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Japanese Spaceplane Concepts
PERSPECTIVE ON JAPANESE SPACE PLANE
RESEARCH AND DEVELOPMENT

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Keyword : Spaceplane, Hypersonic Flight,
System Study

Abstract

For the promotion of extended and diversified space activities in Japan, it is required to build immediately the technology bases capable of supporting such space activities and thereby to expand positively international cooperation as one of Japan's roles toward the world's prosperity of the 21st century. Especially, development of the manned space transportation system to and from lower earth orbit is the key issue, requiring an unprecedented approach. The Space Plane is the unique answer to this issue.

This paper will discuss the perspective on the research and development of Japanese Space Plane. The topics will cover a long range R & D scenario and current activities of the related organizations in Japan.

Introduction

Japan's space policy was deliberated by the Consultive Committee on Long Term Policy under Space Activities Commission, viewing the 21st century with the consideration of the rapid progress and changes in national as well as international situations surrounding space activities.

As stated in the report issued by the Committee (ref.1), Japan's space development is to build immediately the technology basis capable of conducting autonomous space activities solely for peaceful purposes and thus to extend positively international cooperation as one of Japan's international role toward the 21st century.

The Committee recommended that Japan should endeavor to behave as a member of the kernel in space activities in the world in the beginning of the 21st century, and the Committee proposed the fundamental course of Japan's space development programs.

(cf., Figure 2 Japanese Space Activities in 21st Century and Figure 3 R & D of Principal Programs) Promoting future space activities, development of "Space Infrastructure" and the evolution of manned space activities are the fundamental subjects, and above all, development of the manned space transportation system to and from lower earth orbit, i.e., space plane is the key issue.

The Advisory Committee on Space Plane was established in October 1986 to deliberate the Japanese long-term R & D policy for the development of new space transportation systems, with a special emphasis upon the space plane.

Based upon the Report issued by the Advisory Committee (ref.2), the perspective on Japanese Space Plane research and development is outlined in the following sections.

Goal of the Manned Space Transportation System in Japan

To promote the future space activities, the development of the new-generation space transportation systems be the fundamentals. Its significance and necessity are summarized as follows,

• Space transportation systems are the fundamental elements of the Space infrastructure for the promotion of space activities.

• Indispensable to Japan's autonomous space activities.

• To improve global system survivability by eliminating the biased reliance on limited launch means.

• To provide the technology bases for the development of next-generation Hypersonic Transport.

* Professor Emeritus, University of Tokyo
To serve as a Motive force to stimulate promotion of science and technology.

Contribution to the growth of innovative human society.

Basic development concept for space transportation systems viewing technology bases in Japan is:

- For space transportation system, to separate distinctly the development of a manned transportation and an unmanned cargo transportation be essential.

- For manned transportation system, the most important issue be the guarantee of safety, reliability, comfort and also to value the economic aspect in future, while for cargo transportation, on the other hand, to value payload fraction and the cost effectiveness for massive payload.

- For an unmanned cargo transportation, to promote the development of re-entry vehicle based on H-II rocket technology, be recommended.

With these basic development concepts in mind, the goal of the manned space transportation system, i.e., Space Plane, of Japan was proposed to aim at reusable winged vehicle of horizontal take-off and landing with sufficient reliability and operational flexibility as comparable to an airplane, and to promote the research and development aiming at the preliminary operation in the beginning of the 21st century.

Basic Concept for Promotion of Research and Development of Space Plane

Leading countries in space development are promoting the ambitious space policy and developing their activities with the recognition of the significance of the space activities to their prestige or socio-economic development.

Although Japan has not yet established the definite Space Plane program, the aerospace-related agency and national research institutes have been conducting the basic research works. For the promotion of research and development, it is of great importance to enhance and integrate the aerospace technology bases and the integrated research structure of various advanced technology fields such as new materials, electronics and so forth, and to promote this as a large scale national project taking into consideration the improvement and establishment of basic technologies and flexibility of its operation. As for the international cooperation, however, it is necessary to consider the flexible association from the early stage with our great efforts to improve our own technologies to secure Japan's design authority.

Basic plan for Space Plane research and development proposed by the Ad-hoc Committee is schematically outlined in the Figure 4. The program consists of Planning Phase, Technology Readiness Verification Phase and Prototype Development Phase to promote the research and development based on the time-phased scenario to attain the goal of experimental operation to be commenced in the beginning of the 21st century. The outlines of respective phase are as follows;

Planning Phase

- To advance key element technologies
- To start the preliminary design of experimental planes to be test flown in the verification phase

During this phase, the Space Activities Commission will define a long-range national program including development of test sites and facilities.

Technology Readiness Verification Phase

- To verify the technology readiness required for the prototype development through test flights of the experimental planes, such as (1) hypersonic manned flight technology and airbreathing engine, (2) unmanned reentry technology with emphasis on ballistic flight and deorbiting.

Prototype Development Phase

- To start the prototype development based on the aerospace and related technology established in the previous phases.

The program milestone in the Space Plane development is defined the initial operation of the prototype toward the beginning of the 21st century, followed by development of fully operational space plane.

Technological State of the Arts and Issues to be Resolved

Space plane exhibits both aspects of aeroplane and space vehicle, i.e., Space Plane takes off from a runway horizontally and accelerates and
ascends up to the limiting height to utilize the atmosphere as aeroplane. Afterwards, it accelerates and ascends continuously using a rocket engines to reach the lower earth orbit. On orbit, it acts as a space vehicle to supply or exchange crew members after rendezvous / docking to the space station or to another space systems. After the mission completion, it deorbits and re-enters the atmosphere and lands to the runway until it touches down as an aeroplane. For such system configuration be feasible, it will require advanced technology breakthroughs and the key objectives are;

- Airbreathing engines - high specific Impulse, high thrust to weight ratio
- Integrated engine and airframe
- Reductions in structure weight, aerodynamic drag
- Ultra-high temperature materials for thermal protection system
- Design and optimization of vehicle components
- Advanced control technology
- Manned hypersonic flight experience - X-planes, test sites and facilities

As for the development / construction of test facilities including flight test sites required for Space Plane research and development, the Ad-hoc Committee on Facilities for Aerospace R & D was established in January, 1988 under Bureau of Research and Development of Science and Technology Agency and the basic scenario on the development of facilities are currently being carried out.

Current Activities of Related Organizations

Figure 5 illustrates schematically the current activities of related organizations and decision flow chart of Japan's Space Plane R & D program. Based upon the Ad-hoc Committee's recommendation, Liaison Group for Space Plane Research and Development was tentatively organized, which consists of National Aerospace Laboratory (NAL), National Space Development Agency of Japan (NASDA), Institute for Space and Astronautical Sciences (ISAS), academia and industries, and system feasibility study of vehicle configurations on Space Plane Prototype is currently being undertaken (cf., Figures 6 and 7). Related aerospace organizations are carrying out the technology development and concept studies on technology verification including experimental vehicle designs.

ISAS

ISAS is conducting a study on unmanned winged space vehicles. Highly Maneuverable Experimental Space Vehicle, HIME (Figure 8), a multidiscipline working group has been organized at ISAS. The group has worked to identify the following major study areas relevant to winged vehicles: 1) aero-and flight dynamics, 2) navigation, guidance, and control, 3) development of recovery and automated landing system, 4) scientific experiments with the test vehicle, 5) microgravity experiments with the test vehicle, and 6) development of an advanced hydrogen rocket engine. As a first step, a gliding test of a small-scale model was carried out in June, 1986 with follow-on flights in October 1987. (cf., Reference 3)

NASDA

H-II Orbiting Plane (HOPE) is being studied. (Figure 9) HOPE is an unmanned winged space vehicle, which will be launched by H-II rocket, in order to perform recovery of experimental products from the space station and various platforms and also supply logistics to platforms in the latter half of 1990's. Also, the experiments and tests will be carried out in the cargo bay of the HOPE during its flight. HOPE will be to establish technologies for development of future Space Plane, such as rendezvous and docking, de-orbiting, re-entry, automatic landing technologies, etc. (cf., Reference 4 for further details).

NAL

NAL has been engaged in the research and development of a horizontal take-off and landing space plane capable of flying with sufficient safety and reliability similar to an airplane. Elemental technology research items include hypersonic aerodynamics, structure, guidance and control, airbreathing engines, computational fluid dynamics, and also feasibility study is being carried out on the experimental plane to develop technology bases for the manned hypersonic flight. (cf., Fig. 10., Reference 5 for further details).

Agency of Industrial Science and Technology, Ministry of International Trade and Industry is planning to promote the R & D project of combined Cycle Engines as applied to high speed commercial transport, SST/IHT. (cf., Figure 11) The R & D project includes high performance turbojet and ramjet engines and development of
ascends up to the limiting height to utilize the atmosphere as an aeroplane. Afterwards, it accelerates and ascends continuously using a rocket engines to reach the lower earth orbit. On orbit, it acts as a space vehicle to supply or exchange crew members after rendezvous / docking to the space station or to another space systems. After the mission completion, it deorbits and re-enters the atmosphere and lands to the runway until it touches down as an aeroplane. For such system configuration to be feasible, it will require advanced technology breakthroughs and the key objectives are:

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combly cycle engine control and system technology, starting from 1989 as 7-year program.

Next Step for Space Plane R & D Program

Japan's space development is executed in line with the Fundamental Guidelines of Space Policy, established by the Space Activities Commission, and the Space Development Program providing for yearly activities for the respective purpose. On December 1987, the Space Activities Commission decided to review the Fundamental Guidelines of Space Policy, which were set forth in 1984, accounting for the long-term principles of Japan's space activities to deal with changes in space development situations in and out of the country. In reviewing the guidelines, the Commission decided to follow the direction suggested in the report of the Consultative Committee, and set up the Long-Term Policy Subcommittee under the Commission. In the process of the governmental preparations, related organizations are to propose the technology research and development plan which would kick off for the realization of Japan's space plane.

Concluding Remarks

The perspective on Japanese Space Plane research and development was discussed, which included the Japan's space policy toward the 21st century, goal of the manned space transportation system, basic concept for the promotion of R & D of space plane and current activities of the related aerospace organizations in Japan. By our utmost efforts, we would hope to establish the target proposed by the Ad-hoc Committee on Space Plane and chart a course for the promotion of autonomous space activities.

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(Report Issued in May 1987)
  • Goals of Japan's Space Policy
  • Development of Space Infrastructure and Evolution of Manned Space Activities

Science and Technology Agency, Bureau of R&D – Ad-hoc Committee on Space Plane
(Report Issued in June 1987)

NAL
Concept Studies on Manned Hypersonic X-planes and Air Breathing Engines

Spaceplane Workshop
(at NAL July 1986)

System Study on Japanese Spaceplane Prototype

Current Status

Next Step

SAC
Fundamental Guidelines of Space Policy
Space Development Program

Council for Aeronautics,
Long Term Vision on Aeronautics

Establishment of R&D Plan for X-planes

Check and Review

Figure 5 Related Organizations and Decision Flow Chart
Figure 4 Research and Development Scenario on Space Plane in Japan

Figure 6 Concept Study of Space Plane Prototype (SSTO Model)

Figure 7 Concept Study of Space Plane Prototype (TSTO Model)
Figure 4 Research and Development Scenario on Space Plane in Japan

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