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K.SAKATA

Present Status of NAL's Supersonic Project (NEXST) and its Perspectives

Kimio Sakata
Director, Next Generation Supersonic Aircraft Project Center
National Aerospace Laboratory, Japan

Introduction

Next generation supersonic transports (SST) will bring a large-scale revolution to the air travel in about 20 years. In order to realize the next generation SST, significant number of technological breakthroughs on aerodynamics, structures, control and propulsion systems are neecessary. High lift/drag ratio, lightweight composite structures and highly efficient supersonic engines, together with low NOx and low noise features are required for SST. NAL (National Aerospace Laboratory) of Japan initiated the R&D program called NEXST for the SST in 1997. The program is consisting of development and flight tests of unmanned experimental airplanes in order to prove the developed technologies. The advanced computational aerodynamic design technology utilizing the CFD is developed and applied to the experimental airplanes for its verification. Composite materials and propulsion technologies including the air-intakes and nozzles are also studied. The aerodynamic technologies including CFD-based design are applied to the experimental airplanes step by step for the technological establishments as shown by figure 1. Inverse method is for the first non-powered airplane to prove the theoretical possibility of the complete computerized design technology and optimization design method will be applied to the second twinjet powered one.

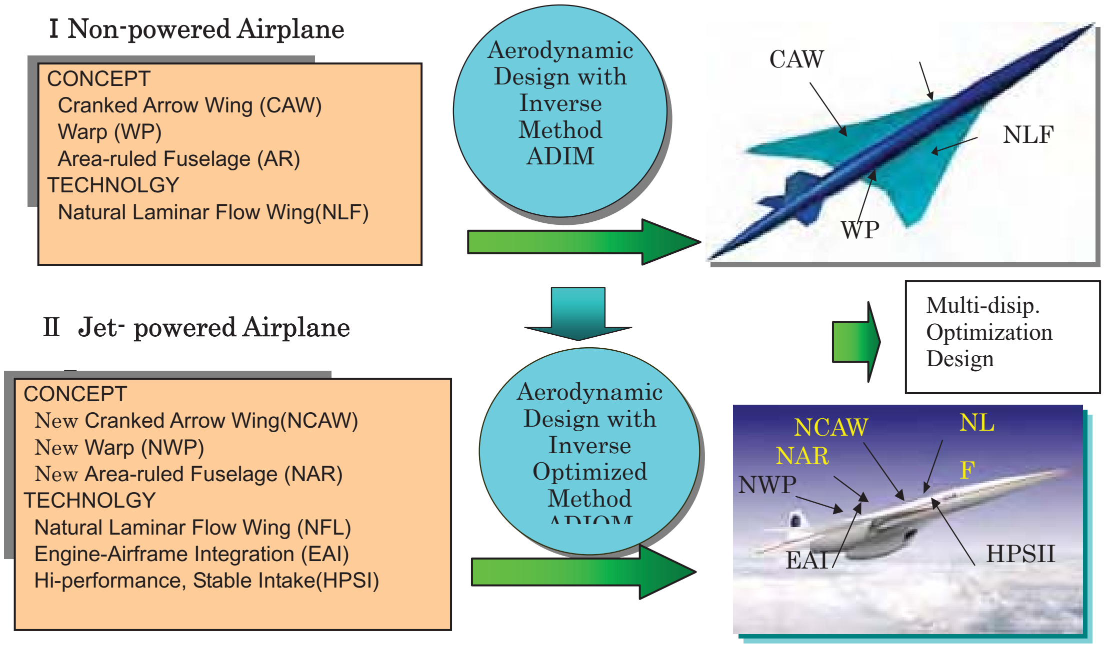

Fig.1 Design technology development plan with the airplanes

Four flights of the non-powered airplane will be conducted in 2002 in Australia. Successively, the jet-powered airplane will be tested as the final phase of the program.

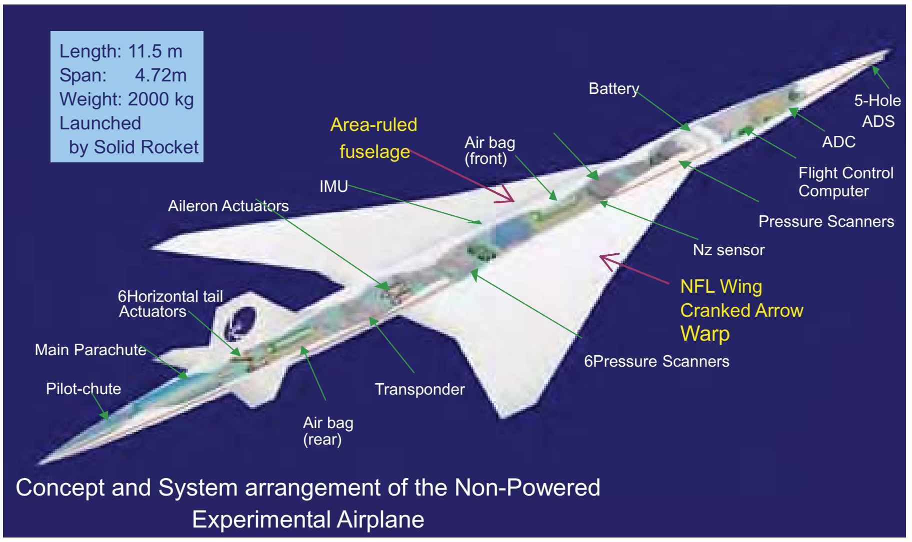

Fig. 2 Design concept and system arrangement of the Non-powered Experimental Airplane NEXST-1

CFD Design Technology

One of the most important technologies for the SST is low drag aerodynamic design in the supersonic speed regime for the air-transport economy. NAL's thick CFD research fruits have been developed for the advanced aerodynamic design based on the fully computerized system. This concept is based on not the empirical technology nor the physical database, but the physics and mathematics to seek the optimized shape minimizing its aerodynamic drag of the supersonic cruiser.

Fig.3 NEXST1 under vibration test

The importance of the computerized design technology with CFD is recognized as follows. (1) Breakthrough in the conceptual and/or preliminary design technology for the aircraft development will be realized by the information technology with HPC and simulation software. (2) Application of the numerical simulation technology, CFD typically, to the computerized system is the key component. (3) Cost reduction using the computerized process in design and

Fig.4 Combustion test of Rocket Booster NAL735 (at Akita, 7th, March, 2001)

manufacturing for the aircraft development and production is promising.

The time-consuming wind tunnel tests will hold a minor role in the new design systems. The developed design technology will be demonstrated by applying those to the experimental airplane design [1].

Fig.5 Launch configuration (Experimental Airplane and Booster)

Development of the Experimental Airplanes

(1) Non-powered Airplane

The non-powered airplane is being developed for the purpose of proving the theoretical possibility of the inverse design technology to realize a low drag configuration. The cranked arrow wing (CAW), area rule (AR) and warp (W) concepts are integrated with adoption of the natural laminar flow wing technology (NLF). The inverse design has been applied to the natural laminar flow wing to determine the cross section of the wing. Figure 2 shows the resultant design configuration and system of the non-powered airplane. The length is 11.5 meters, span is 4.72m and weight is about 2 tons. More than 800 measuring ports are installed including the surface pressures and temperatures together with boundary layer measurement, as shown in the figure 6.

The figure 4 shows the view of the combustion test of NAL735 rocket booster, which is developed by NAL based on SB735 of ISAS. The combined configuration of the airplane and the booster is shown in the figure 5.

(2) Jet-powered Experimental Airplane

As the successive step of the non-powered airplane, the jet-powered experimental airplane will be developed for establishing the optimized-inverse design system and some

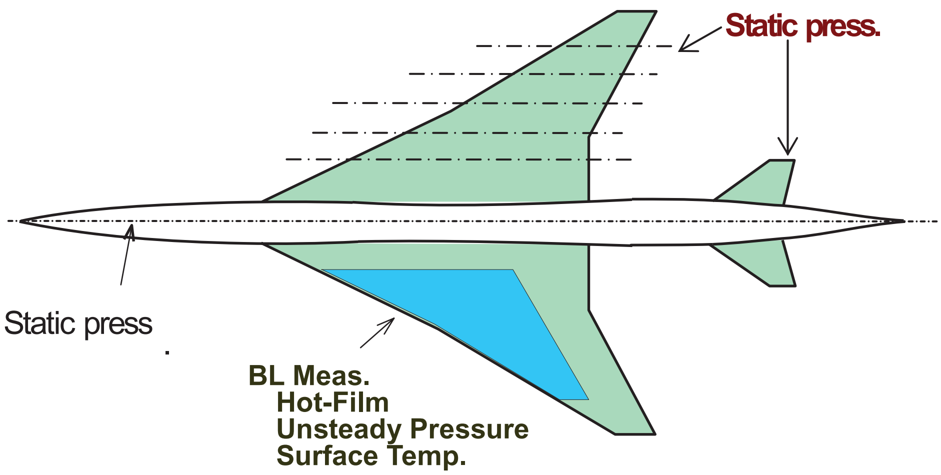

Fig. 6 Aerodynamic Measuring System

component technologies including engine-airframe integration (EAI), high performance stable air-intakes (HPSI) and composite structures to the wings As shown in figure 9, many technical subjects and breakthroughs will be dealt. Engine installation is one of the most important design parameters to be defined for the optimization. Shock-boundary layer interaction, intake optimization and intake-nacelle-wing interaction cause the design to become complicated for the low drag shape. An existing small supersonic jet engine will be used with small modification. We also plan to apply the thermoplastic and thermoset composite materials mainly to the outer wing section.

Flight Test Plan

The flight tests of the non-powered airplane NEXST-1 will be conducted in 2002 to 03 in Australia. The typical flight plan is shown in the figure 7 and 8. The airplane will be launched and boosted by NAL735, and the test phase flight will be carried out followed to the separation from the booster rocket. The test condition for NEXST-1 will be chosen at the speed of Mach2 plus minus 0.05, and at an altitude of 11 to 18km taking into consideration on the Reynolds number variation. The flight test for

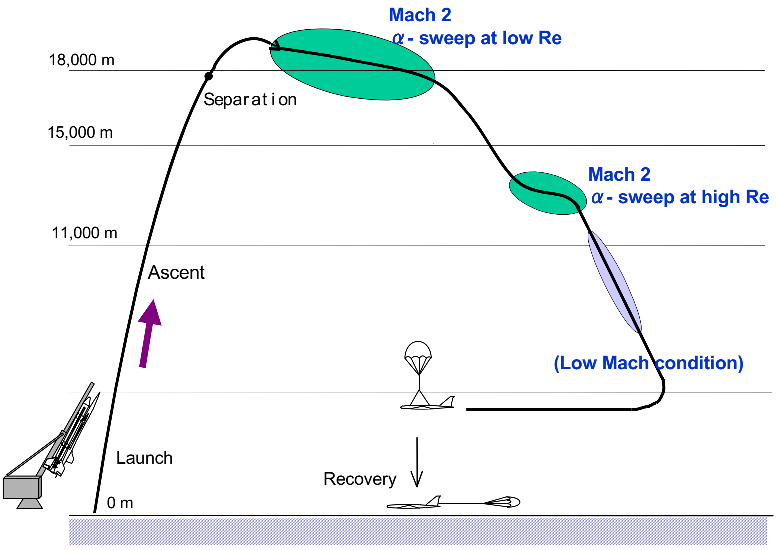

Fig. 7 Flight plan of the Non-Powered Airplane

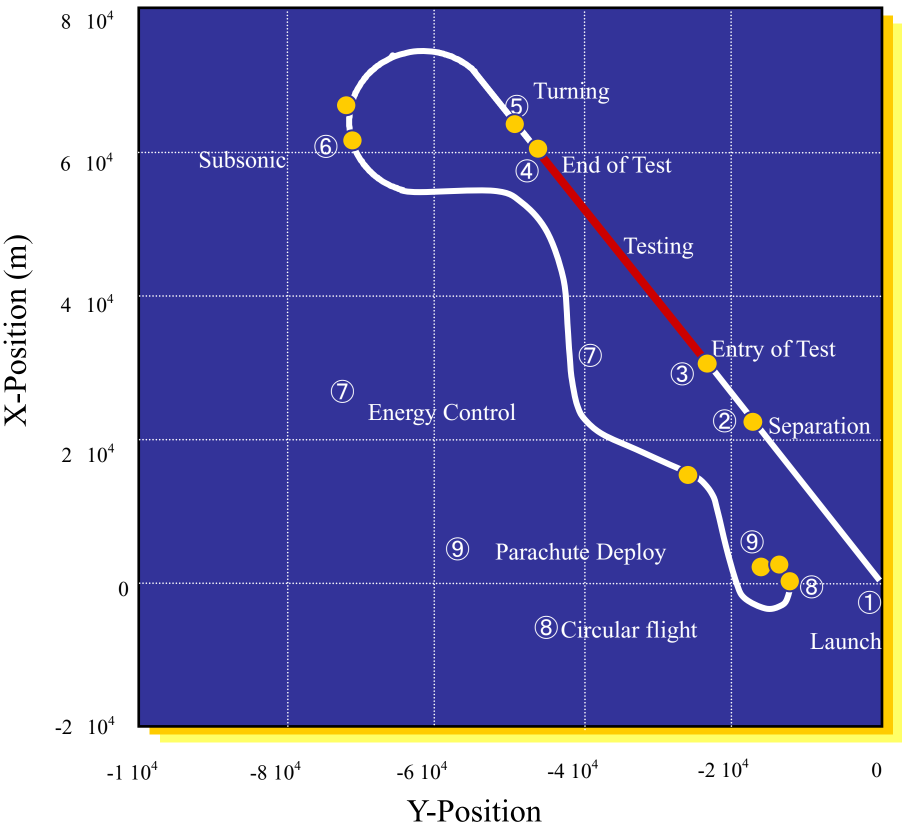

Fig.8 Flight Plan

the jet-powered airplane is planned in 2005 to 06.

CLOSURE

The design of the non-powered airplane was completed in 1999 and its manufacturing and system checking are being processed. Preliminary design of the jet-powered airplane has been initiated early this year. The computerized design system development is being carried out in cooperation with industry and various universities. The research cooperation on the supersonic technology is being conducted with ISAS, Tohoku Univ., ONERA, DLR and so forth.

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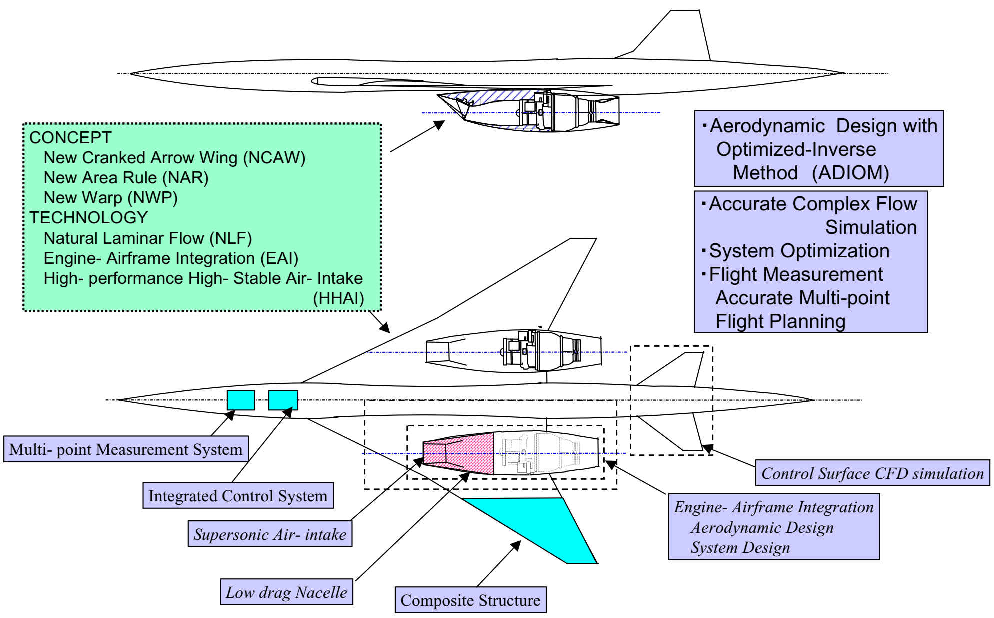

Fig. 9 Concept and technical subjects of the Jet-powered Experimental