History of Rocketry and Astronautics

Proceedings of the Forty-Third History Symposium of the International Academy of Astronautics

Daejeon, Republic of Korea, 2009

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AAS History Series, Volume 40

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 28

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2013

ISSN 0730-3564

ISBN 978-0-87703-599-2 (Hard Cover)
ISBN 978-0-87703-600-5 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 16

The DPRK's Road to Space—A Brief History*

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Introduction

Ever since the attempted launch of a North Korean satellite in August 1998, there has been increased speculation about the origins and aims of the Democratic People's Republic of Korea's (DPRK) missile and space activities.

This chapter represents a very modest—and tentative—effort to summarize what little is known about the early acquisition of missile-related technology by the DPRK, the extent of its space efforts, and the policies and institutions involved. In trying to piece together this jigsaw puzzle of sketchy and even contradictory data, I was naturally obliged to lean heavily on the work of a few respected authorities with access to privileged and sometimes unusual sources.[1] In order to make this chapter as inclusive as possible, it was necessary to look for evidence scattered far from the shores of Korea. This is not, and cannot be, a comprehensive story of North Korea's missile and space ambitions. Rather, it is a modest attempt at reconstructing a part of North Korea's history from a "space" vantage point, rather than the arms control perspective on which most of the literature is based. Or, to quote from veteran Korea watcher Charlie Vick, "this analysis is subject to revision—and represents a work in progress."[2]

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* Presented at the Forty-Third History Symposium of the International Academy of Astronautics, 12–16 October 2009, Daejeon, South Korea, 2009. Paper IAC-09-E4.3.05.

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"First Satellite"

The first timid step into space was taken by the DPRK on 31 August 1998, when an apparent two-stage rocket (but which later turned out to be three-stage), arbitrarily identified in the West as Teapodong-1 (derived from the name of the place where it was first observed)[3] and subsequently identified as Paektusan-1,[4] lifted off from a facility known as Musudan-ri, Hwadae-gun, on the northeastern coast of Korea. This facility had been in existence since the 1980s. Early test launches had taken place in September 1984, when a missile that was later to become known as Hwasong-5 (a derivative of the Soviet Scud-B) was tested there.[5] Following the Earth's rotation, the missile flew due east across the Sea of Japan. The first stage separated some 300 km from the launch site. The second stage continued over the main Japanese island of Honshu before impacting in the Pacific Ocean, some 330 km east of the Japanese port city of Hachinohe, after flying over 1,300 km. Debris was tracked between 4,000 and 6,000 km into the Pacific Ocean.[6]

At first, the DPRK remained silent, prompting Japan to denounce the overflight as a "missile test" and suspending talks at normalizing relations. In view of ongoing nuclear talks, the U.S. government's reaction was somewhat guarded. Then came a surprise announcement from the official Korean Central News Agency (KCNA), abbreviated:

> The Korean Central News Agency broadcast a report today over the successful launch of the first artificial satellite in the DPRK. The report says: Our scientists and technicians have succeeded in launching the first artificial satellite aboard a multi-stage rocket into orbit. The rocket was launched in the direction of 86 degrees at a launching station in Musudan-ri, Hwadae county, North Hamgyong Province at 12:07 August 31, Juche 87 (1998) and correctly put the satellite into orbit at 12 hours 11 minutes 53 seconds in four minutes 53 seconds. The rocket is of three stages. ... The satellite is running along the oval orbit 218.82 km in the nearest distance from the earth and 6,978.2 km in the farthest distance. Its period is 165 minutes 6 seconds. The satellite is equipped with necessary sounding instruments. It will contribute to promoting scientific research for peaceful use of outer space. The satellite is now transmitting the melody of the immortal revolutionary hymns "Song of General Kim Il-Sung" and "Song of General Kim Jong-il" and the Morse signals "Juche Korea" in 27 MHz.[7]

Four days later, KCNA went on to report that "the Great Leader, Kim Jong-il, sent a message of thanks to the scientists, technicians and workers who had contributed to the successful launch." It said that the satellite, which it identified as Kwangmyongsong No. 1 (bright star or lodestar)[8] was now revolving around the Earth. It gave further details on the missile's purported trajectory and

claimed that "the purpose and mission of the rocket were accomplished at the first launch." Three scientists, Professor Kwon Tong Hwa, Professor Han Hae Chol, and Kim Haeng Gyong were quoted listing the objectives of the satellite:

> First, it is to master the technology of putting a satellite correctly into orbit with a multi-stage carrier rocket.
>
> Second, it is to perfect the structural engineering design of a multi-stage carrier rocket and its control technology.
>
> Third, it is to study the circumstances of the space and verify if electronic devices correctly operate in the space.
>
> Fourth, it is to complete the observation system of the carrier rocket and satellite.[9]

A picture, a video, and an animated picture of the satellite in orbit were released to foreign news agencies. Based on this information, the satellite closely resembled the first Chinese Dong Fang Hong I (DFH-1) satellite, launched 24 April 1970, which, likewise, carried a simple battery-fed radio transmitter broadcasting a patriotic song ("Dong Fang Hong" or "The East Is Red"). Both satellites bore an uncanny resemblance to the 1962 Bell Telephone *Telstar* communications satellite, although lacking its sophistication (such as transistors and solar cells), but were smaller and lighter than their American likeness.

But was there really a satellite? With the exception of Russia's ITAR-TASS news agency, which quoted Russian Space Command as confirming the launch (but which later retracted its statement), the reaction of outside observers was one of utter disbelief. The U.S. Space Command asserted it failed to observe any object correlating with the orbital data supplied. Likewise, no transmission at 27 MHz (the so-called "citizen's band" (CB), used by truck drivers and other mobile travelers) could be detected as the object should have passed over U.S. territory.

However, by 5 September, one intelligence analyst told the *Washington Post* that, based on the data intercepted, the object appeared to have a "flight path that was 'a bit odd' ... There appears that something separated from the second stage and it appears to have some thrust behind it. ..."[10] By 13 September, a South Korean government official broke the news: the ROK government had indeed concluded that the Taepodong-1 flight had been "an unsuccessful attempt to place a satellite into orbit." The next day, U.S. State Department concurred. The DPRK had, timidly and tentatively, embarked on the road to space.

Origins

Tracing the origins of the DPRK's space connection brings one back to the aftermath of the Korean War (1950–1953), known in North Korea as the "victorious fatherland liberation war," when the country rebuilt the powerful defense-industrial base it had inherited as a Japanese protectorate from 1910 to 1945. During that period, Japan built some of its major arms industries, particularly in the north, facing Manchuria, including the Showa aircraft factory, the Pyongyang military arsenal center (second in size in Asia to the Mukden arsenal in Manchuria), vast steel plants, and a second-to-none hydroelectrical complex along the Yalu River/Manchurian border. During the war, these industries were devastated by American B-29 bombers.[11] Even as the war went on, however, with Chinese and some Soviet aid, the North Koreans rebuilt their defense industries, often underground where they were protected against bombardments. The North Koreans became masters in underground structures and indeed, many of today's missile and space-related facilities are built underground.[12]

The 1950s also saw the enunciation of the so-called "Juche" (or "chuch'e") ideology. "Ju" meaning "master" and "che" meaning "oneself." Also known as "Kim Il-Sung Chuui" or Kimilsungism, official DPRK history traces this ideology back to the 1930s but it actually became official policy in December 1955, and was adopted as article 3 of the 1998 DPRK Constitution, which, incidentally, was adopted the day following the announcement of Kwangmyongsong-1! Above all, it is an ideology of man's dominance over nature (under the wise leadership of the party) and self-reliance. In ensuing years, this party line was only strengthened as North Korea's relations with its close allies, the Soviet Union and the People's Republic of China, remained dependent on the whims of the times (de-Stalinization, Khrushchev "revisionism," the Chinese "cultural revolution," and so on). In particular, Kim Il-Sung was said to be shocked by Nikita Khrushchev's "cowardly" behavior toward Cuba during the 1962 missile crisis. The 1961 coup d'état in South Korea and the ROK's rapid rise as an economic powerhouse under President Park Chung-hee (and aborted attempts to build a South Korean missile and nuclear potential in the 1970s) also served to solidify this policy. This period also saw the establishment of the so-called "Second Economic Committee," which was to oversee the burgeoning industrial-military complex under the guidance of the National Defense Commission (NDC) headed by Kim Il-Sung.[13]

In these early post-war years, however, the DPRK was totally dependent on Chinese and Soviet-licensed technology and even complete industrial plants.[14] For its air defense, it turned to the Soviet Union, which provided it with a battal-

ion of V-750 Dvina surface-to-air missiles known in the West as SA-2. (This is the missile that downed Gary Powers's U-2 over the Soviet Union in May 1960.) Next, an agreement was concluded to acquire artillery rockets, known in the West as free rocket over ground (FROG) and as Luna in the Soviet Union. The delivery of this single-stage, unguided, spin-stabilized, solid-fuel missile with a 70 km range constituted a major step forward in the DPRK's quest toward acquiring its own offensive missile forces. In later years, the DPRK would be gaining vital "reverse-engineering" experience based on the Luna missile. To this day, FROG-7A missiles are serving in the 1-million strong Korean People's Army (KPA). Also in this period, the Soviet Union supplied coastal defense S-2 Sopka (SSC-2 Samlet) and SS-N-2 Styx antiship missiles. Still later, PRC would supply its HY-1 "Silkworm" version of the Styx, which North Korea also started producing on its own, along with the HQ-2 Chinese version of the SA-2 "Dvina."

A Chinese Intermezzo

By the mid-1960s, it became clear that the Soviet Union was not yet inclined to go beyond supplying the relatively short-range Luna missile to its non-Warsaw Pact allies. Thus, by about 1965, the DPRK leadership decided to establish an indigenous missile production capability, for which reason the Hamhung Military Academy was founded to train North Korean personnel in rocket and missile development.[15] The move proved to be a wise one, as throughout the 1970s, Moscow continued to resist Korean pressure for longer-range missiles then gradually becoming available to non-Warsaw Pact clients.[16]

Seeking ever more independence from the Soviet Union, President Kim Jong-il traveled to Beijing in April 1975 at the invitation of Chairman Mao Zedong. There, minister of defense O Jin U reportedly expressed an interest in purchasing a 500 km range missile capable of reaching targets throughout the Korean peninsula. Having sought an IRBM/ICBM* capability first, the PRC didn't have such a weapon. But a 1966 Fourth Academy Proposal for this class of missile called DF-41, later renamed D-61, which had initially been rejected, was revived in the form of a single-stage, liquid-propellant missile with a range from 600–1,000 km (nuclear and nonnuclear). This project had the added advantage of weaning Pyongyang further away from Moscow. North Korean engineers were likely involved in the project, which progressed for about a year, but in 1978 the project was canceled when its political sponsor, General Chen Xilian, was removed from office, reportedly for his links with the "gang of four." The DPRK

* Intermediate Range Ballistic Missile/Intercontinental Ballistic Missile (IRBM/ICBM).

apparently suffered another setback but may have gained some important know-how from the project.[17] Thus, it was still the Soviet Union, or rather, a Soviet missile, that was destined to become the foundation stone of the DPRK's missile potential and even the space program that was to lead to today's Paektusan/Unha/Kwangmyongsong projects.

Enter: Scud

From the mid-1940s, the OKB-1 design bureau under Sergei Korolev was developing a number of liquid-propellant missiles of increasing range and sophistication: the R-1 and R-2 derivatives of the German A-4/V-2; the R-5 and R-5M IRBM (known as the SS-3 Shyster in the West), which became the first Soviet ballistic missile capable of carrying a nuclear warhead (cloned as the DF-2 in China, to become the foundation stone of China's missile industry); and the R-7 (SS-6) "Semyorka," which was originally intended as an ICBM but which eventually became the most successful space launch vehicle ever built. All these missiles were propelled by engines designed by Valentin Glushko and propelled by liquid oxygen and ethyl alcohol or kerosene. In addition, Korolev's OKB-1 was working on still another missile, the R-11, the lead designer of which was young Viktor Petrovich Makeyev, who later became known as the "father of Soviet submarine-based missile systems." This road-mobile tactical missile became known in the West as the SS-1B or Scud-A. Under Makeyev's leadership, and against vehement opposition by Korolev, this missile was to become a truly revolutionary system. Why is this so?

For a long time, it was believed that the Scud series of missiles—"Scud" being a generic name for a bewildering variety of very different systems—was based on wartime A-4/V-2 technology. However, archives research by Olaf Przybilski of the Technical University in Dresden has shown it was in fact built around an engine designed by A. M. Isayev and first used in the V-300/R-101 (later known as R-102) antiaircraft missile, a virtual copy of the German wartime "Wasserfall" (one more example of "reverse-engineering"). Unlike the A-4, this engine was using a storable, high-boiling propellant, with highly toxic nitric acid as an oxidizer. Unlike liquid oxygen (LOX), this oxidizer can be stored at normal temperatures inside a rocket for long periods, as an antiaircraft missile should be ready at all times. Of course, such a capability would be highly desirable for a road-mobile tactical system, and even more so for a submarine-launched missile, which in fact, the R-11 evolved into. Korolev strongly disagreed with this proposal and a bitter conflict arose, resulting in the R-11 being spun off to the Votkinsk Machine Building Plant in Miass, Chelyabinsk, with Makeyev as the newly

independent chief designer of OKB-385.[18] Incidentally, this missile is interesting because it brings scientists, for the first time, close to space research. Capable of reaching altitudes of over 100 km, it flew several aeronomy missions during the International Geophysical Year (IGY) under the name Kheysa (1958). There is still another reason why this missile is so important in North Korean space history.

Some years after the beginning of the development of the SS-11 and its derivatives, Makeyev designed a successor with an even more powerful engine and twice its range, up to 300 km. This was the R-17 (later known as the R-300 Elbrus). The West did not realize this was an altogether new system and codenamed it Scud-B. This missile went on to become one of the most widely used ballistic missiles ever, with a production run going into the thousands and serving in more than 30 countries. It was extensively used in the Iran–Iraq conflict of the 1980s, including the infamous "war of the cities," during the 1991 Gulf War, and during the war in Afghanistan. Makeyev went on to design even more advanced versions, known in the West as Scud-C and Scud-D, but these missiles are shrouded in some mystery and they merit much more attention than have been given them in the past.

Into the Middle East

By the early 1970s, the DPRK had been frustrated in its attempts to acquire missiles capable of covering all of Korean territory, including U.S. bases in Japan. The Soviet Union was still reluctant about selling the R-17/Scud-B to other than Warsaw Pact clients. The DF-61 project with China faltered. Enter Egypt.

It is well-known that, as far back as King Farouk's time, following the Israeli war of independence (1948), Egypt harbored dreams of developing its own ballistic missiles and even a space launch vehicle (SLV). To that end, German engineers were brought in to build a successor to the World War II A-4 missile. For various reasons, that effort yielded poor results. Egypt did produce the Al-Zafir and Al-Kahir rockets, but none of these reached operational service. Hence, as did North Korea and other countries at that time, Egypt turned to the Soviet Union, which, by then, was gradually losing its reluctance about providing such "obsolete" technology to third world clients. First, Moscow agreed to supply Egypt with FROG-7A missiles. By early 1973, Moscow furthermore agreed to provide Cairo with a limited number of R-17/Scud-Bs. When the October 1973 Yom Kippur War broke out, President Anwar Sadat reportedly used some 200 FROG missiles to disrupt Israel war efforts (with some degree of success). Just before a ceasefire came into effect, Sadat ordered the launch of two or three R-

17s. They came down in the desert, failing to destroy any targets. But Sadat, and heads of state around the region, were very much impressed with the Scud's "red glare" (as evident from, among others, Saddam Hussein's missile and space ambitions of the 1980s and early 1990s). By now, however, relations between Egypt and the Soviet Union had deteriorated, reaching a breaking point in 1976, and Sadat started looking elsewhere to build his missile forces. This is the same time that the DPRK was shopping for Scud-B range missiles. Sometime between 1976 and 1981 (more likely 1980), Egypt is believed to have provided Pyongyang with a number of R-17 missiles (Cairo claims missile collaboration with the DPRK ended in 1996) in return for industrial assistance. This, it is believed, allowed the DPRK to engage in reengineering the revolutionary R-17 missile, training a cadre of engineers, technicians, and KPA personnel and making it the backbone of missile and space effort of today.[19]

North Korea's Missile Industry Takes Off

With the acquisition of the R-17, North Korea's industry set about developing an impressive series of missiles, both for building its own defense potential and for exports. Initially, this effort was entirely based on licensing and, consequently, on the process of "reverse engineering," an industrial process that proved its worth many times over during the cold war. For instance, the Soviet Union's first post-war heavy bomber (on the specific orders of Joseph Stalin, and against the personal ambitions of Andrei Tupolev), the Tu-4, was an attempt to build a replica of a U.S. Air Force Boeing B-29 that inadvertently strayed into Soviet airspace toward the end of the World War II.[20] In the missile area, the A-4/V-2 derived R-1 and R-2 missiles are believed to be a case in point.[21] China's missile and space effort also greatly benefited from this practice. Despite initial encouragements by its Soviet allies, China's early rocket efforts were rocked by the rapid breakdown of relations with the Soviet Union in the late 1950s. Yet, a substantial amount of knowledge and hardware had been obtained, allowing China to build the impressive missile and space potential it has today. Likewise, initial DPRK missiles were clones of the Egyptian-delivered Scud-Bs but went on to become ever more sophisticated. During this period, North Korea built:

- Hwasong-5: an "exact," 340-km range replica of the R-17 with a warhead mass of 1,000 kg, first tested in 1984; the missile was not operationally deployed by the KPA but a substantial number of Hwasong-5s were obtained by Iran in a alleged $500 million deal, which also helped Iran establish a Scud production line where it became known as the Shahab (or Shihab) 1; it is believed that, during the initial phases, the People's Republic of China

provided assistance in the areas of engine and airframe design, among other things. However, according to Joseph Bermudez, an analyst with *Jane's Defence Weekly*, there is no evidence of Soviet involvement.[22]

- Hwasong-6: an improved version of its namesake, with a range of 500 km, sufficient to strike any target within the Republic of Korea (ROK) with a reduced payload and airframe, the latter reportedly based on special stainless steel imported from the Soviet Union.[23] First flight-tested in 1990, the missile went into full-scale production in 1990 or 1991. Several hundred Hwasong-6s were produced for the Korean People's Army (KPA), where they serve today; a great many more were delivered to Syria and Iran (where they became known under the name Shahab-2).
- Nodong: the first North Korean missile said to feature major modifications from the original Scud design. The Hwasong-6 design was scaled up by as much as 150 percent, making the missile 16 m long, with a weight of approximately 16 tons, and the Isayev engine was upgraded, perhaps with assistance from the Russian Makeyev OKB and possibly China and/or Ukraine. Depending on the warhead, the Nodong's range is said to be between 1,000 and 1,300 km (with some sources mentioning 1,500). Work on the Nodong may have started in 1988, shortly after the DPRK began work on the Hwasong-6. Iran helped finance the Nodong, which it started producing under the name of Shahab-3 (also Zelzal-3), which went on to become the core element of its first space launcher, Safir. Reportedly, Soviet and Ukrainian engineers were involved in solving the significant technical hurdles in upgrading the original Soviet design. A first flight test in 1990 probably failed, with U.S. reconnaissance satellites spotting what appeared to be burn marks where a Nodong had been sighted on the launch site of Musudan-ri. Subsequently, a second (1993) flight test was successful, but the missile flew only 500 km, probably on purpose. Following a 1993 visit to Pyongyang by Pakistani Prime Minister Benazir Bhutto, the Nodong was exported to Pakistan, where it became known as the Ghauri,[24] despite Pakistani claims about this missile being an indigenous effort. The Nodong/Ghauri effort in Pakistan was reported to be the domain of the Khan Research Laboratories (KRL), run by nuclear scientist A. Q. Khan (President Pervez Musharraf said in 2003 that all defense cooperation between Pakistan and DPRK had ended.)
- Musudan: in 2003, rumors had it, that following contacts with the Makeyev engineering design office in Miass, Siberia, which took place around 1992, North Korea received a Makeyev-designed missile from an entirely different category, which it apparently reengineered under the

name Musudan (from Musudan-ri), and which it may have supplied to Iran.[25] This 2,000 km range (more, depending on the warhead),[26] liquid-fueled, submarine/sea-launched ballistic missile (SLBM) was employed by the Soviet Navy since mid-1962 under the designation R-27 (code-named SS-N-6 in the West). Like the Scud, it uses an Isayev-designed engine but one of a very different type, though presumably "well within the level of skill and industrialization of the country," according to veteran Korea watcher Joseph Bermudez.[27] This missile would put the U.S. territory of Guam within range of DPRK rockets, according to South Korean government officials.[28] From the space point of view, this missile may have quite a few surprises in store, according to several Korea/Iran watchers.

- Taepodong/Paektusan/Unha: not a separate missile (it was believed to be a first step toward an ICBM capacity in 1998) but a three-stage satellite launch vehicle (SLV), used for the attempted launch of Kwangmyongsong-1 and -2 in 1998 and 2009, respectively. Taepodong may be something of a misnomer, because the vehicles—a "mock-up" Taepodong, still in another version, was spotted by U.S. satellites in Musudan-ri in 1994, and yet another version was apparently tested in 2006, crashing after about 40 seconds—were all very different and may be composed of altogether different components. Though the first stage is probably based on previously mentioned rocket systems, such as Nodong (probably a cluster of four of these, though even that is not certain), the second and third stages are probably based on entirely different components taken from other Russian and Chinese space efforts: systems as widely apart as the Russian R-27 (Musudan), the Chinese DF-3, and even the Russian antiaircraft missile SA-5 Gammon (Almaz S-200 Angara) have been mentioned in this respect.[29]

Thus, in addition to gradually improving the original R-17 missile (and some other former Soviet missiles also), and following the 1979 Chinese example,[30] the 1980s saw the North Korean missile industry becoming a major export earner for the cash-strapped country. Likewise, assisting countries, such as Iran and Pakistan, in setting up their own missile infrastructures may have helped the DPRK make up for the lack of opportunity to test its missiles on its own soil (the Musudan-ri facility is believed to be a very primitive site, active only when rare launch tests are carried out and virtually abandoned at other times). This is certainly true for the Musudan, suspected to be a clone of the Soviet SLBM R-27: this missile was never tested on North Korean soil but was apparently supplied to Iran where components of the rocket[31] are alleged to have been used as part of the Safir launch vehicle, which recently launched its satellite, Omid-1!

The Foundation of a Space Program

The North Korean leadership's decision, in the mid-1960s, to pursue an indigenous missile capacity and the establishment of a dedicated military academy (Hamhung) has been discussed. In the same period, the Second Machine Industry Department was established and reorganized as the Second Economic Commission in the early 1970s. This institution is believed to operate about 130 munitions factories, including the missile industry.[32]

Initially, the focus was on building missiles with a sufficient range of reaching targets throughout the Korean territory and later, U.S. bases in Japan and as far as Guam. Presumably, ICBM capability was also envisaged and was initially suspected to be the real reason behind the Taepodong/Paektusan-1/ Kwangmyongsong-1 test in 1998. It is far from clear if this is true, but recently, some previously skeptical observers were noting that an ICBM capability may finally be nearing reality based on data resulting from the recent Unha-2 test.[33] Also sometime during the 1980s, it is assumed that Kim Il-Sung initiated the planning of a national space program and formed a national committee that is directing the program to this day.[34] In late 1993 or early 1994, following the successful launch of South Korea's Uribyol (Kitsat) 1 and Uribyol (Kitsat) 2 satellites on 10 August 1992 and 26 September 1993, respectively (both by Ariane 4), Kim Il-Sung is reported to have addressed a meeting of the KWP Central Committee, where he expressed the wish to put a satellite into orbit and develop the necessary SLV.[35] Following the "great leader's" death, his son, the "dear leader" Kim Jong-il, continued to show much interest in the space program. During a rare September 2001 visit to Russia, he toured the Khrunichev plant and the space mission control center near Moscow.[36] In early 2009 he was reportedly present at the Tonghae launch center in Musudan-ri to view the launch preparations for Unha-2 and "observed the whole process of the satellite launch at the centre."[37]

The political importance that the DPRK leadership attaches to space spectaculars seems to be reminiscent of Nikita Khrushchev's 1950s insistence on having space launches coincide with major party events. For example, the 4 September 1998 revelation of the (attempted) launch of Kwangmyongsong-1 coincided with the 50th anniversary of the founding of the DPRK and was followed, the next day, by a meeting of North Korean Supreme People's Assembly, during which the new 1998 constitution (enshrining, among other things, "juche") was adopted, making Kim Il-Sung "eternal president" of North Korea in addition to electing Kim Jong-il as the chairman of the all-important National Defense

Commission (NDC) which, among other things, directly supervises ballistic missile developments and the space program.[38]

Unha-2: A Modest Breakthrough?

As is often the case with major DPRK space tests (for instance, three years went by between the first and second tests of Nodong), a long period followed the 1998 Taepodong (Paektusan) launch before another such attempt was made. This despite the fact that as early as 28 December 1998, party daily Rodong Sinmun already announced that North Korea would launch another satellite in the future.[39] (Also, North Korea announced "many satellites" to be in preparation during the July 1999 Unispace conference in Vienna, as Theo Pirard has pointed out in a forthcoming publication.) The satellites were said to include a communications, weather, and Earth resources technology satellite (ERTS).[40]

In addition, satellite imagery taken last year revealed the fast-paced construction of a new, more impressive launch site labeled "Tong'chang" along the west coast (construction has picked up even more in recent months, and completion is now said to be "nearly complete"). Observation satellites have revealed this site to be equipped with an umbilical tower and gantry allowing for the launch of much larger missiles. Work on the remote, primitive, and mostly unoccupied Musudan-ri launch site also progressed. The Taepodong-1 launch pad and gantry umbilical tower was scrapped and an entirely new launch pad and much taller umbilical tower was constructed.

In the end, it took 11 years before a new satellite attempt was attempted.[41] The 5 April 2009 alleged launch of Kwangmyongsong-2 presented many surprises, however.

First, almost two months early, North Korea announced it would launch a missile, named Unha-2 (galaxy), to put an "experimental communications satellite," Kwangmyongsong-2, into orbit. In March 2009, the DPRK provided international maritime and aviation authorities with the "necessary information for the safe navigation of planes and ships" during the prospected launch window from 4 to 8 April. In addition, North Korea announced it was planning to join the UN Outer Space Treaty. Echoing the confidence that the North Koreans had in a successful launch (at least in part), North Korean leader Kim Jong-il was present at the launch site prior to and during the launch.[42]

When the Unha-2 (DPRK designation) "satellite launcher" finally lifted off from Musudan-ri on Sunday, 5 April 2009, at 11:30 a.m. local time, a ROK government official promptly acknowledged that North Korea had apparently "fired a rocket, carrying a satellite." As in 1998, Russian authorities initially confirmed

that the satellite went into orbit. But, as 11 years before, Russia had to retract that statement, having failed to observe the object.[43] Likewise, as 11 years earlier, the U.S. Northern Command (NORTHCOM) stated that the first stage landed in the Sea of Japan while "the remaining stages along with the payload itself landed in the Pacific Ocean."[44] Initially, then, the launch was seen as an almost complete failure.[45] Within weeks, however, that view radically changed. First, U.S. space observer Craig Covault asserted that "new details ... indicate the vehicle flew successfully several hundred miles farther than previously believed and used more advanced steering than has been demonstrated by the North Koreans before... The rocket impacted as far as 2,390 miles from the launch site to about 1,900 miles as earlier announced by the US and Japan." Veteran space analyst Charles Vick of Global Security Org. (previously with the Federation of American Scientists—FAS) asserted that, contrary to earlier beliefs, "the second stage did ignite after separation from the first stage,"[46] demonstrating technological hurdles, such as successful stage separation and a second stage with a step-throttling capability, important assets to boost a satellite into a useful orbit.

Some Preliminary Conclusions

Since those remarks were made, a number of important new elements have come to light. Based on pre- and post-launch images from commercial satellites and a video released by the North Korean authorities, showing the rocket during takeoff, the size of its umbilical tower, the diameter of its airframe, the color of its exhaust, and many more previously obscure details, analysts are beginning to construe a nascent DPRK space program well beyond the 1998 Taepodong/ Paektusan experiment.[47] Some major conclusions include: The splashdown points of the first two stages indicate that both stages fell within the announced area, suggesting that these stages worked essentially as planned.

- However, the third stage "may have separated from the second stage, but it apparently did not ignite and fell into the Pacific Ocean with the satellite it was carrying, near where the second stage splashed down."
- Launch parameters announced by North Korea indicated that the satellite may have weighed around 300 kg, significantly more than Kwangmyongsong-1.[48]

Highly speculative (with widely diverging opinions among experts) but significant information on the launch vehicle was also gleaned from the new data. According to David Wright and Theodore Postol:

- the launcher was determined to have a length of roughly 30 meters and a mass of 80–85 metric tons,
- the first stage used a cluster of "four Nodong engines housed in a single missile casing and sharing a common fuel tank,"
- still, according to Wright and Postol, the second stage "appears identical to the single stage Soviet R-27 SLBM, called the SS-N-6 in the US"; this is a very different system from the Scud-B/Nodong previously mentioned (unlike the second stage of the 1998 Taepodong/Paektusan-1), using much more advanced liquid fuels (unsymmetrical dimethylhydrazine and nitrogen tetroxide), providing it with a higher thrust, and
- the third stage appears to be very similar, if not identical, to the upper stage of the Iranian Safir-2, which placed a small satellite in orbit in February 2009. This stage may use the small steering motors from the SS-N-6 for propulsion. Therefore, it appears the Unha-2 uses liquid-fueled upper stage, unlike the solid-fueled TD-1 launcher.[49]

Another view was aired by Norbert Brügge:[50]

- "The first stage of Unha-2 is derived clearly from the Chinese DF-3 missile. The propulsion is consequently a cluster of four YF-2 engines"[51] without the stabilizing fins (Wright and Postol agree that "China's Long March-1 vehicle is essentially the same size and configuration of Unha-2, the first stage of which was originally designed as the DF-3 ballistic missile with a range of 3,500 km and a 1-ton payload."[52]
- Still, according to Brügge, "the second stage is a scaled-down version of the Iranian Safir SLV, propelled by two small YF-3 engines[53] from the second stage of the Chinese DF-4 missile." In Brügge's view, there is no recognizable evidence of Soviet R-27/SSN-6 technology. The third stage "appears to be a solid fuel motor, like the one used by the first Chinese CZ-1 launcher." This motor is situated within the payload fairing, according to Brügge.

And in the view of veteran Soviet/Korean watcher Charlie Vick:[54]

- the overall booster has a length varying between 27–33 meters in height,
- the first stage has a diameter that can accommodate the four engine cluster of Nodong-A engines. This gives a first stage length of the order of 14.5–16.6 meters,
- "the Nodong-B IRBM launch vehicle that North Korea and Iran are documented to have flight-tested and deployed appears to be at the basis of the second stage." This is a view that clearly differs from the Wright/Postol analysis, which assumes that a Russian R-27/SS-N-6 was involved, and

- "the third stage appears to be a modernized variant of the Chinese Long-March 1 last stage motor with an active attitude control system."

Clearly, several different views are being put forward, and this overview is far from complete.[55] The final outcome will be revealing not only in terms of what the new launcher could achieve, but where and when its technology originated and to what extent the DPRK's newest SLV is based on foreign (Russian, Chinese, Ukrainian[56]) inputs (and feedback from Iran), including wholesale use of imported components. In any case, appearances notwithstanding, North Korea seems to have progressed to an important new capability in both satellite launching terms and military terms.[57]

A Cautionary Note

Ordinarily, concluding remarks of a chapter of this type should try to summarize and evaluate the proposals that have been put forward. I'm going to end this on a very unusual note, you might even say a discordant note. Much of my argumentation has revolved around the idea of "reverse-engineering," indeed, on the idea of "juche." As already stated, reverse-engineering was a very important part of the cold war defense buildup in the Soviet Union, in China, and elsewhere. But a lot of recent information, including, but not only, Unha-2 imagery, has set minds thinking. This chapter already mentioned some peculiar aspects of the DPRK missile program: a "new" missile is sighted, it is tested just once, maybe not even successfully, and a month later, a contract is signed to deliver the missile and even complete production facilities to a third country. Likewise, when Iran introduces a "new" Shahab missile, it is very almost promptly declared operational and, within the shortest time span, serves as part of a satellite launch vechicle. It should come as no surprise that some observers find that hard to swallow. I'm referring specifically to German missile expert Robert Schmucker, a former United Nations Special Commission (UNSCOM) weapons inspector in Iraq, who has thorough knowledge of past Iraqi attempts to copy and improve on the Scud-B and who now heads a consultancy (Schmucker Technologie) in Munich, Germany.

His thinking is this: first, the flight characteristics of North Korean Nodongs and the associated Iranian Shahab and Pakistani Ghauri so closely resemble original Soviet Scud-B parameters that this can hardly be the result of "reverse engineering." He points out that when the Soviet Union stopped producing its many Scud variants, several thousands of these missiles had rolled off the assembly lines, perhaps up to 7,000, according to some sources. Second, indica-

tions are that in later years, Makeyev's design bureau developed and tested extended-range Scud-C and Scud-Ds, which would have become illegal under the Intermediate-range Nuclear Forces (INF) treaty of 1987. So, what do you do? You export them through a third country—the DPRK—but you market them to clients in the Middle East who were stunned at the appearance of missiles during the 1973 war. The same is true with other "obsolete" former Soviet weapons, such as the R-27 and the SS-21 Toshka. And he argues that the development of all the weapons that North Korea (and Iran) have been fielding has been so amazingly fast that it would have required, at the very least, extensive assistance, if not the delivery of complete systems to make it possible (this would make the Korean Nodongs, and Iranian missiles, largely cobbled together from components made elsewhere). Stronger even, in his view, "North Korea merely serves as a go-between for Soviet-Russian" hardware (my translation from the German). There is, he claims, "no indigenous rocket production as claimed in the literature despite claims by defectors who probably wish to please" their interpellators.[58] At most, the argument goes, North Korean, Pakistani, and Iranian space assets are merely, albeit innovatively, cobbled together from existing bits and pieces. Some of the foremost Korea observers, such as MIT's Theodore Postol and David Wright, a DPRK expert with the Union of Concerned Scientists, give this view more than a fair reading.[59]

So, is it all an elaborate hoax? If you look at the admittedly fragmentary but voluminous evidence, it seems hard to believe that the DPRK missile and space program is merely a facade. Observers who have been studying the issue for decades, and who have privileged access to the widest variety of sources, not just open sources, would strongly disagree, though there is an increasing realization that former Soviet entities and other institutions have probably had a far greater input than previously assumed. It makes for an interesting debate.

Endnotes

[1] Naturally, this approach entails the very real danger of, what Professor Robert Schmucker refers to as, "chain quotation" (Ring-Zitierungen), Markus Schiller and Robert Schmucker, "Irans Satellitenträger Safir—ein Schritt zur Langsreckenwaffe?" *Raumfahrt Concret* (February 2009): p. 20.

[2] See: http://globalsecurity.org/wmd/world/dprk/td-2.htm.

[3] Likewise, other North Korean missiles were tentatively named Nodong (or Rodong), Musudan, et cetera, all places near the Musudan-ri facility.

[4] Paektusan, on the other hand, is linked to the mythical Paektu mountain on the Chinese border, where Kim Il-Sung is said to have led his anti-Japanese guerrillas from 1937 to 1943. It is to be noted that several ways of pronouncing Korean words are possible. For instance, Paektusan may also be written as Baektusan, Nodong may be pronounced as Rodong, et cetera.

[5] Joseph S. Bermudez Jr., "North Korea's Musidan-ri Launch Facility," See: http://www.cdiss.org/spec99aug.htm.

[6] See: http://cns.miss.edu/archive/conry_north_korea/factsht.htm.

[7] See: http://www.kcna.co.jp/index-e.htm.

[8] On the occasion of his son's 50th birthday on 16 February 1992, Kim Il-Sung is said to have presented him with a calligraphy poem recalling the "double rainbow and a bright star in the sky" that marked his birth on Paektu mountain (he was, in fact, presumably born in the Soviet Union): "from the eternal snowy summit of our sacred Baektusan Mountain, a bright star shall rise." This is the alleged origin of the satellite's name.

[9] KCNA, "North Korean Scientists on DPRK Artificial Satellite Technology," see: http://www.kcna.co.jp/index-e.htm. Francis Graham pointedly notes that the quoted scientists "never aver that the satellite was in fact in orbit, but merely talk about its purposes," Francis Graham, *Lodestar—The North Korean Satellite Attempt and Its Geopolitics* (Trafford Publishing, 2006), p. 26.

[10] Dana Priest, "N. Korea May have Launched Satellite," *Washington Post* (5 September 1998).

[11] Robert F. Futrell, *The United States Air Force in Korea 1950–1953* (New York: Duell, Sloan and Pearce), p. 175.

[12] Fact sheet, Federation of American Scientists, Defense Industry, http://www.fas.org/nuke/guide/dprk/target/def-industry.htm.

[13] Daniel Pinkston, *The North Korean Ballistic Missile Program* (Strategic Studies Institute, U.S. Army War College, February 2008), pp. 2–4.
See: http://www.strategicstudiesinstitute.army/mil/pubs/display.cfm?PubID=842. NDC is defined by the 1998 constitution as "the highest guiding organ of the military and the managing organ of military matters," making it the most powerful institution in the country.

[14] "North Korea's Nuclear-Capable Missiles," *The Risk Report*, Vol. 2, No. 6 (November–December 1996). See also: Pinkston, *The North Korean Ballistic Missile Program*, p. 4; and Joseph Bermudez Jr., "A History of Ballistic Missile Development in the DPRK," Occasional Paper No. 2, Center for Nonproliferation Studies, pp. 2 and 5. http://cns.miss.edu/opapers/op2/op2.pdf.

[15] Bermudez Jr., "A History of Ballistic Missile Development in the DPRK," p. 6; Pinkston, *The North Korean Ballistic Missile Program*, p. 14.

[16] This may not be entirely accurate, as some reports assert that Moscow provided a number of Scud-B missiles to North Korea in the early 1970s. See the chapter on Egypt.

[17] John Wilson Lewis and Hua Di, "China's Ballistic Missile Programs, Technologies, Strategies, Goals," *International Security*, Vol. 17, No. 2 (Fall 1992): pp. 32–33; Bermudez Jr., "A History of Ballistic Missile Development in the DPRK," pp. 7–8; Robert H. Schmucker, "Third World Missile Development—A New Assessment Based on UNSCOM Field Experience and Data Evaluation, 12th Multinational Conference on Theater Missile Defense, Edinburgh, 1-4 June 1999, p. 2.
See: http://totalwonkerr.com/file_download/25/Schmucker_3d_World_Missile.pdf.

[18] Boris Chertok, *Rockets and People: Creating a Rocket Industry, Volume II*, Asif Siddiqi, editor, (NASA History Series, NASA SP-2006-4110), pp. 243–260.

[19] Pinkston, *The North Korean Ballistic Missile Program*, p. 15; Bermudez Jr., "A History of Ballistic Missile Development in the DPRK," p. 10.

[20] In an e-mail to the author, Professor Schmucker points out that, if anything, the Tu-4 example shows that reverse-engineering may be more mythological than true: "the Soviets were successful only with the basic air frame, however, the dimensions are slightly different to the U.S. original (this is also true for the Soviet A-4, the R-1). The rest of the plane (tires, windows...) had either to be procured from the USA in secret or the Soviets used license-manufactured items like the engines. Look at the performance figures: the range of the Soviet version of the U.S. B-29 is only about half the original figure" (e-mail of 24 September 2009).

[21] Even here, "simple" things, such as rubber parts, could not, at that time, be produced by Soviet industry, and German parts had to be procured to make the rocket work (Boris Chertok tells this story in *Raketi i Lyudi—Rockets and People.*

[22] Bermudez Jr., "A History of Ballistic Missile Development in the DPRK," p. 13.

[23] Bermudez Jr., "A History of Ballistic Missile Development in the DPRK," p. 14.

[24] NTI Pakistan Profile, Missile Overview,
see: http://www.nti.org/e_research/profiles/Pakistan/Missile/index_3066.html.

[25] Richard Fisher Jr., "North Korea's New Missiles," International Assessment and Strategy Center, 20 September 2004;
see: http://www.stategycenter.net/printVersion/print_pub.asp?pubID=3; Joseph S. Bermudez, "Japan Reveals Name of North Korea's R-27 IRBM," *Jane's Defence Weekly* (23 May 2007); Daniel Pinkston, "The North Korean Ballistic Missile Program," February 2008, p. 35. The first report on this issue was by Thomas E. Ricks and Jackie Calmes, "Reports that China Aided North Korea on Missiles Complicates Trade Issue," *Wall Street Journal* (15 March 1994).

[26] The Musudan-version (if there is one) is reported to have a range of up to 3,200 km.

[27] Joseph S. Bermudez, "Japan Reveals Name of North Korea's R-27 IRBM."

[28] Associate Press, "North Korea Displays New Missile That Can Reach Guam, Report Says," *International Herald Tribune* (29 April 2007).

[29] In making these remarks, I am indebted to David Wright (e-mail to the author of 24 September 2009). See also: http://www.ucsusa.org/assets/documents/nwgs/Wright-Analysis-of-NK-launcher-3-18-09.pdf.

[30] John Wilson Lewis, Hua Di, "China's Ballistic Missile Programs, Technologies, Strategies, Goals," p. 33.

[31] David Wright, e-mail of 24 September 2009.

[32] Pinkston, *The North Korean Ballistic Missile Program*, pp. 39–41.

[33] Theodore Postol, "A Technical Assessment of Iran's Ballistic Missile Program—Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential," 6 May 2009, p. 36. See: http://docs.ewi.info/JTA_TA_Program.pdf.

[34] Lewis Franklin and Nick Hansen, "North Korea's Space Programme," *Jane's Intelligence Review* (September 2009).

[35] Joseph Bermudez, "Taeopo-dong Launch Brings DPRK Missiles Back into the Spotlight," *Jane's Intelligence Review* (October 1998): pp. 31–32.

[36] Andrew Jack and Gerard Baker, "North Korean Leader Vows to Continue Missile Project," *Financial Times* (8 September 2001). See also: "Kim Visits Moscow Space Sites," BBC online, (5 August 2001). See: http://news.bbc.co.uk/2/low/europe/1475064.stm.

[37] See: http://www.kcna.co.jp/index-e.htm.

[38] Pinkston, *The North Korean Ballistic Missile Program*, p. 41.

[39] It is possible that on 5 July 2006, another attempt was made at launching a satellite, when a Taepodong/Paektusan missile was launched from Musudan-ri along with several other missiles. However, the Paektusan flew for only some 40 seconds before failing and crashing near the launch site. Shortly before, in June, DPRK announced that it no longer felt bound by a self-imposed moratorium on missile tests, which did not lead to a diplomatic breakthrough in nuclear talks.

[40] Charlie Vick, "Unha-2 Second Flight Test *Kwangmyeongseong-2* Satellite Payload," see: http://www.globalsecurity.org/wmd/world/dprk/td-2-second-flighttest.htm.

[41] However, an attempted Taepodong launch seems to have failed in July 2006 when the first stage of a large rocket, approximately 40 seconds into the launch, caused the missile to crash a few kilometers from the launch site. This "Teapodong-2" vehicle, which is said to have been different from the original 1998 launcher, may also have aimed at launching a satellite. In view of the disastrous failure, DPRK media remained silent about the test, however.

[42] People's Daily Online, "DPRK Leader Kim Jong-il Observes Satellite Launch," see: http://english.people.com.cn/9001/90783/91321/6630374.html.

[43] "Russia Confirms DPRK Satellite Launch, *Xinhua* (5 April 2009).

[44] Peter Crail, "North Korea Launches Rocket, Renounces Talks," *Arms Control Today* (May 2009).

[45] William J. Broad, "North Korean Missile Launch Was a Failure, Exports Say," *New York Times* (6 April 2009).

[46] Craig Covault, "North Korean Rocket Flew Further than Earlier Thought," *Spaceflight Now* (10 April 2009).

[47] For some exciting new insights into DPRK space effort, see:
http://www.globalsecurity.org/wmd/world/dprk/td-2-flighttest.htm;
http://www.globalsecurity.org/wmd/world/dprk/td-2-second-flighttest.htm;
http://www.globalsecurity.org/wmd/world/dprk/td-2-3rd-4th-flighttest-buildup.htm,
and David Wright and Theodore A. Postal, "A Post-Launch Examination of the Unha-2," *The Bulletin of the Atomic Scientists* (29 June 2009), see:
http://thebulletin.org/web-edition/features/post-launch-examinationof-the -unha-2;
also see: Norbert Brügge, "North Korea's Impressive Space Launch Vehicle 'Unha-2'," see: http://www.b14643.de/Spacerockets_1/Diverse/Unha-2/Unha.htm.

[48] Wright and Postol, "A Post-Launch Examination of the Unha-2," see:
http://www.thebulletin.org/web-edition/features/post-launch-examination-of-the-unha-2.

[49] Wright and Postol, "A Post-Launch Examination of the Unha-2," see:
http://www.thebulletin.org/web-edition/features/post-launch-examination-of-the-unha-2.

[50] Brügge, "North Korea's Impressive Space Launch Vehicle 'Unha-2'," see:
http://www.b14643.de/Spacerockets_1/Diverse/Unha-2/Unha.htm.

[51] This is an engine using nitric acid/UDMH as a propellant, see: http://www.astronautix.com/engines/yf2.htm.

[52] Wright and Postol, "A Post-Launch Examination of the Unha-2," see: http://www.thebulletin.org/web-edition/features/post-launch-examination-of-the-unha-2.

[53] Used on CZ-1. See: http://www.astronautix.com/engines/yf3.htm.

[54] Charles P. Vick, "Unha-2/Taep'o-dong 2 (TD-2) Second Flight Test," see: http://www.global.security.org/wmd/world/dprk/td-2-second-flighttest.htm.

[55] An interesting discussion forum is Geoffrey Forden's "Arms Control Wonk," a website devoted to various arms control developments. See, in this respect: "DPRK: ICBM or Space Launch Vehicle?" See: http://www.armscontrolwonk.com/2249/dprk-icbm-or-space-launch-vehicle.

[56] In this respect, Russian authorities in 1992 prevented a number of Makeyev design bureau engineers from traveling to DPRK. This episode is well-documented and was confirmed by ranking Russian officials at the time.

[57] In the views of Wright and Postol, "A Post-Launch Examination of the Unha-2," "the Unha launcher represents a significant advance over NK's previous launchers and would have the capability to reach the continental United States with a payload of 1 ton or more if NK modified it for use as a ballistic missile." According to the same authors, however, the new launcher may depend to such an extent on "technology and assistance from Russian missile experts, although possibly without the involvement of the Russian government" that "efforts to work with other countries to restrict further foreign assistance would be important and could help slow future progress." In this context, it is interesting that the Russian government has offered to launch DPRK satellites with Russian launchers from Russian soil, if the DPRK is willing to forego developing its own launcher. This is in line with earlier DPRK overtures to the United States that it would be willing to give up its own space efforts if the United States would provide it with such a capability.

[58] Robert H. Schmucker and Markus Schiller, "Die Scud-Raketenfamilie—Tor zum Weltraum?" *Raumfahrt Konkret* (4 May 2008): p. 17.

[59] Wright and Postol, "A Post-Launch Examination of the Unha-2," see: http://www.thebulletin.org/web-edition/features/post-launch-examination-of-the-unha-2. In an e-mail to the author, David Wright pointed out that "the position you describe of Schmucker's is stronger than mine... I think it is very possible that North Korea has manufactured missiles of various kinds. They key question is how much foreign assistance they may have had in those manufacturing programs versus how much they were able to do by reverse-engineering. In some cases, it is possible that North Korea may have acquired production equipment from abroad. In other cases, they may have acquired some components and built others. ... My feeling is that there is good evidence to suggest that NK has had significant assistance from outside, and has likely gotten components from outside, but this will remain an open question until there is direct evidence from Russia" (e-mail of 24 September 2009).