ASTRONAUT'S EARTH OBSERVATION ON THE INTERNATIONAL SPACE STSTION

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ABSTRACT:

Ministry of Science & Technology (MOST) and Korea Aerospace Research Institute (KARI) are preparing for the first Korean astronaut program based on the mid and long-term basic plan for space development of Korea from the year of 2003. KARI is making plans for the Korean astronaut's missions with Russia. To participate in the International Space Station (ISS) utilization through the Korean astronaut program, KARI investigates a lot of manned space missions. Among the suggested items, Earth observation on the Russian Module of ISS is the one expected mission for a Korean astronaut. This paper is intended to give readers a brief introduction of ISS Russian Module and research fields of Earth observation for astronaut's mission.

KEY WORDS: Earth Observation, Astronaut, Space Mission, ISS, ISS Utilization

1. INTRODUCTION

The assembly of the International Space Station (ISS) is in progress. Its construction will be completed around 2010. Researchers can use the ISS as a platform from which to study the workings of our world, regularly monitoring small features and change around the world. The scientific utilization of ISS is already started. One of the most significant improvements of ISS is the continuous availability for 10 to 15 years of this system.

Earth observation from space is new to Korea, but is not new to the United States or Russia. Two countries have a lot of experience and historical archives for documenting changes on Earth's surface from low Earth orbit. The primary goal of Earth observations is to use astronaut photographs to document environmental changes and dynamic Earth process such as flooding and droughts, urban growth and land use changes around the world, events related to El Nino, and transient phenomena such as tropical storms, large fires, and volcanic eruptions. A second important objective of Earth observations experiment is to use an operational environment to develop approaches and tools for the next generation of Earth observations from the ISS.

ISS has an extraordinary optical quality window - the best ever flown on a manned spacecraft. The optical quality window in the Russian Segment became part of the orbiting outpost in July 2000. Since that time, ISS crew have become happy, picking their shots of Earth using digital still cameras, 35-mm and 70-mm cameras, and making use of a range of lenses. The first three resident space station crews clicked nearly 13,500 pictures of our home planet. In the process, a new standard has been set for Earth photography. An analysis of the images found that objects less than 6 meters across on Earth can be resolved using cameras on board the high-flying ISS.

Astronauts of NASA and Russia have used hand-held cameras to photograph the Earth for more than 30 years. Since 1981, Space Shuttle astronauts have taken photographs of the Earth. Also, ISS continues the Earth observation with crews. Astronauts including ISS crews are trained in scientific observation of ecological, geological, geographic, oceanographic, environmental and meteorological phenomena. They are also instructed in the use of photographic equipment and techniques. Pre-flight training helps the astronauts make informed decisions on which areas and phenomena to photograph. Specific areas of scientific interest are selected before each flight by a group of researchers.

Ministry of Science & Technology (MOST) and Korea Aerospace Research Institute (KARI) are preparing for the first Korean astronaut program based on the mid and long-term basic plan for space development of Korea from the year of 2003. KARI is making plans for the Korean astronaut's missions with Russia. To participate in the ISS utilization through the Korean astronaut program, we investigate a lot of manned space missions.

2. ISS FUNDAMENTALS

2.1 Orbital Parameters of ISS

ISS is flying between at least 335 ㎞ and 460 ㎞ above the Earth's surface. This corresponds to a velocity of about 29,000 ㎞/h and an orbital period of about 90 minutes. The inclination of the station's orbit is such that the station will cross the Earth's equator at an angle of

51.6° . The station's ground track is a sinusoidal track symmetrical with the equator with its extreme points located at 51.6° latitude North and South, respectively. As the Earth rotates beneath the station at an angular speed of 360° per day, the ground track shifts 22.5° to the West during one flight around the Earth. Due to the westward precession of orbit tracks, the ISS flies over the same area on the Earth's surface about every 3 days and it covers the same lighting conditions about every 3 months. The orbital parameters of ISS allow observation of 85% of the Earth's surface where 95% of the Earth's population lives. The advantage of the ISS being in Low Earth Orbit (LEO) provides a unique vantage point for collecting remote sensing data of the Earth. The altitude of ISS is determined by two factors: logistics and safety. It will be kept as low as possible to maximize the payload capacities of the transport vehicles which will travel to the ISS to deliver supplies. On the other hand, it has to be as high as necessary in order to avoid the residual atmospheric drag of the Earth's atmosphere causing the re-entry of ISS.

2.2 Russian Segment of ISS

Table 1. Zvezda Overview

Weight	19 ton
Wingspan	29.7 m
Length (end-to end)	13.1 m
Altitude	350~460 ㎞
Inclination	51.6°
Pressurized Compartments	3
Window	14
Launch Date	July 11, 2000
Launch Vehicle	Proton
Launch Site	Baikonur

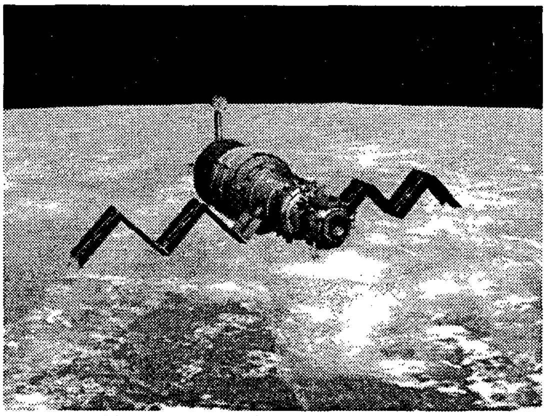

Figure 1. Zvezda Illustration (FSA)

The Service Module (Figure 1 and Table 1) is the first fully Russian contribution to the International Space Station and serves as the early cornerstone for the first human habitation of the station. The Zvezda (Service Module) includes four docking ports, one in the aft Transfer Chamber and three in the spherical forward Transfer Compartment --- one facing forward, one facing up and one facing down. Living accommodations on the Service Module include personal sleeping quarters for the crew, a toilet and hygiene facilities, a galley with a refrigerator/freezer, and a table for securing meals while eating. The module have a total of 14 windows including three 9-inch diameter windows in the forward Transfer Compartment for viewing docking activities, one large 16-inch diameter window in the Working Compartment, an individual window in each crew compartment, and additional windows positioned for Earth and intra-module observations.

2.3 Earth Observation on ISS Russian Segment (RS)

Activities on forming the Russian ISS RS Science Research and Experiments Program were initiated in 1995 following the announcement of a competition among scientific establishments, industrial companies and higher education establishments. Four hundred and six applications from more than 80 organizations in eleven major research areas were received. In 1999 with regard to the technical feasibility study of the received applications performed by RSC Energia specialists the Long-Term ISS Russian Segment Science and Applied Research and Experiments Program was developed and approved by the Russian Aviation and Space Agency and President of the Russian Academy of Sciences. Beginning with the docking of the Soyuz-TM 31 transport vehicle carrying the ISS-1 crew on November 2, 2000 a manned space station operation and research and experiments phase has been started.

The following subjects are the science research on ISS Russian Segment.

- Human Life Research
- *Geophysical Research & Earth Resources Sensing*
- Space Biotechnology
- Technical Research
- Contract Activities
- Study of Cosmic Rays
- Educational and Humanitarian Projects
- Space Technology and Material Science
- Problems of Space Power System

Natural and man-made disasters entail a great number of victims and have a devastating effect upon the economies of many countries. Due to this fact, it is required to arrange at the ISS a permanent monitoring of the areas where natural and man-made disasters are forecasted, as well as prompt notifying the public and local authorities about unfavourable or disastrous development of events. This experiment further develops a sequence of visual observations of the Earth surface started earlier at the Mir station. The ISS RS-based subsequent expeditions will build up an automatic observation system designed to watch the development of catastrophic events via electronic-optical equipment, which is on a par with the world standards set in its characteristics and provides round-the-clock monitoring capability. Initial classification and decoding of catastrophic event signs will be carried out by astronauts onboard the ISS RS using dedicated software. During conduct of a space borne experiment operational recording and downlink transmission of data on catastrophic event origination, development and scope are planned to be carried out.

3. EARTH OBSERVATIONS EXAMPLES AND RESULTS ON ISS

3.1 Earth Observation Experiments in Russia

◦ URAGAN Experiments

- Objective: Observation and registration of development of ISS RS down linked catastrophic phenomena and development of criteria of classification and decoding of catastrophic phenomena indications.
- Tasks: Conduct of visual observations followed by recording of catastrophic phenomena development processes on video and photography apparatus.
- Hardware: Rubinar 40x110 device which includes: Binocular spyglass with a digital video camera Sony DCR-TRV9E (Figure 2)

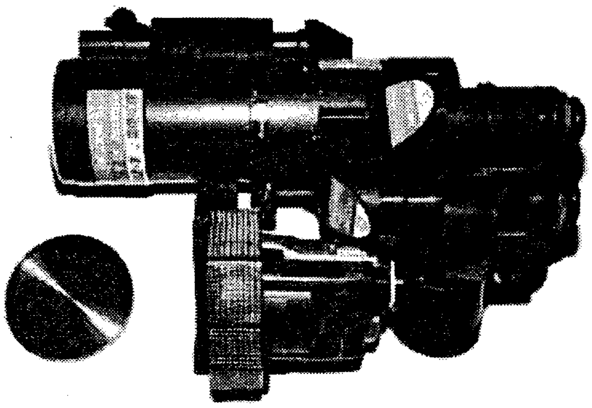

Figure 2. Rubinar 40x110 device (FSA)

- Expected Results
  : Generation of computer-aided data bases on recorded catastrophic phenomena
  : Preliminary development of decoding criteria for downlinked images of catastrophes followed by their classification

• DIATOMEYA Experiments

- Objective: Investigation of stability of geographic location and configuration of boundaries of the World Ocean bio productive water areas
- Tasks
  : Exploration of the world ocean aimed at check search and determination of current coordinates of location of bioproductive water areas
  : Recording of a shape, structure and morphometric characteristics of formations contrasting in colour within specified bioproductive areas of the ocean
- Hardware: Video camera Sony DSR-PD150P for video filming of the World Ocean bioproductive areas (Magnification degree of auto-zoom lens-16, Focal distance range 5.5 - 88 mm, Resolution - 650 TV lines, TV-signal format -PAL); Photographic camera Nikon F5; Dictaphone, Laptop (Figure 3)

Figure 3. Nikon F5 Camera (FSA)

- Expected Results: Creation of a database on bioproductive ocean areas

3.2 Example Areas in Korea

What does the ISS offer in the field of Earth observation? Apart from some research activities in cooperation with foreign countries, Korea has exclusively used unmanned satellites (e.g. KOMPSAT, KITSAT, and foreign satellites, etc.) for Earth observation until the present time. For that reason, research in crewed space flight is a new chance for Korea's Earth observers which must be examined more carefully in order to see whether or not it is suitable for Earth observation purposes and fulfils the operational demands of the users.

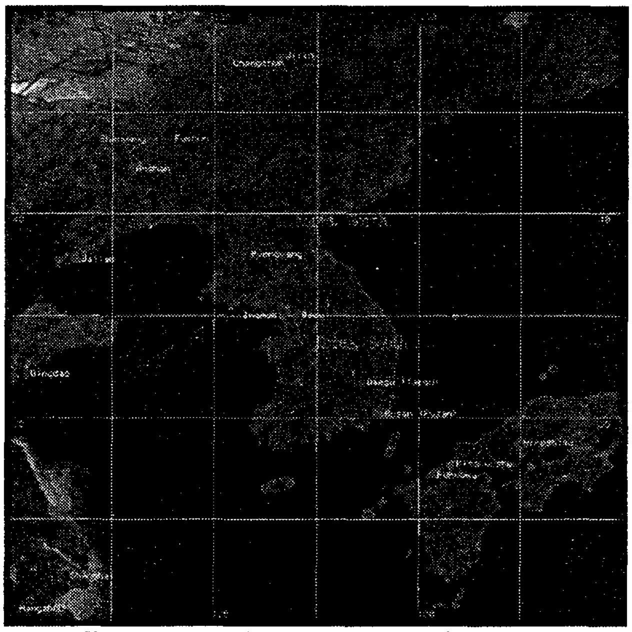

Figure 4. Map of the Korean Peninsula (NASA)

Figure 4 shows the observation point map of Korean Peninsula which observed from ISS Earth observation program. With these data, we can check the sample areas for missions of Korean astronaut. The following examples show the samples for Earth observation mission to be conducted by Korean astronaut (Figure 5, 6, 7).

Example 1: Comparison of Seoul at night

This astronaut photograph illustrates the Seoul urban area at night. Major roadways and river courses (such as the Han River) are clearly outlined by street lights, while the brightest lights indicate the downtown urban core (center of each image) and large industrial complexes.

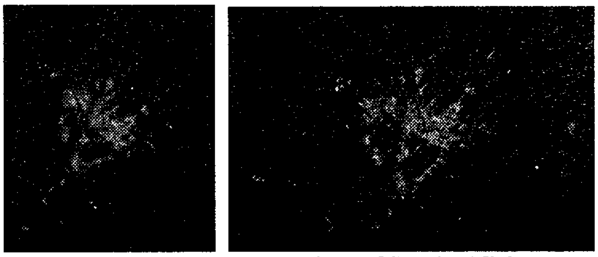

Figure 5. Image Comparison of Seoul at Night [Feb. 9, 2003 (left), Feb. 16, 2005 (right)]

Example 2: Baekdusan

One of the largest known eruptions of the modern geologic period (the Holocene) occurred at 'Baekdusan' Volcano (also known as Changbaishan in China) about 1,000 A.D. The eruption also created the 4.5 ㎞ diameter, 850 meters deep summit caldera of the volcano, which is now filled with the waters of Lake 'CheonJi' (or Sky Lake). This oblique astronaut photograph was taken during the winter season, and snow highlights frozen Lake 'CheonJi' and lava flow lobes along the southern face of the volcano.

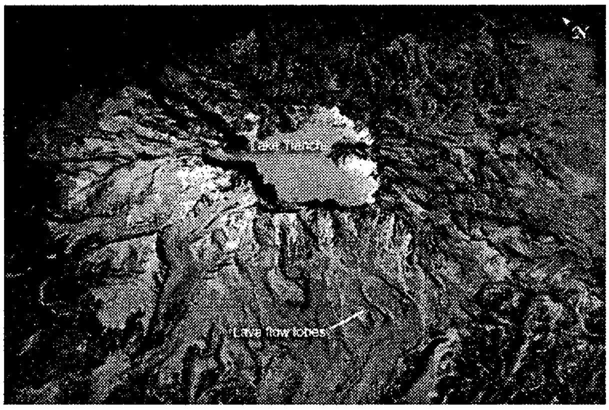

Figure 6. Baekdusan

Example 3: Pohang

The seaport and industrial city of Pohang is visible near the center of this near-vertical photograph. According to a 1980 census, Pohang had a population of more than 200,000. Some of the city's infrastructure can be observed the airport southeast of downtown, wharves jutting into Yongil Bay, and the industrial area south of the river that flows into Yongil Bay. The dark green areas are hills and mountains with elevations ranging from 600 to 1,200 meters. Numerous valleys cutting through the mountain areas help map the rather complex drainage pattern found throughout South Korea.

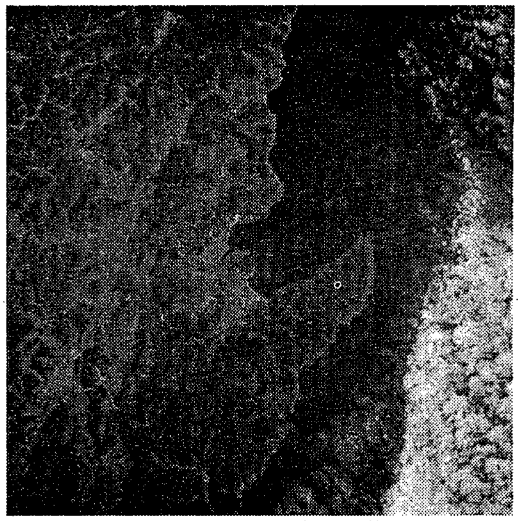

Figure 7. Pohang and Yongil Bay

4. CONCLUSIONS

ISS Russian Segment has the potential to be a valuable platform with window from which to observe the Earth. Researchers can use the ISS RS windows for conducting multi-spectral observations of Earth's land, oceans, and atmosphere. We can also take advantage of the longevity of ISS to observe global changes, geologic activity, land use and agricultural production through remote sensing observations.

To do these researches, we are making plans for an astronaut selection and training with Russia including Korean astronaut's missions. To participate in the ISS utilization through Korean Astronaut Program, we investigate manned space experiment missions. The following subjects are the major expected experiment fields for a Korean astronaut.

• *Earth science (Earth Observation)*

• Biology, Physiology, Physical Science, Education, New Technology etc.

We hope that Korean Researchers suggest many kinds of astronaut's missions in the above fields to utilize the ISS for their researches.

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