JAXA Vision

–JAXA 2025 –

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Japan Aerospace Exploration Agency

Summary

The use of aerospace by aircraft as well as by launch vehicles and satellites already provides the foundation for our various activities today. The advancement in the technology development and the establishment of the sound industry base in the area of aerospace is, therefore, essential for our nation. It is equally important to respond to the growing expectations and increasing requests from various communities by maintaining and further expanding aerospace activities.

Some other countries are vigorously pursuing the expansion of aerospace activities as part of their strategic national policies. The United States, for example, has identified human space exploration to the Moon and Mars as its new goal in the space. Europe, is pursuing a policy that recognizes space activities as a policy-making tool to meet various needs of the society. China recently succeeded in its first human space flight. The global environment surrounding space activities is rapidly changing. In the area of aviation, the demand for air transportation would is expected to see a sharp increase in the coming years, and the United States and Europe, as the leading aerospace nations plan to strengthen their aerospace industries and to maintain their lead in this area.

Under such circumstances, JAXA recognizes its responsibility to provide the society with a clear picture of the future of aerospace activities and to seek for response from the general public. The following describes the ideal situation that JAXA sees for aerospace activities for the next twenty years. This is what JAXA proposes as its vision.

Vision

“JAXA shall develop launch vehicles and satellites with the highest reliability and world-class capability, with a view to building a secure and prosperous society. JAXA shall also work toward taking a leading position in the world in space science and begin preparations for Japan’s own human space activities and for the utilization of the Moon. JAXA shall further conduct a flight demonstration of a prototype hypersonic aircraft that can fly at the speed of Mach 5. With the activities listed above, JAXA shall contribute to the establishment of aerospace industry as a key industry of Japan.”

More details of the vision are provided below under the following five categories.

(1) Contribute to building a secure and prosperous society through the utilization of aerospace technologies.

Meteorological satellites as well as communications and broadcasting satellites have already become indispensable tools for the society. JAXA shall further develop those satellites and implement a new space utilization system that would be useful for managing natural disasters and taking actions to protect the global environment. For example, JAXA proposes the following systems:

System for natural disasters management

JAXA shall implement a system, through cooperation with relevant entities, to gather information by using observation satellites and other means to assess damages caused by disasters, e.g. earthquakes, tsunamis and heavy rains, and to disseminate most accurate warnings in a timely manner as much as possible through communications satellites directly to individual portable terminals, to prevent imminent dangers. JAXA shall establish and operate the system through cooperation with other countries in Asia and the Pacific, so as to facilitate their use of the system.

System for the protection of global environment

JAXA shall implement a system that would allow for continuous observation of the global warming and climate change as well as predictions. The system would be established by integrating satellites, ships, aircraft, buoys, very large supercomputers and other means operated by relevant entities. The system would provide international organizations and governments of other countries with necessary information for their policy making in the protection of global environment.

(2) Contribute to the advancement of knowledge and expansion of human frontier by exploring the mysteries and possibilities of the universe.

JAXA shall develop next-generation technologies for space exploration, for instance to observe galaxies and black holes and to explore the Moon, Venus and Mercury as well as beyond the solar system. On the basis of accomplishments through these activities, JAXA shall turn Japan into one of the world's leading science centers in the field of space science.

JAXA shall develop sound technologies for the establishment of a lunar base and its

utilization. This will be done with the aim to maintain and strengthen the capability for technology development as the engine for expanding activities of Japan and achieving the world-class technological capability.

(3) Establish the capability to independently carry out space activities through the highest-level technologies in the world

Means to transport goods and humans easily to outer space, or space transportation systems, are essential for further implementation of space activities and pursuit of space utilization for building a secure and prosperous society and advancing the human knowledge. JAXA shall, therefore, develop launch vehicles and inter-orbital transportation systems with the highest reliability and world-class capability.

JAXA shall further improve relevant technologies to develop a space transportation system that would have the capability to safely transport humans. JAXA shall continue to acquire technologies necessary for human space activities through its participation in international cooperative initiatives and prepare for the implementation of Japan's own human space activities in the future.

JAXA shall also enhance its technology base to allow for innovative space utilization, such as wireless energy transmission technology to enable the use of space solar power.

(4) Contribute to the growth of self-sustainable space industry with world-class technological capability

The technology level of Japanese space equipment industry has increased to the extent that it is nearing the world-class level. Space utilization service industry is expanding in such areas as communications and broadcasting. Ensuring the sustainable growth of these industries facing international competition has become more important than ever. JAXA shall conduct research and development of new technologies, which could lead to turning space industry into key industry of Japan.

(5) Contribute to the growth of aviation industry and breakthrough for future air transportation

JAXA shall develop Japan's own world-leading technology that would be indispensable

for future aircraft, to realize a "Japan-made" passenger aircraft that would be appealing in the global market.

JAXA shall also demonstrate the technology of hypersonic aircraft that can fly across the Pacific Ocean in 2 hours with a Mach 5 class experimental vehicle.

Planning for the implementation of the Vision

In order to create the ideal situation for space development and utilization and for aeronautical research and development in the future, JAXA would set milestones and take actions strategically to achieve those milestones.

- JAXA will develop a roadmap for the next 20 years, which would be divided into two parts, for the first 10 years and for the subsequent 10 years. For each part, JAXA intends to select activities to be carried out on a priority basis and to concentrate its resources on those priority activities.

- During the first ten years, JAXA will:
  - Focus its efforts on those activities that would promote wider use of aerospace technologies in the society, with a view to contributing to building the secure and prosperous country;
  - Take steps toward innovative space utilization including future human space activities and utilization of the Moon. This would be done by developing pioneering missions and nurturing enabling technologies for those missions. Based on the results of the verification of those technologies, develop options for selection by the government on the course of actions to take.

- During the subsequent ten years, JAXA will:
  - Continue to promote wider use of aerospace technologies in the society and propose innovative ways and means of space utilization. Following a decision to be made by the government, take steps toward new space utilization including the utilization of the Moon and Japan's own human space activities.

Enhancing international cooperation and development of human resources

Toward the implementation of the Vision, JAXA will vigorously pursue international

cooperation with the United States, Russia, European countries and countries in the region of Asia and the Pacific. Through collaborations with the United States, Europe and Russia, JAXA would carry out its space activities in an effective and efficient manner. In Asia and the Pacific, JAXA as a leading agency in space activities would pursue cooperation with other countries in the region to carry out activities that would respond to natural disasters and environmental issues, so that Japan could be considered a reliable country in the region.

Space activities stimulate curiosity and interest among many young people and can inspire the youth as the next generation to pursue their dreams and hopes. Through space activities, one can gain enormous amount of knowledge of and data on space and the Earth environment as well as experience and knowledge in the areas of launch vehicle and satellite development. Such knowledge and experience would be useful for various areas of our activities, including those in classrooms. This is important especially when there is a growing concern over the young people "losing interest in science". JAXA shall, therefore, take actions to provide education and training opportunities for young people.

JAXA hopes that its Vision would lead to better understanding among all stakeholders and the Japanese public of what JAXA has determined to do, and could do, for the better future of Japan, and would eventually lead to the implementation of the Vision.

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INTRODUCTION

The use of aerospace by aircraft as well as by launch vehicles and satellites already provides the foundation for our various activities today. The advancement in the technology development and the establishment of the sound industry base in the area of aerospace is, therefore, essential for our nation. It is equally important to respond to the growing expectations and increasing requests for aerospace activities from various communities concerned with, for example, politics, diplomacy, security, economics, traffic, agriculture and fishery and education, and from the general public.

In the case of other countries, for example, the United States and European countries are convinced of the importance of space activities and promote space development and utilization as one of the most important national policies. Countries such as China, India and Brazil that would have significant impact on the global economy in the coming years are carrying out their space activities in a strategic manner. In the area of aviation, it is anticipated that the demand for air transportation would rapidly increase, and the United States and Europe, leading aerospace countries of the world, intend to strengthen their aerospace industries to maintain their positions.

Against such circumstances as described above, Japan Aerospace Exploration Agency (JAXA) was established in October 2003 as an independent administrative institution to function as the principal entity responsible for research and development of Japan in aerospace areas. The National Space Development Agency (NASDA), the Institute of Space and Aeronautical Science (ISAS) and National Aeronautics Laboratory (NAL) were merged into one entity to establish JAXA. JAXA recognizes its unique status in the country and considers it as its responsibility to provide the society with a clear picture of the future aerospace activities and to seek for genuine response from the general public.

With the above recognition, JAXA developed the present Vision on its own initiative to present the ideal picture of future aerospace activities and to indicate the direction that should be pursued to turn that picture into reality. By presenting the Vision, JAXA hopes to create a momentum to gain better understanding of and wide support for aerospace activities by the general public and all stakeholders.

The present Vision proposes the following for space development and utilization and for aeronautical research and development for the period of about twenty years, while forecasting

the future of Japan and the global society: i) underlying principles of the Vision; ii) content of the Vision; and iii) actions toward the implementation of the Vision. In order to yield tangible results by implementing the proposals contained in the present Vision, JAXA will select its priority activities and concentrate its efforts on those activities thereby promoting space development and utilization as well as aeronautical research and development in an effective and efficient manner.

In order to enrich the content of the Vision, JAXA made efforts to exchange views and opinions with various communities in Japan. Following the formulation of the Vision, JAXA will take initiatives to make proposals for concrete and effective activities, in coordination with relevant entities, toward the implementation of the Vision. Furthermore, JAXA hopes that the Vision would be appropriately taken into account in the decision-making by the government to develop national strategies, various plans and policies.

CHAPTER I: BACKGROUND AND UNDERSTANDING THE PRESENT SITUATION

1. Background

The Vision takes into account the following developments in space activities.

In September 2003, the Space Activities Commission finalized “The Long-term Program for Space Activities, covering the period of approximately ten years. In view of the subsequent developments that followed within and outside the country in space activities, the Council for Science and Technology Policy, in September 2004, adopted “The Basic Strategy for Space Development and Utilization”. The Strategy recognized space development and utilization as important, strategic technology of the nation that provides the basis for sustainable development of Japan as an advanced science-and-technology-oriented nation. The Strategy also indicated an executive direction to be pursued by the government for the subsequent period of about ten years.

In the area of aeronautics, in May 2003, the Committee on Aeronautical Science and Technology, a subsidiary body of the Council for Science and Technology of the Ministry of Education, Sports, Culture, Science and Technology (MEXT), finalized its report on “The Policy for Promotion of Research and Development on aeronautical Science and Technology”. The report identified priority areas of research and development for the period of about five years, while predicting possible developments over the time span of about ten years.

Intense discussions are currently underway toward the formulation of “The Science and Technology Basic Plan” for the period from Fiscal Year (FY) 2006 to FY 2010. As part of the process of preparing the Basic Plan, MEXT is finalizing its basic concept and directions to be pursued regarding “Key Technologies” that should be strategically promoted by Japan.

In January 2004, in the United States, the President announced a new Vision for Space Exploration, which would lead to human exploration to the Moon and Mars. The plan envisions the development of cutting-edge technologies and the expansion of the frontier in the universe. The European Union recognized space activities as a tool to achieve major policy goals and is developing the policy that would expand space activities.

In October 2003, China succeeded in its first human space flight. Not only China, but also India, Brazil and the Republic of Korea are strengthening their efforts to carry out space activities. The

international environment surrounding space activities is rapidly changing. With the above situation in mind, JAXA believes that increasing its contributions through space activities to the international community, particularly to the region of Asia, has become an important issue for Japan as advanced science and technology oriented nation.

The Third Earth Observation Summit (EOS-III), held in February 2005, approved the 10-Year Implementation Plan to establish a Global Earth Observation System of Systems (GEOSS) through international cooperation. GEOSS would provide a comprehensive, coordinated and sustained observation system covering the entire world, using existing and planned satellites and ground observation systems. The Implementation Plan, as endorsed by EOS-III, articulated the goals to be achieved by global observation systems and established an international framework for the relevant actions to be undertaken.

The importance of space development and utilization is increasing, to enhance national security, stimulate economic growth and protect environment all together. In this regard, pro-active approach must be taken to further enhance space development and utilization as an essential strategic technology of the nation to ensure sustainable development of the planet Earth and humanity.

2. Understanding the present situation

The history of Japanese space activities dates back to the development and launch of a Pencil Rocket fifty years ago. In the year 1970, following the first landing on the Moon by humankind through successful Apollo 11 mission of the United States, Japan joined spacefaring nations by successfully launching “Ohsumi”, the first indigenous satellite developed by Japan. In the subsequent years, Japan pursued the enhancement of the capability of M-series solid-propellant rockets, which led Japan to become a leading country in the area of space science. In the area of space utilization, Japan imported launch vehicle and satellite technologies from the United States and made steady progress in developing space technology, with a view to acquiring indigenous capability to develop satellites and launch them. As a result, despite its limited space budget and limited human resources compared to other spacefaring nations, within a short time period, Japan succeeded in acquiring world-class. In the 1990’s, for example, Japan had consecutive successes in launching indigenous H-II launch vehicles and succeeded in the development of large satellites. Based on its space technology capability, Japan joined as an equal partner with the United States and European countries in the International Space Station program and in other international activities in such areas as earth observation, thus establishing its status in the international space community.

In the latter half of the 1990’s, however, with a series of launch failures and malfunctions of satellites, Japan experienced a set back in its space endeavours. It was perhaps inevitable for Japan as a “front runner”, as was the case with other spacefaring nations. While it had limited experience in space activities and had not yet fully established its capability to develop key technologies that would provide the base for space activities, Japan, strived to gain international competitiveness through performance improvement and drastic cost-down. This was pursued in spite of its limited resources made available to space activities. While the reliability should be considered the most important factor in pursuing practical applications, efforts to achieve the reliability were apparently undermined. Lately, Japan succeeded in launching the seventh H-IIA rocket only after thorough preparations. JAXA strongly believes that continuous efforts must be made to further enhance the reliability.

In the meantime, due to drastic cuts in space budget and a decrease in space sales, industry is facing the challenge of retaining experienced engineers and maintaining and upgrading manufacturing facilities. There is a growing concern, for instance, over the deteriorating product quality in the area of space equipment manufacturing and decreasing reliability in implementing space projects. This indicates toward a grave risk of collapse of space industry’s technology

base, which supports space activities as strategic technology of the nation.
On the other hand, other spacefaring nations have recognized space activities as means to enhance national security and to provide solutions for issues of national concern. They are further strengthening the support at national level for their space activities. This reflects a stark difference with the situation in Japan, and one could not help questioning the circumstances under which activities are being placed in Japan.

In the area of aviation, the production level has steadily increased through international collaborative-efforts for technology development. On the other hand, Japan has not initiated the development of its indigenous passenger aircraft for the past forty years or so, since the development of YS-11. Japan has not yet fully undertaken activities covering the entire lifecycle of aircraft, i.e. from development to operation. This made it impossible to carry out autonomous activities in a strategic manner and difficult to expand business in this area.

In order to overcome this impasse, it is essential that Japan pursues aerospace development and utilization as important national policy. At the same time, JAXA recognizes that it needs a sound long-term vision and strategies. Together with all stakeholders and industry, JAXA should acquire the capability to carry out autonomous activities, enhance reliability, and undertake activities toward the establishment of sound technology base of industry.

CHAPTER II: Vision

1. Principles

Today, at the outset of the twenty-first century, we are in the middle of the rapidly changing global situation. While the United States is taking the lead in global economy and politics, European countries are further pursuing their integration, competing with the United States. China is, on the other hand, expanding its market globally in the pursuit for its economic development. This is followed by India and Brazil as emerging countries in the global economy. Turning to Japan, the nature of its industry base is rapidly changing, resulting from the declining birth rate and a growing proportion of elderly people in its population as well as expansion of manufacturing bases abroad, Japan as advanced science and technology-oriented nation needs to strengthen its efforts to establish the knowledge-oriented industry base.

In the middle of such rapid developments in the world around, Japan and its people could gain confidence and pride, and Japan could strengthen its competitiveness and pursue its sustainable development**,** only if efforts are strengthened to enhance the comprehensive national security, contribute to the protection of global environment, and develop its future human resources.

In September 2004, the Council for Science and Technology Policy adopted the “Basic Strategy for Space Development and Utilization”. The Strategy identifies space development and utilization as the typical large-scale systems engineering integrating various advanced technologies. The Strategy also indicates the following as the areas where space development and utilization could make important contributions: i) achieving autonomy of Japan in the international society; ii) yielding a wide range of socio-economic benefits through spin-offs of space applications; iii) heightening pride of Japan and its people through the challenges in exploring the universe as the last frontier. Space development and utilization constitutes important strategic technology of the nation that provides the foundation for sustainable development of Japan as advance science and technology-oriented nation.

Space utilization has provided us with a new perspective, making it possible for us to look at issues of concern to the international society from a global point of view. In addition, space utilization for peaceful purposes in the area of crisis management provides one of the most effective means to collect and disseminate accurate information in a timely manner that is necessary for ensuring comprehensive national security.

The size of Japanese aircraft manufacturing industry, if compared on the basis of gross domestic product (GDP), currently constitutes approximately one fifth of that of the countries with advanced aircraft technologies. It is expected that it would evolve to become a major industry commensurate with the scale of economic activities of Japan.

Bearing in mind the above situation as well as the importance of space development and utilization as effective and essential means to achieve policy goals, JAXA recognizes it as its principal mission to contribute to solving the issues of concern to Japan and its people while coordinating with relevant entities and industry.

Based on the above point of view, JAXA identified the following as the principles in developing its long-term vision.

- ○ Build a secure and prosperous society through the utilization of aerospace technologies;
- ○ Contribute to the hope and better future of the people of Japan through exploring the mysteries and possibilities of the universe;
- ○ Establish the capability for autonomous space activities through the highest-level technology in the world;
- ○ Enhance key industries in the aerospace area.

Through the pursuit of these principles, JAXA as a leading research and development organization in the area of most advanced aerospace science and technology will strive to become a model of excellence, with best organizational structure and culture.

2. Vision

Following the principles as laid out in the previous section, JAXA has developed its Vision as below. The Vision presents the ideal situation of space development and utilization for Japan over the time span of twenty years or so.

"JAXA will contribute to building a secure and prosperous society by developing launch vehicles and satellites with the highest reliability in the world and world-class capability. JAXA will also promote "top science" in the field of space science and prepare for Japan's own human space activities and utilization of the Moon. JAXA will conduct a flight demonstration of a Mach-5 class hypersonic experimental vehicle. Through these activities, JAXA will contribute to enhancing the environment for aerospace industry to become a key industry of Japan."

Further details of the Vision are provided below, with five major categories of activities.

(1) Contributing to building a secure and prosperous society

- ○ Implement an integrated observation, monitoring and warning system, using satellites with the highest reliability in the world and world-class capability, which enables anybody at any time and anywhere to receive information on the current situation and predictions of disasters and global environment, to receive necessary warnings and to dispatch information.
- ○ Establish a new mechanism for space development, operation and utilization together with end-users, including governmental entities, as well as research institutions and industry to implement the above-mentioned system in an effective manner to provide solutions for the issues of concern to the nation and the society.

"The Basic Strategy for Space Development and Utilization", adopted by the Council for Space and Technology Policy in September 2004, indicated that one of the objectives of space development and utilization is to ensure national security and stated as follows: "The government is responsible for protecting the lives and properties of the people from conflicts and disasters, so that the people could lead the safe and fulfilling lives. The government intends to make a full use of space to fulfil its function in this regard."

JAXA will assist in building the secure and prosperous society by proposing a problem-solving-oriented social system that includes space systems as its integral part and by

implementing the proposed system in cooperation with relevant entities. Through products to be derived from the above system, JAXA will contribute to sustainable development of the region of Asia and the Pacific.

In the Vision, JAXA proposes the following systems for integrated observation, monitoring and warning, which would represent new systems to be developed.

① Implementation of an “Information Gathering and Warning System for Disaster and Crisis Management”

JAXA will implement a system that would enable user institutions to: i) obtain comprehensive information on major disasters caused by, e.g. earthquakes, tsunamis and heavy rains, and on imminent crisis; ii) predict the possibility of the expansion of disaster-affected areas in a timely manner; iii) disseminate most accurate warnings in a timely manner directly to individual portable terminals. In cooperation with user institutions and other relevant entities, JAXA will implement the above system ahead of the rest of the world.
JAXA will make available the products to be derived from the system for the benefit of those countries in need in Asia and the Pacific, thereby realizing the concept of individual-oriented disaster prediction services in the region, and eventually for the rest of the world.
Through such system, JAXA will contribute to building the society where anybody can anytime and anywhere receive and dispatch information concerning his/her safety in the event of emergency.

② Implementation of a “Global Environmental Monitoring System Integrating Observations and Predictions”

JAXA will establish a system to provide information on the global environment on a continuous basis by integrating the observations of the global environment, including climate change and water cycle, and predictions of environmental changes. The system would assist in the formulation of appropriate measures and policies at national, regional or global levels to protect the environment.
By making the system available as part of an international network of observation and prediction, JAXA will work toward assisting Japan, as an advanced country, in playing a leading role in the international community to protect the global environment.

Toward the implementation of the above system, JAXA will concentrate its efforts on the

on-going activities to develop key satellite technologies such as observation, communication and positioning technologies. Japan is already in the process of developing and operating information gathering satellites, which are used primarily for crisis management in response to diplomatic and defense needs relating to national security as well as to major disasters. Through the development of key satellite technologies, JAXA intends to continue its contributions to the information gathering satellites.

JAXA will also promote the integration of satellite systems and ground systems as well as their coordination and cooperation as an ideal mechanism for space development, utilization and operation. The new relationship between the European Union (EU) and the European Space Agency (ESA) might offer an example for such mechanism to consider. As part of the policy direction pursued by the EU toward the integration of European countries, the EU and ESA together with industry have been developing the partnership to enhance their cooperation in the development, operation and utilization of space technologies.

Advanced technologies for information gathering and analysis as well as for satellite positioning, necessary for the observation and prediction systems mentioned above, would be widely used in such areas as the management of ecosystem, water resources and energy as well as agriculture and fishery. Wide spread use of individual portable terminals in the society could result in increasing demand for those advanced technologies. Therefore, JAXA will assist in transferring these technologies to user institutions and the private sector toward new space utilization, bearing in mind the importance of security issues involved in transferring sensitive technologies.

(2) Contributing to the advancement of knowledge and the expansion of human frontier: for people's hope and for better future

○ JAXA undertakes solar system explorations using its own technologies and cosmic observation methods in many wavelength bands. The purpose of these studies is to determine the origins and constituents of the universe, to explore planets, and the environments in which life can flourish. Making these endeavors, Japan will become one of the world's leading science centers.

○ JAXA undertakes lunar explorations to establish its bridgehead base on the Moon. This will enable the expansion of the areas of activity on the Moon, and help strengthen Japanese technology development. JAXA develops the necessary technologies to achieve this goal.

○ JAXA envisions the use in the future of the Lagrange point of the Sun-Earth system as a new locale of human activities reaching further out into the solar system. JAXA's naming of this vision is the Deep Space Harbor concept, which can also be referred to as the Gateway to Space concept.

○ JAXA's promotion of these ideas would hopefully motivate young generations to take greater interest in science and technology, and contribute to human resource development.

The advancement of knowledge and the expansion of human activities are challenging unknown frontiers. Demonstrating these abilities to the international community puts Japan's core proficiency on display, resulting in continued international recognition, national pride, economic gain, and encouraging our younger generations to continue these explorations. It is, therefore, important for Japan to develop its own scientific and technological abilities and its own culture, and use them for a wide range of activities, including space science and space exploration.

Space science is a discipline searching for the origins and history of the universe, its constituent materials, the Earth and life. Researchers try to ascertain the environments in which life is created and perpetuated. They also investigate fundamental principles of science which can only be studied in the extreme conditions found elsewhere in the universe.

JAXA's main goals, therefore, are to explore the solar system and observe the universe. Its creative approaches can lead the world in these scientific activities, which will be made in cooperation with academic and research institutions in Japan and overseas. It is an ultimate goal for JAXA to take Japan to the position of the topmost science center specialized in space science in the world. During the coming two decades, JAXA will be able to explore study the

earliest stars and black holes in the universe providing information about the creation of the universe**,** first stars and black holes, discovering the lead to the creation of the universe. JAXA will also make observations of planets outside our solar system. Further research into the solar system, including the Jupiter-type planets**,** will provide information about its origin.

Lunar exploration will yield more scientific knowledge about our Moon. JAXA intends to apply cutting-edge technology to this study to obtain information about possibilities of the utilization of the Moon.

In about twenty years, there will be a base for more human activities on the Moon which will be constructed through international cooperation. JAXA, with its advanced technologies, will play a leading role in this project and will take appropriate responsibility.

Furthermore, JAXA will try to realize a "Deep Space Harbor" by considering a Lagrange point or the surface of the Moon, which will allow extended periods of stay for human space explorations. The effects of gravity are balanced out at these locations and so they offer sufficient stability to be used as a base, which will help promote observations of the universe, the exploration of the solar system, and the development and utilization of space.

(3) Developing indigenous capability to independently carry out space activities

- ○ Develop launch vehicles and inter-orbital transportation systems that would have the highest reliability in the world and world-class capability. Through further development of technologies, develop launch and return vehicles as well as reusable space transportation systems with the capability to safely transport humans.
- ○ Accumulate technologies necessary for human space activities by participating in the International Space Station program and prepare for undertaking human space activities on the initiative of Japan.
- ○ Create new areas of space utilization and establish the technological infrastructure that would facilitate space utilization by anybody.

Japan pursues a public policy to maintain its indigenous capability to launch satellites and space transportation systems on its own initiative in the coming years whenever necessary. In accordance with this policy direction, JAXA is being requested to ensure the reliability as a matter of priority, to strengthen its technology base and to maintain and further enhance its capability for technology development.

Regarding the space transportation systems, JAXA will continuously operate, maintain and further develop H-IIA launch vehicle with the aim of increasing the number of its launches, so that H-IIA would become the most reliable launch vehicle with world-class capability. JAXA will also develop, operate and further enhance H-II Transfer Vehicle (HTV), Japanese re-supply vehicle for the International Space Station (ISS), in order to acquire technologies necessary for human space flight, i.e. technologies for inter-orbital transportation, return flight, reusability and safety.

By developing these technologies, JAXA will work toward the establishment and operation of launch and return transportation systems that can safely transport people in twenty years from now. JAXA will also conduct a flight demonstration of a reusable transportation system that will include technologies for human space flight, thereby taking steps toward initiating the development of a human reusable transportation system.

As for human space activities, JAXA will accumulate necessary technologies through the operation and utilization of the ISS. This will be done with a view to participating in future human exploration of the Moon through international cooperation and conducting human space

activities in near-Earth space on JAXA's own initiative. Based on achievements through these activities and the participation in the ISS and succeeding international human space programs, JAXA will establish technologies required for human presence in space and human space activities, so that it would be ready for its own human space activities in about twenty years.

Along with the above-mentioned efforts to develop its indigenous capability to carry out space activities, JAXA will explore new areas of space utilization that would provide solutions for the issues of significance to the entire humanity, such as energy. With the maximum use of ISS, Japanese Experiment Module (JEM) and HTV as well as a future lunar exploration base, JAXA will strengthen its technology base to explore possibilities for innovative space utilization, such as the use of space solar power and large-structure assembly in space.

If the system that allows for safe transportation in large quantities with high frequency, such as airplane, becomes available for space transportation, the passage between the Earth and space would open wide to transport goods and humans. This would significantly expand possibilities of space utilization. JAXA will pursue innovation in the space transportation technology that would result in high reliability and significant cost reduction. As part of such efforts, JAXA will work to convert expendable launch vehicle into a reusable space transportation system.

As it becomes easier for the general public, industry, government, researchers and educators to use space, needs and demands for space utilization would diversify. JAXA will work toward establishing the technology base and a mechanism to respond to those diversifying needs.

(4) Facilitating the growth of space industry: toward self-sustained and competitive space industry

○ Promote research and development of relevant advanced technologies that would allow for self-sustained growth of the space equipment industry in the global market.

○ Take steps toward enhancing the environment for space equipment industry and space utilization service industry to become a key industry of Japan.

The benefits derived from satellites cover a wide range of human activities, such as communications and broadcasting, weather forecasting as well as global positioning. The satellite technologies have become essential in enhancing the industrial competitiveness of Japan.

In terms of its technological capability, the space equipment industry of Japan has grown enough to be able to manufacture launch vehicles and satellites that are close to the world-class level. The space utilization service industry is responding to various needs of the government and business to some extent. While commercial activities by the space industry have just begun, the space equipment industry of Japan is always exposed to the highly competitive environment in the global market, and it now stands at a critical moment for its survival.

For Japan to achieve autonomy in the space utilization, it must retain its indigenous capability for technology development, manufacturing and operation. It is, therefore, essential that the space equipment industry, which supports the development of key space technologies such as space transportation and satellite technology continues to exist and grows adequately in the future.

In collaboration with industry, JAXA will, therefore, take steps toward providing the foundation and environment that would allow for the space equipment industry to follow other manufacturing industries of Japan, to achieve self-sustained growth in the global market by having products recognized for their high reliability and high quality.

The market size of the Japanese space equipment industry amounts to about 300

billion Japanese yens (or 2.7 billion United States dollars) per annum, and that of the space utilization service industry is about 600 billion Japanese yens (or 5.4 billion United States dollars) per annum. The industry of this scale is too small to retain a reasonable level of earnings for self-sustained growth through reinvestment.

The combined market size of the Japanese space equipment and utilization service industry could grow to achieve the size of some trillions of Japanese yens (or some tens of billions of United States dollars), representing about 1 per cent of GDP in twenty years, a major target to be achieved to become one of the key industries of Japan.

By implementing the Vision, the Japanese space industry in ten years could receive orders for six satellites per annum, which could also be followed by their launches. This could lead to significant growth of the space equipment industry of Japan. If the rate of growth achieved in those ten years is maintained, the Japanese space industry could achieve a significant growth in terms of its industry scale.

The space utilization service industry could also expect the creation of a new market and its growth following the emergence of new utilization services, such as satellite communications services for standard cellular phones. If there is steady growth of such a new market, the entire space utilization service industry could achieve significant growth following the expansion of the government market as well as consumer market.

It is hoped that the Japanese space equipment industry would gain competitiveness and would become self-sustainable in the global market. It is also hoped that, together with the Japanese space utilization service industry, these industries would constitute one of the key industries of Japan in the future. In this regard, JAXA will make its best technological contributions that would enhance the environment for the growth of these industries, bearing in mind the importance of taking a comprehensive approach in cooperation with industry and the government.

(5) Facilitating the growth of aviation industry and breakthroughs for future air transportation

○ Enhance the environment for the aircraft manufacturing industry to become a key industry of Japan.
○ Demonstrate, with a Mach-5 class experimental vehicle, the technology of hypersonic aircraft that can fly across the Pacific Ocean in two hours.

The aircraft manufacturing industry in the leading countries in this area such as the United States and France represents more or less 1.5 per cents of their GDP, while it remains only at 0.3 per cent in Japan, or one fifth of the aircraft manufacturing industry in those countries.

In the coming years, a significant increase in the demands for air transportation is expected, accompanied with market demands for speed and convenience. At the same time, social demands would increase for better measures to protect the environment and to improve safety. If Japanese aircraft manufacturing industry is to become a key industry of Japan, reaching the industry size commensurate with the scale of economy of Japan, it must respond to those market and social demands, to gain bargaining power in the global market.

With highly value-added technologies that would allow for Japan to achieve independence and autonomy in the areas of aviation, Japanese aircraft industry must win recognition for its "Japanese-brand" products in the global aircraft market. It is also important to develop "breakthrough technologies" that would expand possibilities for future air transportation. As the entity to lead the aircraft research and development in Japan, JAXA will acquire highly advanced technologies ahead of others. By developing those "breakthrough technologies", JAXA will also make progressive contributions to the growth of the industry.

At present, jet airplanes, which fly at the speed of Mach 0.8, normally take ten hours from Tokyo to Los Angeles. With hypersonic aircraft, at the speed of Mach 5.0, the flight time can be reduced to about two hours. By using liquid hydrogen as fuel, it would also be environmentally sound as it would not emit carbon dioxide while achieving higher energy efficiency. Demonstration of technologies of the Mach-5 class hypersonic aircraft should be technically feasible in about twenty years based on the technological accomplishments to date and in view

of the perspectives for future in aeronautical engineering in Japan. JAXA will work to create the enabling environment toward that goal.

CHAPTER III: TOWARD THE IMPLEMENTATION OF THE VISION

1. Implementation Policy

The implementation of the Vision requires determining milestones first and undertaking actions to achieve those milestones in a strategic manner. On the basis of the implementation policy provided below, JAXA will propose the milestones as well as plans and strategies to achieve those milestones.

○ JAXA will develop a roadmap covering the period of twenty years, which would be divided into two parts, with the first 10 years and the subsequent ten years. For each part, JAXA will select activities to be carried out on a priority basis and concentrate its efforts and resources on those priority activities.

○ During the first ten years:

- JAXA will concentrate its efforts on those activities that would promote wider use of aerospace technologies in the society, with a view to contributing to building the secure and prosperous country.
- JAXA will also take steps toward innovative space utilization, including future human space activities and utilization of the Moon. This would be done by developing pioneering missions and nurturing necessary technologies. Based on the results of the verification of those technologies, JAXA would prepare options for selection by the government on the course of actions to take.

○ During the subsequent ten years:

- JAXA will further make efforts to promote wider use of aerospace technologies in the society and will propose innovative space utilization. Following a decision to be made by the government, JAXA will make steps toward new space utilization including the utilization of the Moon and human space activities.

2. Building a secure and prosperous society

Space systems provide means for collection, transmission and delivery of information as well as positioning. They, therefore, constitute an important part of the infrastructure of the society. JAXA considers that its primary objective is to contribute to enhancing the safety and vitality of the Japanese society through the demonstration of the use of space systems and their integration into the society for the benefit of a large population and to promoting sustainable development together with countries in Asia and the Pacific.

Background and objectives

○ Information Gathering and Warning System for Disaster and Crisis Management

Major disasters caused by frequent earthquakes and heavy rains in various parts of the world in the recent years reminded us that our modern society is still vulnerable to natural disasters. In the region of Asia, where many areas are characterized with high population density and with insufficient disaster management measures, the extent of damage caused by disasters could be unprecedented. Making full use of the advantages offered by the space systems, with the broad coverage of real-time, disaster-proof services, JAXA considers that it is feasible to develop a problem-solving-oriented system that would enhance the safety of lives and properties of the people.

An “Information Gathering and Warning System for Disaster and Crisis Management”, with the use of observation, communications and positioning satellites, would collect information on rapid changes on the ground and in the atmosphere and compile the information at an integrated information center. This would enable the prediction of disasters and crisis situations as well as the areas under risk and would allow for timely dissemination of warnings. Information on predictions and warnings could be delivered on a real-time basis to portable terminals of the individuals who need such information. Through the operation of such a system, JAXA will contribute to the enhancement of the safety of the people. By extending the service area of this system to cover the rest of the region of Asia and the Pacific, JAXA could contribute to the promotion of the stability of the region and its sustainable economic growth. This would in turn also lead to the stability of Japan, as a large proportion of its economic activities are attributed to trade.

○ Global Environmental Monitoring System Integrating Observations and Predictions

Environmental issues such as those relating to climate change, water cycles and pollutions have been recognized as undermining the global stability. In addition, a population explosion and continuous expansion of human activities are further aggravating these environmental problems. Unless human beings live in harmony with the nature, sustainable development of the human society cannot be expected. The impact of the population explosion and aggressive economic development appears to be particularly serious in the region of Asia, and environmental problems and frictions among various countries could exacerbate. There could be serious consequences affecting Japan, which relies on import for a large amount of food from the region. In order to overcome these challenges, regional or global approach, beyond the national border, is essential. Satellites offer means for global observation and could be used to the full extent to provide an effective tool to solve these challenging environmental issues.

A “Global Environmental Monitoring System Integrating Observations and Predictions” would integrate remote sending data from observation satellites with in-situ data from ground observation regarding the parameters that are important for studies on global environmental change, such as carbon dioxide (CO_2) density and precipitation, to develop datasets that are necessary for understanding the global environment. By combining those datasets with capable prediction system such as the Earth simulator, the System could serve as a useful tool to provide essential information for making decisions at national, regional and global levels on actions to be taken. The appropriate use of such a tool would lead to the promotion of appropriate actions to ameliorate and preserve the global environment. By playing an active role and taking initiatives to solve global environmental issues, Japan could be considered a reliable country in the region of Asia, where the impact of global environmental problems on the society is particularly acute.

Direction to be pursued toward the implementation of the Vision

○ System development from the user’s point of view

JAXA will pursue the integration of the space utilization systems, mentioned earlier in this document, into the society for the benefit of a large population toward the implementation of the Vision that would offer good solutions for the management of disasters and environment. Mere demonstration of the space utilization system would not lead to its integration into the society. JAXA considers that the following two challenges need to be overcome in order to bridge the

gap between the demonstration of the system and its practical use:

- Space utilization systems to date have been oriented toward technology development and have not necessarily been user friendly.
- Demonstration systems have not been provided on a continuous basis, and the end-users have not been able to invest in the space utilization systems.

In order to overcome the above challenges to implement the Vision, JAXA will fundamentally change its way of thinking to date, which was oriented toward space technology development. JAXA will pursue system development from the user's point of view, based on the following basic directions.

- Design the entire system from the user's point of view.
- Ensure the continuity of the system and bridge the gap between the demonstration and practical use.

In line with the directions indicated above, JAXA will strengthen the mechanism to conduct system demonstration and development together with the end-users. Within such mechanism, JAXA would, for example, focus its efforts on the development of user-friendly portable terminals that respond to the demands of end-users in the event of disasters. The end-users would include ordinary people, rescue workers (and their supervisors) disaster management planners.
JAXA will also develop a satellite communications and observation system that would allow the data users involved in disaster and crisis management or the protection of environment to acquire and deliver data that meet their real needs in a timely manner.

○ Close collaboration with user institutions

The systems proposed above cannot be complete with satellite systems only. Their effective functioning requires collaboration and integration with ground observation network. JAXA will pursue close cooperation with research institutions, technology development organizations, as well as user and operational entities within and outside the country.

It is essential that after interpreting and analyzing collected and integrated data and information, only the selected, valid information is disseminated and delivered. Enormous amount of data processing itself, while ensuring the timeliness at the time of disasters and the accuracy for

activities relating to environmental issues, presents a challenging task. In the operation of observation satellites and the processing of observation satellite data, there are common areas to a large extent among various satellites. Establishing an integrated operation and data processing center in collaboration with user institutions, taking full advantage of JAXA's experience and skills on the data processing, is considered one of the most likely courses of actions to be pursued in terms of effective use of the available resources of Japan. JAXA will make efforts toward the establishment of such a center.

○ **Development of key satellite technologies**

JAXA will work to offer its satellite systems that support the implementation of the Vision for use not only in Japan but also in the region of Asia and the Pacific, as well as in the rest of the world. JAXA believes that Japan should take the initiative to establish those systems, based on the advanced, matured technologies that are considered Japan's strength, so that Japan's contribution to the region would be recognized. JAXA will establish the system based on the unique satellite technologies that it has developed over years while pursuing further development and maturity of those technologies.

The establishment of the proposed system requires the following technologies:

- High-resolution optical observation technology
- Synthetic Aperture Radar technology
- Mobile satellite communications technology
- High-speed satellite communications technology
- High precision positioning technology
- Weather and environment monitoring technology (visual infrared radiometer, microwave radiometer, precipitation radar, carbon dioxide measurement sensor, etc.)
- Inter-satellite communications technology

Targets and roadmap

○ Within about ten years, JAXA will work toward establishing the basic elements of the proposed "Information Gathering and Warning System for Disaster and Crisis Management" and the "Global Environmental Monitoring System Integrating Observations and Predictions" through the following missions:

- Demonstration of very-small portable terminals
- Transmission of large amount of data to small antennas

- Establishment of high precision positioning technology (meter-level)
- High-resolution disaster monitoring with highly frequent revisit capabilities.
- Continuous observation of air pollutions and sea pollutions across the border
- Measurement of carbon dioxide at 1 ppmv-level by country
- Continuous observation of climate change with visible infrared radiometer, microwave radiometer, radar and other means
- Participation in the international cooperation for the establishment of a Global Earth Observation System of Systems (GEOSS)

○ Within about twenty years, JAXA will work toward achieving the following:

- Establishment of the proposed “Information Gathering and Warning System for Disaster and Crisis Management”, which would include geostationary Earth observation satellites with 10-meter resolution, and provision of its services for the benefit of Asia and the Pacific
- Establishment of the proposed “Global Environmental Monitoring System Integrating Observations and Predictions” as a policy tool to be integrated into regular administrative activities.

3. Advancing human knowledge and expanding the human frontier

The universe is full of mysteries which stir mankind's imagination and provide profound intellectual challenges. The quest to solve these mysteries calls on all the disciplines of science to advance our understanding. The evolution of the universe, the detailed structure of our solar system, and the origin of life have enticed humans to their study, and mankind has sent a variety of probes into the solar system and many different types of telescopes into space. These missions yielded new discoveries and knowledge, but at the same time revealed new mysteries. The work of our pioneers in space is now being passed on to the next generations, offering them the opportunity of achieving goals we can only dream

Over land, across the oceans, and into the skies --- humans have always sought to expand the spheres of their existence. The boundless expanse of the universe offers a further dimension where mankind will be able to find many more challenges and opportunities. The sustained growth of human society is the foremost goal for the twenty-first century, as global society is beginning to reveal its innate vulnerability. It is quite natural, therefore, for humankind to look beyond the Earth for potential new bases for its continued existence. In this pioneering process, mankind will have to follow the path from discovery, to exploration, to development and utilization.

The Moon, our closest celestial neighbor, has long been considered the gateway to the exploration of the solar system. We have now reached the stage where we can start to make use of the Moon. The Moon is no longer a mere object of exploration. We are already developing strategic technology to tackle this challenge. It is important for Japan to acquire space exploration technologies through the exploration of the Moon and beyond. They will enable Japan to expand its scope of space activities. They will become the driving force for strengthening Japan's technological development, which is an essential source of competitive power.

We describe here our plans for realizing our Vision in relation to space observation, surveying the solar system, and the exploration and utilization of the Moon:

(1) Observation of the universe and exploration of the solar system

Background and objectives

Japan has launched 26 satellites for scientific space exploration since 1970. Supported by cutting-edge engineering technologies to meet the needs of these science missions, these satellites have made many new discoveries, ranging from the Earth's atmosphere to the limits of the universe. In particular, the astronomical observations at X-ray energies and observations of magnetic fields [in the solar system] made by these satellites have helped Japan play an important international role in these branches of science.
Over the next few years, Japan will launch three scientific satellites, each having the potential of becoming the premier observatory in the fields of X-ray astronomy (ASTRO-E2), infrared ray astronomy (ASTRO-F), and solar science (SOLAR-B). In addition, the space probe "Hayabusa", with an electric propulsion system, will bring back to Earth surface material from the asteroid Itokawa. A lunar-orbiting satellite (SELENE) will explore the Moon at a level achieved never achieved before. Several years later, the PLANET-C probe will clarify Venus' mysterious atmospheric phenomenon. ESA-JAXA joint mission BepiColombo will send two spacecraft Mercury Magnetospheric Orbiter (JAXA) and Mercury Planetary Orbiter (ESA) to Mercury.

We have two important goals for the 21st century: determining the origin and composition of the universe and the nature of spacetime, and studying the possibility of life elsewhere in the universe. These are fundamental questions which do not yet have clear answers. JAXA will take on these challenges, and make its share of contributions to the advancement of knowledge for the furthering of space science

Through space observation and solar system probes, JAXA will address these two essential questions. This will entail, in part, studying the structure and constituent materials (matter, dark matter, dark energy) of the universe and their evolution with time, also attempting to clarify the creation of the environment in which the solar system formed and the Earth, with its ability to foster life, exists.

Direction to be pursued toward the implementation of the Vision

○ **Development through international competition and cooperation**

Space science develops through international competition and cooperation. Taking into consideration current international academic interests and priorities and information from space missions, Japan must establish space observation and solar system exploration missions, building upon its current strengths and based on its own initiatives. At the same time, it is

important that Japan, with its own technologies and experiences, should take an active part in cooperating with internationally sponsored science missions.

Advances in science require many creative and resourceful scientists working in concert over many years. Until now, Japan, based on its own exploration observation strategies, has deployed its own space science with mutual assistance and complementary relations with the United States and Europe. Through these cooperative efforts, Japan has achieved an internationally recognized position at the forefront of space exploration and observation. In the future, through the exchange of opinions of people with a wider range of backgrounds and in collaboration with academic communities and research institutions in Japan and other countries, JAXA will pursue new, creative missions in a timely manner.

○ **Taking on challenges of developing cutting-edge technologies indispensable for top-level science.**

Toward new discoveries and advancement of our knowledge through observation of the universe and exploration to the solar system, JAXA will embark on new missions. They will include the development of small satellites, which can be constructed and launched more regularly JAXA will participate pro-actively in foreign space programs and in other international efforts and will use its resources to a maximum possible extent to implement a large-scale missions internationally recognized as being of fundamental importance.

The gateway to the top-level science is opened through the development of cutting-edge technologies. JAXA will take on this challenge by undertaking new missions in fields where JAXA is able to take leadership internationally. These missions include the development of in-space navigation, robotics and miniaturization technologies. Meeting the challenges of pioneering new technologies breaching new frontiers will contribute to the development, furtherance and propagation of new space technologies. Highly advanced space technology stems from advancement of diverse technological fields. These efforts will enhance our technological capabilities and competitiveness.

Targets and roadmap

○ The following missions will be implemented in the next decade:

- A broad multi-wavelength observatory will be launched. Its mission will be to make a multi-faced approach to observations of our galaxy and other galaxies hosting super

massive black holes to understand how these objects are powered, and use their radiation to study the intervening intergalactic medium using a variety of scientific exploration methods This mission will include efforts to resolve the mystery of dark matter, which is believed to constitute almost ten times the mass of normal matter. The mission will also make direct observations of large planets outside the solar system. For this purpose, an orbital telescope mission will be implemented either in low earth orbit or at the L2 Lagrange point, which has a more favorable gravitational and thermal environment.

- Investigate the current conditions of the solar system, and especially, the Earth-like bodies, through probes to the Moon, Venus and Mercury. Efforts will also be made to realize a next-generation inter-planetary using the cutting-edge Deep Space propulsion technology and to prepare for a Jupiter probe.

○ During the subsequent decade:

- Implement missions for observation of the earliest stars, galaxies, and black holes in order to better understand the evolution of the universe. Programs will be implemented to make direct observations of extra-solar system earth-like planets in an effort to observe the nature of life. This will require technologies involving formation flights, and telescopic observations from satellites in orbit around the earth or the Lagrangian point. This will require a deployment of equipment such as a formation flight telescope, high angular resolution interferometric telescopes, and a gravitational wave detector.

- By utilizing the next-generation interplanetary navigation technology and such technologies as planet landing or surface roving technologies, which can be acquired through lunar exploration, JAXA will conduct planetary exploration missions particularly of Jupiter-like planets, asteroids and comets. JAXA will also conduct multi-point observations of the environments of the Sun and planets, studies of planetary interiors, balloon flights in the Venusian atmosphere and probes by aircraft of the Martian atmosphere. Through these missions, JAXA will endeavour to reveal the mysteries of the evolution of our solar system.

○ Further into the future:

- The time has come for us to embark on missions for exploration of the dark energy to examine what its properties are and what its effects have been and will be in the future. The time has come for us to find out what the universe really is: the origin of the universe, matter and space. A new discipline, integrating the theory of elementary particles and cosmology**,** for example, may have to be developed to answer these questions. In addition, there is the possibility that evidence has been discovered to support the existence of life on Earth-like planets outside the solar system.

- We will have entered the age when scientific observations in space surpass, in many ways, scientific observations on the ground. Non-electromagnetic means of observation will be used as a new system. JAXA is aiming to establish a “Deep Space Harbor ” at the Lagrangian point as the base for humankind’s activities over a broader spatial area reaching further into the solar system.

- When mankind’s activities have extended over a broader spatial area, reaching the entire solar system becomes possible, and we would be able to shift our journey for space exploration from one-way trip to a space utilization round-trip. At present, we are supplying and making a one way trip to transport all the resources necessary for space exploration from the earth. When the time comes to use a round trip concept, we will need a relay point at the Lagrangian point or on the Moon. This relay point will be constructed through international cooperation, and used for assembling and maintaining equipment, and for logistical purposes. By using this relay point for trans-shipment of resources and cargoes, more efficient round-trip will become possible. Round trips will be also useful for making regular space journeys for human exploration of Mars, the Moon and asteroids.

(2) Exploration and utilization of the Moon

Background and objectives

Japan considers the exploration to the Moon, the celestial body closest to the Earth, as the first step in its efforts to broaden the horizon of human activities and has pursued the advancement of technologies required to take that first step. In 1998, Japan started Selenological and Engineering Explorer (SELENE) project, which will conduct detailed observation of the Moon.

As many countries focus on the exploration to the Moon today, probing the Moon and exploring possibilities of its utilization, based on the accomplishments to date and using technologies that have been acquired, would enable Japan to achieve the following important objectives:

- Contribution to the expansion of human frontier:
  The expansion of human frontier leads to the advancement of human knowledge, advancement of technologies and expansion of the sphere of life. Beyond near-Earth space, human frontier would expand to the Moon and beyond. Results yielded from the efforts toward the exploration of the Moon and its utilization would be useful for the exploration not only of the Moon itself but also of the solar system in the future.

- International recognition through challenge to develop advanced technologies:
  Taking the challenge to develop advanced technologies in the exploration of the Moon and yielding tangible results would be essential for Japan to gain international recognition as an advanced science and technology-oriented nation. This would allow Japanese industry to strengthen its technological capability.

- Understanding the origin and evolution of the Moon and application of the findings
  The Moon is a celestial body that best represents Earth-like planets in terms of internal stratification structure, raw materials constituting planets, process of planetary evolution at the initial stage, tectonic histories, such as those evidenced by craters formed after collisions, as well as geological features. Scientific findings from the lunar exploration would guide the efforts to explore possibilities of the utilization of the Moon.

Developments in other countries

In 2004, the United States revealed its new Vision for Space Exploration. It declares that the ultimate goal of space activities would be to allow humans to take a continuous journey into the universe, to "…explore space and extend a human presence across our solar system….. [making] steady progress..". The core element of this Vision is the expansion of human frontier. It also envisages the acceleration of development of advanced technologies that would be crucial for future space activities, such as space transportation technologies, enabling technologies for human space activities and robotics technologies. This would be pursued through the exploration of the Moon, which would serve as the platform for sending human beings to Mars. The Vision also envisages the strengthening of industrial competitiveness that could lead to securing rights to acquire resources in outer space in the future.

ESA, China and India as well as other countries have plans for the exploration to the Moon. These countries have expressed great interest in the plan of the United States in this regard, and many of them are exploring possibilities for collaboration and cooperation with the United States. For the time being, efforts made in the Moon exploration are likely to evolve around the policies and the programs of these countries. In particular, the policies to be pursued by the United States, which represents eighty percent of the total investment in space activities, would have significant impact on those efforts.

While the United States is inviting other countries to join in the cooperative efforts to carry out its space activities, the United States is also seeking to select the technologies that it needs from among those proposed by those other countries. The exploration of the Moon can, therefore, be considered to provide an opportunity for international cooperation, with the United States at the center of the cooperative efforts, as well as for international competition in the coming years.

Direction to be pursued toward the implementation of the Vision

○ **Promoting lunar science and examining possibilities of lunar utilization**

Under SELENE project, Japan will conduct high-resolutional, global mapping of the lunar surface. Through this project, Japan will spearhead the efforts to collect data that would determine the distribution profiles of lunar crust constituents and the crust structure as well as increase understanding of the exposed parts of the materials constituting deep layers of lunar structure, areas of concentration of particular materials, and unique topographic features. Based

on the results to be yielded from this project, the exploration and investigation of lunar surface would then be carried out using lunar landing probes and robotic vehicles. Mutual assistance and cooperation with other countries in the Moon exploration will also be pursued.

○ **Taking the challenge to develop most advanced technologies toward future space exploration and innovative space utilization**

Energy supply for explorer spacecraft during night and in shadowed areas is essential in the lunar exploration, as the alteration of day and night takes place only every two weeks, and there are permanently shadowed areas on the Moon. Resource surveys and scientific studies require technologies for high-precision landing at optimal sites and roving as well as collecting and analyzing samples.

JAXA will develop most advanced technologies such as space probes using robotics and nano-micro machines, with which Japan has achieved a high technological level, energy supply technologies and large-capacity communications technologies. These technologies will be used for planet and astronomical observations on the Moon as well as for various other highly sophisticated Moon exploration and utilization missions. They would eventually be used for the exploration to the solar system in the future.

Through the development of these most advanced technologies, JAXA will pursue innovative space utilization, such as the use of space solar power, in anticipation of energy crisis in the future.

○ **Preparing for the establishment of a human lunar base**

Japan has effectively and efficiently accumulated technologies required for human space activities through its participation in the International Space Station (ISS) program. After the completion of the ISS program, the main arena of human space activities could move from low-Earth orbit to the Moon in the future. In preparation for such development, JAXA considers a future “international human lunar base” that might be developed as the place where Japan could fully utilize, maintain and further develop its capability for conducting human space activities. JAXA will, therefore, accumulate in an incremental and strategic manner technologies to support human space activities on the Moon.

Following the year 2015, JAXA will seek for a decision by the government on whether to take

significant steps forward in the technology development and construction of facilities toward the establishment of an international human lunar base. Prior to that, JAXA will evaluate the possibilities of utilizing the Moon that will have been identified and the level of maturity of required technologies.

○ **Establishing mutually complementary relationships with other countries**

JAXA considers the exploration to the Moon as "the first step in the expansion of human frontier" and has initiated the Selenological and Engineering Explorer (SELENE) project, which includes a lunar orbiting satellite. JAXA's idea of the expansion of human frontier resonates with the principle shared by the United States and Europe in their space activities, i.e. the ultimate goal of space activities is "…to extend a human presence across our solar system…" and beyond. JAXA will, therefore, establish mutually complementary relationships with other countries and will take steps forward in the journey into the universe in an effective and efficient manner.

Targets and roadmap

○ Within about ten years, JAXA will develop most advanced technologies as follows:

- Through the implementation of SELENE project and other existing and planned lunar exploration missions, JAXA will develop, ahead of other countries, a detailed map of the lunar surface which would indicate the surface topography as well as geographical features and gravitational field. Such a map would be required for selecting a landing site on the Moon. Data to be obtained from SELENE project would supplement data from Lunar Reconnaissance Orbiter (LRO) planned by NASA. Establishing cooperation between those projects would enable the efficient selection of most appropriate lunar sites for various surveys.

- While probing the Moon and exploring possibilities of its utilization, JAXA will acquire technologies for landing and roving on the Moon and other celestial bodies in the solar system as well as for planet and astronomical observations from the lunar surface. On the basis of results to be obtained from these activities, JAXA will develop options for proceeding in the full utilization of the Moon.

- In preparation for future utilization of the Moon and further exploration to the solar

system, JAXA develop advanced technologies for robotics and for such purposes as in-situ resource utilization on the Moon and planets, thereby establishing the necessary, sound technology base. JAXA would also propose international cooperative initiatives in such areas as the development of high performance sensors and a solar energy supply system, using Japan's competitive technologies. Through these activities, JAXA will take initiatives, make active contributions and achieve a steady progress in the further utilization of the Moon and exploration of the solar system. As for technologies required for the use of solar power, JAXA will acquire key technologies through the utilization of ISS and its H-II Transfer Vehicle (HTV), which would serve as a supply transportation vehicle.

○ Coming twenty years:

- JAXA anticipates that a project to establish an international human lunar base that would allow for long-term human presence on the Moon would be implemented in twenty years. In carrying out such a project, JAXA will ensure that Japan would play an important role by fully utilizing the technologies that it has developed and accumulated in a strategic manner and that Japan, as advanced science and technology oriented nation, would make appropriate international contributions and share responsibilities.

- JAXA will develop key technologies that would enable long-term human presence at a lunar base. Such technologies would concern life-support as well as power generation and wireless power transmission, which would enable the maximum use of solar power.

4. Developing indigenous capability to independently carry out space activities

(1) Space transportation systems

Background and objectives

○ **Developments around space transportation**

The means to transport goods and people to space, i.e. space transportation systems, are essential for space activities and for space utilization, to build a secure and prosperous society and to advance the knowledge of humanity. The tragedy of the Space Shuttle Columbia mission and the launch failures experienced by Europe and the United States, nonetheless, reminded us that the existing space transportation systems in the world are still in the process of overcoming technological challenges.

As part of their national policies, European countries and the United States are maintaining and improving their flagship launch vehicles as well as taking measures to secure demands on a constant basis for their launch vehicles. On the other hand, China, having succeeded with human space flight, as well as India, Brazil and the Republic of Korea are making steady progress in improving their launch vehicle technologies.

The advancement with transportation systems leads to socio-economic revolution and serves as a harbinger of a new era, as seen in the Age of Exploration in medieval time as well as in the twentieth century with the wide spread use of cars and air planes.

○ **Achieving autonomous space activities**

With the development of H-IIA launch vehicle, Japan has acquired world-class launch technology. As advanced science and technology-oriented nation, Japan should recognize launch technology as one of its key technologies. It should ensure continuous launch successes while further enhancing H-IIA with its own technologies, with a view to making it the most reliable launch vehicle with highest capability in the world.

The capability to launch satellites whenever necessary on its own initiative is essential to ensure national security. Such capability is also indispensable to build the secure and prosperous

society. Launch vehicles with the highest reliability in the world as well as world-class capability would also become the driving force behind the efforts of the private sector to expand launch business and the space equipment industry to gain competitiveness in the global market. One of the most important purposes of the development of space transportation systems should be to provide such driving force.

○ **Space as a place for everybody to go and to use**

Bringing the current launch technology to maturity would not be sufficient to establish space transportation systems that will be needed to undertake challenging space exploration or that would allow for space utilization to the fullest extent possible, such as by making space travel possible for the general public or by constructing space solar power satellites. New transportation systems would be required to transport people and goods between orbits as well as to and from space and to collect them in space.

Research and development of new space transportation systems is making progress in Europe and the United States. To share the task of delivering supplies to the International Space Station (ISS), Japan is currently developing H-II Transfer Vehicle (HTV). As for the technology to return goods from space, Japan is also conducting research and development with small experimental vehicles.

Means to significantly enhance access to space to transport goods and people, if acquired, would revolutionize space utilization. It will allow Japan to make its own contributions to what should be collaborative initiative of all humanity, such as space exploration. It will also lead to new activities in space, to space travel by the general public, to investment by the private sector to accelerate space utilization, and to a leap of humankind in the voyage into the universe. JAXA will work toward the development and operation of space transportation systems for the next twenty years with a view to developing and expanding new areas of space activities.

Direction to be pursued toward the implementation of the Vision

In order to achieve its objectives in the development of space transportation systems and to implement the Vision, JAXA recognizes the need to first develop launch vehicles with the highest reliability in the world and world-class capability. This could be done by maintaining and further developing flagship launch vehicles of Japan. At the same time, JAXA will seek for a decision by the government on the development of new space transportation systems

described earlier in this document. It will then take incremental steps toward new space activities that would allow for anybody to travel to space and to benefit from the use of space.

○ **Maintaining and developing launch capability with the flagship launch vehicles**

JAXA will continue to operate H-IIA launch vehicle as a flagship launch vehicle of Japan. JAXA will further develop H-IIA to achieve the reliability at the level high enough to safely carry people, and will preserve the unrestricted launch capability of Japan. JAXA will take an efficient approach to maintain and further develop flagship launch vehicles, bearing in mind the capabilities and responsibilities of the public and private sectors. The possibility of transferring the launch activities to the private sector would also be considered in this regard. As for the development of medium- and small-sized launch vehicles, which would supplement the capacity of the flagship launch vehicles, JAXA will build upon what has been achieved to date through its technology development as well as the activities led by the private sector.

Primarily based on the technologies developed for the flagship launch vehicles, JAXA will take an incremental approach to enhance the technology base for space transportation systems. JAXA will also take steps toward the demonstration of technologies for reusable launch vehicles, which is expected to significantly improve the reliability and safety of transportation systems.

○ **Inter-orbital transportation, recovery and return from orbit**

JAXA will further develop and operate HTV, thereby contributing to the utilization of the ISS and accumulating operation technologies.

HTV requires technologies that cannot be acquired merely through the development of the flagship launch vehicles. The technologies required by HTV include those to ensure safety of human space flight or to allow for orbital control. Continuous operation and development of HTV would lead to the effective development of space transportation systems that Japan will need to expand its space activities. Addition of a recovery capsule to HTV, for example, would be additional, new contribution to the ISS after the retirement of Space Shuttles from service.

By further developing HTV to evolve into unmanned recovery vehicle, with the capability for flexible landing and flying by lift, it would become possible to respond to various demands for recovery of goods and to acquire the key technologies in an efficient manner to develop human return vehicle. Making such transportation system available, however, will require new ground

facilities for launch and landing. Therefore, consideration should be given to long-term planning to construct launch pads, landing sites and any other relevant facilities. The development of an inter-orbital transportation system or a system to transport goods to the Moon will enable Japan to independently carry out its own space activities, and also to make substantive contributions to the international community in space exploration.

○ **Transporting people to space and acquiring efficient means of transportation to and from space**

JAXA will nurture design technologies to achieve the highest reliability, to the extent that the flagship launch vehicles would be able to safely carry people. JAXA will also develop the technologies to maturity for recovery and inter-orbital transportation through application of HTV and its further development. With these activities, the necessary technology base for human space transportation systems should be established. If such technology base were applied progressively to the development of launch and return vehicles, human space transportation systems would become a reality for Japan.

JAXA will first pursue the development of relevant technologies for the flagship launch vehicles and HTV. JAXA will then identify goals for human space activities according to the expectations of the public. Based on the results to be yielded form the verification of the technologies that JAXA would develop to achieve those goals, JAXA will seek for a decision by the government, on the basis of which, JAXA will initiate the development of a human space transportation system. JAXA considers that the approach for developing human space transportation systems as laid out above would be most appropriate.

Space utilization to a full extent, beyond the twenty-year timeframe covered by the present Vision, cannot take place without revolution in the technology development toward efficient space transportation systems. The technology for reusable transportation vehicles would be a key in that process. It would dramatically enhance the reliability and safety of space transportation systems. To develop such technology to maturity would require that its verification be initiated at an early stage, accompanied with the continuous operation through the verification to accumulate necessary technologies.

The ultimate goal in the space transportation would be “human reusable transportation vehicle” that would allow for unrestricted travel between the ground and low-Earth orbit. This would become a reality through well-planned research and development of the relevant technologies

on a long-term basis. The technologies required for high-speed aircraft, if already matured, could also be integrated into the human reusable transportation system.

Targets and roadmap

○ Within about five years, JAXA will:

- Focus its efforts on the research and development of the flagship launch vehicles, with H-IIA as the primary one, and enhance the reliability and world-class capability of launch vehicles of Japan.
- Complete the development of HTV and enhance its reliability through its continuous operation and conduct retrieval of goods in space.
- Demonstrate technologies required for high reliability and fault tolerance systems, to be used for both expendable launch vehicles as well as reusable launch systems, enhancing the robustness of expendable launch vehicles as a result.

○ Within about ten years, JAXA will:

- Develop a flagship launch vehicle that would achieve the highest reliability in the world, acquiring the ability to safely carry people, and world-class capability; with this flagship launch vehicle, develop the key transportation technologies required for expendable launch vehicles.
- Acquire necessary transportation technologies for Japan’s own human space flight by enhancing their reliability through the development and operation of inter-orbital transfer vehicle and unmanned recovery vehicle based on the evolved flagship launch vehicles and HTV.
- Accumulate experience with unmanned ballistic flight using reusable experimental vehicle and develop the technologies required to achieve the reusability to maturity.
- Propose options for human space transportation vehicles for Japan, on the basis of accomplishments by the unmanned transportation systems and seek for a decision by the government on whether to proceed in the development of a human space transportation system.

○ Within about twenty years, JAXA will:

- Develop human space transportation and return vehicle with launches of expendable launch vehicles and take steps toward its operation with a view to establishing human space transportation technologies.
- Evolve unmanned reusable experimental vehicle to establish technologies for

unmanned reusable transportation vehicle; conduct flight demonstration for the technologies of reusable system required for human space flight and take steps toward initiating the development of Japan’s own human reusable transportation vehicle.

Concerning the space transportation systems, JAXA will convert expendable vehicles into the vehicles that provide shuttle flights, and further into those vehicles that provide efficient, repeated flights. JAXA will take steps toward revolutionary technological development in the space transportation that would contribute to increasing the reliability and to dramatic cost reduction. Through these efforts, JAXA will also work to stimulate demands for new transportation systems, including through commercial activities.

JAXA will promote research and development with the primary purpose of achieving the space transportation capability needed for Japan and establishing the necessary technology base. JAXA will not only hope that the private sector would use the results of its research and development but will also support, with the technologies that it has developed, those activities that would accelerate the wide spread use of space among the general public. Those activities include stay in space or ballistic flights that are already feasible with existing transportation systems and technologies and that are led by the private sector as the driving force to turn those activities into new business.

(2) Human space activities

Background and objectives

○ **Dawn of the human space activities of Japan: utilization of Space Shuttle**

Through its astronauts' flight on board Space Shuttle in and after 1992 and various experiments on Space Shuttle, Spacelab and Spacehab, Japan has accumulated experience and knowledge of space systems design compatible with the safety requirements for human space activities, mission operations to support astronaut activities, and training of and health care for astronauts. Those human space technologies have been succeeded and developed in the International Space Station (ISS) program. The Japanese astronauts' activities have been extended and advanced from scientific experiments to operations of the Space Shuttle Manipulator, extra vehicular activities (EVA), ISS assembly and so forth. In 2005, the eighth Japanese astronaut's Space Shuttle flight (with the fifth Japanese astronaut) is scheduled.

○ **Pursuing technology development through the International Space Station Program**

Through the ISS program, Japan has started more serious efforts to accumulate technologies necessary for human presence in space. Japan has acquired human space technologies of the world standard through the development of the Japanese Experiment Module (JEM), on which experiments can be conducted by astronauts, as well as through the cooperation with leading countries in human space activities. The technologies Japan has obtained are those for integrating multiple systems; realizing a high level of safety and reliability; and functioning human space experiment facilities. Through these efforts, Japan has learned a technique necessary for management of the "system of systems", which is required for development of a huge system.

As was mentioned before, JAXA is developing H-II Transfer Vehicle (HTV), which serves as a cargo transportation vehicle for ISS re-supply missions. Through its development and operations, JAXA endeavours to acquire necessary technologies for expansion of future space activities such as transportation vehicle's autonomous flight, rendezvous and re-entry.
By using technologies acquired through the development of JEM and its experiment facilities, JAXA is developing a laboratory and a facility for studying gravitational biology, known as "Centrifuge" (Centrifuge Accommodation Module, Centrifuge Rotor, etc.), which enable precise

investigation of the effect of various gravity levels including microgravity on biological specimens. Through the development of “Centrifuge”, JAXA is making progress in acquiring advanced space technologies for control of large-scaled rotation structure and isolation of bio hazards.

○ **Human space activities in twenty years**

In twenty years, it is anticipated that the United States, Russia, Europe and China would develop advanced human space technologies and expand the boundary of human activities onto the Moon, opening the avenue for new space activities.

Under these circumstances, it is necessary for Japan to acquire human space technologies and to obtain/maintain capability of international cooperation and competition, in order that Japan continues to keep up with other nations and to play an appropriate role in the international community as an equal partner.

The “Basic Strategy for Space Development and Utilization”, adopted by the Council for Science and Technology Policy of the Japanese government in September 2004, indicates the policy for human space activities as provided below. JAXA will carry out its human space activities in accordance with the policy.

- As a goal to be achieved in the coming years (next ten years or so), while Japan would not yet initiate its own human space program, it should promote the fundamental research and development with a view to making it possible to initiate its own human space activities. Japan continues human space activities through the ISS program. And it is necessary to start a study of Japan’s goal and vision for future.
- As for future perspectives for the long-term development (in twenty to thirty years), based on the accomplishments of the on-going and planned activities, Japan should make necessary preparations for enabling its own human space activities that would contribute to various space utilization.

Direction to be pursued toward the implementation of the Vision

○ **Ensuring implementation of the ISS program and acquiring technologies for human space activities**

JAXA will steadily carry out the utilization preparation of space environment including microgravity and the development of JEM and HTV, which it has been pursuing in the ISS program. JAXA will operate JEM and HTV safely and reliably based upon the thorough preparations and appropriate organization structuring. Through steady development and operations in the ISS program, JAXA will give satisfactory results in the international cooperation and obtain international confidence.

- Acquiring development technologies for human space activities
  JEM is a huge system consisting of approximately 2 million parts, which are several to ten times more than those of large launch vehicles and satellites. Through the JEM development, Japan has accumulated the integration technologies of system of systems; the technologies indispensable for human presence such as safety and product assurance, environment control and micrometeoroid/debris protection; and the technologies necessary for human space activities development such as a robotic arm and a docking mechanism.
  During the operational phase of JEM, by evaluating and analyzing JEM on-orbit functioning data as well as data for on-orbit maintenance and repair, JAXA will verify its knowledge bases and make necessary corrections to them, to ensure the acquisition of the above technologies.

- Acquiring operation technologies for human space activities
  The “acquisition” of technology in its true sense means not only to have the capability to develop the system using the technology but also to have the capability to operate it safely and to take a timely and appropriate action to unforeseen incidents. JAXA will truly acquire human space operations technologies through the “operations” in collaboration with the American and the Russian operations teams/facilities as well as the astronauts of the international partners which are the advanced nations in human space technologies,.

  Through the operations of JEM and HTV, JAXA will obtain the operation technologies indispensable for human space activities such as operations control from Japan by international cooperation, capabilities to cope with and dispose of various troubles, and personnel training for operations and crew support. JAXA will broaden its knowledge of human space activities through Japanese astronauts’ flights on board the American and the Russia human space transportation systems; long-duration missions on board ISS; and medical operations and space medicine research.

○ **Direction to be pursued toward next international human space initiatives**

The human beings are striving to expand the boundary of their activities from the International Space Station in the low-Earth orbit at the altitude of 400 kilometers to the Moon orbiting the Earth at that of 380,000 kilometers. In twenty years from now, it is anticipated that space port functions and space infrastructures necessary for human space activities will be established between the Earth and the Moon. In the future, solving the issue of safety and profit, private sectors will conduct commercial human space activities around the Earth.

With such perspectives for the future, Japan will participate in the next international human space program and will step-by-step acquire the technologies needed for human presence in space between the Earth and the Moon.

- Implementation of human space activities that are unique to Japan
  Japan will make notable contributions by offering the technologies of its strength, through international cooperation and competition, and will further promote human space activities more effectively and efficiently. Japan will pursue the human space activities “unique to Japan” such that astronauts and robots cooperate closely.

- Demonstration of essential technologies in space
  Out of the following technologies essential for human space activities, Japan will select those to which its strong commercial technologies can be applied, and which possibly expand in future:
  - Technologies necessary for human presence and activities in space (e.g. technologies of life support and extra vehicular activities)
  - Technologies enabling “cooperative activities between astronauts and robots” (e.g. technologies of advanced robotics, artificial intelligence and advanced information processing)
  - Technologies enabling to build and operate “the sphere” of human space activities (e.g. technologies of inter-orbital transportation vehicles, docking, assembly, energy and large-capacity data relay)

For those technologies that have been selected, JAXA will conduct technology demonstration and verification in space using the Pressurized Module and the Exposed Facility of JEM, HTV and ISS as test beds, and will prepare for its participation in next international human space

initiatives. JAXA will also apply life support technologies to its research and development of human space transportation systems as appropriate.

○ **Toward the promotion of space utilization through human space activities**

- Promotion of diverse space utilization activities
  Human flexible judgement and complex operations in space make it possible to utilize space more diversely and creatively, including scientific and technological experiments and cultural and educational activities in space, which are impossible in satellites utilization. Considering these strong points of human space activities, JAXA will verify various new possibilities of human space utilization on JEM and will spread space utilization results in the society.
  JAXA will attempt to enhance various space utilizations in the areas where sufficient progress has not yet been made: for example, commercial use to realize private sectors' unique ideas, utilization cooperation with countries in the Asia-Pacific region, satellite technology verification on the JEM Exposed Facility, and hybrid utilization of satellites and ISS.

- Spin-off from human space technologies
  JAXA will increase spin-off of human space technologies, such as large systems integration and safety assurance, to the public recognizing that the human space technologies include those applicable to other space development areas and non-space industries. JAXA will also utilize its knowledge of space medicine in the public health care such as preventive medicine for the aging society (osteoporosis and so on). In the possible efforts to be led by private sectors to commercialize space tourism in the future, JAXA will provide support to and cooperate with the entities in such areas as health care for crew and tourists, crew training and human safety design, etc.

Targets and roadmap

○ In about ten years, JAXA will acquire and conduct on-orbit demonstration of important technologies for human space activities by fully taking the opportunity of participation in the ISS program. JAXA will prepare for the international human space initiative following the ISS program.

- Through the operations of JEM and HTV, JAXA will ensure to acquire the technologies accumulated in the development of JEM and HTV and to fully establish its technological capability to operate human space systems. Through the activities conducted by Japanese astronauts, JAXA will acquire the technologies for long-duration presence in space and the knowledge of space medicine.

- Through the utilization of JEM/HTV/ISS, JAXA will conduct on-orbit demonstration and verification of important space technologies such as life support systems, advanced robotics and so forth. JAXA will have better perspectives of the technology development toward next international human space initiatives.

- JAXA will seek for a decision by the Japanese government on the participation in next international human space initiatives. Prior to that, JAXA will present the government with options which will include the readiness level of the technologies based on the on-orbit demonstration results, the required resources, the prospective schedule, and the space development status in the world.

○ In about twenty years, through participation in next international human space initiatives, JAXA will work toward the establishment of technological capability to achieve human presence in space and to undertake human space activities on Japan’s own initiative.

- JAXA will acquire such technologies that would enable advanced human space activities more safely and efficiently. This concept will be achieved by close cooperation between astronauts and robots; and remarkable reduction of consumption and supply of resources such as water, air, electricity, materials, etc. by means of closed environment control and life support system, highly efficient energy system and light and flexible space structure and so forth.

5. Facilitating the growth of space industry

One of the goals for Japan should be that its space equipment industry gains competitiveness in the global market and strength to sustain and expand its commercial activities. In this regard, JAXA will endeavour to take the following actions in cooperation with industry and the government.

- Focus on research and development as well as demonstration of the key technologies that would directly contribute to the practical applications, strengthening the linkage between the space equipment industry and space utilization service industry; through these efforts, Japanese satellite manufacturers could secure some share in the global market for commercial communications satellites.

- Promote collaboration between the public and private sectors to enhance research and development as well as to propose a system for practical applications that would provide solutions in response to the identified needs of the government; make efforts to shorten the time required for research and development and to make maximum use of information technologies, to aim for speedy implementation of the above-mentioned system.

- Strengthen measures to enhance collaboration among industry, academia, and the government that would encourage potential end-users of space applications to seek for new business opportunities and to explore possibilities to realize innovative ideas of space utilization;

- Encourage local, small- and medium-sized, and venture businesses that have superior technologies and ideas in the areas of private domain to participate in space activities, in addition to the space equipment industry that has shouldered the space activities to date, thereby expanding the number of industry entities that support the technology base of space industry.

In order for the space equipment industry to be able to make capital investment in facilities and research and development, it must reach a certain level of industry size and secure a reasonable level of earnings. In other countries, it is common that the government serves as the main user of space products and services to support the base of the entire space industry, resulting in

strengthening of the industrial competitiveness of the nation’s space industry.

Japan should also follow the policies pursued by other countries to support their space industries, so that Japanese space equipment industry could grow to achieve a certain level of industry size to become a key industry of Japan. JAXA will work with the government to support such efforts.

With all the measures mentioned above, it is hoped that the space equipment industry and space utilization service industry of Japan would become a key industry and would expand their commercial activities. By actively promoting international cooperation, it is hoped that the technologies of Japan that provide the foundation for its key industries would be used widely in the rest of the world.

6. Facilitating the growth of aviation industry and breakthroughs for future air transportation

Background and objectives

○ **Future trends in the air transportation and technology**

The aircraft will become more important in our daily lives. The global demand for air transportation is estimated to grow by 2.5 times in twenty years. Particularly in the region of Asia, the air traffic would be 3.3 times the current level in twenty years, creating the largest market for air transportation in the world. Securing a share in the Asian market has become an issue of strategic importance for those engaged in aviation industry.

The aircraft in demand will diversify in the coming years in terms of its model and size, as the demands grow for high speed for the long haul flights and for more convenience for short- to mid-haul flights. The market demands dictate “Faster to distant destinations, more easily to near destinations, and more comfortably” for air travels.

On the other hand, the importance of environmental and safety issues increased. They were once “important issues” to be considered. They are now “absolute must” to take actions. The society demands the air transportation to be “Gentle to humans and the planet Earth and safer”. In view of those demands in the recent years, technologies that allow for “high speed and better comfort” and “environmentally sound products and safety assurance” have become essential to yield the high level of added-value.

○ **Challenges and directions for Japanese aircraft manufacturing industry**

The size of the Japanese aircraft manufacturing industry currently remains at about one trillion Japanese yens, comparing poorly with its counterparts in the United States and European countries in terms of its size, technological base and market performance.

The Japanese aircraft manufacturing industry is unique in its structure. Defense orders account for sixty percent of its sales, larger than that of its counterparts in the United States and European countries. As a significant increase in defense orders cannot be expected under the current circumstances, increase in the demands for commercial aircraft would be a key for the

growth of aircraft manufacturing industry in Japan.

The commercial aircraft manufactures in Japan currently rely on the manufacturing work in the joint international projects to develop aircraft. They have been involved, however, in only a part of the entire life cycle (development and operation cycle) of aircraft, i.e. marketing, manufacturing and operation as well as maintenance. Therefore, they have been unable to deploy substantive strategies to aim for significant expansion in their business.

If the Japanese aircraft manufacturing industry is to grow, to reach the industry size commensurate with the scale of Japanese economy to become a key industry, it needs to develop domestic aircraft, to be involved in the entire development and operation cycle. It will also be important to establish a “Japan made” brand for commuter aircraft.

By strengthening the technologies that it has and making those technologies widely accepted in the world, the Japanese aircraft industry should acquire advantageous technologies that could lead to breakthroughs for future air transportation. It is also necessary that Japan plays a substantive role in the increasing international collaborative efforts for aircraft development.

○ **Role of JAXA**

JAXA will work toward realizing air transportation that is gentle to humans and to the planet Earth. One of the principles pursued by JAXA is to usher in a new era for the aircraft manufacturing industry and for air transportation by taking the lead in the world by developing indigenous advanced technologies. As an entity to lead the aircraft research and development, JAXA will develop highly value-added technologies, to acquire world-class technological capability, and breakthrough technologies for air transportation, thereby contributing to the industry development.

Direction to be pursued toward the implementation of the Vision

JAXA will conduct aviation research and development with a view to achieving the following objectives in twenty years.

○ **Contributing to the growth of aviation industry and breakthroughs for future air transportation**

JAXA will acquire world-class capability through the development of domestic passenger carrier and will take a leading position in the international collaborative efforts with its advantageous technologies to develop new aircraft. Through these efforts, JAXA will enhance the environment for the aircraft manufacturing industry to become a key industry of Japan. Toward achieving this goal, JAXA will undertake the following strategies.

- **Development of domestic passenger carrier aircraft: strengthening world-class capability with highly value-added technologies**

  Japanese aircraft manufacturing industry should develop an aircraft system using highly value-added technologies such as composite materials and low-NOx burner that Japan is leading other countries in their development based on the results of basic research to date. Through such effort, Japanese aircraft manufacturing industry should be able to enter the global market for commercial aircraft and to gain industrial competitiveness through the development of subsequent aircraft systems. JAXA will collaborate with other relevant entities to conduct technology development that covers the entire life cycle of aircraft, from development to operation. JAXA will endeavour to lead the world in the technology development that focuses on the environmental soundness, safety, operational flexibility and comfortability.

- **Research and development of technologies for supersonic/hypersonic aircraft: achieving breakthrough in the technology development for future air transportation**

  The realization of supersonic passenger carrier aircraft and hypersonic aircraft could lead to a paradigm shift in the concept of air transportation. Toward those advanced types of aircraft, JAXA will develop advanced, leading technologies such as designing of silent aircraft, low-noise/low-emission high speed propulsion system and structures consisting of heat resistant composite materials. The hypersonic aircraft, once developed, will also be applied to the first stage of space transportation systems.

Targets and roadmap

○ **By about five years from now**

- Japanese aircraft manufacturing industry should enter the global market with the first generation domestic passenger carrier aircraft, currently in the designing stage, using highly

value-added technologies such as composite materials and avionics that hold the key to gain industrial competitiveness. JAXA will sophisticate evaluation techniques and fully equip the facilities that are needed for the complete coverage of the life cycle of aircraft, from development to operation. To acquire world-class technological capability, JAXA will conduct research and development of technologies that would lead to cost reduction in the operation, weight reduction of aircraft as well as environmentally-sound small engine ("eco-engine").

- Toward the establishment of cutting-edge technologies for supersonic aircraft, JAXA will demonstrate technologies for advanced aircraft design through a flight experiment of a silent supersonic technology demonstrator and will conduct research and development of a high-speed propulsion system.

○ **By about ten years from now**

- Toward the development of "People-friendly passenger carrier" (second generation domestic passenger carrier), JAXA will develop and demonstrate further advanced, highly value-added technologies such as those for low-noise, low fuel consumption and improved safety with the aim of acquiring world-class technological capability.

- JAXA will focus its research and development as well as demonstration efforts on system integration with the aim to develop small supersonic aircraft (supersonic business jet) for civil use. Through such efforts, JAXA will mature the technologies to the practical use for supersonic aircraft with the cruising speed of Mach 2, making it possible to fly across the Pacific Ocean in five hours. Toward the development of a hypersonic experimental vehicle, JAXA will also take steps ahead in conducting research and development in the integration of hypersonic propulsion system and an airframe.

○ **By about twenty years from now**

- JAXA will develop technologies to realize "Intelligent aircraft" (third generation domestic passenger carrier). This would be achieved through the fusion of navigation technology and fuselage building technology and also by making maximum use of information technology (IT) that leads to higher level of flight safety, such as all-weather operations technology, higher volume operations technology and free flight technology.

- JAXA will develop technologies toward the realization of an environment-friendly, economic supersonic passenger carrier (Mach-2 class), which would popularize supersonic air transportation. JAXA will also develop and conduct a flight demonstration of unmanned, hypersonic experimental vehicle with the cruising speed of Mach 5, with the capability to fly across the Pacific Ocean in two hours. The technology developed for this experimental vehicle would be applied to the development of aircraft for practical use and also to the first stage of space transportation systems in the future.

7 Cross-Cutting Approach

(1) Strengthening capability for technology development

Space development and utilization as well as aeronautics require large-scale systems engineering, integrating various advanced technologies. They are also important, strategic technologies of the nation providing the base for sustainable development of Japan. JAXA recognizes it as its responsibility to continue to enhance its technology development capability and to ensure the successful implementation of its missions.

In other parts of the world, diversifying social systems accompanied with a large number of users with various, unique needs have demanded higher accuracy and efficiency in the development and operation of large-scale, complex systems, such as those of the Internet, large-scale software and air traffic control systems. For this reason, new systems engineering methods, such as “system of systems”, have been increasingly introduced, to understand, develop and operate the systems from a more integrated and comprehensive manner. The aerospace system is one of the most complex, largest-scale systems. Advanced aerospace countries such as the United States and European countries are further pursuing the integration of these new systems engineering methods also in the development and operation of the aerospace systems and making further efforts to improve the capability of those systems.

○ Establishing the new systems engineering capability

JAXA recognizes its role as the core institution in aerospace research and development. It will endeavour to establish the capability comparable to that of those advanced aerospace countries in the world in the near future and take steps toward the establishment of an aerospace system of higher quality.

With respect to the technologies for project management and safety and development guarantee as well as specialized aerospace technologies required for the development and operation of an aerospace system of higher reliability, JAXA will continue to improve its methods of business, enhance human resources development and improve its organizational structure, with a view to enhancing its technology development capability in a comprehensive manner.

○ **Coordination with industry, universities and other relevant entities**

In order to strengthen its technology development capability, JAXA will further pursue collaboration with industries and other entities involved in the manufacturing of space systems. JAXA will also actively promote cooperation with universities and research institutions to enhance the human resources development and to identify innovative methods of business to better conduct research and development. As one of the ways to achieve those objectives, JAXA will, through its function as an inter-university institute, continue to strengthen the technology development capability of the entire country, including that of universities. JAXA would promote these activities, bearing in mind that their spin-off benefits could be applied to a wider range of engineering activities besides those in the aerospace area.

(2) Developing human resources

○ Development of human resources for future researchers and engineers in aerospace area

Broad knowledge of science and technology is indispensable for aerospace research and development as an area of advanced science and technology. Skilled personnel with the broad knowledge and the techniques required for the establishment of large-scale, complex systems would be the next generation to lead aerospace research and development.

Through its own activities, JAXA will systematically train aerospace engineers to support the development of various advanced technologies including specialized technologies needed for aerospace research and development, safety and development guarantee technologies, project management technologies as well as systems engineering technologies. Through collaboration with universities and other relevant entities, JAXA will also train engineers who would be responsible for the establishment of next generation large-scale, complex systems including those of aerospace. As part of its training activities, JAXA will endeavour to make training opportunities available not only for its staff but also for the general public, for example, by opening world-class training courses on systems engineering, thereby contributing to the society.

In order that Japan would yield outstanding results and increase its importance in the world in the field of space science, JAXA would enhance the environment for conducting first-rate research and provide opportunities for exchange of researchers with other countries. Through graduate education, JAXA will train its junior researchers and engineers who would lead the future society. JAXA will take make maximum advantage of its unique function as inter-university institute and will cooperate with Japanese universities and research institutions to train its researchers under competitive environment.

○ Contributions to education for young people and children as the next generation

Aerospace activities stimulate curiosity and interest among many young people. Aerospace research and development activities provide the youth, who would be the next generation, with dream and hope for better future. Through its activities targeted at young people, JAXA has accumulated abundance of data and information that would be useful for the education for the

youth.

JAXA believes that one of its important social responsibilities is to cultivate the potential of young people, to have broad mind and insight, through its educational activities. JAXA considers that this would also contribute to building a prosperous society and should be one of its priority activities. JAXA has its strength in responding to needs and increasing demands of various communities, including classrooms, for education activities for young people. No other entity but only JAXA could effectively carry out “education activities” at schools in “space and aeronautics”, the area that always appeals to young people.

○ **Vision and direction to be pursued in JAXA’s educational activities**

JAXA will provide all the youth of Japan with opportunities to experience the excitement and to get inspired through space activities. JAXA will help them gain not only knowledge but also understanding of the thinking process behind the space endeavours and foment their appreciation of science and technology. JAXA will also assist young people in increasing their awareness of their responsibilities to build a prosperous society in the future. In order to achieve these objectives, JAXA will play the central role in carrying out the following educational activities through collaboration with other entities including industry:

- Practical education program
  Through collaboration and cooperation with relevant entities in Japan and abroad, JAXA will develop and implement its own unique education program, taking full advantage of its knowledge, staff resources and facilities.
- Education support program
  JAXA will support the development and implementation of education programs at classrooms, i.e. by schools and teachers.
- Information dissemination program
  JAXA will disseminate information that would be required for classrooms through such means as education products and materials as well as educational programs, taking full advance of its knowledge, staff resources and facilities.

Educational activities for the youth, as the next generation, cannot be sufficient with JAXA’s activities only. Therefore, as its mid-term goal, JAXA will carry out general educational activities through collaboration with those organizations and groups that share the same objectives. As the long-term goal, JAXA will take concrete steps together with industry, the

government and the academic community toward the establishment of an “education center” that would have such functions as training of the educators and hands-on training for young people.

(3) Integrating space-based services and systems into the infrastructure for the benefit of the entire society

The implementation of the Vision requires practical applications of space technology, which could take place in various manners. They could constitute a part of the social system to ensure the security of the people or could lead to the establishment of industry (establishment). Once integrated into the social system, the benefits of space applications would then reach a large number of people (filtration). When such a social system or industry has grown to become self-sustainable (maturity), it could lead also to maintaining and developing the base of space industry that supports key technologies of the nation, such as space transportation and satellite technologies.

The Japanese space development and utilization found its place and was integrated into the society first through weather forecasting as well as communications and broadcasting services. Following the conclusion of the agreement between Japan and the United States on “Policies and Procedures Regarding Satellite Research and Development/Procurement” of 15 June 1990, JAXA concentrated its efforts on the development of advanced technologies. The technology development was pursued with the aim to achieve reliability and to acquire world-class capability for space activities. At the same time, JAXA also started to explore future possibilities of space utilization, such as space applications for environmental monitoring. While much attention was paid to achieve the capability to develop advanced technologies, not sufficient efforts were made to contribute to the society, to integrate space applications into the society for the benefit of a large population.

There is a growing demand in Japan to produce concrete results in enhancing economic development and world-class capability for technology development as well as realizing the secure and prosperous society. JAXA recognizes the importance of taking a comprehensive approach to ensure that benefits of space development and utilization are integrated into the society to reach a large population. A strategic approach must be also pursued by JAXA, as the entity responsible for research and development and for demonstration, together with “user entities” (including those in the government), who would be the main player in the practical applications, and “private companies”, who support industry.

JAXA has set a clear goal “To integrate space applications into the society for the benefit of the population at large”. Through the approaches and actions that have been mentioned above, as

well as the activities indicated below, JAXA will endeavour to increase social benefits of the products of space development and utilization to reach larger population.

○ **From user's point of view**

JAXA will take fully into account the requests from the society and opinions of the user institutions. To ensure the achievement of that goal, JAXA will put in place a mechanism that would allow for planning and project development from the user's point of view and would make proposals to relevant entities.

○ **Contributions to creating a mechanism for the "establishment", "filtration" and "maturity" of space applications and their benefits in the society**

In the United States, a significant amount of federal investment serves as the driving force behind the development of advanced technologies and commercial activities. As mentioned earlier in this document, European countries have already recognized the significance of space activities as a policy tool. The European Union is pursuing the policy to develop a scheme to provide solutions through space activities for the issues of importance to the European society. Bearing in mind the cases of the United States and Europe as examples, JAXA will examine the process in Japan to provide various services resulting from the products of research and development entities, from user institutions to end-users in a continuous manner, leading to the integration of those services into the society. On the basis of the existing process in Japan, JAXA will consider an ideal process of integrating the services based on the results of aerospace research and development and their benefits into the society and will propose it to relevant entities toward its realization.

○ **Development and demonstration adopted to the rapid pace of business**

Regarding the collaboration with private companies, JAXA will clarify, from the beginning of the development phase, together with the concerned private companies, the requirements for establishing business. The requirements include a breakeven point in terms of cost-and-benefit as well as risk sharing during the demonstration phase. JAXA will strengthen measures to achieve early yet successful demonstration of technologies developed through such collaboration that would meet the requirements for establishing business. In case establishing business becomes difficult due to delays in the implementation of a relevant project, JAXA will conduct a fundamental review of the continuation of the project concerned, the results of which

could well mean a cancellation of the project, and will make necessary adjustments in the further implementation of the project.

(4) Enhancing international cooperation, with particular attention to collaboration with other countries in Asia and the Pacific

○ Underlying concept

Research and development in the area of aerospace requires a substantial amount of financial resources and time. The promotion of international cooperation is essential for the effective and efficient implementation of aerospace research and development. JAXA will, therefore, continue to vigorously pursue collaboration and cooperation with the United States and European countries as well as with other countries in the region of Asia and the Pacific, where Japan belongs.

JAXA will pursue international cooperation on the assumption that it would acquire and maintain world-class technologies that are essential to ensure the autonomy of Japan, and steps would be taken forward after sufficient consideration has been given to, among other things, the appropriate sharing of cost and risk. JAXA will also take fully into account the importance of maintaining the lead position of Japan in the world in those areas where it has developed high-level technologies. JAXA will further consider the need to acquire and enhance world-class capability for space activities through cooperation with a view to having markets developed for the resulting services and products.

○ **Collaboration with other advanced countries**

Having recognized the areas where Japanese technology excels others, JAXA will pursue international collaboration and cooperation through mutually complementary and beneficial sharing of work and responsibilities while avoiding too much dependence on other countries and maintaining the autonomy of Japan and its ability to take initiatives.

Regarding in particular the utilization of the Moon and human space activities, JAXA will pursue international cooperation with a view to carrying out its autonomous activities in the future.

In the area of Earth observation, the Earth Observation Summit (EOS) approved the 10-Year Implementation Plan to establish a comprehensive global Earth observation system of systems through international cooperation. EOS also established an international coordination

mechanism for the implementation of the Plan. Within this mechanism, JAXA will work with relevant agencies of other advanced countries on a mutually complementary basis toward the implementation of the system proposed by JAXA to provide solutions to global environmental issues.

○ **Collaboration with countries in Asia and the Pacific**

Collaborations with countries in Asia and the Pacific are considered one of the most important objectives for JAXA in its implementation of the Vision. JAXA will take into account the unique circumstances and features of those countries, respond to their specific needs and demands, and work together with them in the aerospace activities to provide solutions for the issues of importance to the region. Through those activities, JAXA aims to be a reliable partner as a leading agency in space activities in Asia.

- **Provision of services of "the information gathering and warning system for disaster and crisis management" for the benefit of the region of Asia and the Pacific**

While ensuring its contributions to the enhancement of the infrastructure in Japan, JAXA will, at the same time, extend its contributions to Asia and the Pacific by providing services of the system that would respond to the specific circumstances and needs of the countries in the region. In doing so, JAXA will endeavour to develop and operate the system together with space agencies and other user institutions of those countries.

- **Servicing as a bridge between Asia and rest of the world through "the integrated global environmental observing system for environmental observations and predictions"**

Monsoon-prone areas in Asia are considered very important for the climate change observation and study, as they yield valuable data as study subjects. By acquiring data from those areas, Japan could play a leading role in the climate change observation and study. JAXA will provide available observation data and information on climate change in these areas to Asian countries, with the aim of contributing to their land management.

- **Human resources development and exchange of researchers for the benefit of Asia and the Pacific**

JAXA will train future researchers and experts who could become valuable partners of Japan in future aerospace activities and will aim to increase the number of such researchers and experts. To achieve this objective, JAXA will contribute to developing human resources of the next generation in Asia and the Pacific by receiving researchers and experts at JAXA facilities and providing them with training. Through those projects to demonstrate the utilization of technologies, JAXA will seek to ensure that space utilization would become an integral part of the society at large. JAXA will also provide technical assistance to various countries in Asia and the Pacific in their development of small satellites and relevant ground systems, thereby contributing to the enhancement of space capability in the region.

JAXA will further develop and operate various aerospace systems together with engineers and researchers from various countries as well as conduct joint research and development projects, with the aim to develop a network of aerospace specialists in the region of Asia and the Pacific.

(5) Securing resources

○ Financial resources

To provide estimates of funding requirements for the implementation of the Vision, a detailed, further examination of the matter would be required. The rough estimates for funding requirements at this point would be as follows.

During the first ten years, the necessary funding level is estimated to be approximately 250 to 280 billion yens (or 2.3 to 2.5 billion United States dollars) per annum. This estimate is provided based on the assumption that those activities relating to space utilization would be carried out together with various user institutions, which would share the cost of the activities depending on the roles they play and on the extent to which they use the services and products concerned.

The budget of JAXA (or the total of the combined budgets of NASDA, ISAS and NAL, before the establishment of JAXA) has constantly declined in the past years, from approximately 230 billion yens (or 2.1 billion United States dollars) per annum in the late 1990's to 180 billion yeans (or 1.6 billion United States dollars) per annum at present. Sales by space industry have also decreased. Against this background, the workforce of space industry in the recent years has been shrinking each year. It has already become a challenge to keep skilled engineers and to maintain and upgrade manufacturing facilities. The situation concerning the technology base has deteriorated to the extent that it has nearly reached the absolute limit.

The implementation of the Vision requires first and foremost taking necessary actions to rectify this grave situation. In order to ensure the implementation of the activities as proposed in the Vision, it is absolutely essential to secure the necessary funds on a continuous basis. The budget of JAXA must be restored at least to the level in the latter half of the 1990's at the earliest possible date.

During the subsequent ten years covered in the Vision, it is envisaged that a space utilization system would be built into the society. JAXA would make efforts toward the ideal situation where not only JAXA but also other entities would take initiatives to allocate their funds to undertake space utilization activities.

As for full-fledged Moon utilization and Japan's own human space activities that are anticipated in those ten years, JAXA would first seek for a decision by the government at an appropriate time whether to proceed in that direction. If the decision turns out to be positive, JAXA considers that the space budget must be increased to the level commensurate with the scale of the activities to be approved.

The implementation of the Vision must be supported with the availability of necessary and appropriate resources. JAXA will make every effort to secure the resources bearing in mind developments in socio-economic areas and major decisions to be taken by the government in the coming years.

○ **Human resources**

Due to declining sales and to difficulty in achieving sufficient profits in the recent years, space industry has been losing each year their skilled workers that support the industry base. Space equipment industry, for example, had about 10,000 employees in the fiscal year (FY) 1995. In FY 2003, the number came down to less than 6,000. "Manufacturing sites" are experiencing serious impact of this shrinking workforce. When established, JAXA had about 1,800 staff. JAXA is aware of a plan to reduce the number of staff by about 100. However, if JAXA is to undertake the activities indicated in the Vision in an orderly manner, it must be provided with the required workforce. This also applies to the industry.

In order for Japan to ensure the continuous development of cutting-edge, highly advanced technologies in the world, as well as the implementation of the Vision, there is clearly a need to secure and sustain the human resources in all sectors involved in aerospace activities, including industry, academic community and the government.

Based on the above understanding, and keeping in mind the challenging budget situation of the government, JAXA believes that the following approaches could be vigorously pursued in close collaboration with industry, academic community and the government, to strengthen the human resources in an effective and efficient manner:

- JAXA will take concrete steps to "secure staff resources of high quality, pursue strategic staff placement and strengthen staff resources through training in an organized and systematic manner" that would be necessary for the implementation of the Vision.

- JAXA will review [its relationship with manufacturing industry] to achieve appropriate sharing of functions and responsibilities and to articulate them. JAXA will focus its capability and resources on those functions and activities that are appropriate for the entity with a central role in research and development in the area of aerospace in Japan.

- JAXA will expand cooperation with universities and other research institutions as well as industry and will promote the participation of scientists and engineers of JAXA and those entities in various each other’s activities.

Final Remarks

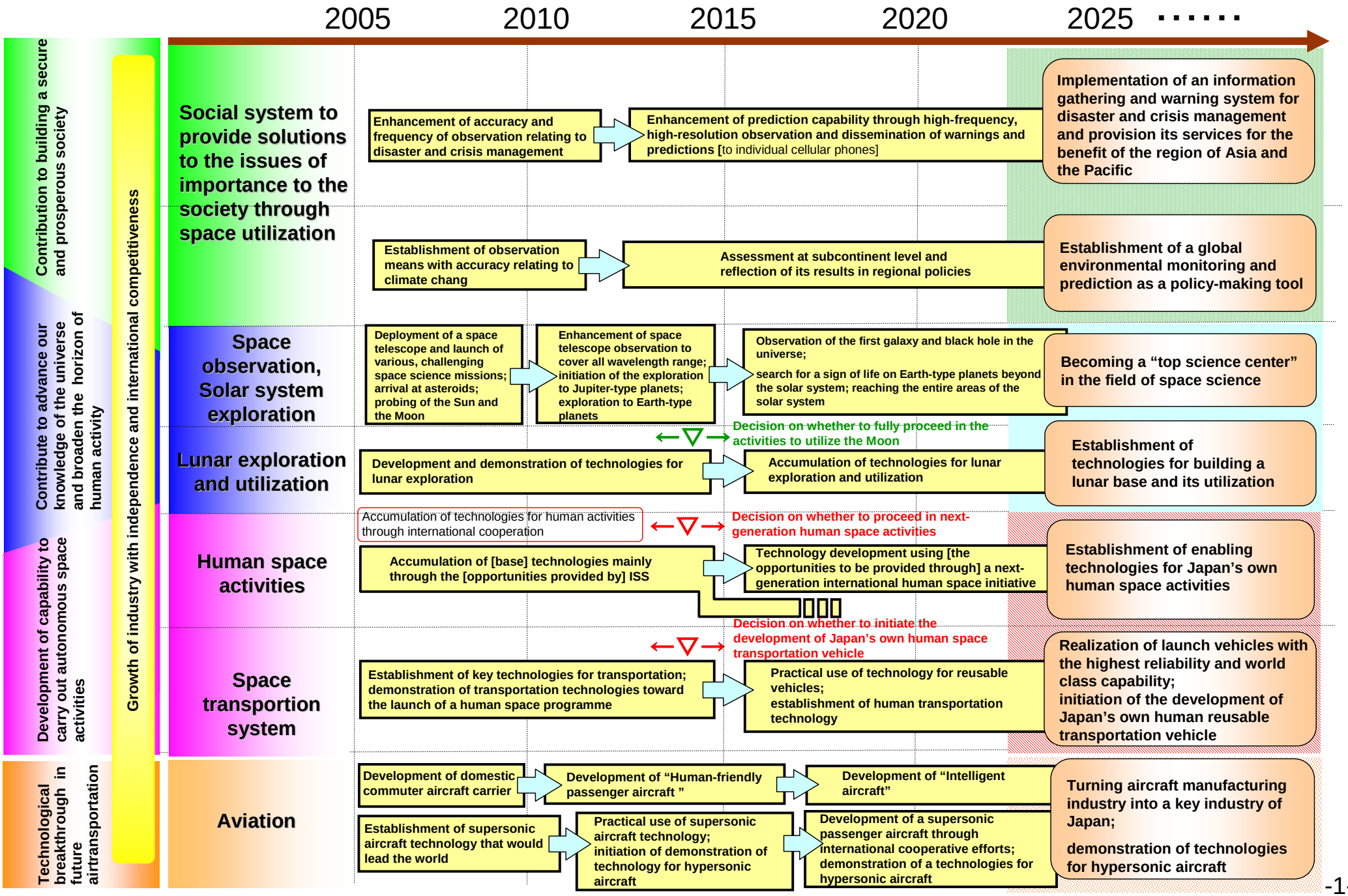
The formulation of the Vision is the first step taken by JAXA by its own initiative toward reforming itself into a desirable agency. It also reflects the future of aerospace activities that JAXA would like to see for Japan as well as the growing alarm over the present situation of aerospace activities. JAXA understands that the present Vision does not provide answers to all questions. However, JAXA hopes that this Vision would lead to creating a momentum within and outside JAXA for further discussions and consideration of future aerospace activities.

The present Vision was considered by the Committee on the Vision and Strategies, consisting of JAXA staff, including both its senior managers and junior professionals. The Vision had been prepared based on proposals submitted by JAXA staff, inputs received from various stakeholders through hearings, as well as comments received from the Advisory Committee on JAXA Vision, consisting of eminent experts, covering a wide range of subjects.

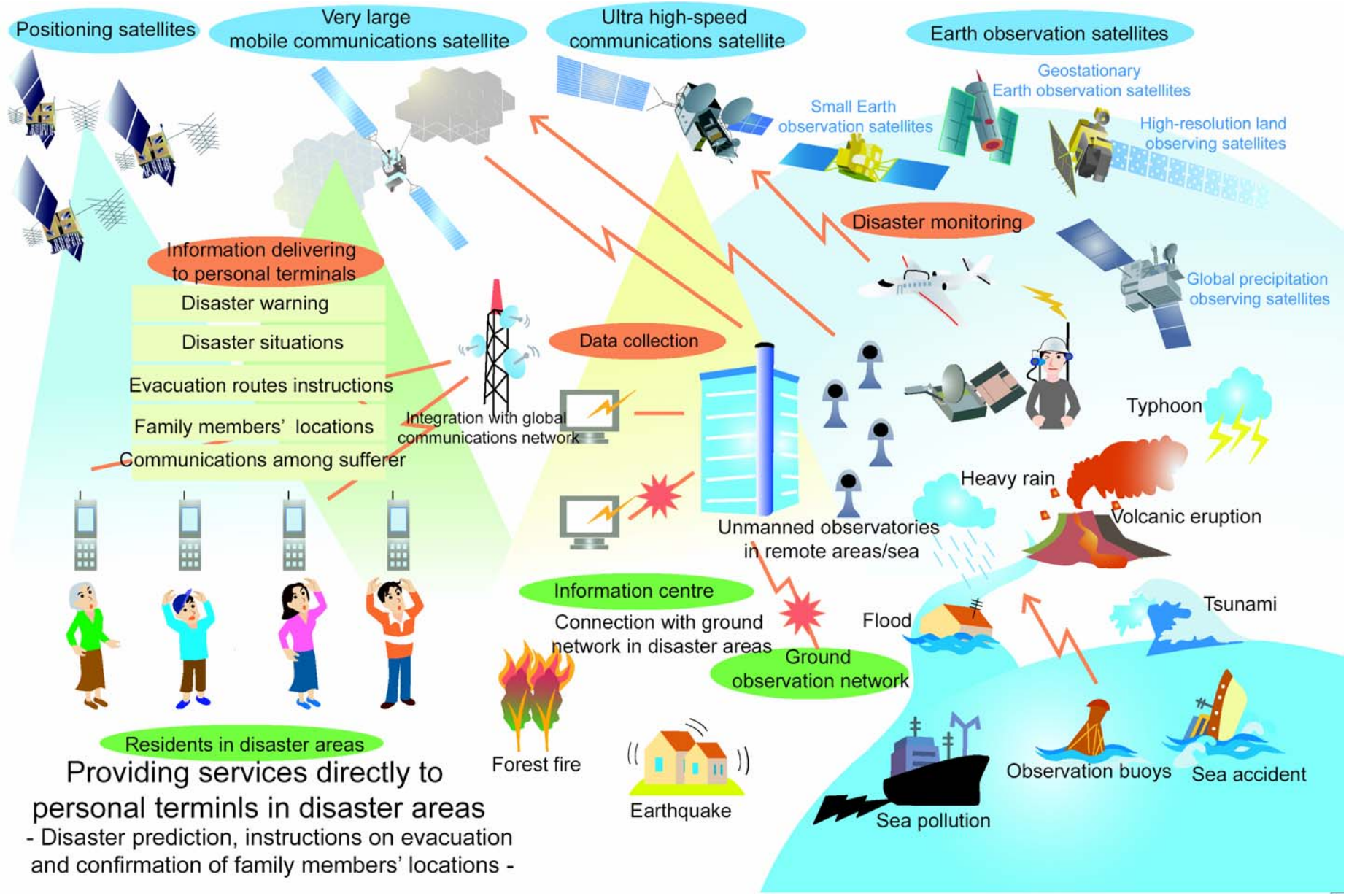
JAXA should like to express its profound appreciation to all those who have cooperated and offered guidance for the preparation of the Vision. JAXA would fully take into account their valuable opinions and comments as it would further articulate this Vision to plan for concrete actions as well as to conduct a review of the Vision in the future.

ANNEX

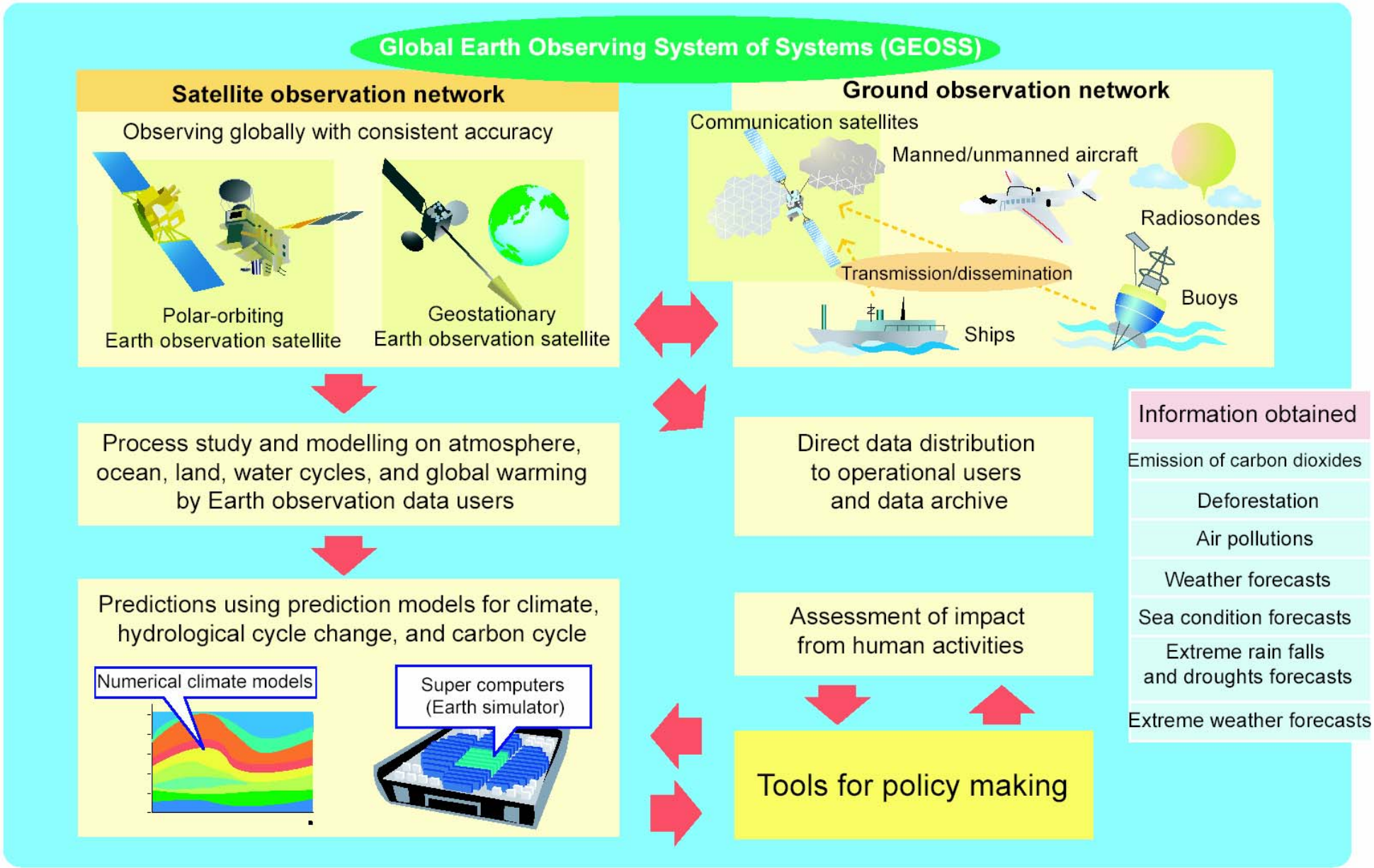
JAXA Vision Overall Roadmap



Information Gathering and Warning System for Disaster and Crisis Management（Image）



Global environmental monitoring system integrating observations and predictions（Image）

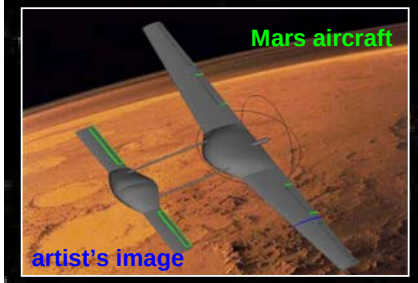


Contribute to advance our knowledge of the universe
and broaden the horizon of human activity

Future Space Observation and Solar System Exploration (Image)

Next generation technologies for interplanetary cruise, e.g. solar sail

Next generation technologies for solar system exploration



Observing

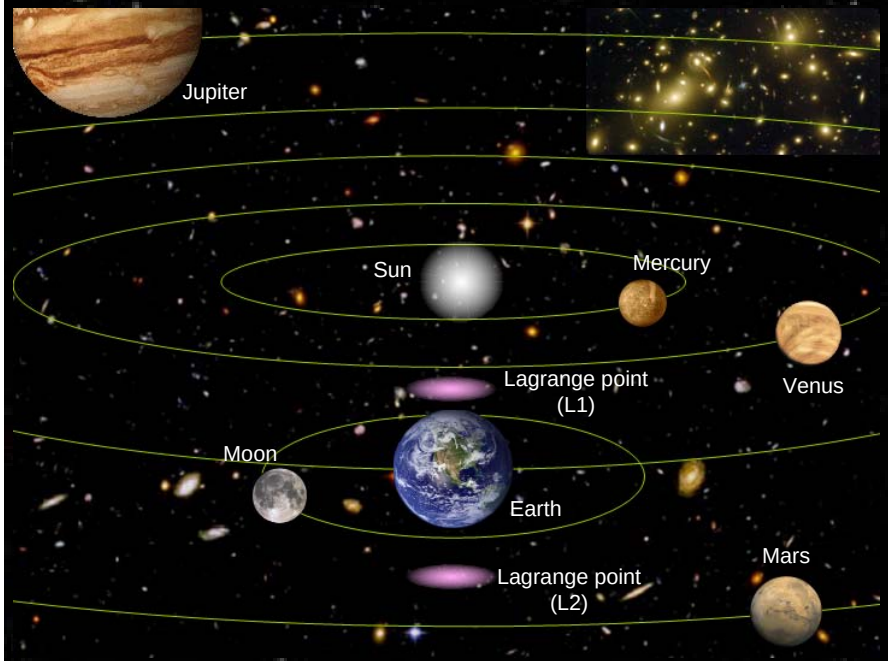
first galaxy and black holes

Investigating some trails of lives on Earth-type planets beyond the solar system

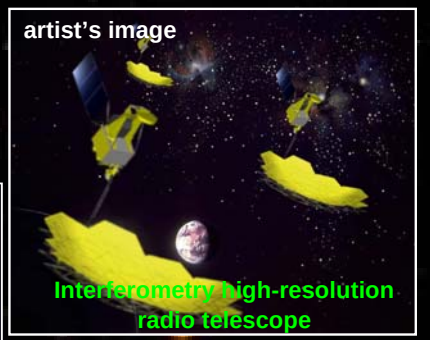
Revealing the unknowns of the dark energy

Reaching the entire area with in the solar system

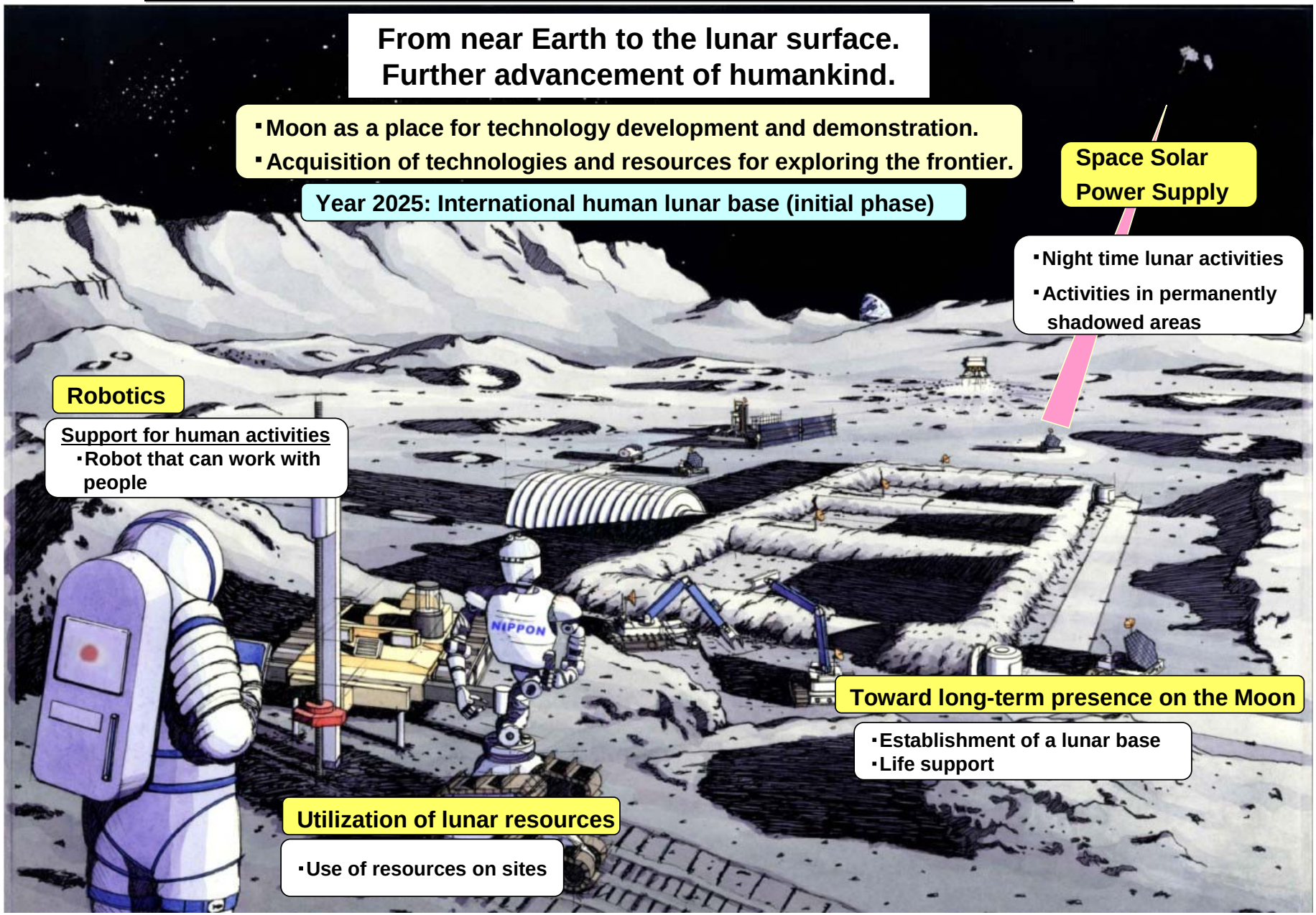
Sample return from mainbelt asteroids
Reachin Jupiter; polar orbit; detailed explorations
Venus balloon; realizing a spacecraft to Mars; and unveiling planetary climates



**space telescope developed at L.P.
with tech's of multiple fly-bys and observation in formation**



Future Lunar Exploration and Utilization Activities (Image)



Development of the capability for autonomous space activities

Future Human Space Activities (Image)

Acquisition of enabling technologies for Japan's own human space activities

Within about 10 years

Accumulation of base technologies mainly through the participation in ISS initiative

Acquisition of technologies for human space activities

- Technologies for large system integratio
- Safety of human activities
- Environment control
- [Integration] technology, etc.

Acquisition of technologies for manned operations

- Operation control
- Actions and measures to deal with troubles

Demonstration of key technologies in space

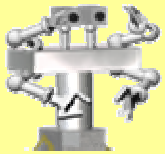
- Life support

- Advanced robots

Within about 20 years

Technology development with the use of a next-generation international manned space initiative

Implementation of human space activities that are unique to Japan

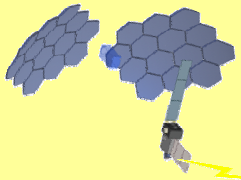


- Cooperation between artificial intelligence and human beings

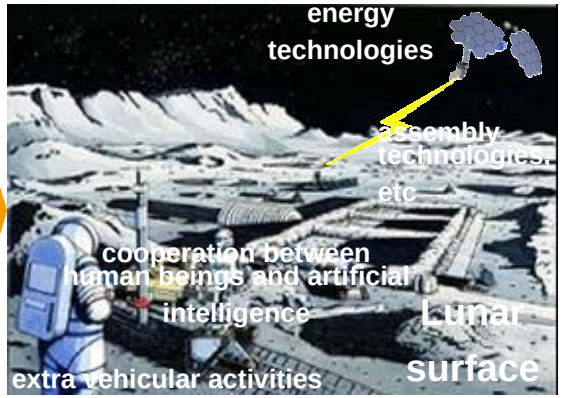
- Technologies for extra vehicular activities

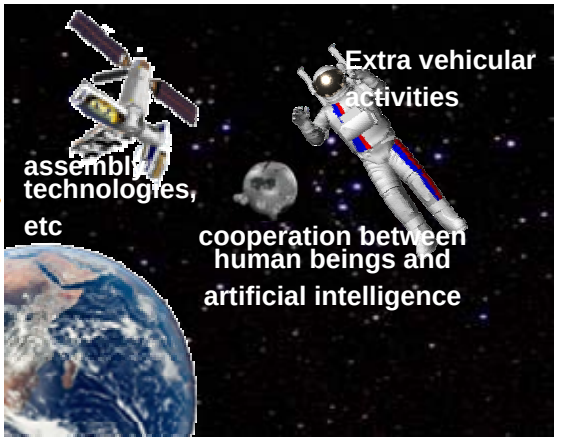
- Orbital transfer vehicles

- Assembly technologies



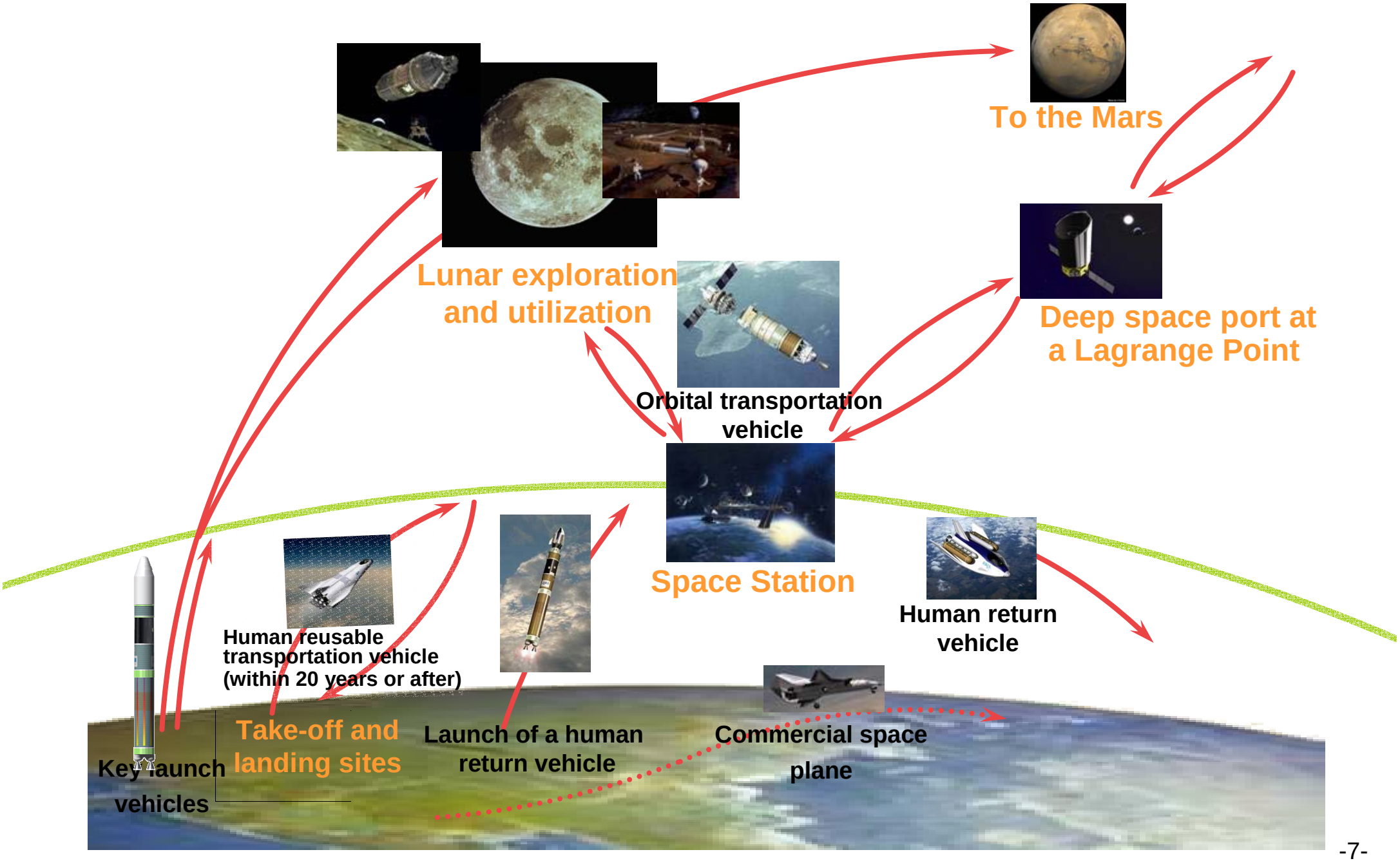
- Energy technologies





Development of the capability for autonomous space activities

Future Space Transportation (Image)



Future Aerospace (Image)

Toward the growth of aeronautical industry and a breakthrough for future air transportation

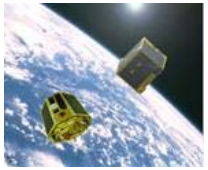
"Turn aircraft manufacturing industry into a key industry"

"Further and faster"

"Intelligent aircraft"

(The third generation domestic passenger aircraft)

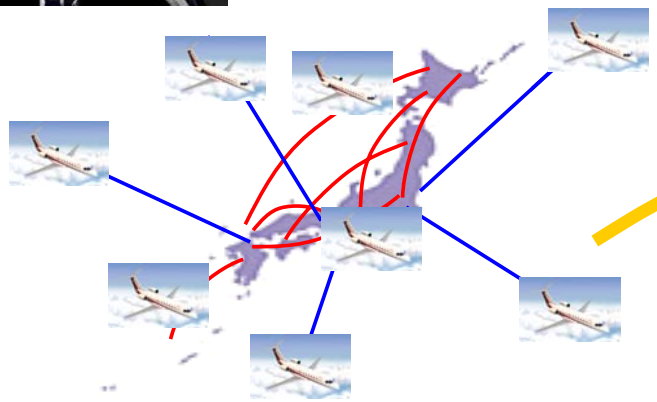
(Realization of convenient air travel)



application space transportation

Hypersonic experimental vehicle : around the year 2025

（Verify the technology to achieve the cruising speed of Mach 5 ）



Japan/Asia

"Human-friendly passenger aircraft"

（The second generation domestic passenger aircraft ）

Providing comfort and safety for the passengers; causing no trouble for the people on the ground

Western coast of the United States of America

Supersonic passenger aircraft: around the year 2020

Contribution to international development efforts of a Mach 2 class supersonic transport;flying across the Pacific Ocean within 5 hours