The Korean Space Programmes[i]

South Korea

South Korea's geo-political position during the Cold War and its alliance with the United States has both driven and constrained its space programme. The Korean War and national division have exacerbated inter-Korean security dilemma dynamics, which drove both Seoul and Pyongyang to consider developing weapons of mass destruction and related delivery systems. For South Korea, the process began in earnest in 1971, when then-president Park Chung-hee issued directives for both nuclear weapons and ballistic missiles to be developed because he had doubts about the credibility of US alliance commitments.

Initially, Park wanted to develop a ballistic missile with a range of at least 200 km by 1975, equipping Seoul with an independent capability to strike Pyongyang. In May 1974, the South Korea Agency for Defence Development (ADD) selected the *Nike-Hercules* (NHK) surface-to-air/surface-to-surface missile because of political development timelines. The *Nike-Hercules* was in fact a poor choice for a ballistic missile, but the South Korean army had developed some experience with the two-stage, solid-fuel missile since the US deployed it to South Korea in 1961, making it a more viable option. The *Nike-Hercules'* primary mission was air defence, with a secondary role of surface-to-surface strikes. The US began deactivating its domestic *Nike-Hercules* units during the 1970s, but began to transfer the Korean deployed systems to the South Korean military for air defence purposes. In January 1975, the US began to train South Korean engineers and military personnel in operating the system, and only four months later Park summoned Richard Sneider, then-US ambassador, to say South Korea would develop a missile capable of striking North Korea. This was at the same time that Seoul was actively pursuing the capability to produce a plutonium-based nuclear weapon. US intelligence discovered the nuclear programme and the administration of then-president Gerald Ford put tremendous pressure on Seoul to abandon it.

Nike-Hercules in Korea (1968). [Republic of Korea Air Force]

South Korea conducted its first successful flight test of the reverse-engineered *Nike-Hercules*, renamed *Paekkom*, in September 1978. US proliferation concerns led to Washington demanding Seoul limit the ranges and payloads of South Korean missiles in exchange for any licensing or further technical assistance. In 1979, a confidential bilateral memorandum of understanding (MoU), seen by Jane's, limited the number of South Korean ballistic missiles and their range to 180km or less.

Table 1: South Korean space related time-line[ii]

1960 — South Korea receives the first Nike-Hercules (NHK) surface-to-air missiles from Washington.
1975 — The Agency for Defense Development develops a NHK-1 surface-to-surface variant.
1978 — South Korea tests the NHK-2 surface-to-surface missile.
1979 — Seoul and Washington establish a Memorandum of Understanding (MoU) limiting South Korea's indigenous missile developments.
1987 — The Hyon Mu (NHK-A) short-range ballistic missile is test-launched.
1989 — The Korea Aerospace Research Institute (KARI) is established as an affiliate to the Korean Institute of Machinery and Metals (KIMM).
1992 — South Korea's first satellite, the Uribyol-1, is launched atop an Ariane rocket. The Ministry of Trade, Industry and Resources announces Seoul's aspirations to become a top nation in the aerospace industry by 2000.
1993 The Uribyol-2 is launched. June — South Korea's first domestic sounding rocket, the KSR-I, is launched from Anhueng, in South Chungchong Province. September — The KSR-I gets its second test-launch.
1995 The South Korean telecommunications satellite, Mugunghwa-1, is launched aboard a Delta rocket. July — The South Korean Foreign Ministry announces plans to abandon the 1979 MoU. October — Seoul renews its desire to abandon the 1979 MoU after its initial request was rejected by Washington.
1996 The Mugunghwa-2 is launched. April — The National Science and Technology Council issues its "Basic Long-Term Plan for Korea's Space Development." August — Satellite photos show South Korea preparing for a ballistic missile test, according to U.S. media reports four months later. November — KARI becomes an independent institute. December — U.S. officials suggest Washington would welcome South Korea's entry into the Missile Technology Control Regime.
1997 The second South Korean sounding rocket, the KSR-II, is launched.
1998 The KSR-II gets its second test-launch.
1999 March — The South Korean Ministry of Defense says Seoul will not participate in the U.S. Missile Defense System. April — South Korea allegedly tests a longer-range Hyon Mu ballistic missile. April — The Aerospace Industry Development Council issues its "Basic Plan for Aerospace Industry Development." November — The Agency for Defense Development announces its Chon Ma surface-to-air missile, jointly developed with Korean and French technology. December — The Korean Multipurpose Satellite, the Arirang-1, is launched aboard a Taurus rocket from Vandenberg Air Force Base. December — The "Five-Year Plan for Science and Technology Innovation" is adopted by the Presidential Commission on Science and Technology. December — Seoul begins review of 11 possible sites for a domestic space facility.
2000 February — KARI receives the first data from the Arirang-1.
2001 January — The Foreign Ministry announces that Seoul and Washington have come to an agreement on lifting the restrictions of the 1979 MoU. January — The Ministry of Science and Technology announces that Oenardo island, in South Cholla province, has been chosen as location for South Korea's new space center.
2002 November — Korea Sounding Rocket-III launches.
2003 May — Seoul and Moscow sign a preliminary agreement to cooperate on space technology, and South Korean President Roh Moo Hyun plans to visit Moscow later in the year to formalize the agreement. June — The South Korean Ministry of Science and Technology says it is seeking an MoU with Russia's Aviation and Space Agency to cooperate on the development of South Korea's first satellite launching rocket, the KSLV-1. August — South Korea officially starts construction of the nation's first space center, scheduled to be completed by late 2005. September — STSAT-1 launches.
2004 September — South Korea and Russia sign an intergovernmental agreement for cooperation in space.
2005 May — South Korea enacts the Space Development Promotion Act.
2006 July — KOMPSAT-2 launches. July — South Korea's first completely indigenous satellite, the Arirang-2, launches atop a Russian rocket. September — The South Korean army announces plans to establish a missile defense command. The command will be responsible for multiple-launch rocket systems and surface-to-surface missiles, as well as defending against threats from missiles and long-range artillery. October — South Korea and Russia sign a technology safeguard agreement for space technology cooperation.
2007 South Korea's basic space development promotion plan and its detailed space development program road map are established. October — South Korea announces it is set for its first rocket launch in 2008 from the Naro Space Center. November — South Korea announces plans to launch its first lunar exploration satellite in 2020. If the plan succeeds, it will launch a lunar probe in 2025.
2008 April — South Korea sends its first astronaut from a space center in Central Asia to the International Space Station, along with two Russian cosmonauts. October — South Korea's Ministry of Education, Science and Technology and NASA sign a Statement of Intent for Cooperation in Civil Space and Aeronautics.
2009 February — South Korea announces that it intends to complete its own missile defense system by 2012. June — South Korea approves plans to launch its first rocket into space, scheduled in July 30 at Naro Space Center. June — South Korea completes the construction of the Naro Space Center. August — South Korea sets the date for its first space rocket launch for Aug. 11. August — South Korea announces that its first space rocket will be launched Aug. 19, after repeated delays. August 25 – the Naro-1/KSLV-1 is launched, but failed.

Seoul produced the *Paekkom* for deployment with one missile battery, and in December 1982 the Ministry of National Defence decided to dismantle the ADD's 'guided weapons team', effectively terminating plans to extend and upgrade ballistic missile systems. However, this policy was soon reversed when the perceived threat from North Korea became more immediate. In October 1983, North Korean commandos detonated a bomb in Yangon (then Rangoon) killing 21 people, including four South Korean cabinet ministers. The incident resulted in Seoul reactivating its missile programme and South Korea subsequently upgraded the *Paekkom* as the *Hyon mu*. The *Hyon mu* retained the same basic airframe but included improved guidance and components. The first flight was in September 1984, and the second was conducted to full range in May 1985. The *Hyon mu* missile battery was deployed and operational by late 1987 to replace the *Paekkom*. The renewal of South Korean ballistic missile development in the 1980s, although still within the limits of the 1979 MoU, stimulated proliferation concerns as North Korea was expanding its ballistic missile programme. In 1989, the South Korean government established the KARI and decided to launch its satellite development programme. The government announced the establishment of an aerospace committee and began to draft a space law in April 1990, but the following month the US cancelled export licences of all parts and materials for South Korean guided missiles. In October that year, the government of then-president Roh Tae-woo reiterated the South Korean commitment to abide by the bilateral missile constraints; failure to do so would have brought pressure from Washington that could have quashed Seoul's nascent space exploration plans.

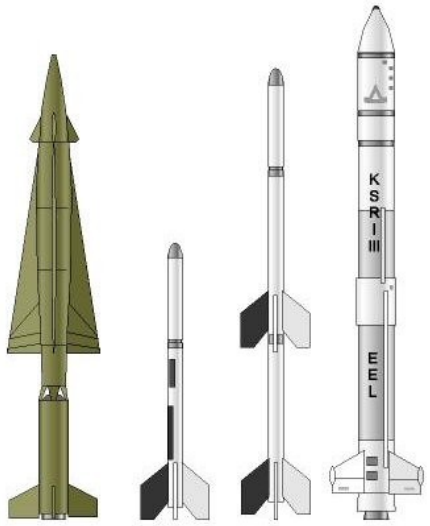
South Korea's space programme has a strong import substitution and industrial policy component. The government seeks to localise satellite and SLV production, and supports the development of human resources to sustain the programme. International co-operation is usually sought with technology transfers in mind and with the goal of long-term commercial development for South Korean firms. South Korea's successful and expanding satellite programme enabled a group of SaTReC[iii] engineers who worked on the *Uribyol* programme to form a spin-off company, Satrec Initiative, in January 2000. The firm develops precision engineering components for the South Korean space programme, and also designed and assembled the United Arab Emirates' *OubaiSat-1*, which was launched on July 29, 2009. Satrec Initiative jointly developed the Malaysia's *RazakSAT* 180kg microsatellite with Astronautic Technology (M) Sdn Bhd (ATSB). The *RazakSAT-1* was placed into orbit on July 14, 2009. Seoul is poised to continue its pursuit of niche markets. South Korea also has entered into agreements to provide imagery and, although supplying satellite components and assembly are most promising commercially, Seoul will probably aim at becoming a low-cost provider of space launch services, which will be necessary to justify the expenditure for the development of the KSLV-2.

South Korea concluded a bilateral space co-operation agreement with Russia in September 2004, another with the European Union (EU) in September 2006 and a third with Ukraine in December 2006. The agreement with Russia included Russia providing the first stage of the Naro-1 SLV and a flight for one Korean astronaut aboard the Soyuz spacecraft to the International Space Station. The EU agreement provides South Korean participation in the EU's Galileo global navigation satellite system (GNSS), which is currently under development.

In July 2008, the KARI signed a letter of intent with the US National Aeronautic and Space Administration (NASA) to participate in the International Lunar Network (ILN). The joint project includes several countries and aims to send six to eight unmanned robotic spacecraft to the lunar surface. The KARI is currently reviewing the project and its level of future participation

South Korea launch vehicle development

With its satellite programme continuing apace, it was evident that South Korea was far ahead of North Korea's rudimentary capabilities. Nonetheless, as Seoul was embarking on its satellite development programme in the early 1990s, North Korea was pushing ahead with its long-range rocket development programme. In response, the KARI began developing sounding rockets in 1990, and conducted two launches of the *Korean Sounding Rocket* (KSR-1) in 1993, and two launches of the KSR-2 in July 1997 and June 1998. These sounding rockets were solid-fuelled, but the KSR-3 was liquid-fuelled and was tested successfully in November 2002. The KARI had only built one KSR-3 as part of its development programme for the *Korean Space Launch Vehicle-1* (KSLV-1).



NHK-1 KSR-I KSR-II KSR-III

South Korean rockets. [Mark Wade]

Meanwhile, Pyongyang was able to extend the range of its missiles and move towards an SLV capability. On August 31, 1998, North Korea tried to place a small satellite, the *Kwangmyongsong-1* , into orbit with the *Paektusan*-1 SLV. Despite the third-stage failure of the North Korean rocket, South Korea responded in November of that year by revising its space plans to include a satellite launch with an indigenous South Korean SLV by 2005. However, the KARI's sounding rockets and subsequent SLV development programme required many foreign technologies and components, and South Korea was constrained by the 1979 bilateral missile MoU with the US. As North Korea continued to improve its rocket capabilities, South Korean military policymakers began to question the utility of the constraints, although unilaterally renouncing the agreement would have alienated Washington and made future foreign procurement and technology transfers for the civilian space programme virtually impossible.

In 1996, the US and South Korea began negotiations to revise the 1979 bilateral missile agreement. Several rounds of sometimes contentious talks were held in the late 1990s, during which US intelligence determined that South Korea already appeared to be developing missiles beyond the range limits set in the 1979 MoU. In July 1999, South Korea's then-president Kim Dae-jung told Bill Clinton, then US president, that South Korea must have the

right to develop and test missiles with a range of 500 km. Seoul finally joined the international Missile Technology Control Regime (MTCR) in March 2001, despite the concerns of some conservative politicians and activists who continued to express the need to develop missiles beyond MTCR limits to counter a perceived North Korean missile threat.

KSLV-1 is wheeled to its launch pad from the assembly complex at Naro Space Centre. [en.ce.cn]

The KARI had expected to be able to acquire components, materials and technical assistance from the US in support of its SLV development programme, but US policy has been to neither encourage nor obstruct South Korean efforts. This caused considerable disappointment in South Korea, and Seoul ultimately turned to Moscow when it began to face technical hurdles in developing the KSLV-1. In 2004, a group of Russian technical advisers visited the KARI to assess the KSLV-1 programme and the KARI began employing a Russian engineer on a full-time basis. In September 2004, South Korea's then-president Roh Moo-hyun visited Moscow and signed a bilateral scientific co-operation agreement that included terms on space co-operation. The KARI immediately began talks with the Khrunichev State Space Research and Production Centre in Moscow, and in January 2005 the KARI announced it would base the KSLV-1 on Khrunichev's *Angora* launcher. The two sides agreed Russia would build the liquid-fuelled first stage and KARI would build the solid-fuelled second stage.

In the 1990s, South Korea had planned to have its KSLV ready for a 2005 launch but the launch date has been postponed several times, first to 2007 and then into 2008. Even before the delays, by early 2005 the KSLV-1 project's budget had increased from an initial level of approximately US$370 million to approximately US$524 million. Cost overruns and inter-governmental struggles over funding have worried the KARI and space exploration advocates about the sustainability of public support during the global economic downturn. The Naro Space Centre,

located on Oenaro Island, South Cholla province, was completed in June 2009 at a cost of KRW300 billion (US$270 million). Planning for the centre began with the revised national space plan in December 2000, at about the same time North Korea began building its new space launch facility at Tongchang-ri on the country's northwest coast. Construction of the Naro Space Centre began in August 2003 and it includes a launch pad, control and tracking facilities, rocket assembly and testing facilities, a space science hall and a media centre.

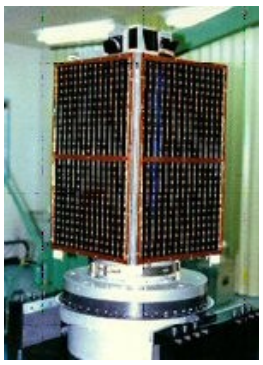
Table 2: South Korean rockets and space launch vehicles

Launch Vehicle	Height [m]	Diameter [m]	Mass [tonnes]	Other information
KSR-I	6.7	0.42	1.25	Solid fuel
KSR-II	11.1	0.42	2	Solid fuel
KSR-III	14	1	6	Liquid fuel
KSLV-1 / Naro-1	33	2.9	140	1st stage liquid/2nd stage solid fuel

South Korea's Naro-1 SLV has a liquid-fuelled first stage built by Russia's Khrunichev State Space Research and Production Centre, and a solid-fuelled second stage built by KARI. It took seven years to develop the Naro-1 at a cost of KRW500 billion (US$450 million). The booster is 33m tall with a diameter of 2.9m and a mass of 140 tonnes. The first stage engine is the RD-191, which burns liquid oxygen, kerosene and a small amount of hydrogen. The Naro-1 launch is the first flight test of this engine.

South Korea satellite development

The US decision to end export licences and the bilateral MoU were obvious constraints on Seoul's ability to develop longer-range rockets, but it did not hinder the country's satellite ambitions. Seoul was able to pursue an indigenous satellite capability, with both commercial and military applications, heightening the competitive dynamic between the two Koreas in the space arena. However, without its own rockets, South Korea needed to rely on other countries to place the satellites into orbit. South Korea's first satellite, *Uribyol-1* (*Our Star* or *Kitsat-1*) was launched by the European Space Agency on August 11, 1992. The 50kg microsatellite was assembled by the Satellite Technology Research Centre (SaTReC) of the Korea Advanced Institute of Science and Technology (KAIST) at the University of Surrey in the UK. The *Uribyol-2*, a replica of the *Uribyol-1*, was assembled in South Korea and launched in September 1993. The launch took place during the Taejon Expo, a domestic showcase for South Korea's scientific development. Seoul had sought to localise satellite inputs, but only 6.8% of *Uribyol-2*'s components were Korean made. The first communications satellite, the *Mugunghwa-1* or *Koreasat-1* was launched in August 1995, but the launcher failed to place the satellite in geosynchronous orbit. The satellite used some of its internal fuel to reach geosynchronous orbit, but

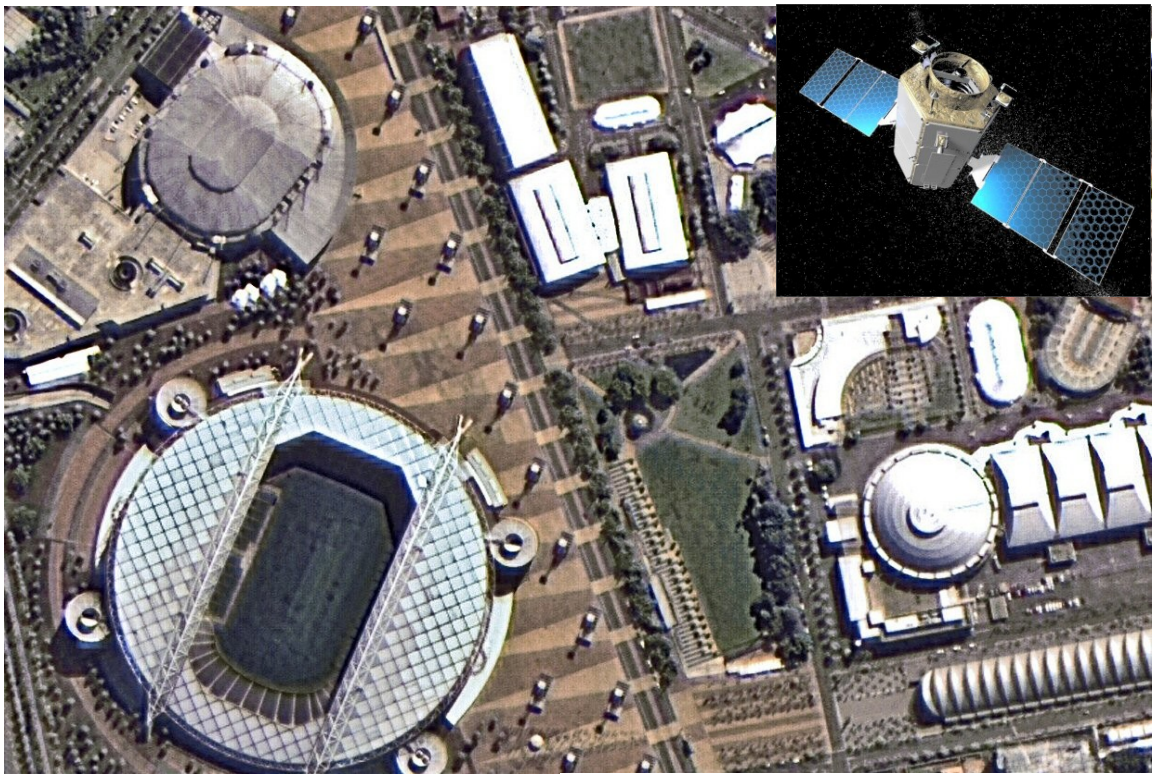


Kitsat-2/Uribyol-2

this reduced its lifetime. Although earlier satellites had potential military applications, South Korea partnered with Alcatel Space to orbit its first dedicated military satellite in August 2006. The *Mugunghwa-5* (*Koreasat-5*; the name Koreasat-4 was avoided as four is an unlucky number in South Korea) provides both civilian and military telecommunications services, as well as broadband multimedia and digital television transmissions. The ADD has established a military satellite communications control centre, which is operated by the National Defence Command and Communications Headquarters, in the city of Taejon.

At its final orbital slot at 116° East, the Koreasat-6 satellite will carry 30 active Ku-Band transponders that will provide Direct Broadcast Services (DBS) and Fixed Satellite Services (FSS) to South Korea. The STAR-2 platform will support 3.4 kW of payload power and will have a 15 year on-orbit mission life. Koreasat-6 is scheduled to be delivered and launched in mid- to late-2010. [Gunter Dirk Krebs]

The *Arirang* (*Kompsat*) series focuses on multi-purpose Earth observation. The *Arirang-2*, launched in July 2006, is equipped with a one-metre resolution, multi-spectral camera developed in co-operation with Israel's Electro-Optics Limited (ELOP), providing Seoul with a significant intelligence-gathering capability. *Arirang-3* is scheduled for launch in late 2009 and will provide imagery with a resolution of less than one metre for a planned mission period of four years.



Kompsat-2 imagery. [KARI]

Kwahakkisulwisong-2/STSAT-2. [KARI]

The launch of STSAT-2 on August 25, 2009 (Failure). [Yonhap News]

The STSAT-2 has a mass of 99.4kg and dimensions of 61.5cm x 67.3cm x 89.8cm. The expected mission life-span is 2 years in an ellipsoidal orbit of 300km x 1,500km, during which it will carry out Earth and at-mospheric monitoring. The STSAT-2 is equipped with a pulsed plasma thruster, a dual-head star tracker, a line digital sun sensor, a compact on-board computer and a high-speed data transmission system (10 Mbps).

This combination Photo shows the Korean Space Launch Vehicle-1 (KSLV-1) or Naro-1, South Korea's first space rocket, is being launched from its launch pad at the Naro Space Centre in Goheung.

Table 3: South Korean satellites

Satellite	Mission	Mass [kg]	Features	Partner	Launch Vehicle	Launch Date
Uribyol-1 [Kitsat-1]	Experiments/ Earth Observation	48.6		University of Surrey (UK)	Ariane-42P	19920811
Uribyol-2 [Kitsat-2]	Experiments/ Earth Observation	47.5		University of Surrey (UK)	Ariane-40	19930926
Mugunghwa-1 [Koreasat-1]	Communications	1,464		Lockheed Martin (US); AS-3000 bus	Delta-7925	19950805
Mugunghwa-2 [Koreasat-2]	Communications	1,464		Lockheed Martin (US); AS-3000 bus	Delta-7925	19960114
Uribyol-3 [Kitsat-3]	Earth Observation	110	Oceanography		PSLV	19990527
Mugunghwa-3 [Koreasat-3]	Communications	2,790		Lockheed Martin (US); A2100A bus	Ariane-42P	19990904
Arirang-1 [Kompsat-1]	Multipur-pose/Earth Ob-servation	460	6.6m resolution EO camera; multispectral imager (ocean scan-ning); ionosphere meas-urement scanner; high energy particle detector	TRW (US)	Taurus-2110	19991221
Kwahakkisul-wisong-1 [STSAT-1]	Scientific space observation	100	Far-Ultraviolet imaging spectrograph; space physics package		Kosmos-3M	20030927
Arirang-2 [Kompsat-2]	Multipur-pose/Earth Ob-servation	800	1m resolution multis-pectral camera		Rokot-KM	20060728
Mugunghwa-5 [Koreasat-5]	Civilian and Military commu-nications	4,465	Multimedia	Alcatel Space; Spacebus-4000	Zenit-3SL	20060822
Kwahakkisul-wisong-2 [STSAT-2]	Earth atmosphere monitoring	99.4	Pulsed plasma thruster; dual-head star tracker; fine digital sun sensor; high-speed data trans-mission system	Khrunichev	Naro-1 [KSLV -1]	20090825 (Failure)

North Korea

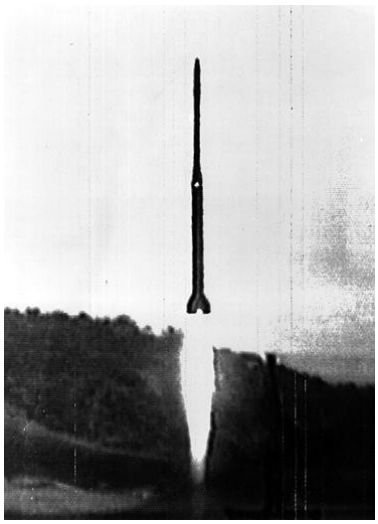
South Korea's space programme has not developed in isolation. As Seoul has moved through guided missile development, satellite production and soon an SLV launch, North Korea has pursued a similar path towards the prestigious goal of the first indigenous Korean satellite launch. Although more rapid, the North Korea programme has been less successful. Assessed three SLV launches have failed to place a satellite into orbit, despite official claims to the contrary. The most recent launch, of the *Unha-2* SLV on April 5, 2009, failed in the third stage and fell into the Pacific Ocean, failing to place the *Kwangmyongsong-2* satellite into orbit.

Much media attention surrounding these launches has concentrated on the possibility of such technology being used for intercontinental ballistic missiles (ICBMs). The *Unha-2*, with its relatively large first stage draws suspicion of a long-predicted ICBM, but the absence of a

militarized launcher or re-entry vehicle/warhead testing programme suggests that this vehicle and both launch pads are primarily for satellite launches at this time, with the added benefit of dual-use military rocket technology spin-off. Analysis of commercial high resolution satellite imagery, North Korean-released video of two of its three launches and public announcements on space activities, suggests that North Korea is currently focused on SLV and satellite development. However, Pyongyang remains eager to pursue a space programme for the nationalistic, commercial and military benefits, probably including military space.

North Korea launch vehicle development

In the mid-1980s, North Korea's then-leader Kim Il-sung initiated the planning for the country's space programme and formed a national Committee of Space Technology that has the overall executive direction of the programme to this day. Following his father, current leader Kim Jong-il has shown great interest and involvement in the space programme as well. In early 2009, he visited the *Tonghae launch centre* to view the pre-launch preparations, and viewed the April launch. North Korea's SLVs are based on modifying three tactical missiles: the Russian *SCUD*; its successor, the North Korean scaled-up SCUD called the *Nodong*; and the Russian *SS-N-6 (R-27)* which was copied and reverse engineered from the 1980s to the early 2000s. Three launches of SLVs have taken place: the *Paektusan-1/Taepodong-1* in 1998; the *Paektusan-2/Taepodong-2B*, probable *Unha-2* in 2006; and *Unha-2* in 2009. A follow-on SLV larger than the *Unha-2* is probably under development.



North Korean satellite rocket Paektusan-1, is test launched in an undisclosed facility somewhere in North Hamgyong Province, North Korea in this August 31, 1998 photo released by Korea News Service. Top US officials confirmed that North Korea has an untested ballistic missile capable of reaching the western United States. [AP Photo/Korea News Service]

These SLVs carried one of two variants of *Kwangmyongsong* satellites, both of which were primarily propaganda missions to glorify Kim Il-sung and Kim Jong-il, and demonstrate to their citizens that the country is in the forefront of space activity. North Korea claimed both the 1998 and 2009 SLV launches were successful and the satellites were transmitting revolutionary songs, although this was denied by NORAD and Russia.

Handout photos released by North Korea's official Korean Central News Agency on April 8, 2009, and made available on April 9, 2009, shows the pre-launch and launch of the Unha-2 rocket, which Pyongyang says put the experimental communications satellite Kwangmyongsong-2 into orbit on April 5, 2009. [EPA/KCNA]

A handout photo released by North Korea's official Korean Central News Agency on April 8, 2009, and made available on April 9, 2009, shows scientists and technicians of the DPRK seated at their workstations as a large screen shows the launch of the Unha-2 rocket on April 5, which Pyongyang says put the experimental communications satellite Kwangmyongsong-2 into orbit. [EPA/KCNA]

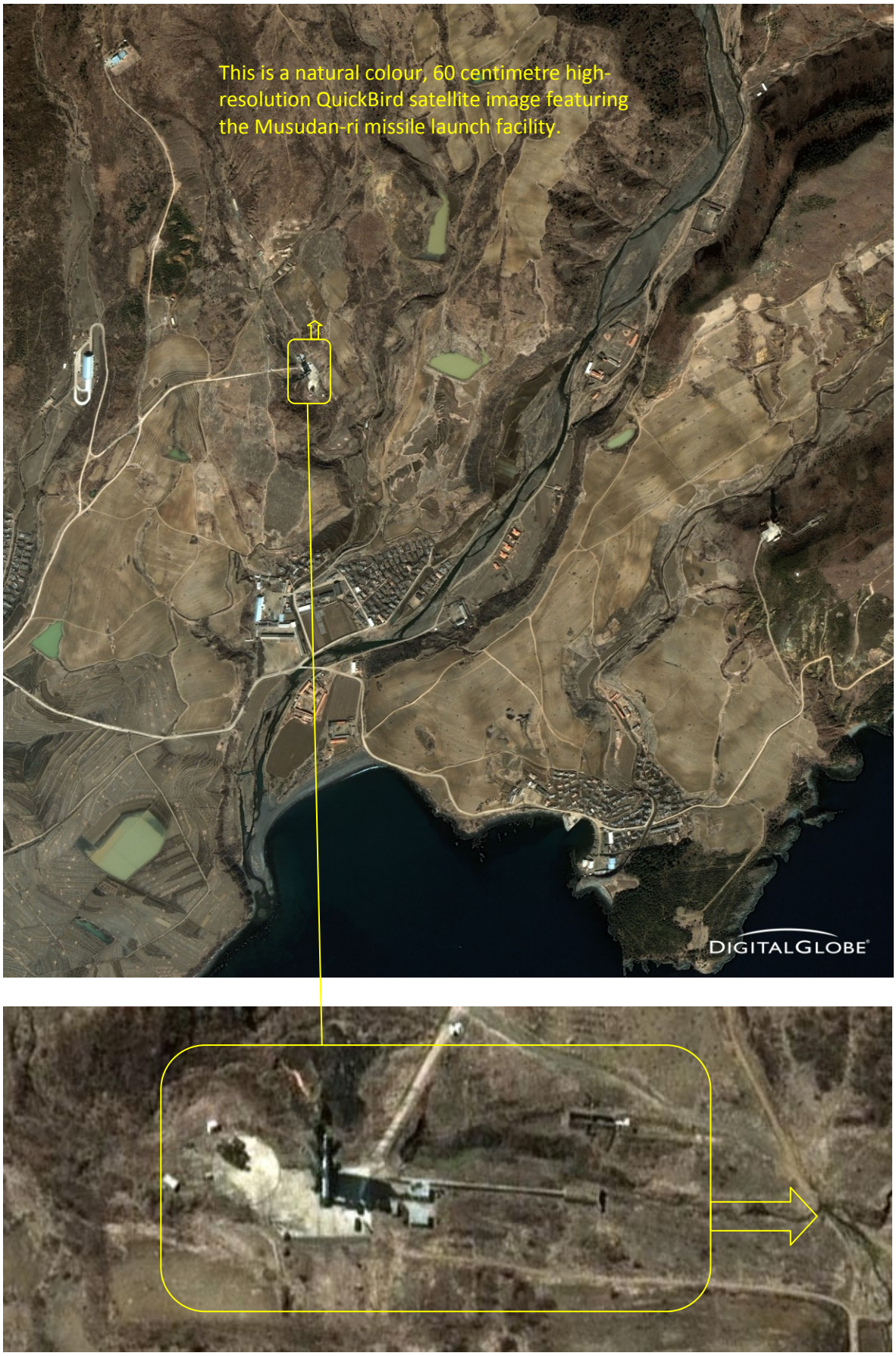
ISIS (Institute for Science and International Security) has obtained commercial satellite imagery from GeoEye of the North Korean missile taken on April 5, 2009 at about 11:05 am local time. The image shows the clearly distinguishable white figure of the missile on the launch pad approximately 30 minutes prior to launch. The shadow cast by the missile can also be seen extending to the right side.

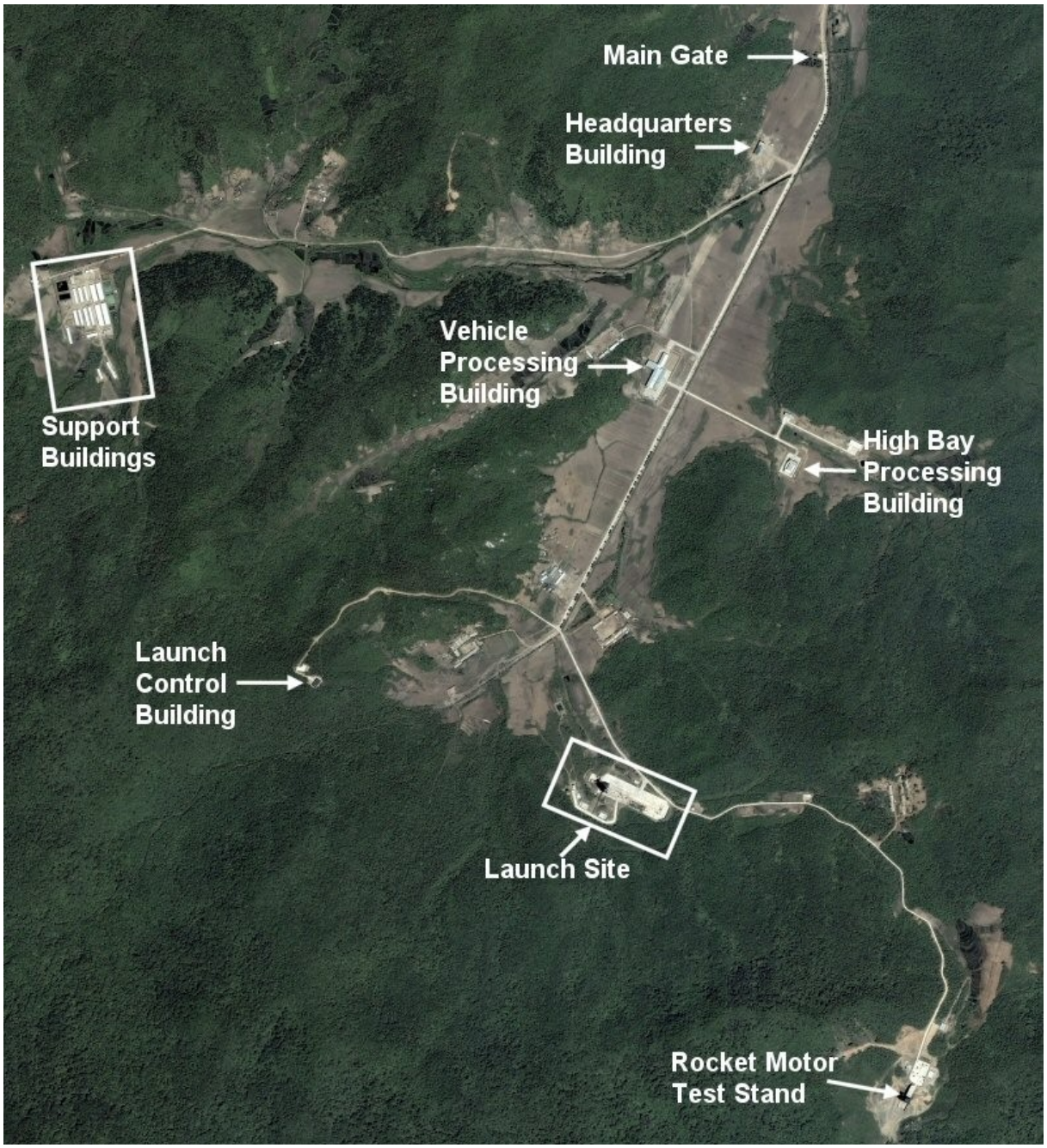
North Korea launch complexes

The importance of the space programme to North Korea is demonstrated by its investment in two physically different but functionally similar complexes to launch large liquid-fuelled rockets. Each complex has a single launch pad capable of launching larger SL*Vs* than the recently launched *Unha-2*. Both have the infrastructure required to support these activities: a drive-through building for pre-launch checkout of the SLV and a gantry with multiple fold-out platforms for technicians to perform final checks, with a built-in fuelling system to fill the SL*V* tanks with two different fuel/oxidiser combinations. Demonstrating North Korea's commitment to its space programme, rather than its related missile programme, the launch pads at both complexes are optimised, probably exclusively, for SLV launches.

Tonghae (also *Musudan-ri*) on the east coast was converted from a simple tactical launch area in the late 1980s to a satellite launch site in the mid-1990s. It was first used for the failed August 31, 1998, launch of the *Kwangmyongsong-1* satellite using the small *Paektusan-1* SLV. Two more launches have been conducted at *Tonghae* since then. The newer probable *Unha-2* SLV, tested in 2006, failed in the first stage, and required modifications to the gantry and a new launch stand, maintaining the procedure of on-pad vertical assembly of the SLV stages. In April 2009, an *Unha-2*, carrying the *Kwangmyongsong-2* satellite, was launched, but this time the third stage probably failed.

In addition to *Tonghae*, construction of *Tongchang* on the west coast was started in the late 1990s. The complex is now near operational status. The major differences between the two complexes are the much larger scale of facilities at *Tongchang* and their optimum launch direction: due east for *Tonghae* and south for *Tongchang*. Based on activity seen in recent space imagery, *Tongchang*'s inaugural flight will be a southward-launched *Unha-2*, possibly in 2010.





Overview of the Tongchang launch complex as of June 3, 2009. [Globalsecurity.org and DigitalGlobe]

A further demonstration of North Korea's focus on SLV development as part of an inter-Korean space race came in a 2009 post-launch official press report in which it was revealed that Pyongyang has a general satellite control and command centre. Previously this facility was identified only as the launch control centre. A video filmed inside shows five large screens displaying launch video, tracking and telemetry data and a large-screen display superimposing the ascent trajectory and in-orbit satellite path. For this launch, the centre screen showed a curved trajectory consistent with an SLV launch. [See page 12]

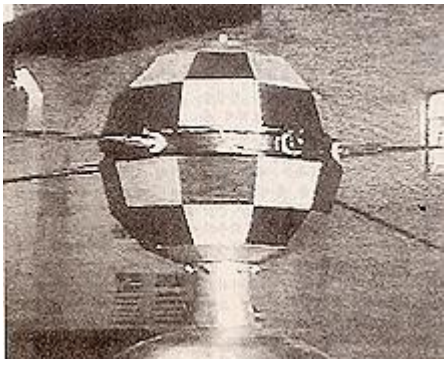
A comparison of launch pads at the two complexes illustrates that both were built for future rockets larger than the *Unha-2*, most likely SLVs, and *Tongchang* has even more growth potential than *Tonghae* because of its taller gantry and much larger flame bucket and launch stand. The 4.5m mobile launch stand opening is too large for the *Unha-2*, requiring an adapter with a 2.5m opening, which was recently seen installed. This indicates a future SLV with a 1.8 times larger diameter first stage, allowing for a booster diameter of 4.3m, in comparison to the *Unha-2*'s 2.4 m. Rather than replacing *Tonghae*, *Tongchang* adds the capability to launch southward into polar orbit, without the ascent phase overflying any country, as now happens at *Tonghae*, where all launches must overfly Japan.

Table 4: North Korean launch complex comparison[i]

Launch pad particulars	Tonghae	Tongchang
Pad length x width; area	45m x 31m; 1665m^2	188m x 55m; 8460m^2
Opening to flame bucket	2m x 2m	6m x 6m
Flame bucket outlet	5m x 12m	6m x 6m
Launch stand rails separation	6m and 8m	10m
Gantry tower height (not incl. crane)	30m	40m
Rail-movable launch stand	6m x 6m	10m x 12m
Launch stand opening diameter	2.5m (for Unha-2)	4.5m (currently fitted with 2.5m adapter for Unha-2

North Korea satellite development

Developing satellites has not been a major focus of North Korea's space programme so far. The *Kwangmyongsong* satellites were primitive by modern technical standards, having no real space mission and with only simple on-board sensors, telemetry and two-way communications. A *Kwangmyongsong-1* model from 1998 has been displayed with a cut-away shroud at the space museum in Pyongyang, and is a 0.6m diameter, 48-sided sphere with six equally spaced VHF/UHF antennas, very similar to a photograph released in 1998. Estimates of the satellite/shroud mass are around 50kg and its payload was a recorder playing songs on 27 MHz.



Kwangmyongsong-1

The *Kwangmyongsong-2*, which failed to orbit in April 2009 also, was only slightly more advanced although no picture has so far been released. The satellite reportedly had three missions: again to transmit patriotic songs of the two leaders but now on 470 MHz; to test relay of UHF communications; and to transmit data on the movement situation inside the satellite. In addition, offi-

cial statements claimed "control commands" are sent by multiple ground control posts to the satellite and relay of communications between ground stations. The mentioned "orbital tracking detector" probably uses a radar system seen at *Tonghae*. They also mentioned North Korea's next satellites would be "practical applications satellites for communications, natural resources development and weather forecasting purposes". It would seem likely that early missions might also include military surveillance technology, aimed at filling a gap in North Korea's current ability to assess South Korean and US forces status and other security issues.

Comparison and Forecast

North and South Korea have pursued parallel space programmes, with their origins in ballistic missile programmes. However, their paths to an indigenously launched satellite have been different. While South Korea has been hindered by its bilateral MoU with the US, it has benefited from external assistance and cooperation, developing satellites and finally a launch complex and SLV. By contrast, North Korea has progressed from externally supplied missiles without significant outside help but equally without any legal hindrance. Pyongyang has therefore been able to concentrate on the delivery vehicles rather than the satellites, albeit with little success.

The motivations for these space programmes are both strategic and political. South Korea, for example, is inspired by several factors in developing its space programme, including national prestige, scientific nationalism and the expectation of external benefits from space development. Moreover, its National Space Committee includes ministers with prominent cabinet portfolios, so in some respects the space programme can be seen as a political issue with perceived benefits for various ministries. As the cabinet expects to capture benefits from the space programme and the National Assembly must pass budgets to support it, public support for the space programme is critical. There is also a military or national security aspect to South Korea's space programme, particularly in the realm of intelligence collection. South Korea depends on the US for a considerable amount of intelligence data, which makes many South Koreans uncomfortable.

In the case of North Korea's nuclear tests and ballistic missile exercises, the inability to collect real-time intelligence from satellites has concerned a number of South Korean officials. For Pyongyang, developing an indigenous satellite capability could have potential military benefits, although the rudimentary nature of its current satellites suggest this is a secondary motivation. Rather, the national pride to be gained from developing an indigenous satellite capability of any form is more likely a driving force behind the programme. This was made apparent by official statements through the state-run media. Immediately after the April 2009 launch, KCNA called the satellite payload a "shining product of self-reliance" and a "striking demonstration of the might of our [juche-] oriented science and technology". To be able to develop this capability before its rival, South Korea, would be a significant fillip to the Kim Jong-il regime, particularly at a time of uncertainty over the country's political succession. In addition, the possibility that North Korea could use its SLV capabilities as an interna-

tional launch centre for other states, with concomitant commercial benefits, is likely to further motivate Pyongyang's programme.

Such factors suggest a 'space race' has been ongoing between North and South Korea since the 1980s, with both competing to become the first to launch a satellite. The South Korean media and some politicians often compare the status of the two programmes. North Korea's advantage in long-range missile and SLV development is commonly mentioned as undesirable and something to be surmounted. However, any future competition is likely to be limited. Seoul denies space race dynamics with Pyongyang are a motivating factor in its space programme, with various other commercial, military and domestic political benefits of a space programme encouraging the satellite and SLV development. In addition, South Korea's pursuit of international co-operation and commitment to exploring outer space peacefully combined with budget constraints will preclude Seoul from embarking on large-scale and accelerated SLV development. South Korea's next generation KSLV-2 programme will proceed, but is likely to take several years before reaching fruition. In the meantime, North Korea will also continue its space programme, but problems over SLV reliability will ensure that South Korea will be able to demonstrate its superiority over its neighbour's space capabilities. The inter-Korean space race therefore appears to be between an eager tortoise and a disinclined hare. The development of South Korea's space programme has largely been shaped by the inter-Korean security dilemma and United States constraints on missile technology. Although development so far has been encouraged by competitive rivalry with North Korea, budget constraints are likely to limit any future space race dynamics.

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[i] This report is largely based on information by Jane's Intelligence Review – Proliferation and Procurement – August 14th, 2009: "Space cadets – The Korean peninsula's rocket competition". South Korea by Daniel Pinkston; North Korea by Lewis Franklin and Nick Hansen.

[ii] This table is based on "South Korea's Commercial and Military Missile Programs: A Timeline" by Stratfor Global Intelligence. August 16, 2009.

[iii] Established in 1989, the Satellite Technology Research Centre (SaTReC) is a university based research centre for satellite technology and applications research. SaTReC, which is located within the Korea Advanced Institute of Science and Technology (KAIST), promotes the education and training of satellite engineers through research programs in satellite engineering, space science and remote sensing.