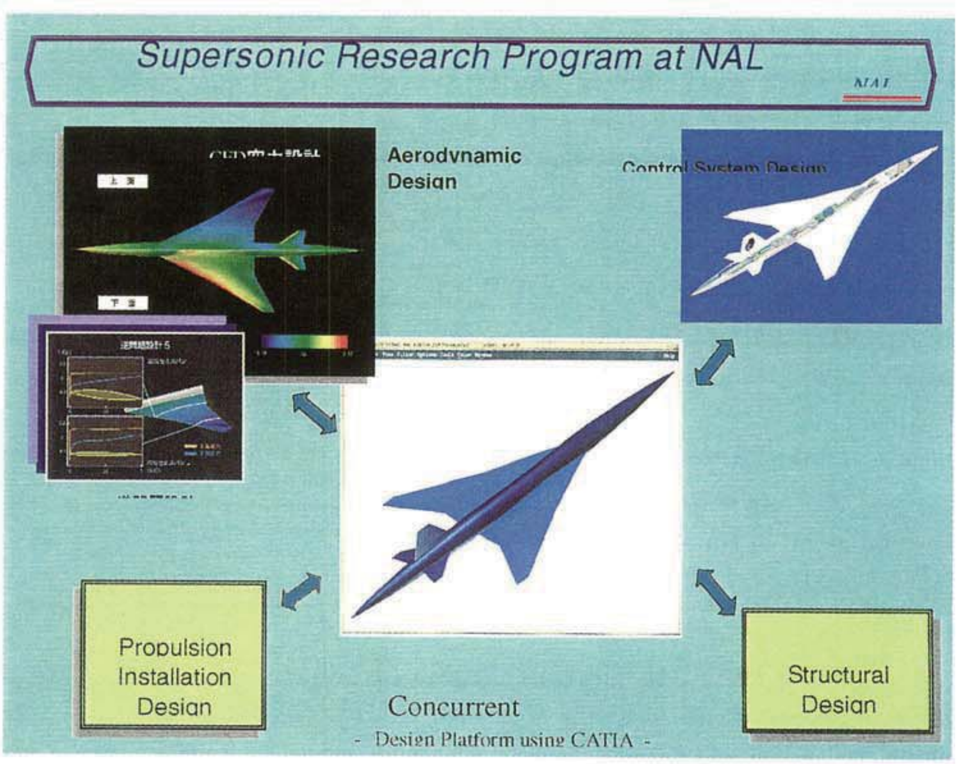

Figure 6 Concurrent designing with computational design system

3. Experimental air-planes

NAL planes to develop two types of unmanned experimental airplanes. In the first phase, the non-powered airplane is to prove the theoretical possibility of the inverse design technology aimed at an adequate target value to be achieved. Natural laminar flow concept integrated with the arrow-wing, area-rule and warp configuration is adopted in order to accomplish high lift/drag ratio at Mach 2. Figure 5 shows the 3 views of the non-powered airplane at the combined configuration with booster rocket. The scale of the airplane is about 1/10 of the actual next generation SST. The critical design of the non-powered airplane has been completed in 1999 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. Figure 6 shows the concurrent design work based on the NAL's aerodynamic design using new software in collaboration with SSET and another component engineers. NWT (Numerical Wind Tunnel) of NAL has been used as the center computer and engineering workstations are the peripheral processors. The jet-powered experimental airplane will be developed with more advanced way based on that learned through the first airplane development. Engine installation is the most important design space to be defined for the optimization.

4.CLOSURE

In 1999, design of the non-powered airplane was completed. Preliminary design of the jet-powered airplane will be initiated within a year from now (Jan. 2000) just after completion of optimization method development. The computerized design system development is going well in cooperation with the industries and universities domestically. International cooperation is also welcomed. The flight tests will be conducted from 2002 to 2005 sequentially in Australia.