Korea Economic Institute of America

ACADEMIC PAPER SERIES

KEI KOREA ECONOMIC INSTITUTE OF AMERICA | 한미경제연구소

SEPTEMBER 10, 2014

JOINING THE ASIA SPACE RACE: SOUTH KOREA'S SPACE PROGRAM

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Introduction

The Republic of Korea (ROK or South Korea) is an emerging space-faring nation seeking to expand its space capabilities in the realms of science, communications, commerce, and national security affairs. The country has passed three important space milestones: the launch of Korea's first satellite, Kitsat-1 (*Uribyŏl-1*) on 10 August 1992; manned space flight by Korea's first astronaut, Yi So-yeon (Yi So-yŏn), on 8 April 2008; and the successful satellite launch with an indigenous Naro (KSLV-1) space launch vehicle (SLV) on 30 January 2013.

Korea now has ambitious plans to develop powerful space launchers, advanced satellites, lunar probes, and deep space exploration capabilities. Seoul's space ambitions partially have been driven by an inter-Korean space rivalry,[1] but the two Korean space programs have significant differences. This paper first will explain the legal and institutional foundations of the ROK space program before turning to the development of space launch vehicles, satellites, and deep space probes. The paper will explore ROK plans for space applications and space security, as well as the possibilities for international competition, conflict, and cooperation in outer space.

International and Domestic Legal Framework

The ROK is a signatory to four of the five United Nations space treaties including the Outer Space Treaty,[2] the Rescue Agreement,[3] the Liability Convention,[4] and the Registration Convention.[5] However, Seoul has not signed the Moon Agreement.[6] The ROK is a member of most relevant international space institutions and conventions, and Seoul recently has been an active member of the UN Committee on the Peaceful Uses of Outer Space (COPUOS). Seoul joined the Missile Technology Control Regime (MTCR)[7] in 2001, and subscribes to the International Code of Conduct against Ballistic Missile Proliferation (ICOC).[8] Seoul also became a member of the Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite (Brussels Convention) in March 2012.[9]

In contrast, the Democratic People's Republic of Korea (DPRK or North Korea) has signed the Outer Space Treaty and the Registration Convention, but has not signed the Rescue Agreement, the Liability Convention, or the Moon Agreement. Pyongyang is a member of the Agreement on the Establishment of the Intersputnik International System and Organization of Space Communications.[10] Both Koreas are members of the Agreement Relating to the International Telecommunications Satellite Organization (ITSO),[11] the Convention on the International Mobile Satellite Organization (IMSO),[12] and the International Telecommunication Constitution and Convention (ITU).[13]

The ROK space program is regulated directly and indirectly by a number of domestic statutes and executive orders such as the Space Damage Compensation Act, the Civil-military Compatible Technology Project Promotion Act, and the Defense Industry Act. However, the Aerospace Industry Development Promotion Act and the Space Development Promotion Act are the primary legal instruments governing ROK space activities. These acts provide the basis for institutional structures and lines of authority and responsibilities. The first clause of the Space Development Promotion Act stipulates that "the objective of the law is to promote the systemic development of space for peaceful purposes, and to develop space probes to provide national security and the sound development of the civilian economy and to improve the standard of living." In general, ROK domestic space law includes an element of import-substitution industrial policy and grants the president broad authority or discretion in several aspects.[14]

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Origins of the ROK Space Program and Institutional Framework

The ROK government's first satellite development plan was unveiled on 11 November 1981 as part of the telecommunications plan in the country's Fifth Five-Year Plan for Economic and Social Development. The government was motivated to provide television broadcasts to remote areas while realizing that greater telecommunications infrastructure would be required for the 1988 Seoul Summer Olympics.[15] The vice minister of telecommunications was appointed to lead a 10-member committee of government officials and private researchers to assess the possibilities for a ROK space program. The committee commissioned two studies, one by the Electronics and Telecommunications Research Institute (ETRI) and another by the Korea Industrial Development Institute (KID).[16]

The two institutes concluded that the timing was premature and it would not be economical due to insufficient demand. Therefore, in February 1982, President Chun Doo-hwan (Chŏn Du-hwan) issued a directive to postpone national space development and to reconsider launching a space program in the 1990s.[17] In January 1985, the Ministry of Science and Technology released a 10-year space development plan, and in December 1987, the Aerospace Industry Development and Promotion Act was enacted (and since revised) to provide the legal foundation for the establishment of the Korea Aerospace Research Institute (KARI).[18] Momentum for the space program began one month before the December 1987 presidential election when candidate Roh Tae-woo (No T'ae-u) pledged to implement a plan to acquire and develop satellites for telecommunications and broadcasting.[19] Following Roh's election, the government drafted a plan in August 1988 to acquire telecommunications and broadcasting satellites; the president approved the plan in April 1989 and the ROK space program began to take form.[20]

The Korea Aerospace Research Institute (KARI) was established in October 1989 and initially was affiliated with the Korea Institute of Machinery and Materials (KIMM) before becoming completely independent in November 1996.[21] KARI's parent ministry is the Ministry of Science, ICT and Future Planning (미래창조과학부), and KARI is responsible for the development of aerospace technologies related to space launch vehicles, satellites, and unmanned aerial vehicles. KARI has six subordinate research centers, and it also manages the Naro Space Center satellite launching facility.[22] Furthermore, there are preliminary plans to establish more R&D centers and work teams under KARI in accordance with the "Medium- and Long-term Space Development Plan,"[23] and presidential directives that resulted from the Korea National Space Committee's consultative meetings.[24]

Since KARI's establishment, growth in its budget and human resources has expanded significantly, but the ROK's space budget is small compared to that of other space powers. In 2012, KARI's budget was $194 million or about 0.017 percent of GDP, the lowest among the space-faring nations.

Table 1. National Space Budgets (Units: US$ million; percent of GDP)

U.S.	Russia	France	Germany	Italy	UK	Japan	India	China	ROK
42,689	8,597	1,742	623	609	341	3,699	1,259	3,432	194
0.283	0.440	0.108	0.048	0.049	0.027	0.062	0.065	0.042	0.017

Source: "우주개발 중장기 계획," 2013년, 11월.

Despite low budget figures compared to those of other nations, Korean citizens tend to view the space budget as high.[25] The ROK government provides multi-year funding for long-term projects, but the budget is subject to review every year; budgets may be increased or decreased depending on the circumstances. Projects along with funding and resource requirements are submitted to the Ministry of Science, ICT and Future Planning (MSIFP) for

Table 2. KARI Annual Budget (Units: years; million wŏn)

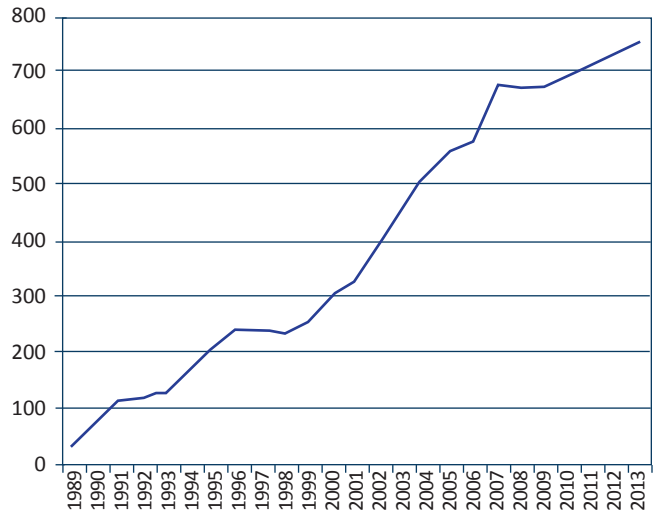
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Budget	9,095	10,363	9,206	10,091	32,124	40,592	59,644	85,827	78,272
Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Budget	72,562	69,758	89,530	121,424	153,700	174,200	220,300	317,959	348,000
Year	2008	2009	2010	2011	2012	2013	2014		
Budget	363,000	325,000	365,500	274,837	295,708	392,356	450,316		

Source: KARI data.

review. ROK law stipulates that any government project over ₩50 billion (about $50 million) must be subjected to a feasibility study for approval. In KARI's case, the MSIFP delegates the review to the Korea Institute of Science & Technology Evaluation and Planning (KISTEP), and if approved, the MSIFP submits the KARI project budgets and total budget to the Ministry of Strategy and Finance for incorporation into the national budget.[26] The executive branch then submits the budget to the National Assembly for approval. Because space projects are expensive, competitors for government funding often demand reductions since the expenditures can appear to lavish in comparison. Nevertheless, KARI views the Park Geun-hye government and the former Lee Myung-bak as being quite supportive of the space program.[27]

Over the last three years, the government has begun to provide funding for R&D by private firms.28 In particular, the government is trying to foster an expansion of the private sector in the realm of satellite applications under its Satellite Information 3.0 (위성정보 3.0) program, which will be explained below.

Figure 1. Growth of KARI Personnel



The Space Development Promotion Act stipulates that the government must draft a "Medium- and Long-term Space Development Plan" (or "Space Development Plan" for brevity) every five years that addresses or explains policies, objectives, strategies, promotion plans, required funds and resources, the development of human resources, international cooperation, the promotion of space industries, the use and management of spacecraft, applied results from research, and other items as decreed by the president. The act also requires the establishment of a national space committee that serves directly under the president.[29] The committee can have up to 15 members and is chaired by the Minister of Science, ICT and Future Planning, but otherwise presidential discretion determines the committee's constitution.[30]

The Korea National Space Committee (KNSC; 국가우주위원회) oversees the inter-agency production of the space development plan, and the committee subsequently is responsible for drafting policies and procedures for implementation of the plan. The current plan was released in November 2013, and the KNSC convened its seventh meeting on 30 May 2014 to discuss its realization.[31] At his meeting, the KNSC released two planning documents outlining the details of the government's space policy objectives and the strategies to achieve them.

Rockets, Missiles and Space Launch Vehicles

South Korea's development of rockets and missiles originated with the military's weapons modernization program—codenamed the *Yulgok* Project—in the 1970s. In December 1971, President Park Chung-hee (Park Chŏng-hŭi) issued a directive to develop a ballistic missile with a range of 200km, sufficient to strike Pyongyang from ROK territory, by 1975. The extreme time constraint pushed ROK engineers to reverse-engineer the Nike-Hercules, an American surface-to-air missile with a secondary surface-to-surface role that had been deployed with U.S. Forces Korea. The result was the Paekkom (백곰), which was flight-tested in 1978. However, the ROK was heavily dependent upon the U.S. for technology and components,[32] and Washington insisted that Seoul enter into a bilateral military agreement in 1979 to limit the range of ROK ballistic missile to 180km in exchange for U.S. technical assistance.[33] This bilateral agreement later became an impediment to the ROK's efforts to extend the ranges of its ballistic missiles and to develop space launch vehicles.

KARI began developing rockets in 1990, successfully launching the solid-fuel KSR-I sounding rocket in June and September 1993, and the solid-fuel two-stage KSR-II in July 1997 and June 1998. The liquid-fuel single-stage KSR-III, the final sounding rocket in the series, was flight tested in November 2002 as KARI embarked upon the development of its first SLV. After several delays due to budget constraints and unanticipated barriers to receiving technology transfers, KARI turned to Russia's Khrunichev State Space Research and Production Center in 2004 to establish a joint SLV project.[34] An agreement was announced in January 2005 that provided for the development of the two-stage

KSLV-I (Naro-1) based on the Russian Angara booster. Under the bilateral agreement, the Russian team built the liquid-fuel first stage and KARI built the solid-fuel second stage with Russian technical assistance.[35]

Three launches of the Naro-1 SLV were conducted from the Naro Space Center in South Jeolla (Ch'ŏlla) Province. The first two launches in August 2009 and June 2010 failed,[36] but the third and final launch on 30 January 2013 was a success, placing the *Science and Technology Satellite 2C*, or *Naro Science Satellite* (나로과학위성), into low earth orbit.[37] KARI officially began developing the KSLV-II in 2010, but in 2008 the government already was commissioning SLV-related research projects at the nation's top engineering schools to support the development of SLVs and other space hardware.[38]

The three-stage KSLV-II is being built without foreign technical assistance, and it is designed to launch 1.5-ton satellites into low-earth orbit (600-800km).[39] The original target date for the first launch was 2020-2021, but that has been moved up to 2019. The first stage is liquid-fueled and has four clustered engines producing 75 tons of thrust each, while the second and third stages each have one of these engines. KARI plans to conduct the first flight test with only a modified first stage configured with one engine in 2017. In 2019, KARI intends to launch the complete three-stage system, probably with a dummy payload before launching a functioning satellite in 2020.[40] The total development cost of the KSLV-II is estimated to be about ₩1.957 trillion (or about $1.9 billion).[41]

By the end of the next decade, KARI plans to have used the KSLV-II to launch 23 next-generation medium satellites (14 single launches; nine launches with dual payloads); four next-generation micro-satellites (three single launches; one dual payload); two multi-purpose satellites; as well as an unmanned lunar orbiter and an unmanned lunar landing craft. KARI seeks to provide space launch services for seven foreign satellites by around 2025, just as KARI intends to turn towards development of a new SLV with a launch capacity of 3.0-tons.[42] KARI also intends to launch a lunar orbiter and a lunar landing mission with the KSLV-II, but the Park Geun-hye government currently is discussing the issue to determine whether it will provide the funding and resources for the lunar landing mission, which would take place around 2025, or long passed President Park's tenure.[43]

To secure government support for space projects, KARI generally needs to demonstrate the economic feasibility and benefits. International cooperation can help justify KARI's space endeavors since collaborative projects already have foreign validation. For example, KARI and the U.S. National Aeronautics and Space Administration (NASA) have agreed to cooperate in NASA's International Lunar Network (ILN) initiative,[44] and KARI had planned to utilize the KSLV-II to launch payloads to the moon's surface in support of the project. This provided a strong rationale for KARI to pursue or even accelerate the KSLV-II program, but in February 2014 NASA told KARI that it would not permit KSLV-II launches for the ILN. KARI officials were very surprised at NASA's refusal to accept KSLV-II launch support, apparently for nonproliferation reasons and supposed opposition from the U.S. State Department.[45] Nevertheless, the ROK has no intention of suspending the KSLV-II program. It will continue but the setback with the ILN project could delay completion of the KSLV-II and the ROK's subsequent launch schedule if the Park government decides to slow down funding.[46]

The ROK also intends to move forward with the development of more powerful boosters to expand ROK capacity and autonomy in space. According to the 2013 Space Development Plan, KARI will begin development of the KSLV-III around 2027. This launcher will have the capacity to place a 3-ton payload into mid-level orbit (20,000 km), and smaller payloads into geosynchronous orbit (36,000 km). The ROK intends to enter the market for space launch services with the KSLV-II, and then start developing a larger SLV around 2033. To build the KSLV-III, KARI will develop an improved 75-ton thrust engine and solid-fuel boosters.[47] With the development of Korea's fourth generation SLV, KARI intends to transfer satellite launch services to the private sector while focusing on projects such as deep space exploration and a space station, most likely with international partners. To continue its SLV development projects, the ROK will seek to acquire foreign technologies and conduct joint research in the following areas: high-performance, multi-stage combustion cycle engines; engine control; methane engines; and hydrogen engines.[48]

The Naro Space Center

The Naro Space Center is located on Outer Naro Island, on the southwestern coast of South Jeolla (Ch'ŏlla) Province. Work on the center began in 2000 and ground was broken for construction in August 2003.[49] Russia's Khrunichev State Research and Production Space Center, provided technical assistance in building the center, but the project was delayed.[50] The space center was completed in June 2009 at a cost of ₩312.4 billion (about $300 million)[51] and now the facility is undergoing expansion (as explained below).

Three launches of the Naro-1 (KSLV-I) SLV were conducted at the site, and much of the design and development work for new SLVs will be done at the expanded space center. The geographic location enables launches towards the south to place satellites into polar orbits;[52] however, rockets launched directly eastward would pass very near Hiroshima and directly over Osaka, which probably would bring strong protests from Japan. According to the 2013 Space Development Plan, expansion of the Naro Space Center will continue until 2040 in order to launch larger and more powerful rockets, including the fourth-generation KSLV slated for development around 2040.[53]

The expansion of the Naro Space Center consists of three main parts: facilities for developing and testing new rocket engines; the pads and launch tower facilities for SLV launches; and the tracking, control and support facilities onsite and offsite. For SLV development, KARI has been building 10 testing facilities for rocket engines including facilities for liquid-fuel engine static test firings and turbo pump testing. The total cost of these facilities is ₩440 billion (about $430 million), or about 23 percent of the total development costs for the KSLV-II.[54] Construction of the engine combustion and turbo pump testing facilities was scheduled for completion in April 2014,[55] and they should be complete and ready for use by the end of this year.[56] If construction remains on schedule, the plan is to test fire a new liquid engine with seven tons of thrust by July 2015, and then flight-test a 75-ton-thrust liquid engine mounted on a modified KLV-II first stage in December 2017.[57] To certify the reliability of the new engines and turbo pumps, KARI will conduct about 200 engine test firings and about 150 turbo pump tests.[58] Final adjustments or modifications of the engine design should be finished by March 2018 in order to meet the KSLV-II flight-test target date in 2019.[59]

As KSLV-II development progresses, KARI will expand the SLV assembly facility and the satellite testing facility at the space center; KARI also will build a second launch platform. Satellite tracking and control facilities at the Naro Space Center and on Cheju Island will be expanded and upgraded. KARI also will explore the possibility of establishing partnerships abroad to build or share satellite tracking facilities. Once the ROK's tracking and control infrastructure is completed and becomes operational in the next decade, South Korea plans to provide commercial space launch services in the international market.[60] If KSLV-II development succeeds according to plan, KARI plans to conduct two or three space launches per year from the Naro Space Center, and then transfer launch services to the private sector sometime after 2025. If the development of the KSLV-III and the fourth-generation launcher proceeds according to plan, KARI also will build a third and a fourth launch pad at the space center.[61]

> ***"Governments provide the greatest demand for satellite imagery, so the ROK government can support national firms by purchasing imagery products in accordance with its industrial policy goals."***

Satellites and Satellite Applications

Satellites have a broad range of applications that affect our everyday lives, and these applications continue to expand with the development and integration of new technologies.

The ROK assembled its first satellite, the 50-kg microsatellite *Kitsat-1* (*Uribyŏl-1*), for launch with a European Space Agency Ariane SLV in August 1992.[62] The Satellite Technology Research Center (SaTReC) was established in 1989 within KAIST to develop satellites and to train human resources. SaTReC has moved up the technology ladder over the last 25 years as it has been working with KARI and other government agencies as well as private sector firms. The SaTRec Initiative, private spin-off firm established by former KAIST engineers, became the first ROK company to enter the foreign satellite market when the firm built a satellite bus for Malaysia's *RazakSAT* satellite and another for the United Arab Emirates' *DubaiSat-1* for launches in 2009.[63]

Initially, the ROK acquired expertise and technology in the satellite sector before beginning its indigenous SLV program. South Korea's first two attempts to orbit a satellite with the Naro-1 SLV failed on 25 August 2009 and on 10 June 2010, but the third attempt succeeded on 30 January 2013. However, the DPRK won the inter-Korean satellite race when the Ŭnha-3 SLV launched the *Kwangmyŏngsŏng-3* into low earth orbit on 12 December 2012.[64]

In May 2013, only two months after President Park's inauguration, the ROK government issued a directive to foster the growth of ROK firms that provide satellite imagery to the domestic market, and to strengthen their competitiveness in satellite service markets for imagery, communications, and applications. This directive was reflected in the Medium- and Long-term Space Development Plan released in November 2013.[65] The government views the

space industry as a new frontier that is very important for the ROK's effort to climb the technology ladder. The ROK government believes space development will help foster the creation and expansion of high-tech firms that will create more high-paying jobs while new services derived from space technologies will improve the Korean quality of life. Between now and 2017, the size of the Korean market for space services is expected to triple from ₩880 billion (about $870 million) to ₩2.8 trillion (about $2.7 billion).[66] The number of venture capital firms working in the space industry is expected to grow from six to about 50, and the number of jobs in this sector is expected to grow five-fold to about 4,500.[67]

The ROK government's vision of the space industry's trajectory is outlined in its "First Comprehensive Plan for Satellite Information Applications" (제1차 위성정보 활용 종합계획).[68] The plan and the future outcome of its successful execution are called "Satellite Information 3.0" (위성정보 3.0). The satellite app dimension of the ROK space program highlights the benefits of space development for average citizens, and Satellite Information 3.0 is to receive industrial policy support typically received by other growth industries in the past. MSIFP Minister Ch'oi Mun-gi disclosed the satellite app plan during the seventh meeting of the Korean National Space Committee on 30 May 2014.[69] Minister Ch'oi said that "the plan was drafted in order to realize the establishment of a creative economy (창조경제)"[70] which has been one of President Park's main domestic policy objectives.

Governments provide the greatest demand for satellite imagery, so the ROK government can support national firms by purchasing imagery products in accordance with its industrial policy goals. In the South Korean case, between 2006 and 2013, the ROK government obtained imagery from ROK satellites worth ₩400 billion (about $390 million), which otherwise would have been purchased from foreign suppliers.[71] However, between 2000 and 2013, ROK satellite imagery sales to nongovernmental entities amounted to only ₩24 billion (about $23 million).[72] Therefore, the ROK government views the nongovernmental market as having the greatest potential for growth.

KARI's Satellite Information Research Center (SIRC; 위성정보연구소) currently maintains a satellite imagery database and network for ROK government customers. The center has 79 staff divided into two offices and seven teams.[73] The SIRC collects the imagery data and processes it into data packages according to government agency needs. The ROK government plans to make the SIRC independent from KARI within the next couple of years as it ramps up efforts to provide more services to the public. The government also plans to establish a "National Satellite Information Application Support Center" in 2015 to manage the roll out of the "Satellite Information 3.0" program.[74]

The SIRC will help manage the ROK national satellite collection effort by providing input to satellite operators regarding customer needs. Furthermore, the center will establish and manage a consolidated platform that will integrate satellite data with other databases so that the information will be searchable with new computer software. This data will be opened to the public in the form of new applications according to the "Satellite Information 3.0" plan. By 2017, the number of end-users is expected to reach about 50,000.[75]

The applications that will be available under "Satellite Information 3.0" are being provided under the acronym GOLDEN (Solution): **G**eographic information; **O**cean; **L**and; **D**isaster; **E**nvironment; **N**ational security. The plan describes these categories as areas that significantly impact citizens' quality of life, and therefore worthy of government support. ROK government agencies are receiving government funding to support the development of space-based applications with the aim of transferring these technologies and apps to the private sector for mass marketing.[76]

Table 3. ROK Government Agency Work on Satellite Applications and 2014 Budgets

Government agency	Applications	2014 budget
Ministry of Agriculture, Food and Rural Affairs	Development of technology to create a "smart palm app" to monitor agricultural production	₩2.4 billion (about $2.3 million)
Ministry of Environment	Establishment of a land database	₩4.4 billion (about $4.3 million)
Ministry of Land, Infrastructure and Transport	Creation of maps for areas where public access is restricted	₩2.0 billion (about $1.9 million)
Ministry of Oceans and Fisheries	Research into applications derived from a maritime satellite in geosynchronous orbit	₩2.4 billion (about $2.3 million)
Korea Meteorological Administration	Research into the operation of a meteorological satellite and the related apps technologies	₩11.2 billion (about $11 million)

Source: "제1차 위성정보 활용 종합계획," 관계부처합동, 2014 년 5월, p. 20.

(The GOLDEN Solution project currently is in the planning stage, but the intention is to improve the government online network for 23 ROK government agencies first before releasing a complete

data platform to the public in 2017. The SIRC, in cooperation with IT firms, will develop software to search, access, and deliver data to customers in a user-friendly manner. To support this effort, the Korea Space Technology Promotion Association (KSTPA; 한국우주기술진흥협회) and its Subcommittee on Satellite Information Industries (위성정보산업 분과위원회) were established in May 2014.[77] To enter foreign markets, the ROK government is prepared to provide Official Development Assistance (ODA) funds to countries in Southeast Asia and South America so that aid recipients will be able to purchase products and services from ROK suppliers in the GOLDEN Solution project.[78]

The industrial policy program to support the establishment and growth of Korean firms in accordance with the GOLDEN Solution project is outlined in its affiliated STAR Exploration project. STAR is an acronym for "**S**a**T**ellite Intelligence **A**pplication for **R**enovative space business" and the project seeks to identify and support successful firms. In practice, the KSTPA and its Subcommittee on Satellite Information Industries will consult with the private sector and work to link established government satellite services with private firms. The subcommittee will identify successful business models and share them with the private sector. Next year, the KSTPA is to unveil a roadmap to develop and support satellite information technologies, and to transfer those technologies to private firms when appropriate. In sum, the plan is to promote strategies for the development of new services that integrate imagery, communications, and navigation data, and then support the commercialization of these services in domestic and international markets.[79]

A prime example of cooperation between the government and private sector to commercialize space technologies is the current *Kompsat-3A* project. KARI designed and built *Kompsat-3* (아리랑 3호), an earth observation satellite that was launched in May 2012 from Japan's Tanegashima Space Center. Now KARI is assisting Korea Aerospace Industries (KAI; 한국항공우주산업) and Asia-Pacific Aerospace (AP 우주항공) build the *Kompsat-3A*, a near replica of the *Kompsat-3*, in an exercise that will transfer technologies to these firms and enable them to enter the satellite supplier market.[80] The Ministry of Science, ICT and Future Planning is tasked by the president to conduct studies and to develop strategies for the commercialization of the space sector, but the ministry delegates most of the actual work to KARI for subsequent review by the MSIFP's Space Policy Division. The MSIFP has commissioned KARI's Policy and International Cooperation Division to conduct an ongoing study on the commercialization of space technologies. When new space policies require revised or new legislation and/or new presidential decrees, KARI's Policy and International Cooperation Division usually drafts the text, which generally has been accepted with little or no change by the MSIFP and the presidential office.[81]

The "First Comprehensive Plan for Satellite Information Applications" also includes efforts to cultivate human resources and to encourage international cooperation and joint research. The National Satellite Information Application Support Center will provide internships and help connect job seekers with employers in the public and private sectors. In 2012, there were about 360 people working in South Korean firms and research institutes in the field of satellite imagery. By 2017, South Korea will need about 600 specialists to work in this field. Currently, about 100 university and graduate students per year are majoring in this area. To support the development of these human resources,

Table 4. Status of ROK Government Institutions Working with Satellite Imagery Applications

Entity	Date of establishment	Primary functions and activities	Organizational structure	Number of personnel	2014 budget
KARI's Satellite Information Research Center	December 2007	Satellite tracking and data reception; processing and distributing satellite imagery	Two offices; seven teams	79	₩1.85 billion
Korea Meteorological Administration's National Meteorological Satellite Center	April 2009	Draft and manage policy on meteorological satellites; establish foundation for satellite operation	Three departments	78	₩1.11 billion
Ministry of Oceans and Fisheries' Maritime Satellite Center	December 2012	Manage plans for Coms (천리안) satellite; process satellite data; research satellite apps; international cooperation	Three teams	27	₩3 billion
National Geographic Information Institute's Geospatial Imagery Information and Photogrammetry	July 2003	Establish database infrastructure for aircraft/satellite imagery; mapmaking; imagery analysis & management	One department; three teams	17	₩25 billion

Source: "제1차 위성정보 활용 종합계획," 관계부처합동, 2014 년 5월, p. 31.

the government plans to establish the Space Specialist Education Center (우주전문교육센터). This center will manage a program to strengthen the capacity of human resources in the private sector, government, and research institutions.[82]

"Satellite Information 3.0" recommends cooperation with international partners such as NASA, the European Space Agency (ESA), international organizations, as well as academic and research institutions.[83] For example, the ROK is a member of the Group on Earth Observations (GEO) and its Global Earth Observation System of Systems (GEOSS). The GEO has established a division of labor among participants to provide satellite data on specific problems, and it provides an institutional network whereby members can contribute their data to mitigate international problems.[84] For example, the pooling of satellite data could be applicable in the search for the missing Malaysian Airlines flight 370 that disappeared in March 2014, or in the case of a large national disaster. The ROK currently has two tasks in the GEO: Integrated Water Information (including floods and droughts); and High-Impact Weather Prediction and Information.[85] Another example of international cooperation is the ROK's participation in the Sentinel Asia,[86] an international initiative under the Japan Aerospace Exploration Agency (JAXA) and the Asia-Pacific Regional Space Agency Forum (APRSAF).[87]

Manned Space Flight

The ROK first began planning for a manned mission in 2001, seven years before Yi So-yeon (Yi So-yŏn) became the first and only Korean astronaut to travel to space.[88] On 8 April 2008, Yi boarded the Soyuz TMA12 with cosmonauts Oleg Kononenko and Sergei Volkov to travel to the International Space Station (ISS) where she conducted scientific experiments and promoted the ROK space program.[89] Yi was selected as one of two Korean astronauts from among 36,206 applicants in 2006.[90] The other successful candidate, Ko San, had been chosen for the mission but one month prior to launch he was disqualified for having violated protocols at the cosmonaut training center. Ko, a 30-year old computer scientist, obtained training documents he was not authorized to have and then removed the documents from the training center.[91]

At the time of her mission, Yi was 29 years old and had just earned her Ph.D. in engineering from the Korea Advanced Institute of Science and Technology (KAIST). Yi also excelled in athletics having received her third *dan* in *t'aekwŏndo* and having competed in a marathon.[92] Yi was praised by ROK media and she was admired as a national role model, particularly by young Korean women. Yi officially spent a total of 10 days, one hour and four minutes in space, but during reentry a malfunction caused the Soyuz-TMA-11 space capsule to go off course on a ballistic trajectory. Yi and her colleagues, American Peggy Whitson and Russian Yuri Malenchenko, were subjected to twice the normal amount of G-forces during dangerous reentry that took the space capsule 420km away from the target landing area. Yi suffered trauma to her back and had to be hospitalized but she fully recovered.[93]

Despite Yi's accomplishments, some Koreans questioned whether Yi's flight was worth the price tag of ₩26 billion (about $25 million) even though private sponsors paid ₩20 billion of the cost.[94] After her mission, Yi became an adjunct professor at KAIST and a researcher at KARI. She also made several public appearances and gave public lectures to promote the space program. But in 2013,[95] controversy surrounding Yi emerged after it was learned that she had gone to the U.S. to enroll in an MBA course and was getting married to a Korean-American ophthalmologist on 1 August 2013. Shortly thereafter she was under attack by critics who suggested the investment to train her as an astronaut has been wasted.[96] In July 2014, she sent her letter of resignation to KARI, effective the following month.[97] Despite media reports of resentment or disappointment over Yi's life choices and resignation from KARI, Hwang Chin-young, director of policy and international cooperation said that Yi made great contributions to the ROK space program and she fulfilled all her responsibilities and obligations. Hwang said that people should not feel animosity towards her for falling in love and getting married.[98]

KARI took advantage of the opportunity for a manned mission, but there are no current specific plans for another. A few years ago there was another potential opportunity to send a Korean astronaut to the ISS as part of a NASA experiment on Polarimetric Spectral Intensity Modulation (PSIM). KARI submitted a proposal to participate as a partner. The science and technology of KARI's proposal was accepted but the proposal lost out to a competitive bid. If KARI had been selected, a strong argument could have been made to send a ROK scientist to the ISS as a participant.[99] KARI has not abandoned the goal of manned missions, but the priority now is the development of SLVs, advanced satellites, and an unmanned lunar mission. The issue of manned space flight will be revisited in the future, after 2030 and the development of new SLVs.

ROK Space Security Plan

As government agencies and firms deploy assets into earth orbit, they naturally become concerned about the vulnerability of those assets because they are expensive to design, develop, assemble, and launch into space. Plus, if they malfunction or are lost, it is costly to replace them. In May 2014, the ROK government released a 10-year (2014-2023) space security plan, literally: "The First Space Danger Preparation Basic Plan [Proposed]" (제1차 우주위험대비 기본계획[안]).[100] The Park government created the initiative for the plan when it issued directives in May 2013 to "make the ROK a space power with independent space technologies" and to "strengthen national systems for managing (and responding to) natural disasters."[101] The government began an inter-agency policy research project on space security in October 2013, then held inter-agency consultations and conducted planning research in May 2014 before the seventh meeting of the Korean National Space Committee.[102] [103]

Space-Based Threats

Space-based threats or dangers pose risks to: satellites and spacecraft on lunar missions or deep space voyages; human beings on earth; and terrestrial facilities and structures. The threats originate from: man-made sources such as space debris or space weapons; natural objects originating in outer space such asteroids, meteors or comets; and electromagnetic pulses from solar flares. Every day about 100 tons of natural objects fall to earth but most of it burns up before reaching the earth's surface.[104] About 20-30 satellites fall out of orbit every year, with some of them sending debris to the ground. Some of these satellites contain nuclear power sources that can release radioactive materials into the atmosphere and onto the earth's surface.[105]

Since *Sputnik-1* was launched in 1957, about 7,000 satellites have been placed into earth orbit, but about 3,000 of those have decayed and fallen back to earth. This does not include space debris from rockets and other pieces of man-made materials orbiting the earth. There are about 21,000 pieces of space debris measuring 10cm or more in diameter, and over 50,000 pieces measuring over 1cm in diameter, posing a serious risk to satellites.[106] This problem was greatly exacerbated by a Chinese anti-satellite interception test in January 2007,[107] and by the collision of the Iridium-33 satellite and Russia's Cosmos-2251 satellite in February 2009.[108]

The Inter-Agency Space Debris Coordination Committee (IADC) is an international governmental forum for coordinating activities related to the issue of space debris. The ROK is not a member yet, but the ROK is an active participant in UN Committee on the Peaceful Uses of Outer Space (COPUOS), which receives an annual report from the IADC space debris mitigation.[109] National space agencies share data on space debris, but they do not share all of their data due to national security concerns. The ROK government seeks greater international cooperation on space debris, but is not satisfied with the level of data sharing. For example, according to the ROK government, the U.S. Joint Space Operations Center (JSpOC) only shares data on about 40 percent of the objects it tracks in earth orbit due to the sensitivity of U.S. reconnaissance satellite orbits[110] and the likely desire to protect sources and methods that constitute the U.S. satellite tracking capability. The result is that Seoul has decided to deploy advanced monitoring and tracking assets to address its space security concerns.

The ROK government's awareness and concerns about space security were elevated by these recent events: a large meteor exploding over Chelyabinsk, Russia in February 2013;[111] the EU satellite GOCE falling out of orbit in November 2013;[112] and meteorites striking Korea in March 2014.[113] These events may have accelerated the unveiling of the space security plan in May 2014, but the issue already was on the government's radar screen.

In December 2010, the ROK government drafted the "Space Fragment Collision Response Manual" to protect its satellites.[114] Currently, the Korea Astronomy and Space Science Institute (KASI; 한국천문연구원) has been tracking space debris and satellites that could threaten ROK satellites.[115] In November 2013, the ROK government drafted the "Standard Manual for Crisis Management [in the case of] Space Debris Impact" (or Space Debris Impact Manual).[116] In 2013, when the ESA's GOCE satellite (Gravity field and steady-state Ocean Circulation Explorer) was falling out of orbit,[117] the ROK government formed an inter-agency monitoring team consisting of personnel from what then was called the Ministry of Education and Science and Technology, KASI, KARI, and the ROK Air Force.[118]

The ROK government's sense of space insecurity resulted in the 10-year space security plan that will have important implications for legal and institutional frameworks, budgets and resource allocation, and the U.S.-ROK alliance relationship. The space security plan stipulates that two monitoring systems will be developed and deployed by 2024: one for tracking and monitoring space debris that could threaten ROK space assets; and another for monitoring and tracking objects that could strike ROK territory.

The government is still discussing the institutional arrangements and necessary changes to legislation and presidential decrees

to implement the plan. The aim is to revise the legal framework by the end of this year, and to establish the institutional structures in 2015.[119] According to the plan, the government will establish the Space Danger [Threat] Monitoring Center (SDMC; 우주위험감시센터) to cooperate with international partners and coordinate with domestic institutions to integrate surveillance and tracking data, conduct threat analysis, and provide reports to senior policymakers and government responders.[120]

The SDMC will analyze the data to assess the likelihood of space objects falling on ROK territory, as well as the likelihood of objects colliding with ROK satellites in outer space.[121] In the case of a possible satellite collision in earth orbit, the center will notify KARI so it can direct the satellite to take evasive maneuvers. And in the case of a possible surface strike on ROK territory, the SDMC will provide early warning and other information to the ROK government so that it can mobilize national crisis management institutions and natural disaster responders.[122]

The goal is to develop and roll out a system between 2018 and 2023 with the capability to track, monitor, and assess dangerous space objects in orbit. Initially, the system will focus on large natural objects and satellites over one ton. The plan calls for the deployment of five optical cameras around the North Pole and high latitude areas,[123] and the installation of 5X5 arrayed radar systems in the ROK by 2023. The system also will include the installation of five Omni-Directional Weapon Locating Radar (OWL-Net) systems at overseas locations.[124] The goal is to develop a system with precision tracking radars and large-aperture electronic optical equipment for tracking objects 10 cm in diameter by 2020, and one centimeter in diameter by 2040.[125]

The second system will focus on objects that could fall from deep outer space or earth orbit and strike ROK territory. The subsystems and hardware in each of these arrangements are slightly different because they monitor different things traveling different trajectories and areas. The surface strike early warning system will have a network of 25 detection and surveillance facilities that will be deployed in the ROK by 2020. The system also will include five optical telescopes installed in the ROK and abroad by 2023 to monitor the horizon and calculate the expected orbits of objects. For more precise tracking data, the system will include radars and 2-meter optical surveillance telescopes that will be installed by 2023 in the ROK and abroad. The goal is to deploy a network and system by 2023 that will have the capability to determine the trajectory and expected impact location of asteroids 50 meters in diameter.

"The ROK government's sense of space insecurity resulted in the 10-year space security plan that will have important implications for legal and institutional frameworks, budgets and resource allocation, and the U.S.-ROK alliance relationship."

The government assessment is that it currently has the equivalent of 30 percent of the U.S. space tracking capability, but the goal to improve to 80 percent of the U.S. benchmark by 2025, and to 90 percent by 2035.[126] As the ROK acquires a more sophisticated capability to track man-made and natural objects in space, the government believes this will enhance Seoul's data-sharing opportunities with other friendly space powers. The integration of foreign data into ROK databases should improve ROK analysis, but the average citizen probably greatly overestimates the ROK's current and future capabilities. The systems will not be perfect, but their symbolism provides politicians and bureaucrats with an opportunity to demonstrate to citizens that they are upholding their responsibilities to protect the public.[127]

It is expensive to deploy these monitoring and surveillance systems, so when considering their costs, imperfections, and the probability of space objects striking ROK territory, questions naturally emerge regarding dual-use applications and integration into air defense and missile defense systems. International treaties and domestic law restrict the ROK to peaceful uses of outer space; however, land-based, sea-based and space-based early detection and tracking systems that feed data into missile defense systems do not violate international or ROK domestic space law. Nevertheless, these systems as they might relate to ROK missile defense plans and future deployments could generate significant controversy because of opposition from China in particular, but also from Russia and the DPRK.

The ROK government, whether led by the ruling party or opposition party, seeks to maintain good relations with China. The bilateral relationship is important because of deep economic ties and Seoul's desire to obtain Beijing's cooperation in managing DPRK-related problems or challenges. Therefore, the ROK is reluctant to alienate China out of the fear that Beijing could be less than cooperative in the case of a crisis with the DPRK, and Beijing frequently has expressed strong opposition to enhanced

U.S.-led missile defense in Northeast Asia. The ROK is planning to deploy its Korean Air and Missile Defense (KAMD) system, but so far the government has expressed ambivalence towards the U.S. deployment of Terminal High Altitude Area Defense (THAAD) missiles even though such a deployment could be critical for the U.S. fulfilling its alliance commitments in the case of a military conflict breaking out on the Korean Peninsula.[128]

The third dimension of the ROK's space security plan is related to the potential damage from solar flares that emit large amounts of electromagnetic pulses sufficient to damage satellite electronics and electrical systems, and in extreme cases, electronics and electrical systems on earth. To monitor and assess the risks of damage from increases in dangerous solar energy pulses, the ROK seeks to deploy sensors such as the *GEO-Kompsat-2A* in geosynchronous orbit, and acquire or develop the necessary software, human resources, and systems to provide analysis and early warning of the risks.[129]

International Cooperation

James Clay Moltz writes that a space race is underway in Asia, but that the prospects for rivalry, competition, conflict, or cooperation are uncertain.[130] Moltz correctly ascertains that regional relations regarding outer space issues are a "*subset* of broader political, economic, and strategic relations within Asia."[131] Regional relations are characterized by what President Park calls "the Asian paradox." Regional trade, investment, and product supply chains have resulted in East Asia becoming more integrated economically than Europe. The economic interdependence literature seems irrelevant as territorial issues, historical legacies, and rising nationalism all contribute to underlying tensions despite the absence of war. Several countries in the region are now democracies or transitioning to democracy: the Republic of Korea, Japan, the Republic of China (Taiwan), India, Indonesia, the Philippines, and Burma. However, it seems that the "democratic peace" hypothesis could be facing hard tests in the region, and if the hypothesis is rejected, rivalry or conflict between regional democracies could spill over into their outer space activities.

The Republic of Korea is bound by international treaties and domestic law to confine its space activities to "peaceful" endeavors. However, the regional space race is characterized by strategic interaction—no single actor has complete control over outcomes. Seoul's actions will be influenced by the actions of others, especially the U.S., Russia, China, India, Japan, and the EU. If the outer space commons becomes militarized, the ROK will have no choice but to follow suit. Furthermore, we should expect the ROK to implement strong countermeasures to DPRK space-based threats, whatever the potential ROK targets might be.

We cannot assume that space rivalry, competition, and conflict are inevitable in Asia; the gains from cooperation create strong incentives to avoid negative and costly outcomes. However, negative outcomes cannot be ruled out. If Asia's space-faring fail to cooperate, all of their space assets will be at risk of being degraded or lost. There would be no winners, and even though the ROK has fewer space assets than other space powers, the ROK is in a weaker position to run an antagonistic space race compared to some of its Asian neighbors. Therefore, the ROK has tried to remain neutral when the big space powers—the U.S., Russia, and China—have been deadlocked over issues of governance and arms control in space.[132] In other words, Seoul seeks to influence the big space powers to exercise restraint and avoid rivalry and conflict in space.

A cooperative environment is necessary for the ROK to pursue its international cooperation goals that will greatly influence the trajectory of the ROK program. KARI and other Korean entities in government, research institutions, and the private sector seek international cooperation for mutual goals but also for technology transfers in support of import substitution and greater autonomy. However, it can be difficult to balance these goals since they can be incompatible at times. The ROK's long-term strategy is to provide space-based data and contribute to international public goods in the realms of disaster relief, search and rescue operations, environmental protection and resource management. An example of this strategy is Seoul's participation in the Sentinel Asia and the Asia-Pacific Regional Space Agency Forum (APRSAF). However, strategic considerations have led the ROK to decline participations and membership in the China-led Asia-Pacific Space Cooperation Organization (APSCO).[133] Beijing has encouraged Seoul to join APSCO, and although the ROK could benefit from membership, the potential costs are perceived to be greater than the benefits since NASA, JAXA, and the ESA probably would be less willing to cooperate with KARI if the ROK embraced APSCO.[134]

The ROK seeks greater space cooperation with the U.S., but Washington's long-term proliferation interests have been an obstacle. The past U.S. policy has been neither to obstruct nor to encourage the advancement of the ROK space program. This approach probably was appropriate and arguably was successful in underlining Washington's nonproliferation objectives. However, the U.S. position will become more difficult to justify and support as the ROK space program becomes more advanced. The ROK is a treaty ally and close strategic partner. Space assets and technologies have multiple dual-use applications that

can be utilized to further U.S.-ROK bilateral interests. The U.S. policymaking process is complicated by the fact that its space policy is a complicated and technical issue area, and there are divergent views and interests across the American domestic political landscape, which is alien to ROK space specialists. This means that in the realm of space cooperation, the bilateral relationship likely will face more friction in the coming years before greater cooperation can be achieved.

Conclusion

The ROK is a signatory to all of the major international space treaties and ROK domestic law stipulates that space development must be for peaceful purposes. Seoul also is in compliance with its export control commitments to prevent the illicit transfer of missile systems, components and technologies. Over the last 25 years, the ROK has made impressive progress in the realm of satellites and satellite applications. The development of space launch vehicles came later, and in January 2013, the ROK launched its first satellite into space with a ROK rocket.

The Naro-1 was made with Russian technical assistance, but now KARI is developing the KSLV-II, and indigenous SLV with greater launch capability. The Naro Space Center is in the final stages of an expansion program to support the development and launching of the KSLV-II. The KSLV-II will be capable of launching larger payloads into earth orbit as well as lunar probes. The ROK seeks to enter the international market for launch services in the next decade before embarking on the development of third generation and fourth generation SLVs, which will have the capacity to launch deep space probes.

The ROK currently has no concrete plan for manned space flights, but will revisit the issue in the coming years. Over the next decade, the ROK space program will focus on creating and expanding public access to new satellite data and applications. To protect its space-based assets and territory from space-based threats, the ROK also has an ambitious plan to deploy advanced tracking and detection systems to provide early warning.

Finally, the ROK seeks international cooperation to achieve common goals in space, and to acquire foreign technologies to advance ROK space capabilities. However, many countries and firms are either restricted or reluctant to share sensitive space technologies, so the depth and pace of international cooperation might not meet Seoul's expectations or desires. The future of space in Asia is uncertain. Although unlikely, intense rivalry among the ROK and its neighbors could obstruct Seoul's plans for peaceful cooperation in space.

Endnotes

[1] For example, see Daniel A. Pinkston, ""Space Cadets - The Korean Peninsula's Rocket Competition," *Jane's Intelligence Review,* Vol. 21, No. 9, September 2009. Thomas Piketty, *Capital in the Twenty-First Century* (Cambridge: Harvard University Press, 2014), p. 16.

[2] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967). For background on international space law and some domestic space law, see the United Nations Office of Outer Space Affairs website, http://www.oosa.unvienna.org/.

[3] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (1968).

[4] Convention on International Liability for Damage Caused by Space Objects (1972).

[5] Convention on Registration of Objects Launched into Outer Space (1975).

[6] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.

[7] The MTCR is a voluntary export control regime established in 1987. Before joining the MTCR, ROK ballistic missile ranges were limited to 180km under a bilateral military agreement with the U.S., hence Seoul joined the MTCR relatively late. For background on the MTCR, see "The Missile Technology Control Regime at a Glance," Arms Control Association, http://www.armscontrol.org/factsheets/mtcr.

[8] The ICOC or "Hague Code of Conduct" is a voluntary code that seeks to raise and maintain transparency in space launch activities. For example, ICOC subscribers agree to provide notification prior to ballistic missile and SLV launches, as well as annual declarations on policies and an outline of the ballistic missile launches over the previous year. "International Code of Conduct against Ballistic Missile Proliferation (ICOC)," available at Arms Control Association, http://www.armscontrol.org/documents/icoc.

[9] The Brussels Convention is an agreement among parties to manage and protect the property rights of satellite signals when passing inadvertently through the territory of other states. See "Brussels Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite," World Intellectual Property Organization, http://www.wipo.int/treaties/en/ip/brussels/.

[10] Intersputnik was established in 1971 as an intergovernmental organization headquartered in Moscow. It has 26 member states, mostly former Soviet republics and Soviet bloc allies. Intersputnik's "core business is leasing satellite capacity to telecommunications operators, broadcasters and corporate customers under agreements with partner operators as well as providing full-scale services for the establishment and operation of satellite networks through its subsidiary Intersputnik Holding, Ltd." More information is available at the organization website, http://www.intersputnik.com/.

[11] "ITSO, formerly INTELSAT, essentially was the American equivalent of the Soviet Union's Intersputnik. INTELSAT was established in Washington, DC by 11 member states in 1964. ITSO now includes 149 member states and it provides telecommunications services through 53 satellites to 200 countries and territories. More information is available at the ITSO website, http://www.itso.int/.

[12] IMSO has 98 member states and its main purpose is to provide maritime mobile satellite communications services under the International Maritime Organization's Global Maritime Distress and Safety System (GMDSS). For mor details, see the IMSO website, http://www.imso.org/.

[13] The ITU is specialized UN agency that deals with information and communications technologies, including the provision of assistance in assigning satellite orbits. For additional information, see http://www.itu.int/.

[14] The law also provides definitions of spacecraft and facilities, liability, and requirements for registration and licensing of activities, etc.

[15] 무궁화위성 백서 (서울: 한국통신 위성사업본부, 1996), p. 98.

[16] Ibid., pp. 98-99.

[17] Ibid., p. 99. Chun's economic policy at the time was general austerity after the inflationary pressures and excess capacity as a result of the push for heavy and chemical industry development in the 1970s, so many government agencies faced budget and personnel cuts.

[18] Daniel A. Pinkston, "North and South Korean Space Development: Prospects for Cooperation and Conflict," *Astropolitics*, Vol. 4, No. 2, Summer 2006, p. 211.

[19] 무궁화위성 백서 (서울: 한국통신 위성사업본부, 1996), p. 99.

[20] Ibid.

[21] KARI website, "History," http://eng.kari.re.kr/sub04_04.

[22] KARI's subordinate research centers deal with the following areas: aerospace technologies; satellite technologies; integrated/fused technologies (융합기술연구소); satellite information; transportation and navigation; and aerospace (materials and components) certification. There are also two departments or work teams: one for satellite development, and one for the development of space launch vehicles. KARI website, "조직도," http://www.kari.re.kr/sub0506.

[23] "우주개발 중장기 계획," 2013년, 11월.

[24] 국가우주위원회.

[25] Interview with Hwang Chin-young, director of policy and international cooperation, KARI, Dajeon (Taejŏn), Korea, 29 August 2014.

[26] Ibid.

[27] Ibid.

[28] The R&D trend over the last six years has been to graduate from research in basic technologies to core technologies. Ibid.

[29] 우주개발 진흥법, 제5조 (우주개발진흥 기본계획의 수립).

[30] 우주개발 진흥법, 제6조 (국가우주위원회).

[31] The first meeting was held on 19 December 2006. "[경제캘린더] 12월18일 ~ 22일," 서울경제, 2006년 12월 17일; "'위성정보 3.0' 실현으로 우주분야 창조경제 촉발," 보도자료, 미래창조과학부, http://www.msip.go.kr.

[32] For a brief background of the ROK's science and technology capacity during the period leading up to the beginning of the space program, see James Clay Moltz, *Asia's Space Race* (New York: Columbia University Press, 2012), pp. 138-142.

[33] The range limit was in effect until the ROK joined the MTCR in March 2001. Daniel A. Pinkston, "North and South Korean Space Development: Prospects for Cooperation and Conflict," *Astropolitics*, Vol. 4, No. 2, Summer 2006, p. 212.

[34] KARI originally planned to launch its own satellite by 2005. Daniel A. Pinkston, "North and South Korean Space Development: Prospects for Cooperation and Conflict," *Astropolitics*, Vol. 4, No. 2, Summer 2006, p. 213.

[35] Ibid., pp. 213-214.

[36] Choe Sang-hun, "South Korea Launches Satellite," The New York Times, 25 August 2009; "South Korean Space Rocket Explodes Two Minutes after Launch," *The Guardian*, 10 June 2010.

[37] Chris Bergin, "South Korea launch STSAT-2C via KSLV-1," Nasaspaceflight.com, 30 January 2013, http://www.nasaspaceflight.com/2013/01/south-korea-stsat-2c-via-kslv-1/; Justin McCurry, "South Korea Launches Rocket Carrying Satellite in Battle for Space Supremacy," *The Guardian*, 30 January 2013.

[38] Some of the technologies include engines, turbo-pumps, advanced ceramic materials and other materials, and guidance and control. "우주핵심기술사업 지원현황 및 실적," MSIFP website, http://www.msip.go.kr/.

[39] "우주개발 중장기 계획," 2013년, 11월, p. 13.

[40] Interview with Hwang Chin-young, director of policy and international cooperation, KARI, Taejŏn, Korea, 29 August 2014.

[41] 임은희, "나로호가 불붙인 '우주도전'…한국형 발사체가 잇는다," Hello DD, 2014년 1월 26일.

[42] "우주개발 중장기 계획," 2013년, 11월, pp. 13-15.

[43] Interview with Hwang Chin-young, director of policy and international cooperation, KARI, Dajeon (Taejŏn), Korea, 29 August 2014.

[44] The ILN is a NASA project that invites other programs to establish lunar nodes to collect geophysical data on the moon's surface. The network will collect data in the realms of seismic activity, subsurface heat flow, electromagnetic sounding, and lunar laser ranging. The establishment of several nodes will provide better data to assess the moon's initial composition, differentiation, crustal formation, and magmatic evolution. These experiments will enable scientists to better understand the origins and transformation of the solar system's terrestrial planets including earth. Science Definition Team for the ILN Anchor Nodes, "ILN Final Report," NASA, January 2009.

[45] Interview with Hwang Chin-young, director of policy and international cooperation, KARI, Taejŏn, Korea, 29 August 2014. The relevant U.S. policymaking authority on this issue would the State Department's Office of Missile Defense and Space Policy in the Bureau of Arms Control and International Security.

[46] Ibid.

[47] "우주개발 중장기 계획," 2013년, 11월, p. 15.

[48] Ibid., p. 16.

[49] "S. Korea Completes Work on Naro Space Center," *The Korea Times,* 10 June 2009.

[50] Kim Tong-hyung, "Russia Dragging Feet over Korean Rocket Launch," *The Korea Times*, 23 July 2008; Eun-jung Kim, "Leadoff of Korea Space Launch Vehicle Delayed to 2Q 2009," *Maeil Business Newspaper* (*매일경제*), 10 August 2008.

[51] "S. Korea Completes Work on Naro Space Center," *The Korea Times*, 10 June 2009.

[52] The first Naro-1 launch failed to place the satellite into orbit and debris fell on Australian territory near Darwin. United Nations Office for Outer Space Affairs, "Highlights in Space 2009," United Nations, New York, 2010; "Rocket Debris 'Falls on Australia'," *The Chosun Ilbo*, 27 August 2009.

[53] "우주개발 중장기 계획," 2013년, 11월, p. 17.

[54] 임은희, "나로호가 불붙인 '우주도전'…한국형 발사체가 잇는다," Hello DD, 2014년 1월 26일.

[55] 임은희, "나로호가 불붙인 '우주도전'…한국형 발사체가 잇는다," Hello DD, 2014년 1월 26일.

[56] Interview with Hwang Chin-young, director of policy and international cooperation, KARI, Dajeon (Taejŏn), Korea, 29 August 2014.

[57] Ibid.; 임은희, "나로호가 불붙인 '우주도전'…한국형 발사체가 잇는다," Hello DD, 2014년 1월 26일.

[58] Ibid.

[59] Ibid.

[60] "우주개발 중장기 계획," 2013년, 11월, p. 17.

[61] Ibid., pp. 17-18.

[62] The satellite was assembled by a team at the Korea Advanced Institute of Science and Technology (KAIST) with assistance from Surrey University in the UK. *Uribyŏl-2* was a replica of *Uribyŏl-1* but assembled indigenously in the ROK. Daniel A. Pinkston, "North and South Korean Space Development: Prospects for Cooperation and Conflict," *Astropolitics*, Vol. 4, No. 2, Summer 2006, p. 215.

[63] James Clay Moltz, *Asia's Space Race* (New York: Columbia University Press, 2012), p. 148.

[64] The launch took place from the DPRK's Sŏhae Space Center in Tongch'ang-ri on the DPRK's northwestern coast. The satellite was confirmed to be in orbit, but it appears to have malfunctioned and is not operating. "DPRK's Satellite Enters Its Preset Orbit: Scientist," Korean Central News Agency, 13 December 2012; William J. Broad and Choe Sang-hun, "Astronomers Say North Korean Satellite Is Most Likely Dead," *The New York Times*, 17 December 2012.

[65] "제1차 위성정보 활용 종합계획," 관계부처합동, 2014 년 5월, p. 3.

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[68] "제1차 위성정보 활용 종합계획," 관계부처, 2014년 5월.

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[71] "제1차 위성정보 활용 종합계획," 관계부처합동, 2014 년 5월, p. 8.

[72] Ibid.

[73] Ibid., p. 14.

[74] Ibid., pp. 14-15.

[75] IIbid., pp. 13-17.

[76] Ibid., pp, 18-22.

[77] Ibid

[78] Ibid., p. 22.

[79] Ibid., p. 24.

[80] Interview with Hwang Chin-young, director of policy and international cooperation, KARI, Dajeon (Taejŏn), Korea, 29 August 2014.

[81] Ibid. In the ROK's policymaking process, ministries, which are executive branch agencies, can submit draft legislation to the National Assembly.

[82] "제1차 위성정보 활용 종합계획," 관계부처합동, 2014 년 5월, p. 27.

[83] Ibid.

[84] For information on the Group on Earth Observations, see the GEO website, http://www.earthobservations.org/.

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[99] Ibid.

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[101] Ibid., p. 3

[102] To support the planning effort, the government hosted a workshop for space security specialists in April 2014 before additional inter-agency consultations the following month. In May 2014, the National Assembly passed a resolution in support of revising the Space Development Promotion Act to reflect legal requirements for support of the plan. Ibid.

[103] Ibid.

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[123] The optical cameras are to be deployed by 2020. "우주개발 중장기 계획," 2013년, 11월, p. 36.

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