

Future Earth Observation Program in JAXA

Naoto Matsuura
Senior Engineer

Earth Observation Research and application Center (EORC)
Japan Aerospace Exploration Agency (JAXA)
Chuo-ku, Tokyo, 104-6023, JAPAN

ABSTRACT

The Japan Aerospace Exploration Agency (JAXA) has some Earth observation programs such as disaster and crisis monitoring, investigation of the Earth resources, global environmental to contribute to a safe and secure society. Presently, there are many global issues such as shortage of water resources, desertification, increase in natural disasters, which inflict a serious impact on our community. To overcome such problems and take appropriate measures against them, it is necessary to cooperate among many countries and ensure the establishment of a comprehensive, coordinated, and sustained Earth observation. The 2nd Earth Observation Summit was held in April 2004 and adopted the framework for the 10-year implementation plan, aimed at the establishment of an integrated earth observation system of systems, so called Global Earth Observation System of Systems (GEOSS). JAXA has been developing a future Earth observation program to contribute the GEOSS in cooperate with other space agencies. JAXA committed the contribution to GEOSS using satellites such as ALOS, GPM/DPR and GOSAT mainly focused on observations of global warming and water cycle at the 2nd Summit. In addition, JAXA will propose a series of satellites for establishing GEOSS to monitor climate change. JAXA is studying the Global Change Observation Mission (GCOM) to contribute to process study, prediction of the global change phenomena and the preservation of the global environments.

Keywords: JAXA, GEOSS, ALOS, GPM, DPR, GOSAT, GCOM

1. INTRODUCTION

The National Space Development Agency of Japan (NASDA) had played an important role in the field of Earth observation from space. On October 1, 2003, 3 space related agencies in Japan: the Institute of Space and Astronautical Science (ISAS), the National Aerospace Laboratory of Japan (NAL) and NASDA were merged into one independent administrative institution: the Japan Aerospace Exploration Agency (JAXA). Earth observation programs such as disaster and crisis monitoring, investigation of the Earth resources, global environmental observation are important mission of JAXA to contribute to a safe and secure society. Presently, there are many global issues such as shortage of water resources, desertification, increase in natural disasters, which inflict a serious impact on our community. To overcome such problems and take appropriate measures against them, it is necessary to cooperate among many countries and ensure the establishment of a comprehensive, coordinated, and sustained Earth observation. Such an effort has been made in the Committee on Earth Observation Satellites (CEOS) and is the Integrated Global Observing System (IGOS).

Furthermore, the 2nd Earth Observation Summit was held in April 2004 and adopted the framework for the 10-year implementation plan, aimed at the establishment of an integrated earth observation system of systems so called Global Earth Observation System of Systems (GEOSS). JAXA has been developing a future Earth observation program to contribute the GEOSS in cooperate with other space agencies.

matsuura.naoto@jaxa.jp; phone +81-3-6221-9000; fax +81-3-6221-9191; <http://www.jaxa.jp>; Earth Observation Research and application Center (EORC), JAXA, Harumi Island Triton Square Office Tower X 23F, 1-8-10, Harumi Chuo-ku, Tokyo, 104-6023, JAPAN

2. EARTH OBSERVATION FEATURES IN JAXA

Earth observation from space makes it possible to continually monitor the same broad areas under the same conditions, and to observe areas where there is much difficulty for human beings go. JAXA has launched a number of Earth observation satellites for marine, land, atmosphere, environment and climate. Data collected by these satellites allow us to understand the processes and interactions among landmasses, oceans, and atmosphere. Moreover, we use these data in many ways for the benefit of our everyday lives: weather forecasts, disaster monitoring, exploitation of natural resources, and fishery. JAXA is committed to promoting the observation of Earth from space. JAXA's Earth Observation System is responsible for developing Earth observation satellites, collecting observation data via ground stations, and the storage and utilization of the data in research and application.

In last October, JAXA made 5 new departures in the pursuit of its mission:

- (a) To put together acquired technologies to create space transport systems with the world's highest reliability;
- (b) To use space technology for the improvement of the global environment;
- (c) To develop quality-of-life space technology that will help build a society in which people can live safer, richer lives;
- (d) To promote the world's most advanced astronomical satellite observation, and lunar/planetary exploration to improve the world through scientific expertise; and
- (e) To promote research and testing of domestic jet-engine technology in order to contribute to the development of a Japanese airplane industry.

JAXA's Earth observation programs are new departures to improve the global environment and to build a society in which people can live safer and richer lives. The Office of Space Application, based at the Tsukuba Space Center (TKSC), is responsible for the promotion of Earth observation in Japan. The office develops satellite technology and instruments in areas ranging from Earth observation to communications technology. It also promotes the use of satellites in various applications. In the Office of Space Application, the Earth Observation Research and Application Center (EORC) develops data processing and analysis algorithms; proofs and verifies data to ensure high quality; and takes the initiative in research on data utilization. EORC has the Earth Observation Center (EOC) for receiving, processing, and providing satellite data for public use.

To contribute to a safe and secure society, EORC provides data, products and information taken by Earth observation satellites, necessary for determining disaster conditions to mitigate damage quickly and accurately, investigating and managing agricultural, forestry, fishery, and water resources, and studying the current global environment and forecasting its future. EORC shares the results with society by promoting the use of satellite data as a field center to provide information concerning the data, such as a domestic promotion committee of satellite remote sensing and international committee of Earth observation satellites, and conducting symposia and seminars for data users. To promote the use of satellite data, EORC also cooperates with related domestic and foreign institutions as well as international organizations, and engage in mutual use of data, data research, and application.

3. ON-GOING EARTH OBSERVATION PROGRAMS OF JAXA

In its history, NASDA has passed through various stages in the development field of its Earth observation activities. Firstly, NASDA developed meteorological satellites by importing foreign technologies and also developed an application technology. Secondly, NASDA strengthened its own technology for satellite, sensor and ground system development and proceeded with Earth science using Earth observation data. Thirdly, NASDA supported the global effort to address contributing to the solution of Earth's the global environmental problems and contributed globally to the society by improving the quality of life through the development of an Earth observation system.

JAXA is developing Earth observation programs via these steps based on the following two primary missions: disaster monitoring and observation for natural resource management, and continuous global observation for global warming and global water cycle.

3.1. Disaster Monitoring and Observation for Natural Resource Management

In the NASDA era, with the Marine Observing Satellite (MOS-1/1b) launched in 1987 and 1990, the Japan Earth Resources Satellite-1 (JERS-1) launched in 1992 and the Advanced Earth observing Satellite (ADEOS) launched in 1996 could contribute to disaster monitoring and observation for natural resource management.

The Advanced Land Observing Satellite (ALOS) will be launched in 2005 as the successor of JERS-1 for the fields of mapping, precise land coverage observation, disaster monitoring, and resource surveying. ALOS has 3 sensors: the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), which is comprised of 3 sets of optical systems to measure precise land elevation; the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), which observes what covers land surfaces; and the Phased Array type L-band Synthetic Aperture Radar (PALSAR), which enables day-and-night and all-weather land observation. (Fig. 1)

Various products derived from ALOS are expected to contribute widely to the advancement of science as well as to application fields such as natural resource management, disaster monitoring and damage mitigation, and regional development and planning.



Fig. 1 ALOS satellite

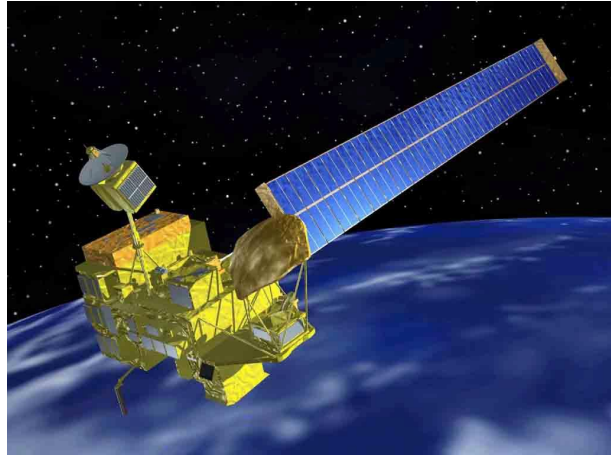


Fig. 2 ADEOS-II satellite

3.2. Continuous Global Observation for Global Warming and Global Water Cycle

The mission of continuous global observation for global warming and global water cycle is categorized in 3 missions: water cycle observation, climate change observation, and greenhouse gas observation.

MOS-1/1b could contribute to water cycle observation, climate change observation, and ADEOS could contribute to climate change observation and greenhouse gas observation. The Advanced Earth Observing Satellite-II (ADEOS-II), the successor of ADEOS was launched in December 2002 in order to understand environmental problems such as global warming, ozone depletion, and abnormal weather. (Fig. 2) ADEOS-II carried 5 sensors; the Global Imager (GLI), the Advanced Microwave Scanning Radiometer (AMSR), SeaWinds, Polarization and Directionality of the Earth's Reflectances (POLDER) and Improved Limb Atmospheric Spectrometer-II (ILAS-II). GLI and AMSR were developed by JAXA. AMSR was a passive microwave sensor, which could observe geographical parameters related to water, regardless of the presence of clouds, and GLI was an optical sensor, which could extensively and accurately observe oceans, land and clouds. NASA's SeaWinds measured sea surface wind speed and direction with high accuracy. CNES's POLDER was a sensor, which measures the polarization, directional and spectral characteristics of the solar light reflected by aerosols and from land surfaces. IILAS-II was developed by Japan's Ministry of the Environment, for the purpose of monitoring the high-latitude stratospheric ozone layer.

ADEOS-II unfortunately stopped its operation due to a power supply anomaly on October 25, 2003. For about 10 months from the launch to the anomaly occurrence, ADEOS-II had been exposed to about 4,400 heat cycles. During the period, the highest temperature of the solar array paddle (PAD) harness exceeded the allowable temperature (200° deg. C) and reached 230 deg. C by its self-heat generation while the satellite was in the sun side. As the harnesses heated up and adhered to each other, damages occurred in the harnesses' insulators. When the satellite was in the shade side or was passing through the aurora belt, the not-grounded multi layer insulators (MLI) of the PAD harness charged, and trigger discharge occurred between the charged MLI and damaged harness, generating discharge plasma. Through the discharge plasma, intermittent discharge arose between the adjacent harnesses with damages.

On October 25, 2003, when ADEOS-II passed through the aurora belt, the MLI charged more than usual and produced an environment that discharge easily occurred. The trigger discharge between the MLI and harness, and the subsequent intermittent discharge between the harnesses developed to short accompanying heat generation through the carbonized conductive path formed between the damaged harnesses. This process gradually spread to the entire harness, resulting in open or short circuit of the big power harness bundle. JAXA will continue calibration and validation activities and make the best use of data obtained during a short period of 9 months.

3.2.1. Water Cycle Observation

Aqua was developed as a joint project by the United States, Japan and Brazil. (Fig. 3) It was launched in May 2002. JAXA developed the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), which is almost equal to AMSR that could monitor the Earth day and night. The antenna of AMSR-E has the largest-diameter microwave scanning radiometer (about 1.6 meters), and it can collect water data with an unprecedented high definition. AMSR-E has demonstrated the usefulness and viability of microwave-based observation of the Earth's land and sea-surface under clouds. The data obtained from AMSR-E is provided to meteorological agencies, fishery agencies and so on. It is expected to improve the accuracy of weather forecasting and to provide other practical benefits.

NASA and JAXA jointly established the Tropical Rainfall Measuring Mission (TRMM), launched in November 1997, to measure rainfall conditions in the tropics and subtropics from space and obtain various data concerning the amount and distribution of such rainfall in an effort to shed light on how rainfall affects the global energy balance. (Fig. 4) TRMM has been observing rainfall conditions and obtaining various data including the largest El Niño Southern Oscillation (ENSO), occurred in 1997. The Precipitation Radar (PR) data, combined with the TRMM Microwave Imager (TMI) and the Visible Infrared Scanner (VIRS) data, is expected to contribute to predicting global climate changes. While the satellite is designed to perform required observations over 3 years, it was boosted up from about 350km to 402km in 2001 to extend its mission life.

The Global Precipitation Mission Measurement (GPM) led by NASA will succeed TRMM to cover precipitation (rainfall and snowfall) measurements in tropical to sub-polar regions of the Earth. GPM must have a wider area of observation and the capability to accurately measure precipitation. In order to understand rainfall systems and water cycles on a global scale, it is important to expand the observation area to the mid- and high-latitude regions, as well as the observation at tropical regions.

GPM will be configured with a core satellite integrating the DPR (Dual frequency Precipitation Radar) developed by JAXA and National Institute of Information and Communications Technology of Japan (NICT), and the GMI (GPM Microwave Imager) from United States, and 8 small satellites, each equipped with a small microwave imager. (Fig. 5) The 8 small satellites will measure global rainfall distribution every 3 hours. Collected data will be calibrated using the DPR onboard the core satellite. In addition, the DPR will collect data on three-dimensional rainfall structures. GPM will be targeted for be launched around 2010.



Fig. 3 AQUA satellite



Fig. 4 TRMM satellite

3.2.2. Climate Change Observation

The ADEOS-II scientific objectives can be summarized into 3 parts:

- (a) Understand the fixed quantity of the water-energy cycle in the climate system;
- (b) Estimate the quantity of biomass and primal production in relation to the carbon cycle, which is responsible for global warming; and
- (c) Detect signal changes in long-term climatic changes, through continuous observations by ADEOS.

In particularly, the investigation into “(a) water-energy cycle” is a distinguishing characteristic of the ADEOS-II mission. The 5 sensors onboard ADEOS-II was useful in understanding fixed quantity of water-energy cycle on global scale. ADEOS-II could not achieve the detection of signal changes in long-term climatic changes, but the follow-on satellite will turn over it.

3.2.3. Greenhouse Gas Observation

Global warming has become a very serious issue for human beings. Scientists have suggested that, at the rate the Earth’s temperature is raising, an extreme form of global climate change could occur in a few centuries. In 1997, the Kyoto Protocol was adopted at the Third Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3), making it mandatory for developed nations to reduce carbon dioxide emissions by 6 to 8 percent of their total emissions in 1990, and to meet this goal sometime between 2008 and 2012.

The Greenhouse gases Observing Satellite (GOSAT) is a satellite that aims to contribute to these treaties by monitoring the distribution of the density of carbon dioxide, which is one Greenhouse gas. GOSAT is a project that has been jointly developed by JAXA and Japan’s Ministry of the Environment. (Fig. 6) JAXA is responsible for the development of the satellite and an observing sensor, while the ministry is mainly in charge of the data utilization. GOSAT will be launched in 2008.

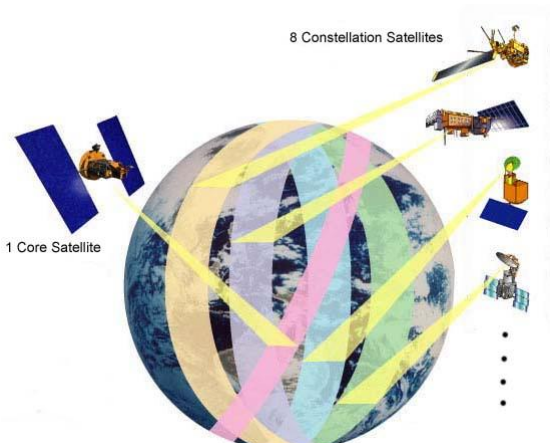


Fig. 5 GPM concept

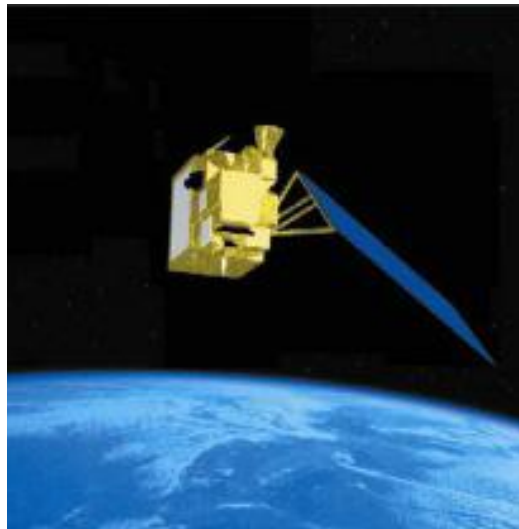


Fig. 6 GOSAT satellite

4. INTERNATIONAL FRAMEWORK IN EARTH OBSERVATION PROGRAMS

One country cannot observe the Earth to monitor and analyze global environment conditions. International cooperation is essential to observing and understanding the Earth to guarantee our safety and quality of life.

The Committee on Earth Observation Satellites (CEOS), created in 1984, is an international coordinating mechanism for optimizing international space-borne missions, and for interaction of these programs with users of satellite data. CEOS has 23 Members, most of which are space agencies, and 21 Associates, which are associated national and international organizations. The primary objectives of CEOS are to optimize benefits of space-borne Earth observations, to as a focal point for international coordination, and to exchange policy and technical information. JAXA is one of the CEOS secretaries for supporting the coordination activities.

On the other hand, the Integrated Global Observing Strategy (IGOS) provides a comprehensive framework to harmonize the common interests of the major space-based and in-situ observation systems. The IGOS Partnership (IGOS-P) was established in 1998 by a formal exchange of letters among the 13 founding Partners for the definition, development and implementation of IGOS. IGOS is a strategic planning process that links research, long-term monitoring and operational programs, as well as data producers and users. It helps determine observation gaps and identify the resources to fill observation needs, and seeks to improve observing capacity and deliver observations in a cost-effective and timely manner. IGOS has adopted a process of themes in which observations are made for selected fields of common interest among a group of partners. The adopted current IGOS themes are global carbon cycle, geo-hazards, ocean, water cycle, and atmospheric chemistry. (Fig. 7)

In 2003, a consensus emerged among governments and international organizations that global cooperation for Earth observation systems must be strengthened supporting and developing existing systems. Starting from the Earth Observation Summit at Washington DC in July 2003, the 2nd Earth Observation Summit at Tokyo in April 2004 adopted a Framework Document which marks a crucial step in developing the 10-Year Implementation Plan for the creation of a comprehensive, coordinated, and sustained Earth observation system or systems.

At the 2nd Summit, 9 specific areas of socio-economic benefit were identified to achieve sustainable development, including: disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity.

To achieve the many benefits of coordinated Earth observations and to move from principles to action, governments adopting the Framework Document set forth the primary components of a 10-Year Implementation Plan for establishing the Global Earth Observation System of Systems (GEOSS). The Implementation Plan will be developed by the 3rd Summit at Brussels in February 2005.



Fig. 7 IGOS Themes

5. FUTURE EARTH OBSERVATION PROGRAMS IN JAXA

JAXA committed the contribution to GEOSS using ALOS, GPM/DPR and GOSAT mainly focused on observations of global warming and water cycle at the 2nd Summit. In addition, JAXA will propose a series of satellites for establishing GEOSS to monitor climate change.

JAXA is studying the Global Change Observation Mission (GCOM) to contribute to process study and prediction of the global change phenomena and the preservation of the global environments. The series of GCOM satellites consist of 2 satellite series: the sea surface observation mission, so called GCOM-W, will have AMSR F/O and a scatterometer, and the climate observation mission, so called GCOM-C, will have GLI F/O. Each satellite series will have 3 satellites with 5 years mission life to exceed 11 years which is a nominal period of solar cycle and is the longest period of climate change. The series totally covers 13 years overlapping 2 years. To improve reliability of satellite bus system after the ADEOS-II accident, JAXA will develop a series of middle size bus system from GOSAT in common. The bus system

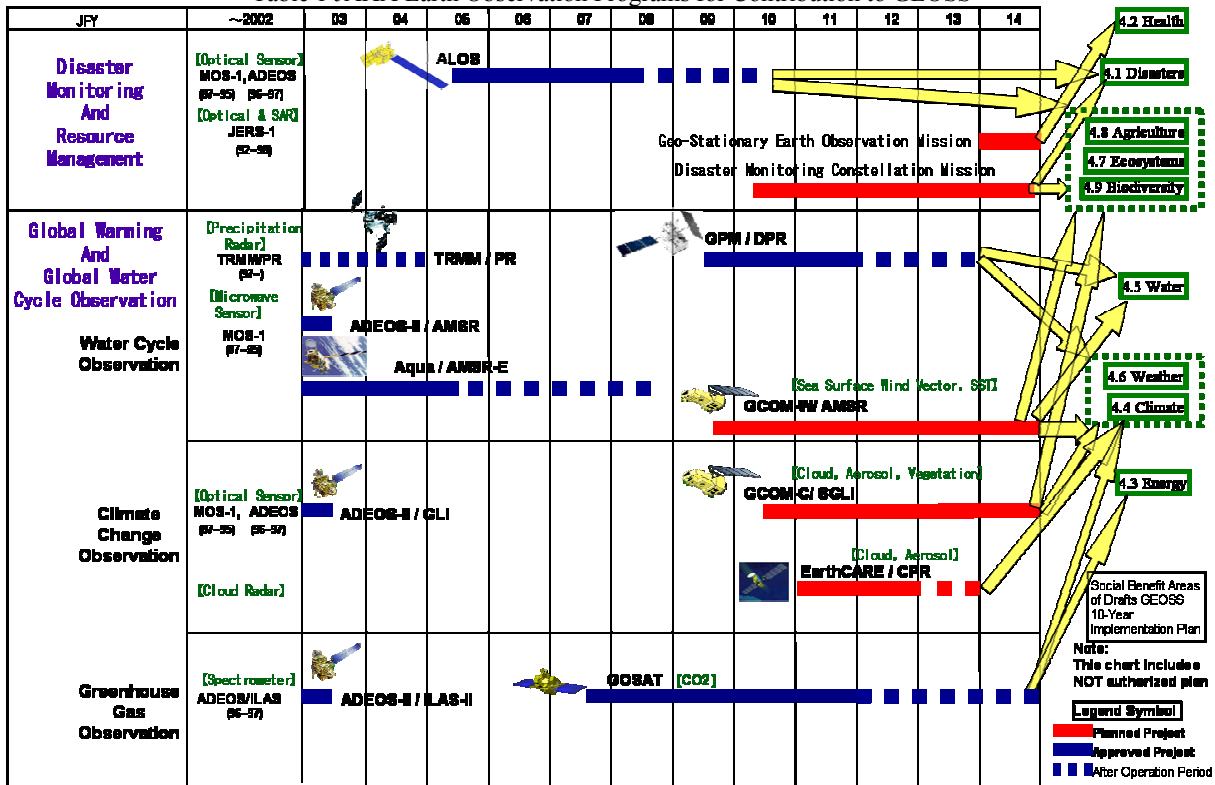
uses same basic design, develops specific modules fitting each mission and improves the basic design. The middle size bus system will basically have 1 mission (not sensor) as risk management. The GCOM will be started in around 2010.

JAXA, jointly with NICT, is proposing the Cloud Profiling Radar (CPR) to the EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) mission, which is a joint Japanese-European mission with the specific scientific objectives of quantifying aerosol-cloud-radiation interactions so they may be included correctly in climate and numerical weather forecasting models. The difficulty of representing clouds and aerosols and their interactions with radiation, constitutes a major source of uncertainty in predictions of climate change using numerical models of atmospheric circulation. CPR can observe vertical profiles of liquid, super-cooled and ice water, cloud overlap, particle size, convective updraft, and ice fall speed and extinction. GCOM-C can monitor the global distribution of cloud and aerosols. The combination of EarthCARE and GCOM-C will lead to more reliable climate predictions and better weather forecasts through the improved representation of processes involving clouds, aerosol and radiation.

JAXA studies future missions for disaster and crisis management, and investigation of Earth resources as ALOS F/O. The current study has 2 missions: disaster monitoring constellation mission and geo-stationary earth observation mission. The disaster monitoring constellation mission consists of 4 satellites with L-band SAR to observe an afflicted area every 3 hours. The geo-stationary earth observation mission is a geo-stationary satellite with high resolution telescope to observe the afflicted area on a steady basis. Both missions have a good combination for disaster and crisis management.

These programs are suitable for the social benefit areas of draft GEOSS 10-Year Implementation Plan such as disaster, weather, climate and so on. JAXA will prioritize a program consulting with the Space Activity Commission (SAC) by March 2005. According to current discussion, JAXA will mainly focus on climate change observation including water cycle observation using the series of GCOM satellites. (Table. 1)

Table 1 JAXA Earth Observation Programs for Contribution to GEOSS



6. CONCLUSION

JAXA are studying Earth observation missions for disaster and crisis management, investigation of Earth resources and monitoring the global environment. To contribute a safe and secure society, JAXA does:

- (a) Quickly and accurately determine disaster status to mitigate damage,
- (b) Investigate and manage agricultural, forestry, fishery, and water resources, and
- (c) Study the current global environment and forecast its future.

JAXA will continue providing important information essential to our daily safety and lives using Earth observation from space.

REFERNCES

1. JAXA Web site, http://www.jaxa.jp/index_e.html
2. EORC Web site, <http://www.eorc.nasda.go.jp/en/index.html>
3. EORC brochure
4. CEOS Web site, <http://www.ceos.org/>
5. IGOS Web site, <http://www.igospartners.org/>
6. Framework for a 10-Year Implementation Plan, April 25, 2004
7. Communiqué of the Second Earth Observation Summit, April 25, 2004
8. EarthCARE handout, Earth Explore User Consultation Meeting, April 19 and 20, 2004